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The Use of Probiotics in Poultry Nutrition: A Literature Review

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ABSTRACT

Animal production is inextricably linked to human nutrition and health. Animal intestinal illnesses like *Campylobacter*, *Salmonella*, *Listeria* and *Yersinia* can directly lead to food contamination. As a result, innovative approaches to animal breeding are being used with the goal of producing meat that is safer and of higher quality while also taking environmental preservation and animal welfare into consideration. All together, these developments have sped up research for substitute feed additives that can achieve some of the advantageous effects of antibiotics. Alternative materials for antibiotics studied, commercially marketed and developed for use in practical utilization. The bacteria that make up the gastrointestinal microbiota vary from those that are believed to be advantageous to the host to those that could be detrimental. Feeds containing probiotics provide a ray of hope for that area of the feed industry. The information currently available regarding the effects of probiotics on animal health is required; they conclusively demonstrate how probiotics function to lower bacterial gastrointestinal pathogen populations. Worldwide interest for probiotics is rising due to customers seeking safe therapeutic and preventive health benefits as well as the introduction of promising new products to the market. Increased health consciousness among the general public and the availability of probiotics as dietary supplements are the primary drivers of the global probiotic market's expansion. The aim of this article is to discuss how probiotics and alternative chicken production techniques might enhance food safety and poultry health by reducing pathogenic organisms and increasing the yield and quality of eggs and meat.

1.Introduction

The poultry makes a substantial contribution to animal protein, which has a high nutritional value and is linked to other businesses like the animal feed sector, it is also one of the main sources of income. Therefore, the latest technology must be employed to enhance the nutrition of chickens during the production (Abbas *et al.,* 2023a; Kumalo *et al.,* 2024). Feed is defined as a combination of several components that provide the nutrients needed for optimal growth in terms of both quantity and quality (Abbas *et al.,* 2024a). It is clear that a significant amount of the total cost of raising hens is spent on feed (Abbas *et al.,* 2023b). The demand for organic poultry meat and egg products are continues to expand alternative poultry farming systems, these production methods do, however, come with difficulties because of the shifting climatic conditions and potential for exposure to foodborne pathogens. As a result, the performance and health of poultry can be enhanced by the introduction of feed additives (Ricke, 2021). Vitamins, urea, antioxidants, antibiotics, vitamin C, medicinal plants and other substances may be added to the feed (Alshelmani *et al.,* 2020; Abbas *et al.,* 2024b). Concerns about antibiotic resistance and Europe's ban on the use of subtherapeutic antibiotics have made the search for antibiotic alternatives for chicken production more widespread (Kairalla *et al.,* 2022a: 2022b; 2023). Enteric infections are a significant issue for the poultry industry because they reduce production, increase mortality, and have the potential to contaminate poultry products meant for human consumption (human food safety). Probiotics is one of the many techniques that can be utilized to reduce poultry enteric illness and the resulting contamination of poultry products (Gibson and Fuller, 2000; Kareem, 2020; Urban *et al.,* 2024). Probiotics are live microbial feed supplements that improve intestinal equilibrium when given to animals or humans, and have a positive impact on the host's health when taken in sufficient quantities. (Huys *et al.,* 2013). The term "probiotic," which means "for life," is derived from the Greek words "pro" and "bios". Numerous factors affect how effective probiotic supplements are. As a result, selecting the appropriate bacterial strains and dosage are essential. Probiotics are frequently present in animal feed, particularly for chickens, because they improve health and encourage growth. Probiotic cultures must meet specific criteria before being put to feed, and certain probiotic microorganisms can enhance the intestinal barrier's performance by changing the phosphorylation of tight junction and cytoskeletal proteins. Both the "stability" of the cell and the relationships between cells inside the intestinal mucosa may be impacted by this (Singh *et al.,* 2021). Probiotics are beneficial microorganisms that reside in the host's digestive tract and when taken in enough amounts improve health. Yogurt is one type of food that is high in probiotics (Fan *et al.,* 2021). They accomplish these goals by controlling the proliferation of intestinal bacteria, lowering blood cholesterol, and modifying inflammatory reactions (Gibson and Wang, 1994; Aminlari *et al.,* 2019; Liu *et al.,* 2018). The aim of this article is to discuss how probiotics and alternative chicken production techniques might enhance food safety and poultry health by reducing pathogenic organisms and increasing the yield and quality of eggs and meat.

2. Origins and history of probiotic

The Latin origin of the word probiotic means "for life." Long before the existence of probiotic microbes was known, fermented foods like cheese, kefir, kumis, and bread were widely used for therapeutic and nutritional purposes. Most people agree that fermented goods were most likely found/or rather, found on their own. Probiotics have a long history that parallels the growth of the human species and may be traced back to around 10,000 years ago thanks to modern, sophisticated procedures (Ozen and Dinleyici, 2015). Humans have been using probiotics since 2000 BC, when they discovered a way to prolong the shelf life of milk. The earliest food producers really used bacteria and yeasts to transform milk into fermented dairy products, even though they were unaware of their existence (Nakazawa and Hosono, 1992).

Probiotics have been used since before bacteria were ever discovered. Egyptian hieroglyphs depicted fermented milk products, and Tibetan nomads have long utilized fermented yak milk to preserve milk throughout their arduous journeys (Guo *et al.,* 2014). During the 1940s, the majority of microbiologic research was focused on identifying pathogenic bacteria rather than types of bacteria or yeasts that promote health. Identifying the mechanisms of action of probiotic strains and screening possible probiotic strains from isolates in nature or from human hosts were the main goals of probiotic research in the 1950s - 1980s. The intricate relationships between normal flora and their capacity to withstand the invasion of pathogenic bacteria-a process known as colonization resistance-have been better understood via continued research (McFarland, 2000). The original meaning of "probiotic" was "a live microbial supplement, which beneficially affects the host by improving its microbial balance" (Fuller, 1991). Since then, studies have examined the potential therapeutic applications of these agents, in 1995, as knowledge of their characteristics grew; the term "biotherapeutic agents" was coined to refer to microorganisms possessing particular therapeutic qualities that simultaneously impede the growth of pathogenic bacteria (McFarland and Elmer, 1995).

The number of evidence-based trials investigating the safety and usefulness of various probiotic products has increased exponentially since 2000 (McFarland, 2015). Better methods have been developed to identify microorganisms that cannot be cultivated in conventional culture media, which accounts for 75-95 percent of colonic bacteria (Frank and Pace, 2008; Aagaard *et al.,* 2013). With the use of these more advanced instruments, scientists can now concentrate on studying how disruptive events, like exposure to antibiotics, modify the microbiota and how different probiotic strains can balance or restore it (McFarland, 2014). In accordance with the FAO/WHO definition, the International Life Sciences Institute and the European Food and Feed Cultures Association probiotics are defined as "a live microbial food ingredient that, when taken up in adequate amounts, confers health benefits on the consumers" (Huys *et al.,* 2013).

3. Probiotic species

Streptococcus thermophils, Bifidobacterium bifidum, Lactobacillus bulgaricus, Lactobacillus L. *plantarum*, and *Aspergillus oryzae* are examples of probiotic organisms (Khaksefidi and Rahimi, 2005). A host's intestinal health and susceptibility to disease can be impacted by the bacterial microflora in both good and negative ways (Holzapfel *et al.,* 1998). Microorganisms from the small intestine's duodenum, jejunum, and ileum, including *Lactobacillus* species, *Streptococcus* species, and *Escherichia coli*, have been isolated (Mead, 1997). It is commonly known that keeping some bacteria in the intestine, like *Lactobacillus* and *Bifidobacterium* species, offers advantages for the animal host (Cowen *et al.,* 1987). There has been a lot of development on probiotics, which are believed to help maintain and increase lactic acid bacteria (LAB) in the gut (Klein *et al.,* 1998). Prior research has indicated that good bacteria in the bowel can be maintained and increased by using *Lactobacillus* species, *Bifidobacterium* species, and *Bacillus subtilis* (Hoa *et al.,* 2000). *B. subtilis* is one of these organisms that are utilized in the feed business (ACAN, 2000). Along with encouraging beneficial alterations in the gut microbiota (Hosoi et al., 2000), diarrhea recovery (Maruta *et al.,* 1996), body weight gain, and feed efficiency in the hosts were observed in animals given *B. subtilis* (Jiraphocakul *et al.,* 1990).

The potential applications of probiotic/FOS prebiotic combinations in chicken production have sparked significant interest in the field. Combining probiotic bacteria with FOS could be a potential feed supplement because certain LAB and *Bifidobacterium* digest FOS, which is also a probiotic candidate. These mixtures are referred to as synbiotics (SYN) (Adebola *et al.,* 2014; Hamasalim, 2016; Markowiak and Śliżewska, 2018; Kariyawasam *et al.,* 2020). Since the proper probiotic candidate needs to be matched with the prebiotic to be employed as a substrate, these combinations rely on the strain and species (Rastall *et al.,* 2005; Saminathan *et al.,* 2011]. Markowiak and Śliżewska (2018) summarized the application of SYN feed additives in animal nutrition and proposed that a SYN candidate should satisfy all probiotic and prebiotic match requirements. For example, some probiotics can only consume the monosaccharides of the crude FOS preparations, Hence, the purity of the FOS can be a problem (Fan *et al.,* 2021). Probiotics such as colonizing species of *Streptococcus, Lactobacillus, Clostridium, Bacillus,* and *Enterococcus* are frequently added to chicken feed as in-feed supplements. A gram-positive anaerobe called *Clostridium butyricum* (CB) is mostly found in the digestive tracts of humans and other animals (Yang *et al.,* 2010).

4. Probiotics for poultry

Animal welfare concerns are still a major factor in the laws and regulations pertaining to the production of commercial food animals. Systems for managing the production of poultry were changed as a result, therefore, prohibiting the use of antibiotics in the diets of chickens, the use of pasture-raised and free-range management approaches has increased in the production of broilers, Exposure to foodborne pathogens and disease-causing organisms in these surroundings still presents difficulties, as a result, probiotics are available as commercial feed additives to complement chicken diets (Diaz-Sanchez *et al.,* 2015; Ricke and Rothrock Jr, 2020; El Jeni *et al.,* 2021; Abd El-Hack *et al.,* 2022).

In addition to being home to a vast array of microorganisms, the gastrointestinal tract of animals is crucial for immune function and serves as the primary barrier that shields the host from poisons, infections, and the inflammation that results from their actions. Further research is necessary since the data currently available about the effects of symbiotic relationships on animal health are inadequate. Nonetheless, they unequivocally show how probiotics and prebiotics work in concert to reduce the populations of bacterial gastrointestinal pathogens (Singh *et al.,* 2021).

Probiotics improve gut integrity and maturation, improve the balance of bacteria in the gastrointestinal tract, boost immunity and reduce inflammation, improve feed intake and digestion by increasing the activity of digestive enzyme and decreasing the activity of bacterial enzyme as well as decreasing ammonia production, neutralize enterotoxins, and stimulate immune function in all ages and classes of poultry (Kabir, 2009; Alagawany *et al.,* 2016, 2018; Soomro *et al.,* 2019). *Bacillus* spp. are the most widely employed spore-forming probiotics in the poultry sector (Ricke and Saengkerdsub, 2015; Abd El-Hack *et al.,* 2020). Table 1 shows the effect of probiotic supplementation on poultry growth performance.

Table 1: Probiotic supplementation's effect on poultry growth performance

Species	Amount of probiotics used	Results revealed	Conclusions	References
Meat-type quails	0.1 g/kg feed	The best feed conversion values, improved growth performance, which reduced the mortality rate.	Probiotic supplementation as a growth enhancer for improved growth outcomes.	(Soomro *et al.,* 2019; Abd El-Hack *et al.,* 2017)
Broiler	100 mg/kg feed	Both live body weight and feed conversion were higher in the probiotic-fed animals.	In the fourth, fifth, and sixth weeks, adding probiotics to the diet considerably increased the live weight and feed conversion rate, and the broiler carcasses had fewer coliform and compylobacter bacteria.	(Khaksefidi and Rahimi, 2005)
Broiler	0.3% FOS with 0.1% *Bacillus (B.) subtilis*	Enhanced growth performance and decreased diarrhea in comparison to the control group of broilers.	When compared to controls or individual treatments, the probiotic combination seems to be the most successful in raising Lactobacillus populations while decreasing cecal *E. coli, Salmonella*, and total aerobes.	(Li *et al.*, 2008)
Laying hens	200 g/t *B. licheniformis* (3.2 * 109	Over the course of the entire week-long experimental period, *B. licheniformis*	Because *B. licheniformis* DSM5749 can improve laying performance, support intestinal health, affect the	(Pan *et al.,* 2022)

	CFU/kg)	DSM5749 considerably increased laying performance, as evidenced by an increase in average daily egg yield and egg production rate as well as a drop in feed-to-egg ratio (P < 0.05).	composition of cecal bacteria, and regulate the intestinal micro-ecological balance, it is a good choice for usage in the laying hen breeding.	
Laying hens	Control plus probiotic (*B. subtilis* PB6, 500 g.ton^{-1}). Control plus CrProp (50 g.ton^{-1} of propionate of chromium) Diets that combine probiotics with CrProps	In terms of mass, thickness, shell strength, and percentage, chickens fed the control + probiotic or the control + probiotic + CrProp diets produced noticeably more eggs during the course of the experiment. The metabolizability of dry matter, nitrogen, and energy increased in the birds fed the control + probiotic + CrProp diet.	Diets treated with *B. subtillis* PB6 and chromium propionate improved the productive performance, eggshell quality, and nutrient metabolizability of layer breeders without altering serum cortisol, albumin, or triglyceride levels.	(Souza *et al.,* 2021)
Laying hens	*Pediococcus acidilactici* (PA) was added to the basal diet at 100 mg/kg of feed during the first 12 weeks and 50 mg/kg after that. For the duration of the trial, provided PA 2 with 100 mg.kg^{-1} supplementation for the next 12 weeks	The feed efficiency ratio per kilogram of eggs was improved, and the specific gravity, weight, thickness, and relative weight of the eggshell were rose. Following six months of probiotic treatment, notable changes were also noted in the egg yolks' fatty acid composition and cholesterol level.	In conclusion, there may be commercial uses for dietary supplementation of PA MA 18/5M at a dose of 100 mg.kg^{-1} in order to enhance hen performance and eggshell quality during the early laying season.	(Mikulski *et al.,* 2012)
Broiler breeder hens	Base diet supplemented with 1 g.kg^{-1} of *B. subtilis* PB6 (2 * 107 cfu/g)	The results show that adding *B. subtilis* significantly enhances egg production (P<0.05). Enhanced the hatching egg, decreased the blood heterophil to lymphocyte ratio, elevated the total cholesterol, improved the egg haugh unit, and demonstrated a highly significant improvement in the fecal score of the Bacillus subtilis-fed group.	The addition of *B. subtilis* considerably improves egg production, according to the results (P<0.05). The egg haugh unit was improved (P<0.05). Egg hatchability, eggshell thickness, and hatching egg were all significantly increased (P<0.05).	(Darsi and Zhaghari, 2021)

4.1. Probiotics enhance immunity for poultry

Bacterial enzyme activity is decreased and digestive enzyme activity is increased by probiotics, improve feed intake and digestion by boosting immunity, promoting gut integrity and maturation, boosting immunity, reducing inflammation, reducing ammonia production, neutralizing enterotoxins, and stimulating immune function. Additionally, they enhance growth, health, and immunity in poultry of all ages and classes (Kabir, 2009; Alagawany *et al.,* 2016, 2018; Soomro *et al.,* 2019). Probiotic use has sparked a lot of interest in chicken farms since it has been linked to hens' immune systems being stronger. It also benefits the hosts by changing their intestinal microbiomes, which enhances feed efficiency, digestion, and productivity (Awad *et al.,* 2006; Mathivanan and Kalaiarasi, 2007; Forte *et al.,* 2016). Products containing probiotics may include one or more specific microbial strains. In the EU, the majority of microorganisms utilized as feed supplements are bacteria, the majority of *Streptococcus, Pediococcus, Lactobacillus,* and *Enterococcus*. Additionally, several cultures of *Kluyveromyces* species and *Saccharomyces cerevisiae* are probiotics (Singh *et al.,* 2021). By improving the balance of bacteria in the intestinal tract, probiotics (PRO) are live organisms or microbial feed supplements that are intended to change the gastrointestinal tract (Xu *et al.,* 2022). By boosting the activity of digestive enzymes, probiotics can improve intestinal health, strengthen and preserve the integrity of the gut, and enhance feed intake and nutrient utilization in chickens. Additionally, they have the ability to alter inflammatory and immunological responses (Souza *et al.,* 2021; Mikulski *et al.,* 2020; Pan *et al.,* 2022). Figure 1. Summarizes the enhancing poultry health with probiotics.

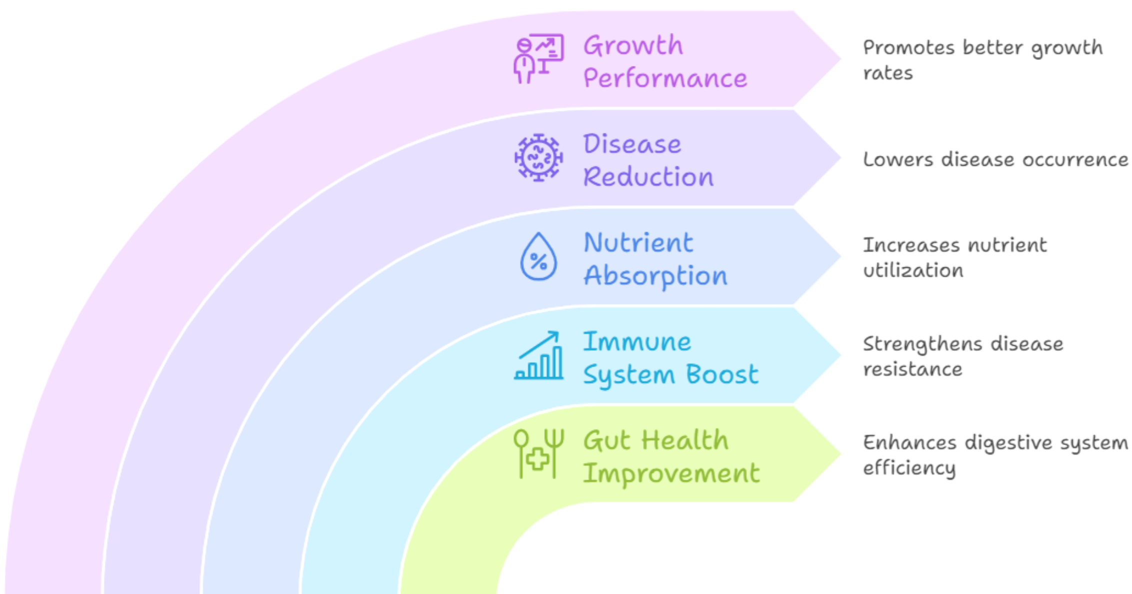

Figure 1: Enhancing poultry health with probiotics

4.2. Probiotics and intestinal pathogens for poultry

Increased use of last-resort medications like colistin due to the emergence of AMR in zoonotic infections (Liu *et al.,* 2016), is a significant obstacle for human medicine since it can result in infections that are incurable. Strong evidence connects animal-human AMR to common foodborne diseases resistant to quinolones, like *Salmonella* and *Campylobacter* species (Engberg *et al.,* 2021). AMR poses a threat to the livestock industry as well, endangering the livelihoods of millions of people who rear animals for food (Lowder *et al.,* 2016).

Probiotics have been suggested as a means of competitively preventing intestinal pathogen colonization in chicken, particularly since certain nations have outlawed the use of several antibiotics that are commonly used as growth boosters in rations (Salminen *et al.,* 1998). according to Maruta et al. (1996) Giving chickens probiotics (*B. subtilis* C-3102) reduced the quantity and frequency of salmonella and campylobacter in their digestive tracts, because

Salmonella, *Campylobacter*, and *Coliforms* contribute to the contamination of carcasses after slaughter, reducing their intestinal colonization in chickens may potentially reduce the incidence of infections in humans. Human gastroenteritis has frequently been attributed to *Salmonella* and *Campylobacter* (Jejuni), with chicken frequently being identified as the source of these infections (Khaksefidi and Rahimi, 2005). Table 2 shows general sources of probiotics.

Table 2: General sources of probiotics

Sources	Used	Beneficial effects	References
***Lactobacillus* spp**	Used as possible probiotics for chicken feed additives in SYN blends with FOS.	Research demonstrating the positive impacts of FOS and *Lactobacillus (L.) plantarum* on pathogens and chicken performance has revealed a reduction in *E. coli* O78-induced jejunal damage and an increase in cecal SCFA levels. The mortality rate of broilers that were challenged by infections has therefore dropped.	(Ding *et al.*, 2019; Koenen *et al*., 2002)
Clostridium butyricum	In addition to LAB, other probiotics-FOS combinations have also been investigated.	Together, *Clostridium butyricum* and FOS improved the quality of layer hen eggs, the digestibility of amino acids, the shape of the jejunum, and the physiological responses, which raised poultry output.	(Obianwuna *et al.,* 2023)
***B. licheniformis* DSM5749**	The laying hens' intestinal health and productivity.	Because *B. licheniformis* DSM5749 can improve laying performance, support intestinal health, affect the composition of cecal bacteria, and regulate the intestinal micro-ecological balance, it is a good choice for usage in the laying hen business.	(Pan *et al.,* 2022)
***B. subtilis* PB6**	Is a naturally occurring strain produced by components of antimicrobial agents with wide antibacterial activities that were extracted from the intestines of healthy chickens.	In laying hens, *B. subtilis* PB6 reduced serum and yolk cholesterol levels, enhanced feed efficiency, and reduced moisture in excreta.	(Teo and Tan, 2005)
***Pediococcus acidilactici* (PA) strain MA18/5M**	To determine the effect of diet on the fatty acid content, cholesterol level, and egg qualities of laying hens.	The number of damaged eggs decreased significantly when *P. acidilactici* MA 18/5M probiotic-supplemented diets were used to improve early laying metrics such egg weight, yolk color, and eggshell quality. Later, a decrease in yolk cholesterol levels was also observed after a 24-week feeding period with improved diets.	(Mikulski *et al.,* 2012)

Luoma et al. (2017) demonstrated that a commercial SYN including *Bifidobacterium* animalis, *Enterococcus faecium*, *L. reuteri*, and *P. acidilactici* with FOS decreased the cecal load, irrespective of the laying hens' vaccination status. Maintaining a healthy gut microbiome and the associated physiological equilibrium requires a balance of beneficial bacteria (Talapko et al., 2022). By producing a range of physiologically active compounds, such as peptides, bacteriocins, and mediators of the neurological, endocrine, and immunological systems, probiotics (beneficial bacteria) enhance the host's health and stress response when administered in adequate amounts (Bienenstock *et al.,* 2015; Hegarty *et al.,* 2016; Mazzoli and Pessione, 2016). Probiotics and prebiotics work together to provide benefits that exceed the effects of either supplement alone to form a symbiotic (Basturk *et al.,* 2016). Figure 2. Summarizes the general sources of probiotics.

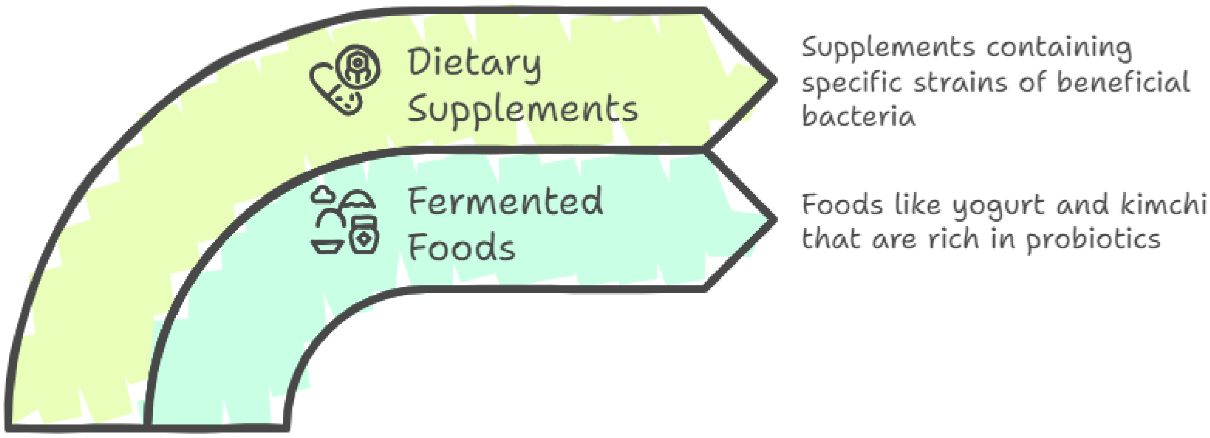

Figure 2: General sources of probiotics

4.3. Probiotics and effects of nutrition on gut health poultry

One of the key elements in the development of a stable ecosystem in the intestinal tract is the variety of bacterial species found in the gut. Because juvenile animals have fewer bacterial species in their intestinal tracts than adult birds do until the bacterial populations are fully established, their gut microbiota is more susceptible to disruptions than that of adult animals (Mead, 1989). sub-common (103–106 CFU/g sample), common (> 106 CFU/g sample), and the rest (<103 CFU/g sample) bacteria are the three categories into which they are divided within the host. Gram-positive facultative anaerobes from the crop to the lower ileum make up the majority of the chicken gastrointestinal tract (GIT), whereas *Lactobacillus*, *Enterococcus*, *coliforms*, and yeasts make up the ceca (Yadav and Jha, 2019). Chicken GIT is home to a dynamic and diverse community of microorganisms (Zhu *et al.,* 2002). The study of Apajalahti *et al.* (2002) has shown groundbreaking findings on the relationship between food and microbiota, including changes to microbial communities; the data clearly shows that the fermentative characteristics of the intestinal microbiota in chickens can be regulated by diet in poultry (Choct *et al.,* 1996). More investigation is required to identify different feed additive combinations, such as probiotics and prebiotics-with alternative strategies that would be more successful in preventing the growth of *Campylobacter*. One strategy could be to utilize phages specific to *Campylobacter* to lower the initial concentrations of the bacteria, and then use probiotic and prebiotic combinations to stop subsequent colonization (Kim *et al.,* 2019; Deng *et al.,* 2020). One important clinical pathogen linked to the GIT was found to be campylobacter (On, 2001; Butzler, 2004). Many researches (Silva *et al.,* 2011; Mughini-Gras *et al.,* 2014; Kaakoush *et al.,* 2015; Marder, 2018) have suggested that *Campylobacter* is currently one of the primary causes of bacterial foodborne GIT disease in the world. Poultry products are one of the main ways that individuals are exposed to *Campylobacter* (Skarp *et al.,* 2016; Taylor *et al.,* 2013).

It was discovered that the broiler GIT microbial population might affect the bird in ways other than avoiding pathogen colonization when effective probiotics and other feed additives were introduced. Interactions between the avian host and the GIT microbiota have been shown to offer nutritional advantages, enhance GIT health, and increase immunity (Dittoe et al., 2022). In light of these circumstances, enhancing and/or promoting a healthy, naturally occurring microbiota is becoming more and more popular as a potential natural treatment (Quigley, 2010; Butel, 2014). Probiotics are beneficial bacteria that have a positive impact on poultry health (Rajput *et al.,* 2013), Probiotics can be enhance egg quality and development performance (Nahashon *et al.,* 2013). Improve the immunoregulatory capacities and intestinal shape and barrier function in poultry (Patel and DuPont, 2015).

5. Probiotics and heat stress for poultry

To ensure the health of the birds produced and lower the mortality rate, the environment in poultry houses must be continuously monitored. High humidity, abnormally high or low temperatures, and elevated carbon dioxide are among the environmental factors that contribute to disease and a higher death rate (Abdulalwahhab *et al.,* 2020). The poor performance of laying hens around the world is linked to heat stress, one of the main environmental stresses that alters the oxidant/antioxidant system and jeopardizes the health of laying hens (Lara and Rostagno, 2013). The capacity to mitigate environmental stress in broiler chickens is a critical factor in the success of poultry production. Stress is a physiological reaction to external or internal stimuli that threatens an organism's normal physiological equilibrium (Elitok and Bingüler, 2018). As a result, the use of nutritional manipulation under extended heat stress strengthens the use of modern technologies to reduce stressors in poultry farms, preserving the health and productivity of chickens (Abdel-Moneim *et al.,* 2021). Thus, nutritional and management strategies can be implemented to reduce heat stress brought on by elevated environmental temperatures during the broiler production process (Wasman, 2022). Probiotic effectiveness for hens can vary depending on the microbiological species composition, diet, additional dosages, interactions with other additives, and environmental stressors (Mikulski *et al.,* 2012), (Table 3). The trace element chromium is necessary for the metabolism of fat, protein, and carbohydrates (Evans and Bowman, 1992; Chen *et al.,* 2006), Hens in the laying stage (Lien *et al.,* 1996; Sahin *et al.,* 2018) as well as the carcass features and growth performance of broilers (Toghyani *et al.,* 2012), assist in overcome performance and well-being decreases brought on by oxidative stress (Sahin *et al.,* 2017). According to Spears *et al.* (2024), the US Food and Drug Administration have approved the addition of chromium propionate, also known as CrProp, to broiler feed at a maximum dosage of 0.20 mg Cr/kg.

Using the same commercial synbiotic, Mohammed *et al.* (2019) investigated how well it worked to reduce heat stress in broilers. They found that the heat-stressed birds had lower levels of *E. coli* in their cecum and more *Bifidobacterium* and *Lactobacillus* species but less *Enterococcus* species, in addition to regulating physiological stress responses and enhancing antioxidant status. Table 3 shows the effectiveness of probiotics in combating heat stress in poultry.

Table 3: Probiotic effectiveness for poultry heat stress

Species	Beneficial effects	References
Broilers	It has been merous studies suggested that birds' exposure to heat could be decreased by including probiotic by *B. subtilis* in their food.	(Zulkifli *et al.,* 2000; Ahmad *et al.,* 2022; Wang *et al.,* 2022)
Laying breeder hens	Although it has been suggested that supplementing birds' diets with *B. subtilis* may lessen heat stress, organic chromium has been the primary additive that has shown promise in preventing stress in birds.	(Souza *et al.,* 2021)
Laying ducks	Recent studies suggest that chromium (Cr) may be able to mitigate the negative effects of heat stress on cattle and poultry	(Chen *et al.,* 2021).
Quail	The detrimental effects of heat stress on the production of laying Japanese quail eggs can be mitigated by supplementing a chicken's diet with Cr.	(Sahin *et al.,* 2002)
Broiler	That dietary supplementation of synbiotic (contains 4 microbial strains of probiotic selected from different parts of the gastrointestinal tract) significantly improved the antioxidant status, intestinal bacterial community, and stress response, as evidenced by increased levels of GPX and Nrf-2, a decreased H/L ratio, and the inhibition of harmful bacterial growth in heat-stressed broiler.	(Mohammed *et al.,* 2019)

The effectiveness of probiotics for poultry heat stress is illustrated in Figure 3.

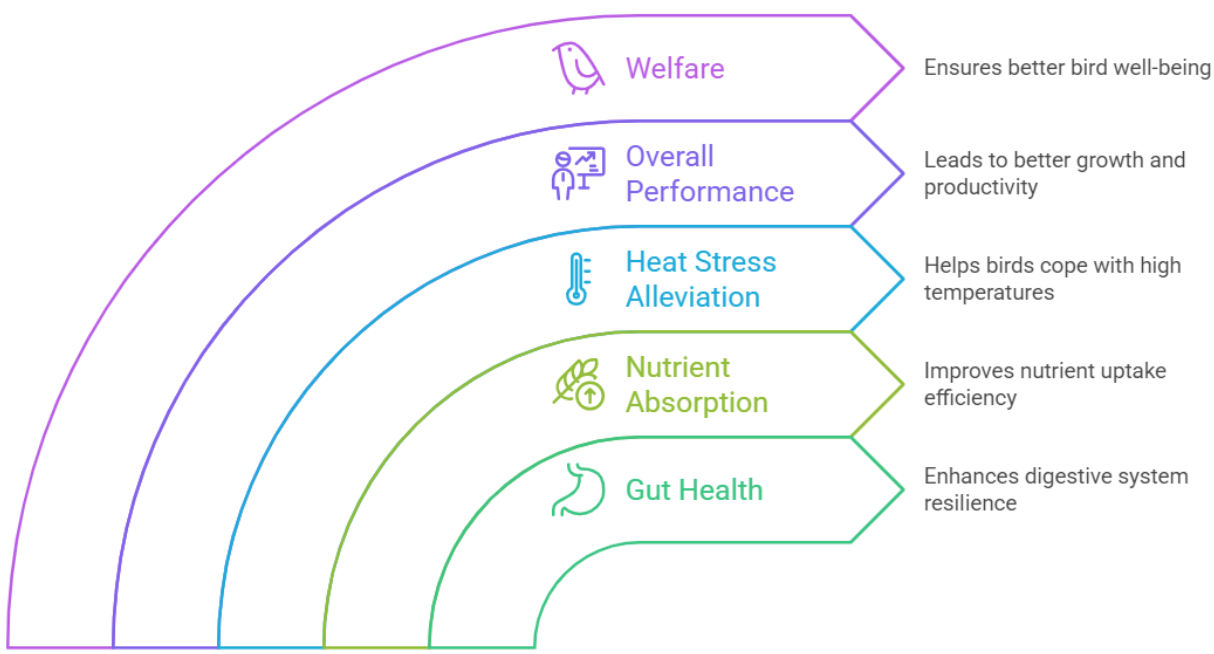

Figure 3: Probiotic effectiveness for poultry heat stress

Conclusions

A Probiotics are advised as a prophylactic measure to preserve the equilibrium of the gut microbiota and improve overall "well-being." Probiotics have been demonstrated to provide a number of benefits for birds and chickens, such as enhancing intestinal health, boosting feed intake and nutrient utilization by boosting the activity of digestive enzymes, and improving and suppressing immunological and inflammatory responses, the probiotics therefore as opposed to antibiotics and chemotherapeutic agents can be employed for growth promotion in poultry.

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