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Role of pelleted fermented feed in poultry: A review

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Abstract

The global rise in the prices of feed materials called for ways to reduce the cost of feed consumed (as the cost of feed constitutes 60-70% of the cost of poultry breed) and at the same time provide balanced feeds in terms of the availability of energy, protein, amino acids, vitamins, and minerals. Feed fermentation is a cheap method, and it is very easy through which it is possible to improve the level of nutrients necessary for the needs of birds and improve the readiness and efficiency of benefiting from the feed, whether the fermentation is done for the whole feed or each feed material separately, as studies indicate an increase in the level of protein, vitamins, and minerals in the fermented feed materials, and that the process of drying the feed and then Converting it into pellets is a new and necessary method, as it increases the ease of handling, transporting, and storing fermented feed materials, as it was at the beginning fermented the feed and provided wet for the birds, and this makes it difficult to transfer the feed through the automatic feeder. Therefore, the method of fermenting and pelleting the feed is a modern and promising technology in the farm poultry industry.

Keywords: fermented feed, pelleting, nutrition, poultry industry

Introduction

Fermentation of forage with probiotics is to improve feed quality (Lokman *et al*. 2009), fermentation is associated with a large number of lactic acid bacteria, low pH, and high concentration of organic acids (Engberg *et al*., 2009; Canibe and Jensen, 2012) [28]. It has been shown that these latter features, alone or in combination, may protect feed from pre-feeding pathogen contamination (Niba *et al*., 2009) [122], benefit chicken digestive health (Missotten *et al*., 2013) [112] and chicken growth and development (Xie *et al*., 2016) [187]. Therefore, the technology of feed fermentation was considered one of the most important techniques that improve the nutritional level of the feed, as the fermentation with the probiotic causes inhibition of the growth of pathogenic bacteria in the feed (Cotter *et al*., 2013) [39].

The fermentation of feed led to an increase in the protein content (Pranoto *et al*., 2013) [137], in addition, the fermentation process increased the amino acids, including methionine and lysine, and increased the availability of mineral elements (Pranoto *et al*., 2013; Nkhata *et al*., 2018) [137, 123], which increases the protein digested and absorbed from The bird also showed that the fermentation process increases the digestibility of feed grain protein, removes trypsin inhibitors, and reduces phytic (Hassan *et al*., 2010), as well as the production of antioxidant vitamins (LeBlanc *et al*., 2011; Nagy *et al*., 2016) [94, 117], which is reflected in the productive and reproductive performance of birds. Fermented fodder was used in the form of granules for ease of transportation, handling, and storage as well as taking advantage of the benefits of the feed granulation process (Yeh *et al*., 2018) [192]. AL-Dhanki *et al*. (2019) concluded that feeding on fermented fodder with Bacillus subtills and Saccharomyces cerevisiae in roosters and broiler breeders improved the weight of produced eggs and the proportion of hatched eggs, which may be due to the work of microorganisms on protein breakdown into small water-soluble peptides.

The end product of fermentation contains more digestible nutrients. Also, researchers Yeh *et al*. (2017) [191] showed that the decrease in pH in the intestinal lumen due to the production of large quantities of lactic acid in the fermented feed encourages positive changes in the digestive system, including killing harmful bacteria, increasing the action of enzymes, and improving the histological characteristics of the villi.

Fermentation feed

Fermentation is a dynamic process carried out by beneficial microorganisms that convert some complex basic materials into simpler compounds, and the results of fermentation can be highly variable and this variation depends on the nature and type of basic materials used in fermentation as well as the fermentation conditions such as heat, humidity, and availability Gaseous O2 and CO2 and fermentation process procedures (amount of fermentable material and time of fermentation) and depending on the microorganisms used in fermentation and the type of fermentation (aerobic and anaerobic) for example lactobacilli produce citric acid while yeasts produce ethanol (Renge *et al*., 2012; Subramaniyam and Vimala, 2012) [139, 167].

As the process of fermenting animal feed is one of the oldest methods of food preservation and processing to reduce some nutrients that the bird cannot digest and benefit from, and thus achieve maximum benefit from the ingested feed materials (Niba, 2008) [121], in addition to recent developments on the use of lactic acid bacteria in fermentation Poultry feed to reduce harmful bacteria present in the feed (Heres *et al*., 2003) [70], as fermentation is defined as a set of processes that cause changes in the physical, chemical and microbial characteristics of the feed, which improve the nutritional value of the feed material (Al-Asheh and Davnjak, 1995) [8]. Recent scientific studies have shown that fermentation converts complex organic compounds into simpler compounds by increasing the secretion of enzymes as a result of this process by microorganisms and yeasts. In addition, these enzymatic processes work to break the bonds of nutrients, such as the protease enzyme, which breaks down protein into simpler units. Amino acids are easy to digest and absorb by the organism, whether human or animal (William and Akiko, 2007) [184] and the amylase lipase breaks down carbohydrates into simple, easily absorbed sugars (Santoso *et al*., 2001) [147] and the lipase that breaks down fats into free fatty acids (Chen *et al*., 2009) [32] Hence the importance of fermentation and the important role it plays by increasing the secretion of these enzymes and then changing the specific characteristics of the food. Especially in domestic birds, which are characterized by having a simple stomach that does not possess all these enzymes in their digestive system, and this improvement in the feed or food item depends on the amount of change that this process causes in the physical, chemical, and microbial characteristics to obtain the maximum benefit from it, and the fermentation process requires factors Several factors, including the temperature, the amount of water added to moisten the feed, the type of feed used, as well as the amount of time required for this process (Heres *et al*., 2002) [69].

Beal *et al*., (2006) [20] fermentation of feed with lactic acid bacteria reduced the pH of the fermented feed to about 3.8-4.0 and the concentration of lactic acid was 150-250 mmol/L. While Moran *et al*., (2006) [115] found that forage fermentation reduced the pH to less than 3.8. Christensen and others (2007) showed that the pH ranged between 3.6-4.2 when fermenting with lactic acid bacteria. It is believed that the high concentration of lactic acid in the fermented feed and the low pH is the reason for the resistance of these feeds to the growth of harmful bacteria such as *Salmonella* (Beal *et al*., 2006) [20] and *Campylobacter* and *coliforms* (Heres *et al*., 2004) [71] due to the inability of this bacterium to live in acidic media, as lactic acid can enter into the bacterial cell, causing damage to DNA and protein (Moran *et al*., 2006) [115] due to the action of lactic acid On lowering the pH inside the bacterial cell, which stops the work of enzymes and protein synthesis and its damage, or may cause the rupture of the outer wall of the bacteria, causing its death (Alakomi *et al*., 2000) [5]. The fermentation process and what accompanies it in terms of improving the value of feed and breaking some bonds that the bird cannot break, and thus improving the efficiency of utilization of feed depends mainly on the conditions of fermentation (environmental conditions for fermentation).

There are two types of fermentation techniques, solid fermentation and liquid (submerged) fermentation (Couto and Sanroman, 2006) [40]. Solid fermentation involves the use of solid fermentation base materials such as grain, rice, and wheat bran with low water percentages and through which fermented dry fodder can be produced that can be added to feed mixtures. essential because of its low moisture content (Supriyati *et al*., 2015) [171] and this type of fermentation can only be carried out with specific types of microorganisms, especially fungi such as *Aspergillus spp*, *Rhizopus spp*, and types of lactic bacteria such as *Lactobacillus spp*. and unlike this method, liquid fermentation uses liquid base materials for fermentation such as liquid culture media, molasses, etc. (Sugiharto *et al*., 2015) [168]. Solid fermentation includes the growth of microorganisms on solid and moistened feed particles with small amounts of water, as microorganisms will initially grow in the spaces between the feed pellets, given the presence of gas and water available to them, then the water is absorbed by the feed pellets to begin the work of the bacteria by secreting enzymes and analyzing the components of the feed (Mitchell *et al*., 2006) [113]. Moo-Young *et al*., (1983) [114] suggested using the term - solid substrate fermentation - to denote any type of fermentation that includes the use of solids as a basic material for fermentation, and solid fermentation has a large scale and new technology in the field of animal feed to take advantage of these high-quality products. Solid fermentation has a large number of applications, including the production of enzymes, the production of organic acids and vitamins, and the biological treatment of anti-nutritional factors from various by-products and feed materials (Parmar *et al*., 2019) [135]. The enzymes produced from the fermentation process are important products that are obtained from beneficial microorganisms. For birds as well as other animals, enzyme production is higher in the case of solid fermentation (Pandey *et al*., 1999) [133].

The research differed in the percentage of water that should be added to the feed to get it, as some studies suggested adding one liter of water per kg of feed, and others suggested adding 1.5 liters of water per kg of feed (Awojobi and Meshioye, 2001) [16], while Ogbonna and others (2001) concluded that hydration Fodder is more beneficial for birds than dry fodder in improving product performance and raising the vitality of birds, in addition to providing the bird with useful microbial farms while creating appropriate conditions for microbial growth from a temperature that ranges between 35-37 degrees Celsius and the time required to complete the fermentation process. Fermentation occurs under anaerobic conditions because 90% of the beneficial microorganisms in the gastrointestinal tract belong to the group of anaerobic organisms and are Gram-positive, especially lactic acid bacteria. The most well-known of these types are *Lactobacilli*, *Bifidobacterium*, and *Bacteroides* (Huyghebaert, 2005) [76] and aerobic fermentation for yeast. Bread due to its high ability to consume oxygen, and thus its presence provides anaerobic conditions suitable for the growth and reproduction of *lactobacilli* and can withstand. The high acidity produced by *lactobacilli* is a result of fermentation processes (Dickinson, 1999) [45]. The fermentation process takes place for extracting energy from oxidation-reduction reactions of food compounds, including carbohydrates (Klein *et al*., 2004) [86], while recent research indicates the use of two stages of aerobic and anaerobic feed fermentation for the purpose Utilization of aerobic and anaerobic bacteria present in the probiotic (Yeh *et al*., 2018) [192].

The fermentation process plays an important role in an atmosphere of anaerobic conditions, as there is no oxidative phosphorylation to maintain the production of ATP energy by the decomposition process, and sugars are the most common basic substrate for this process, and the products of the fermentation process are lactic acid, ethanol, and hydrogen, in addition to that many compounds are produced (Voet *et al*., 1995) [182], and fermentation occurs due to some microorganisms such as bacteria, mold, and yeast. The mold works on the mixture of sugar with mineral salts, producing penicillin, and the yeast decomposes the sugar resulting from the grain soaked in water into ethyl alcohol and carbon dioxide (Stryer, 1975) [165]. The fermentation process, utilizing microorganisms and their enzymes such as protease, amylase, and lipase, improves the quality of food in terms of flavor, texture, and palatability, and preserves it for a longer storage period without spoilage, in addition to the health benefits that the animal obtains when eating fermented fodder. Amylase and phytase enzymes also work on the secretion of probiotic bacteria during the fermentation process, which degrades carbohydrates and phytic, which increases the availability of phosphorus (Liang *et al*., 2008) [96].

Enzymes resulting from the fermentation process by microorganisms

The fermentation process is the basic technology for the production of different and multiple types of enzymes, especially when using appropriate basic materials, as solid fermentation and liquid fermentation is used to produce enzymes, and usually, liquid fermentation is used to produce enzymes from bacteria because of their need for a higher percentage of water (Chahal, 1983) [30] and solid fermentation is used to produce enzymes resulting from fungi (Troller and Christian, 1978) [178] since more than 75% of industrial enzymes are produced using liquid fermentation, many enzymes of industrial importance were extracted from fungi belonging to the genus Aspergillus, as it was found that *A.niger* fungus is a typical microorganism for the production of Different types of enzymes It is the largest source of enzymes from fungi and this mushroom is used in probiotics (Holker *et al*., 2004) [73]. As for bacteria, they also produce different types of enzymes such as amylase, xylanase, L-asparaginase, and cellulase, and it was previously believed that liquid fermentations were the best in producing bacterial enzymes, but recent studies indicated that solid fermentations are more efficient in producing bacterial enzymes, and this is attributed to Metabolic differences between the two types of fermentation, as many intermediate metabolites accumulate in the liquid fermentation, causing a decrease in enzyme activity (Subramaniyam and Vimala, 2012) [167]. Exogenous enzymes such as β-glucanase, xylanase, amylase, α-galactosidase, protease, lipase, and phytase may also be used in feed fermentation (Adeola and Cowieson, 2011). And the role of these exogenous enzymes used in fermentation is to overcome anti-nutritive substances or to make more use of some nutrients that the body cannot digest, which in turn reduces the cost of feeding and makes use of unconventional feeds more efficiently (Costa *et al*., 2008) [38], as usually Unconventional feeds contain a high percentage of fiber, and the birds do not contain internal enzymes to digest them. In addition, part of the starch and protein of these non-traditional feed materials are confined and associated with these fibers, which makes them unavailable for digestion by the bird as well, but these materials can be used with Exogenous enzymes to benefit from (Jha and Berrocoso, 2015), exogenous enzymes can also produce polysaccharides oligosaccharides that reduce the growth of fungi and molds in the cecum and are used as food for beneficial bacteria (prebiotic) and close the receptors on the surface of intestinal cells and thus prevent the adhesion of pathological bacteria, that Beneficial bacteria work to produce these enzymes and use a small part of carbohydrates as a basic material for their growth when each of the Carbohydrates and protein are available in the alimentary canal (Jha and Berrocoso, 2016) [79] and thus they use carbohydrates as a substrate for the purpose of secreting enzymes and digesting protein and fiber to achieve maximum benefit by the bird and that these enzymes are also necessary from an environmental point of view as they reduce harmful emissions from waste - such as ammonia - (Jha and Berrocoso, 2015) as bacteria use carbohydrates and produce a percentage of lactic acid and some organic acids, and increase the production of short-chain fatty acids and reduce the production of ammonia (Yadav and Jha, 2019) [188].

Studies have shown that the fermentation process containing probiotics causes changes in the feed specifications, and these include changes in the physical and chemical specifications and microbial content. Fermentation (Al-Asheh and Davnjak, 1995) [8], and in general, the effect of the fermentation process in feed is determined by the amount of activity of the microbial content produced after the fermentation process because doubling the numbers of microorganisms means increasing the secretion of digestive enzymes such as protease, amylase, lipase, phytase, and catalase, and thus is The decomposition of complex nutrients such as carbohydrates, proteins, and fats into simpler units that are easily digested and absorbed by poultry (William and Akika, 2007) [184].

Probiotic

Over the past years, the word probiotic has been used in different ways, as it is defined as microorganisms that do not cause pathological disorders and enhance the intestinal microbial balance, which improves the function of the intestinal epithelium and improves the function of the mucous membrane, which is considered the first line of defense, which prevents the entry of intestinal pathogens, and with the gradual decrease of continuous use Antibiotics in the field of animal production due to some of their side effects and may sometimes lead to harm to the consumer (Nava *et al*., 2005) [118] and they must be characterized by advantages through their work in two ways, as indicated by (Ricke, 2018) [140]:

1- Be able to hinder the growth of disease-causing bacteria and establish their colonies.

2- It is indigestible, stimulates the growth of beneficial bacteria, and prevents the colonization of pathogenic bacteria in the digestive tract of birds, thus expelling them to the outside through competitive exclusion.

Probiotics are considered preventive factors and substances that support the immunity and health of birds and maintain the health and safety of poultry products, thus protecting the consumer (Kabir, 2009) [81]. The addition of beneficial bacteria to the digestive system of poultry is not a new concept. However, a full understanding of where, when, and how to use them is important for achieving maximum benefit from them. Chickens can be protected against *Salmonella enteritidis* infection by inoculating them with the contents of healthy adult chickens (Higgins *et al*., 2007) [72]. The so-called competitive exclusion, as Peralta-Sánchez *et al*. (2019) indicated that feeding laying hens on the contents of the intestines containing *108 Enterococcus faecalis* bacteria improved the microbial content of the intestines of birds and increased microbial diversity, especially in the two cecums, and increased egg production compared with control treatment. Therefore, nutritionists seek to produce economical feeds to reduce production costs, but at the same time these diets must be balanced to meet the nutritional needs of birds, and the constant change in the composition of diets affects the microbial balance of the bird's intestines, which causes digestive disorders that negatively affect the health of the bird, so it is considered Probiotics are preventive agents and substances that support the immunity and health of birds and maintain the health and safety of poultry products, thus protecting the consumer (Kabir, 2009) [81].

Probiotic action

The probiotic performs several roles within the body and has many benefits, as it increases the number of beneficial bacteria, reduces harmful bacteria, prevents the adhesion of harmful bacteria to receptors on the surface of intestinal cells (Kizerwetter-Swida and Binek, 2009) [85], and improves metabolic processes by increasing enzyme activity. It reduces the activity of bacterial enzymes and ammonia production (Yoon *et al*., 2004) [194], improves feed consumption and digestion (Dierck, 1989) [46], and stimulates the immune system by ensuring the maintenance of microbial balance in the intestine, covering the receptors on the epithelial cells lining the gastrointestinal tract, and preventing the access of harmful bacteria. These receptors, reduce intestinal pH and prepare the mucous layer under which immune cells such as macrophages and T-lymphocytes are activated (Brisbin *et al*., 2008 Adapted *et al*., 2009) [24, 2]. The provision of probiotics to adult chickens increased their resistance to *Salmonella S. infantis* within the process of competitive exclusion. This is why the modern approach to breeding has become vaccinating chicks against diseases with the provision of probiotics in various ways because of their impact on gut functions and disease resistance (Roberto *et al*., 2003) [141] as well. Probiotics have been shown to increase disease resistance in chicken, turkey, quail, and pheasant against salmonella and other intestinal diseases (Schneitz, 2005) [153]. The interaction between the bacteria used as a probiotic and the bacteria present in the intestine enhances the formation of the microbial community, as the beneficial bacteria produce some substances that have antibacterial action against harmful bacteria and inhibit their growth, which allows for an increase in the growth of beneficial bacteria (Ruiz Rodríguez *et al*., 2013) [145], and also works on some physical changes Inside the alimentary canal of the bird, which increases the height of the villi and the depth of the crypts (Awad *et al*., 2008) [15], which increases the surface area for digestion and absorption, thus increasing the digestive susceptibility of nutrients (Park *et al*., 2016) [177].

Therefore, the main mechanism of action of the probiotic included several functions, including supporting the cells of the intestinal epithelial layer, increasing the adhesion of the intestinal mucosa, and the accompanying failure to enable pathogens to adhere to, competitive exclusion, production of anti-pathogens, and support for the immune system. The process of strengthening the epithelial layer of the intestine is very important because it is in constant contact with the contents of the lumen of the intestine, and the intestinal barrier is considered a major defense mechanism used to maintain the integrity of the epithelium and the organism from diseases, and once the function of this barrier is disrupted, the intestinal wall will be exposed to the contents of the gastrointestinal tract and will allow the adhesion of pathological bacteria to intestinal cells, causing digestive disorders and inflammation in the intestine (Sartor, 2006) [149]. The functions of the intestinal barrier, as there are many studies on the mechanism of action of the probiotic and the types of bacteria used (Anderson *et al*., 2010), for example, lactobacilli can increase the modification and regulation of some genes responsible for the production of some adhesion proteins such as E-cadherin and β-catenin in intestinal epithelial cells, and incubation of intestinal cells with lactobacilli increased protein phosphorylation processes inside the cell, especially Adhesion proteins, as successive forms of protein kinase such as C (PKC) and PKCδ (Protein kinase C-delta) were formed, and these proteins have a major role in modifying the function of the epithelial barrier of the intestine (Hummel *et al*., 2012) [175]. Recent research indicated the ability of probiotics to repair The function of the epithelial barrier after damage resulting from infection with *E. coli* bacteria, as it not only prevents infection with coli bacteria but also works to restore the integrity of the mucous membrane of the intestinal cells as it works to redistribute adhesion proteins and the mucous layer in the affected area (Zyrek *et al*., 2007, Stetinova *et al*., 2010) [198, 165] By using probiotics, it is possible to reduce the damage that occurs to the epithelial layer of the intestine as a result of inflammation (Sartor, 2006) [149] and may also contribute to strengthening the mucosal barrier, as Two isolated and purified peptides secreted by Lactobacillus rhamnosus GG (LGG), namely P40 and P75, were shown to inhibit apoptosis caused by the effects of inflammatory cytokines by activating antiapoptotic protein kinase B (PKB/Akt). (Yan and Polk, 2002; Yan *et al*., 2007) [189, 190], also, these peptides induce increased gene expression of heat shock proteins and activation of mucin glycoproteins, which are large molecules that are components of intestinal epithelial mucus (Tao *et al*., 2006) [176].

Locations of microorganisms in the digestive gate of chickens

Different types of microorganisms are distributed within the alimentary canal of the bird. The difference in the shape and nature of the microbiota, metabolism within the alimentary canal, the environment of the microbiota, and the heterogeneity in the pH of the alimentary canal led to the diversity of microorganisms along the alimentary canal (Yeoman *et al*., 2012). As the number of bacteria gradually increased from 105 bacterial cells/gm in the duodenum to 107-1012 bacteria cells/gm in the colon and according to recent studies, showed that the number of beneficial bacteria present in the mucous layer of the intestine was more numerous than the number of bacteria present in the lumen of the gastrointestinal tract Lumen, especially in the ileum and caecum (Borda-Molina *et al*., 2016) [23].

According to different research and studies, it was found that the microbial community integrates its growth in birds at the age of one week (Yadav and Jha, 2019) [188]. The avian gut contains 100 billion bacterial cells, most of which are anaerobic bacteria (Wei *et al*., 2013) [183]. By the age of 12 days of age, the dominant microbiota changes about 10-15 times between aerobic and anaerobic bacteria (Albazaz and Bal, 2014) [9]. And that a healthy and balanced microbial community inside the gut should mostly contain beneficial bacteria, at least 85% of the total bacteria, while the remaining bacteria are Salmonella, Campylobacter for young chicks, in addition to E. coli in adult chickens, in the absence of any disturbance. Intestinal (Choct, 2009) [35], and some types of microorganisms present inside the avian gastrointestinal tract are *Lactobacillus sp., Bacteroides sp., Eubacterium sp., Clostridium, Escherichia coli, Streptococcus sp., Prevotella sp., Fusobacterium sp. Selenomonas sp., Megasphaera sp.* and *Bifidobacterium sp.* Therefore, the health of the bird, in general, comes from the interaction of many factors, including the physiological state, nutrition, metabolism, and the effectiveness of the immune system of the bird. 2016). The gut microbiota includes hundreds of bacterial species, but the dominant bacteria are *Firmicutes, Bacteroidetes, Proteobacteria,* and *Actinobacteria* (Oakley *et al*., 2014; Clavijo & Florez, 2018) [124]. Carrasco *et al*., (2019) [27] indicated that the beneficial microorganisms present inside the gastrointestinal tract have a major role in maintaining the health and integrity of the intestine by performing some physiological functions required to maintain the intestinal microbial balance, mainly through competition and competitive exclusion of harmful bacteria. And prevent their sticking to the intestinal cells and thus reduce the amount of energy required for the immune system to eliminate these pathological bacteria) in addition to the ability of beneficial bacteria to produce some secondary metabolic products such as lactic acid and short-chain fatty acids such as acetic, propionic, and butyric. When the chicks are hatched (when commercial breeding), some beneficial microorganisms settle inside the gastrointestinal tract, but the microbial community is not complete until after 2-3 weeks of age of the birds. Donaldson *et al*., 2017) [147] and for this reason, there was a need to use probiotic compounds for the early colonization of microorganisms in the digestive tract of the bird and the completion of the microbial community (Simon *et al*., 2016 and Rubio, 2019) [158, 144] as it was observed that the microbiota in the intestines of laying hens goes through four stages of changes, especially during The first year of life (Videnska *et al*., 2014) [180]. It was noted that these changes are related to changes in cytokines produced inside the intestine as well as anti-inflammatory cytokines secreted from immune cells (macrophage cells and T-helper lymphocyte cytes). The immune balance thus affects the health of birds (Oakley and Kogut, 2016) [125]. There are examples of the importance of the microbial community in maintaining the health of the intestine and its normal function, as many studies dealing with the relationship between beneficial and harmful bacteria and the health of the intestine and the bird, as it was found that the beneficial bacteria act as a barrier Anti-infectious by inhibiting the multiplication of harmful bacteria and their adhesion to the walls of intestinal cells, as it works to ferment complex sugars producing some secondary metabolites such as short chain fatty acids (SCFA) that reduce the intestinal pH by 1-2 This, in turn, leads to an increase in the lag phase of harmful bacteria and hinders their rapid growth and reproduction. As many pathogens such as *E.Coli* and Salmonella bacteria are sensitive to acidity, so contact with the organic acids produced during fermentation will destroy the envelope of these cells, causing fluids to enter the cell and then explode (Carrasco *et al*., 2019) [27] and primary interactions between the community can The microbiome and the alimentary canal of the bird leads to an inherent immunity, which in turn causes an adaptive immune response, which is represented by the B-L lymphocyte or depends on the T-lymphocyte (Pan and Yu, 2014) [131], since the compound Beta-defensins, which is They are small antimicrobial peptides present on the surface of the intestinal epithelium and are an important part of innate immunity (Shimizu *et al*., 2008). These peptides are produced on the intestinal lining upon exposure to lipopolysaccharide (a major component of the outer membranes of Gram-negative bacteria, which are giant aggregate molecules called Fatty polysaccharides, which are of a high degree of complexity, consisting of a carbohydrate part and a fat part) (Akbari *et al*., 2008) [24] and that the decrease in bacterial numbers A beneficial effect due to microbial imbalance caused by a decrease in the production of beta-defensins in the duodenum and two caecum (Butler *et al*., 2016) [26]. Thus, the beneficial microorganisms inside the gastrointestinal tract have an important role in stimulating inherent immunity, which subsequently leads to an adaptive immune response by giving the opportunity to B lymphocytes From antigen recognition and antibody formation (Pan and Yu, 2014) [131] as well as through macrophage cells and T-lymphocytes by secreting interleukins (IL,1- IL,10) (Kumar *et al*., 2018) [90] as indicated by Cheled-Shoval *et al*., (2014) [31] that the decrease in the number of beneficial bacteria inside the intestine causes a decrease in the amount of mucin fibers, which is a network of glycoprotein fibers on which mucus secreted from goblet cells rests, and thus it will provide an appropriate environment for the presence of microorganisms, and it may be called (glycocalyx) in Some scientific sources and that increasing the thickness of this network will lead to a narrowing of the alimentary canal, and this in turn will slow down the speed of passage of the food mass and thus will provide a greater opportunity for digestion and absorption of nutrients availability Al-Jebory and Naji, (2021 a,b) [7].

Effect of feed pelleting process on bacterial and yeast cells in the probiotic

High temperatures above 45 degrees Celsius may kill bacteria or yeast cells in the probiotic, as exposing the cells to a temperature of 65 degrees Celsius for 30 minutes led to a decrease in the number of bacterial cultures, as it killed 6 bacterial cultures, each containing 3.6-5 log/log. Bacterial cell gram (Mansouripour *et al*., 2013) [105]. Bacteria and yeasts are used in the form of probiotics and nutritional supplements in the rearing of poultry, large animals, and even aquatic organisms to increase the ability of animals to resist diseases and to increase the process of competitive elimination of pathogens in the intestine (Cutting, 20100) [42]. And probiotic bacteria are widely used by feed or water because of their ability to resist stomach acid (Rosales-Mendoza *et al*., 2016) [143].

Lu *et al*., (2009) found the ability of yeast to continue growing when exposed to heat shock and high temperatures, as the yeast can resist environmental stress by carrying out several mechanisms by which it resists conditions that are not suitable for growth, including increased carbohydrate metabolism, detoxification and protein processing DNA damage and cell wall modification (Gasch *et al*., 2000) [64]. As shown by Amerah *et al*., (2013) [12] that manufacturing feed in the form of pellet feed at a temperature of 70 and 80 degrees Celsius did not significantly affect the number of probiotic bacteria, but manufacturing under a temperature of 90 degrees Celsius significantly reduced the number of bacteria. Yeh *et al*. (2018) [192] also found that fermenting the feed with different types of bacteria improved the physical properties of the feed as it increased the number of bacteria and reduced the pH of the feed and increased the concentration of modified volatile fatty acids and the fermentation process also increased the level of amino acids in the fermented feed After that, the fermented fodder was converted into fodder tablets, as the granulation process significantly reduced the number of bacteria. I attribute the reason for the survival of part of these bacteria to the ability of these bacteria to withstand high temperatures, especially Bacillus bacteria, as the researcher indicated that heating up to 100 degrees Celsius did not limit its growth.

Effect of the probiotic in improving the availability of nutrients

The role of the probiotic extracted from Microbiota is to improve digestion and increase the availability of many nutrients such as proteins, fats, and carbohydrates as well as some minerals and vitamins (Tonkinson *et al*., 1965) [175] (a newer source if possible) in addition to that many Beneficial bacteria and yeasts such as *Saccharomyces cerevisiae* used in (Probiotic) secrete digestive enzymes that support the work of digestive enzymes that are naturally secreted into the gastrointestinal tract and increase the digestion factor for some nutrients by delaying the presence of these nutrients in the gastrointestinal tract due to their association with the cell wall of bread yeast, which consists of a substance An oligosaccharide (a type of polymeric carbohydrate, whose molecules contain a small number of monosaccharides in the form of a chain that plays an important role in the intestine by increasing the activity of bifido-lactic acid bacteria) (Stanley *et al*., 1993) [164]. Ebune and others (1995) [52] indicated that the improvement of the availability of nutrients as a result of adding beneficial microorganisms to barley and wheat and because of the activity of the phytase enzyme produced by beneficial microorganisms, and thus leads to an increase in the proportion of available phosphorus in wheat and barley. In addition to increasing the effectiveness of the internal enzymes present in the seeds, two-thirds of the phosphorus present in the plant seeds are bound and in the form of phytate, and this amount of phosphorous is not benefited by the bird due to the absence of the (phytase) enzyme in its digestive system, either Savage (1987). It was found when giving the probiotic containing *Saccharomyces cerevisiae* a significant increase in each of the gross energy and the absorption coefficient of phosphorus, calcium, barium, potassium, manganese, and magnesium. Crow (2000) [41] indicated that by giving the probiotic to the host, whether human or animal, the microorganisms will supply it with some vitamins such as vitamin K and B12, in addition to the host getting vitamin A extracted from alpha and beta-carotene pigments found in the diet.

Effect of using the fermented feed on productive and physiological traits of laying hens

Loh *et al*., (2007) [98] indicated the use of fermented feed in feeding laying hens type Babcock B380 at the age of 13 weeks by four treatments. As Kabir, (2009) [81] showed the use of probiotics improved egg production and the activity of laying hens. Also Lokhande *et al*, (2013) [99] that the use of probiotics from different bacterial strains to laying hens at concentrations (0, 0.05, 0.10, and 0.15%, respectively) improved the immunity of birds and the productive performance of Hy-Line Brown laying hens, as the researcher indicated an improvement Egg production and the qualitative characteristics of eggs, especially at the last part of the productive period. As shown by Lei *et al*., (2013) [95] the use of probiotics containing Bacillus bacteria in the diets of laying hens Hy-Line at concentrations (0, 0.01, 0.02, 0.03, 0.06, and 0.09%, respectively) and the researchers noted an improvement in egg production and the quality of the eggs produced (increased thickness and the strength of the eggshell product). In an experiment conducted by Forte *et al*. (2015) [56] using laying hens of the High Line breed, the probiotic containing Lactobacillus acidophilus and Bacillus subtilis at concentrations of 0, 0.01, and 0.05%, respectively, did not affect egg production but improved the health and immune status of the birds by increasing Concentration of lysozyme protein and antibodies directed against Newcastle disease in the blood. It was also found that feeding on the probiotic improved egg production and egg quality (Zarei *et al*., 2011) [196]. It was also shown that the probiotic affects fat metabolism in chickens, as it reduced the level of cholesterol in the egg yolk and the blood serum (Kurtoglu *et al*., 2004) [91]. Likewise, Park *et al*., (2016) [177] indicated that the use of probiotic (Enterococcus faecium) with feed for Essa Brown strain at concentrations of 0, 0.005, and 0.01%, respectively, improved egg production, eggshell thickness, and digestive ability of birds, and feed consumption and reduced the number of *E. coli* bacteria in the contents of the intestine. Fathia *et al*. (2018) [55] reported that the addition of different concentrations of the probiotic (0, 200, 400 g / kg) using three different strains White Leghorn, Saudi Black, and Saudi Brown increased the thickness of the shell, improved the quality of the shell, decreased the percentage of broken eggs, and increased the mass of eggs. Eggs, IgM level, cholesterol, and triglyceride levels in laying hens subjected to heat stress. The quality of eggs usually includes several aspects such as the weight of the shell, the quality of the whites and yolks of the eggs, and the quality of the eggs has a genetic basis and varies between the breeds of laying hens. The use of probiotics affects egg production and improves the immunostaining qualities of the shell (Mazanko *et al*., 2018 Mikulski *et al*., 2020) [108, 109]. In a study conducted by Abd El-Hack *et al*. (2017) [1] on laying hens of the Hi-sex Brown strain, to see the effect of the commercial probiotic on production performance and egg quality characteristics, as the probiotic was added at levels of 0, 50, 100, and 150 g/kg feed. Bioassays showed an increase in the weight and volume of eggs, the weight of albumin and yolk, and the thickness and strength of the eggshell compared to the control treatment. Mazanko *et al*. (2018) [108] referred to a study to investigate the effect of aerobic feed fermentation on laying hens and roosters by fermenting soybeans with a probiotic containing B. subtilis katmira1933 and *B.amyloliquefaciens B-1895*. The birds were divided into four treatments, the first treatment was a control treatment and soybean ferment for the second treatment with 0.1% of B. subtilis KATMIRA1933 and soybean ferment for the third treatment with 0.1% with *B.amyloliquefaciens B-1895*, while soybean ferment for the fourth treatment with 0.1% From both strains, the results showed that both strains led to an improvement in the proportion of egg production, the quality of the eggs produced, and the quality of the roosters' sperm. Earning the feed materials resulting from the extraction of oils and others with bio-fortified to benefit from them as low-cost feed materials and at the same time increase the efficiency of benefiting from them as a result of their exposure to fermentation and reduce the fiber content in them. As found by Neijat *et al*., (2019) [120] in a study on a flock of Shaver White strains to which *B. subtilis* was added as a probiotic at a level of 0, 0.05, 0.5, and 0.1%, and the addition improved the whiteness height and unit he of eggs throughout the production period from 19 to 48 weeks of age. Age birds and reduced eggshell-breaking strength at week 20 compared to the control treatment. Xiang *et al*., (2019) [186] confirmed that adding a probiotic containing *C. butyricum* and a mixture of *S. boulardii* and *P. acidilactici* to the diet of laying hens of Lohmann Browne strain at concentrations of 0, 0.05, 0.5, and 0.1 g/kg feed significantly improved the rate of egg production and the histological and healthy condition of the intestine.

Strains of different beneficial microorganisms have been studied for their effect on these histological characteristics of the intestine. Elucidation of the histological and morphological changes of the intestinal mucosa in birds is vital in determining the characteristics of the strain and its methods of action. Strain-to-strain (Chichlowski *et al*., 2007) [34], Forte *et al*., (2016) [57] found that when using the probiotic in Hy-Line laying hens diets at 16 weeks of age containing 0.1% L. acidophilus and 0.05% B. subtilis, transactional birds did not appear There was a significant difference in the histological characteristics of the intestine, the length of the villi, the width and the depth of the crypts, compared with the control treatment, but it improved the microbial content in the intestine as it reduced the numbers of *E. coli*, *clostridia*, and *staphylococci*, as research indicates that the probiotic bacteria have an inhibitory effect on the growth of harmful bacteria in chicken intestines (Pascual *et al*., 2001) [136].

Relationship of probiotic feeding with cocks fertility

The increase in poultry production (meat and eggs) depends on the fertility of the maternal herds. It is clear that the fertility of the poultry herds is linked to the fertility of both males and females, but the decrease in the number of males used in natural or artificial insemination gives it more economic importance in the poultry industry (Kamali *et al*., 2017) [82]. Enhancement of semen volume, sperm concentration, longer sperm viability, motility, and polyunsaturated fatty acids in sperm as well as protection against oxidative damage can improve sperm membrane function, mitochondrial activity, sperm penetration into the egg, and thus Fertility (Fouad *et al*., 2020) [60], in the rearing of maternal flocks of different bird species the male is responsible for producing a large number of fertilized eggs, which can exceed more than 1,000 fertilized eggs per year in some species such as chickens (Lagares *et al*., 2017; Wu *et al*., 2017) [92, 185]. 2017), semen characteristics including volume, sperm concentration (total count), number of live sperm, dead sperm, and sperm Abnormal spermatogenesis and forward motility are generally tested to assess and predict male fertility in poultry (Chen *et al*., 2016; Sun *et al*., 2019) [33], various factors can impair semen characteristics and reduce the fertility of poultry males such as genetic susceptibility, rearing under stress, toxins, and aging (Hu *et al*., 2013; Fouad *et al*., 2016, 2019) [58]. In male poultry over 45 weeks of age the testosterone level is affected (Lagares *et al*., 2017) [92], semen volume, sperm concentration, vitality, forward motility, polyunsaturated fatty acids in sperm, antioxidant concentrations are decreased and lipid oxidation is increased in sperm, Seminal plasma (Iaffaldano *et al*., 2018; Min *et al*., 2018; Surai *et al*., 2019) [77, 172]. These changes are accompanied by reduced sperm membrane functions, mitochondrial activity, and sperm penetration into the egg, thus lowering fertility (Altawash *et al*., 2017; Bazyar *et al*., 2019) [11, 19].

The intestines of birds contain many different types of bacteria, and therefore the semen can be exposed to contamination with these bacteria. Therefore, the semen collected from roosters has been exposed to different types of bacteria, such as *Escherichia coli, Salmonella, Clostridium, Campylobacter, Bifidobacterium animalis*, and *Lactobacillus acidophilus* (Triplett *et al*., 2016) [177] Studies also showed that all of these bacterial species led to a decrease in the index of sperm quality and motility, which may affect the fertility rate (Fouad *et al*., 2020) [60] Moreover, it was found that probiotic bacteria such as *B. animalis* And *L. acidophilus* may negatively affect the quality of semen and its fertile ability. For this reason, many studies have been conducted to find out whether probiotic bacteria that are usually added to poultry feed may have negative effects on semen quality and fertility, as Saccharomyces cerevisiae and *Bacillus subtilis* were added to rooster diets to test their effect on semen quality (dos Santos *et al*., 2018 a and b) [48, 49], and the results showed that both had no adverse effects on testicles, Semen characteristics, such as volume, concentration and numbers of live and dead sperm In contrast, feeding roosters with diets containing *Bacillus subtilis KATMIRA1933* and *Bacillus amyloliquefaciens B-1895* increased sperm concentration and decreased abnormal sperm count, as well as increased fertility (Mazanko *et al*., 2018) [108], which in general could enhance. Dietary prebiotics enhances the absorption and utilization of nutrients by improving gut morphology and antioxidant status and decreasing the abundance of pathogenic bacteria (Forte *et al*., 2016; Seifi *et al*., 2017; Zhao *et al*., 2020) [57, 154, 197].

Effect of Pelleted fermented feed in laying hens and cocks production

Al-Jebory and Naji, (2021a) [6] were found the use of *lactobacilli, Bacillus subtills, Bifidobacterium, Saccharomyces cerevisiae* to produce fermented feeds (FF), The FF was pelleted to investigated for its influences in production performance for laying hens, the (FF) was ferment with 10 g / kg feed of the probiotic with a wetting ratio of half a liter/kg of feed for 48 hours where it was used at rates 0, 25%, 50 %, 75%, and 100% for the treatments T1, T2, T3, T4, and T5 respectively, and the duration of the study lasted for seven periods, each period was two weeks, as for the following study results: Significant superiority ($P \leq 0.05$) for treatment T5 during The first and sixth period and the treatment T4 during the second, third and fourth periods compared with the control treatment in the percentage of egg production, in egg weight significantly increased ($P \leq 0.05$) of treatment T3 in the second, sixth and seventh periods, and treatment T4 during the third period exceeded treatment T5 during the fourth period, men while in the feed conversion factor, T4 treatment improved significantly ($P \leq 0.05$) during the third period and together with The treatment of T5 during the fourth period and all treatments of (FF) in the fifth period and the treatments T3, T5 in the sixth period and the treatment T3 in the seventh period, a significant ($P \leq 0.05$) superiority was obtained for the treatments T4 and T5 during the second, third, fourth and sixth periods in the cumulative egg production and egg mass, meanwhile when study eggshell quality Al-Jebory and Naji, (2021b) [7] with same treatments found Significant superiority ($P \leq 0.05$) for all FF treatments during the second period and treatment T5 during the third and sixth periods, and for treatments T3, T4 and T5 during the fourth period in the shell weight. As for the shell thickness, a significant superiority ($P \leq 0.01$) was obtained for treatment T3 in the fourth period and for treatment T2 in the fifth, sixth, and seventh periods, and the yolk height, there was a significant superiority ($P \leq 0.01$) for the treatment T4 during the first, second and seventh periods, and for the treatments T2 and T5 during the fourth and fifth periods, as for the yolk diameter, a significant superiority ($P \leq 0.01$)was obtained for the treatments T2, T3, and T4 in the fourth and fifth periods, and T2 during the seventh period, and in albumen height, a significant ($P \leq 0.01$) was increased for the treatments T3, T4, and T5 during the second period, and a significant superiority was obtained for treatment T5 in the fifth period and a significant superiority for the two treatments T1 and T2 in the seventh period. Al-Jebory, (2022) [7] used 30 roosters were used in a study fed on fermented feed with different levels in poultry farm/ agriculture college/ Al-Qasim green university. The cocks were divided into 5 treatments T1, T2, T3, T4, and T5 fed on F.F. (0, 25, 50, 75, and 100%), respectively, some qualitative characteristics of semen were measured, and the experiment continued for 20 weeks. It was found that there was a highly significant ($P \leq 0.01$) superiority in the total average ejection volume for treatment T5 and all fermented feed treatments in mass motility and individual motility of sperms and sperm concentration, as well as a highly significant improvement ($P \leq 0.01$) for all treatments of fermented feed in the percentage of dead sperm.

Conclusion

It can be concluded from the review that providing fermented feed to laying hens improves the productivity and quality characteristics of eggs and textile characteristics when increasing the percentage of fermented pelleted feed. Therefore, we recommend conducting studies on aerobic and then anaerobic feed fermentation to benefit from the secondary metabolism products of fermented microorganisms, which will have a greater role in improving the readiness and digestibility of the feed. The use of fermented feed and its comparison with granulated fermented feed in poultry diets and its effect on performance. These processes are considered a promising industry in raising poultry, especially the high global feed prices, which reduce the cost of feed, as it is not difficult to devise machines to ferment the feed and then dry it using a hot air stream after which it is pelleted.

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