Selcuk Journal of Agriculture and Food Sciences SJAFS

http://sjafs.selcuk.edu.tr/sjafs/index

(2022) 36 (1), 120-126

e-ISSN: 2458-8377

DOI:10.15316/SJAFS.2022.017

Review Article

Usage of Probiotics in the Poultry Industry and Effects on Meat Quality

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ARTICLE INFO

Article history:
Received date: 23.11.2021
Accepted date: 04.03.2022

Keywords:
Probiotics
Feed additives
Poultry
Meat Quality

ABSTRACT

Currently, a significant survey field is the use of probiotics as feed additives. There are many essays about the effect of the use of probiotics on meat quality. There is common agreement that probiotics supplementation could improve meat quality. Probiotic treatment increases meat tenderness however probiotics on lipid composition and oxidation of meat and sensory properties may change. The products obtained can be presented to the consumer as a healthy, taste and aroma enhanced and safe food. Thus, while providing delicious and nutritious food to the consumer, it also has positive effects on consumer health. Especially today, consumption of functional foods containing probiotics is increasing rapidly. Consumer interest has accelerated research on probiotics. On the other hand, there is a continuous increase in the number of microorganisms used in the market as probiotics. The current situation will be taken one step further with the discovery of new and active microorganism varieties that can be used as probiotics in the future probiotics will be the subject of many studies in the future. Therefore, it is thought that this issue should be emphasized. Apart from all these; as a group of growth promoters, the supplement of probiotics to the diet of poultry has been found to develop growth performance, increase feed conversion yield and develop immune responses.

1. Introduction

The poultry industry has become a significant economic activity in a lot of countries (Kabir 2009). The manufacture and consumption of poultry meat has been dramatically increasing. This speedy growth is to an enormous degree associated to the requests of the consumers for a healthy diet and meat as it is basic component (Popova 2017). For the purpose of achieve income, efficient and economical production, safety and quality, beside essential nutrient, for several years, antibiotics have been added to poultry diets (Okanović et al 2014). This common use of antibiotics in poultry in order to promoting growth rate, increasing feed conversion efficiency and for the prevention of intestinal infections have led to an instability of the beneficial intestinal flora and the appearance of resistant bacteria (Gupta & Das 2013; Popova 2017).

After the prohibition of antibiotics, the search for alternative additives to antibiotics has gained momentum with the increasing concerns that the continuity and profitability of production may be adversely affected as a result of the losses that may occur in the performance of the animals (Üstündağ & Özdoğan 2017).

With rising attention about antibiotic resistance, there is rising attention in discovering alternatives to antibiotics for poultry production. Natural feed additives, such as live “probiotics” have potential to decrease enteric disease in poultry and latter contamination of poultry products (Gupta & Das 2013; Popova 2017). Thus, probiotics are being considered to fill this emptiness and several farmers are using them in prefer to antibiotics (Kabir 2009).

As a result of marketing studies based on the relationship between food and health, there is an increase in the interest of consumers in this direction. In this context, probiotics, one of the product groups that have the largest share in the development of new and functional foods, are also welcomed by the consumer (Doğu & Sarıçoban 2015).

Probiotics are healthy bacteria, yeast and other microorganisms that maintain the natural balance of the digestive system (Palamutoğlu & Sarıçoban 2013).

Probiotics are culture of living microorganisms that are used as functional ingredients to manipulate and maintain good health by controlling gut microflora and

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increasing digestive enzyme activity (Alloui et al 2013). The term 'probiotic' comes from the Greek words 'pro' and 'biotic,' meaning 'for life' (Gibson & Fuller 2000 ; Dhama et al 2011) and was first used in 1965 as contrary to the word antibiotic, to indicate unknown growth promoting substances produced by a ciliate protozoan that stimulated the growth of another ciliate (Krâl et al 2013; Popova 2017). Many definitions have been proposed for the term "probiotic". The more widely accepted one is "live microorganisms which, when consumed in adequate amounts, confer a health effect on the host" (FAO/WHO, 2002; Gaggia 2010; Popova 2017). This description implies that a health influence must be demonstrated for the probiotic (Francesca et al 2010; Krâl et al 2013; Park et al 2016).

Probiotics are live, in general non-pathogenic microorganisms supplemented to both human and animals diet (Getachew 2016). They are one by one microorganisms or groups of microorganisms which have positive influence on host by developing the properties of intestinal microflora. Their influence on production consequences reflects in reduction of risk of illnesses, probiotics develop the function of the immune system and display important effect on morpho-functional properties of intestines (Okanović et al 2014). Probiotics also prevent contamination of carcasses by intestinal pathogens during processing (Kabir 2009).

Aims of the use of probiotics as feed supplements can be listed as (Alloui et al 2013):

- Pathogenic bacteria control
- Improve health and production performance
- Reduce antibiotic use in poultry

Probiotic microorganisms that are generally used for animals (Table 1) include *Bifidobacterium, Lactococcus, Lactobacillus, Bacillus, Streptococcus* and yeasts such as *Candida*, which are usually found in the poultry intestine (Park et al. 2016). Apart from these, one of the most successful probiotic bacteria used in poultry are *Bacillus subtilis* (Alloui et al 2013).

Table 1
Probiotic microorganisms (Holzapfel et al 2001)

Lactobacillus species	*Bifidobacterium* species	Other lactic acid bacteria	Nonlactic acid bacteria
L. acidophilus	*B. adolescentis*	*Enterococcus faecalis*	*Bacillus cereus var*. toyoi
L. amylovorus	*B. animalis*	*Enterococcus faecium*	*Escherichia coli* strain nissle
L. casei	*B. bifidum*	*Lactococcus lactis*	*Propionibacterium freudenreichii*
L. crispatus	*B. breve*	*Leuconstoc mesenteroides*	*Saccharomyces cerevisiae*
L. delbrueckii subsp. bulgaricus	*B. infantis*	*Pediococcus acidilactici*	*Saccharomyces boulardii*
L. gallinarum	*B. lactis*	*Sporolactobacillus inulinus*	
L. gasseri	*B. longum*	*Streptococcus thermophilus*	
L. johnsonii			
L. paracasei			
L. plantarum			
L. reuteri			
L. rhamnosus			

Probiotics could be infectious, particularly in debilitated and immuno-compromised populations (Getachew 2016). Some species of *Lactobacillus*, *Bifidobacterium*, *Leuconostoc*, *Enterococcus* and *Pediococcus* have been isolated from infection areas. Lately, emphasis has been given to the selection, preparation and practice of probiotic strains, particularly lactic acid bacteria (Otutumi et al 2012).

2. Mechanisms of Action of Probiotics.

Probiotics show some significant ways of action. The mechanism of action of probiotics needs to be fully elucidated (Ülger et al 2015). However, how probiotics realize their mechanism of action is still a matter of debate (Kıran & Osmanağaoğlu 2012). A number of the recommended modes of action of probiotics are given below:

1) Maintaining a beneficial microbial population by "antagonism" and "competitive exclusion" (Ghadban 2002); an antagonistic effect towards pathogen bacteria by modification of gut pH, direct antimicrobial influence by secretion of products which prevent their improvement, such as organic acids, bacteriocins, and hydrogen peroxide, production of short chain fatty acids in the intestine, regulation of the immune system of the host, normalization of gut microbiota, and another metabolic effects (Alloui et al 2013).

2) Improving feed intake and digestion (Ghadban 2002; Apata 2008; Budak Bağdatlı & Kundakçı 2013);

3) Changing bacterial metabolism (Ghadban 2002).

4) Stimulating the immune system (Haghighi et al 2005; Kabir 2009).

Probiotic microorganisms have signified much healthy beneficial effects via in-vivo trials, accompanied by much promising recent facilities as advanced by in-vitro experiments. Generally, probiotics have been demonstrated to develop intestinal microbial stability, supply prevention against gut pathogens and modulate

immune system (Park et al 2016). There are lots of effects of probiotics on health, including regulation of intestinal microbial homeostasis, enzymatic activity inducing absorption and nutrition, stabilization of the gastrointestinal barrier function, expressions of bacteriocins, interference with the ability of pathogens to colonize and inhibition of procarcinogenic enzymes (Figure 1) (Gaggia et al 2010).

However probiotic use has not reached the expected prevalence in Turkey. The biggest reason for this is that the probiotics used are not only imported, but also maintain their viability for a long time in the process from production to use (added to feed and stored) and the problems associated with their use with other feed additives (Kocabağlı & Alp 2015).

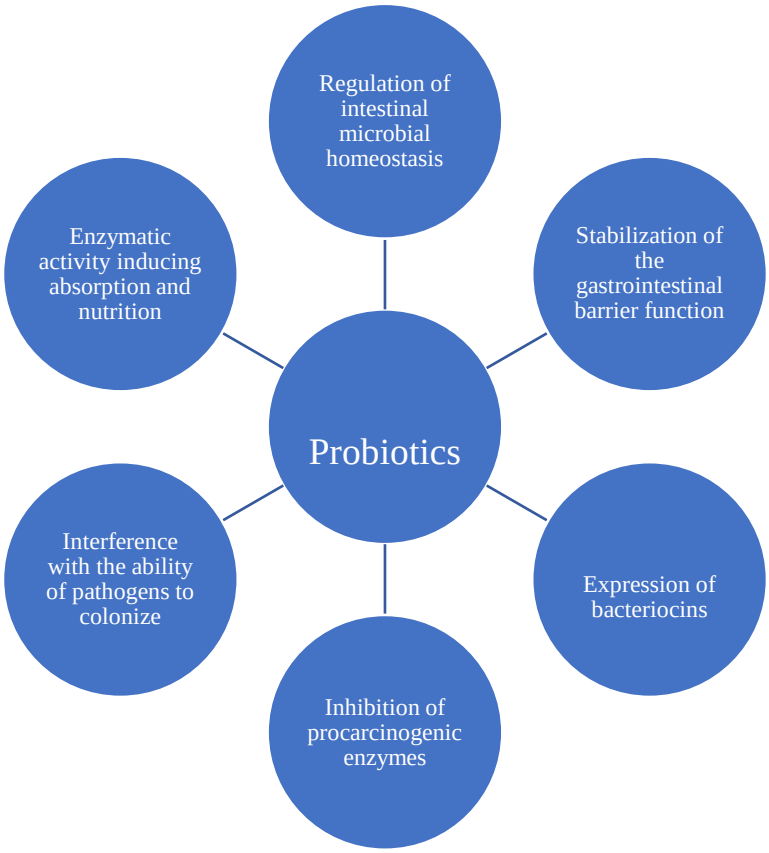

Figure 1
Effects of probiotics on health (Gaggia et al 2010)

3. Effects on Growth Performance

Probiotics, which have been used to increase productivity since the 1970s, have commercially prepared preparations containing live bacterial, yeast and fungal cultures and various enzymes (Karademir & Karademir 2003).

There are studies investigating the effects of probiotics on the performance of poultry. As a result of these studies, it was reported that significant increases were observed in the growth performance of broiler chickens, layer chickens, ducks, turkeys, quails and ostriches with the addition of probiotics (Üstündağ & Özdoğan 2017).

Especially after the prohibition of the use of antibiotics as growth promoters, probiotics became one of the important feed additives used for this purpose. Indeed, Baidya et al (1993) reported that probiotics are the most effective growth accelerators. There are many reports that chickens fed diets containing probiotics gain more weight (Ülger et al 2015). As a group of growth promoters, the supplement of probiotics to the diet of poultry has been found to develop growth performance, increase feed conversion yield and develop immune responses (Dhama et al 2011).

In a study practice of probiotic to poultry resulted in 5–6% less mortality rates through the first week, completely suppressing the growth of *E. coli*, developing daily gain and feed conversion ratio. Used a probiotic bacterial culture from *Bifidobacterium pseudulongum*, *Bifidobacterium thermophilium*, and *L. acidophilus* in dose of $6.8x10^6$ for acquiring safe and healthy poultry products (Ghadban 2002).

For example addition of probiotic *Streptococcus faecium* M-74 to broiler diet (0.5 mill. CFU /g and 1.0 mill. CFU/g) from 14th to 21st day of age increased body weight, developed feed conversion ratio, and reduced mortality of the treated chickens. Containing the probiotic Lactosacc and *S. faecium* JMB 52 cultures (400 mill. CFU/g) to the feed of broilers leads to the

development of their productivity, consistent development (Ghadban 2002).

Stanley et al (1993) reported that the addition of 0.1% live yeast (S. cerevisiae) to broiler feeds caused an increase in carcass weight.

In a study was evaluate effects on performance characteristics in quail by dietary addition of *Saccharomyces cerevisiae* and lactic acid bacteria (*Pediococcus acidilactici*). In this study performance parameters (body weight gain, feed intake and feed conversion ratio) were determined weekly. Performance characteristics were affected significantly by dietary addition of *Saccharomyces cerevisiae* and *Pediococcus acidilactici* throughout the experiment. Birds fed diet containing *Saccharomyces cerevisiae* and *Pediococcus acidilactici* significantly improved body weight gain, feed intake and feed conversion ratio. These results suggested that the usage together with yeast and bacteria in quail diets could be more effective than alone yeast or bacteria (Parlat & Göçmen 2010).

In contrast , in a study in the probiotic addition had no effect on feed conversion ratio and body weight gain during grower (16 to 29 d) and finisher (30 to 45 d) periods. Further, no significant differences in body weight at 29 and 44 d were found between chicken groups. Similarly, marginal effects of *Bacillus* spp. and a commercial probiotic (containing *Lactobacillus* spp. and *Bifidobacterium* spp.) (Kim et al 2016).

Karaoğlu and Durdağ (2005) investigated the effects of adding different levels (0.1% and 0.2%) yeast culture (*S. cerevisiae*) to the rations on carcass characteristics and performance in 19-day-old broiler chicks. rate, feed consumption and carcass yield did not create an effect in terms of reported.

Miles et al. (1981a, b) in their study by adding two different levels of probiotics (*L. acidophilus*) to breeder quail rations, egg production, feed consumption, reproduction, brood yield and mortality between quails fed with feeds containing probiotics and quails in the control group. found that there was no significant difference between the rates.

4. Effects of Probiotics on Meat Quality

Physical and chemical properties of meat such as colour, flavor, odour, texture and pH are the basic parameters that determine meat quality.

Probiotic meat products have become one of the health-related products that have increased their importance today. In addition to the positive effects of these products on health, they also have features such as improving the taste, aroma and physical structure of the product as added value and being effective on the microbiological flora (Doğu & Sarıçoban 2015).

It is thought that probiotics and organic acids, which increase the number of beneficial microorganisms in the digestive tract and act by reducing the pH of the environment, can be used as an alternative to antibiotics in the poultry industry to increase performance and meat quality, and studies have been carried out on this subject (Dama 2019).

There is common agreement that probiotics supplementation could improve meat quality (Park et al 2016). Probiotics including *Bacillus licheniformis* in the poultry diet improved the meat colour, flavour and juiceness in fresh meat (Liu et al 2012) , in spite of the fact that *Bacillus subtillis* indicated unimportant effect on the texture in cooked meat (Alfaig et al 2013; Popova 2017). Mahajan et al (2000) emphasize that the scores for the sensory properties of the meatballs; appearance, texture, juiciness and overall acceptability were significantly higher and those for flavour were lower in the probiotic fed group (Kabir 2009; Jadhav et al 2015; Park et al 2016).

4.1. Tenderness of Meat

Tenderness is known as one of the most significant properties of meat that extremely effect its consumer acceptability. As tenderness accounts as a main meat eating satisfaction, food scientists have always looked for effective tenderization processes that are capable of improving meat quality (Barekat & Soltanizadeh 2017).

Studies have shown that probiotic treatment increases meat tenderness. Improved tenderness which was shown by reduced shear force was determinated by Yang et al (2010) when probiotic *Clostridium butyricum* was added in diet of broiler (Park et al 2016).

Zhang et al (2005) conducted an experiment with 240, day-old, male broilers to search the effects of *Saccharomyces cerevisiae* cell components on the meat quality and they reported that meat tenderness could be improved by the whole yeast or *Saccharomyces cerevisiae* extract (Kabir 2009).

4.2. Lipid Composition and Oxidation of The Meat

Lipid oxidation is an important issue related to off-flavour, off-odour and warmed-over flavour seems to be relative to lipid oxidation in meat. Lipid autooxidative degradation gives products that alter the food quality, e.g. the colour, texture, flavour, aroma and the nutritive value.

Probiotics on lipid composition and oxidation of meat are changing. Latest research showed either positive or lack of adverse effect of the probiotics on the lipid stability of chicken meat. In spite of the reduced content of polyunsaturated fatty acids (PUFA) and the higher total fat content, *Aspergillus awamori* and *Aspergillus niger* reduced crucially the content of thiobarbituric acid reactive substances (TBARS) in broiler breast (Popova 2017).

Investigation on the influence of diverse probiotics on the fatty acid profile of meat is relatively limited, but the overall results point out positive influence of the probiotics, mostly related to decrease in saturated and increase of polyunsaturated fatty acids. Feeding broilers with *Aspergillus awamori* and *Saccharomyces cerevisiae* or combination of them led to important

reduction in the saturated C16:0 and C18:0, and increase in C18:1 as well as in the polyunsaturated C18:2, C18:3, C20:4 (Saleh et al 2013). The same was observed when the diet of the birds included *Aspergillus awamori* and *Aspergillus niger* in diverse amounts (0.01%, 0.05%, 0.1%) as well as *Aspergillus awamori* in combination with selenium nanoparticles (Saleh 2014). Increase in the C18:3 in breast and C18:2 and C18:3 in the thighs after probiotic administration (Hossain et al 2012); however, in the other test, decrease in the n-6 polyunsaturated fatty acids (PUFA) in both breast and thigh (Popova 2017).

Endo & Nakano (1999) reported a greater tendency of higher ratio of unsaturated fatty acids to saturated fatty acids in breast and thigh meat of broilers fed with probiotics (including *Bacillus, Lactobacillus, Streptococcus, Clostridium, Saccharomyces* and *Candida*) (Park et al 2016).

4.3. Microbiological Properties of Meat

In poultry meat production, some microorganisms present in meat deteriorate meat quality, shorten its shelf life, and pose a risk to human health. Therefore, one of the factors that affect the meat quality and is closely related to the shelf life of the meat is the microbial load of the meat (Dama 2019).

Since meat is a food of animal origin, the quality of raw materials is very important in terms of the quality of the product to be formed. The microbial load of meat products is closely related to the raw material (Doğu & Sarıçoban 2015).

Mahajan et al (2000) reported that broiler breast fed diets including probiotics had lower total aerobic bacterial counts than drumsticks (Aksu et al 2005). In a study in total bacterial counts of vacuum-packaged legs and drumsticks stored at 0^{o}C for 16 days were lower compared with aerobically packaged samples along the first 8 days of storage. They rapidly increased. Using total bacterial counts, determined that vacuum packaged broiler carcasses could be preserved at 2^{o}C for 10 days (Aksu et al 2005).

Concerning the microbiological quality of meat, competitive put out of cultures for broilers can be used to decrease contamination by *Salmonella enteritidis* in processed carcasses, decreasing thus the exposure of consumers to food-borne infections (Otutumi et al 2012).

4.4. Sensory Properties of Meat

Probiotics on sensory properties of meat are changing. Some studies show a positive influence of probiotics on sensory properties whereas other studies show no influence of probiotics. Probiotics may have an influence on flavour of meat. In a study in a favorable influence of probiotics including *Bacillus licheniformis* and *Bacillus subtilis* spores on the flavor of broiler meat after cooling for 5 days however in a different study in probiotics fed with water and feed did not had any influences on sensory characteristics of meat. In a study in probiotic addition significantly increased the meat tenderness and meat quality. Majority of the carcass characteristics are forthrightly commensurate to the increased body weight at the time of slaughter. In contrast, in the other experiment, no significant difference in carcass % between probiotic treated and untreated treatments on the sensory parameter basis (Jadhav et al 2015).

5. Conclusion

There is a popular opinion that consumers would prefer to buying poultry meat from animals processed with natural agents rather than antibiotics, hormones, or other chemicals. Probiotics can present enormous potential as alternatives for antibiotics to completely eliminate antibiotic use, because probiotics do not lead to microbial resistance. In addition to probiotics constitute a cost-effective alternative to antibiotic growth promoters. Probiotics seem to be the feed additives of the coming years, particularly under the politics of banning of antibiotics. Probiotics are gaining importance because they have a number of beneficial effects in poultry. These are: to supply nutrient to the feed, to improve immunity, to prevent intestinal tract disease, to promote growth and meat quality and stability, environmental friendly.

Find out more information and gaining experiences on comprehend probiotics and find out their overall practicability for poultry meat quality in the coming years would help in making further improvements.

In recent years, the use of probiotics has become clearer than in previous years. Probiotics can be seen as an important alternative to antibiotic agents for growth promotion in poultry. It is thought that this resource will be utilized more effectively in the future.

As it is a relatively new field of study, research on the subject continues. Considering the benefits, it is thought that more studies should be done on this subject.

Although the use of probiotics is quite old, there are still unexplained points in terms of the mechanism of action and measurement of effectiveness. However, it is predicted that the use of probiotics and prebiotics will increase in the future as a result of the restriction of antibiotics as growth promoters and also because consumers avoid products produced using antibiotics. Giving probiotics to animals, in particular, will stimulate the immune system, thereby reducing susceptibility to disease. In addition, both the positive results obtained and the economic nature revealed that the use of probiotics, at least at a certain level, will continue in the short and long term.

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