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ENHANCING PROBIOTIC AND VITAMIN E SUPPLEMENTATION TO OPTIMIZE GROWTH POTENTIAL IN BROILER CHICKS

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Abstract:

Consumption of broilers is very high worldwide because broilers are source of protein. Many countries have restricted use of antibiotics for birds and are using probiotics as an alternative source of antibiotics. Probiotics are living microbes which increase immunity and boost growth of birds and other animals Vitamins are among essential nutrients including vitamin E. The research conducted on broiler chicks aimed to evaluate the impact of vitamin E supplementation and probiotics on growth performance and body composition. A total of 21 broiler chicks were divided into three treatment groups. Treatment 1 received a control diet, Treatment 2 was given Protexin probiotics (500 mg/Live), and Treatment 3 received both Protexin probiotics and vitamin E supplement (180 mg/kg). The study spanned 40 days, with weekly measurements taken for parameters such as body weight, weight gain, feed intake, feed conversion ratio (FCR), and specific growth rate (SGR). Analysis of body composition was conducted using various methods. Results indicated that Treatment 3 exhibited the highest significant weight gain, followed by Treatment 2 and then Treatment 1. Treatment 1 had the highest FCR value, while Treatment 3 showed the lowest. Feed intake and SGR were significantly higher in Treatment 3 compared to Treatment 1. Treatment 3 also displayed higher levels of crude protein and ash content compared to Treatment 1. Conversely, Treatment 1 had higher values of crude fat and moisture content compared to Treatment 3. The findings suggest that the combination of vitamin E supplement and Protexin probiotics can effectively enhance the growth performance of broiler chicks. This research contributes valuable insights into optimizing the economic efficiency of broiler production.

I. INTRODUCTION

One of the best sources of protein is thought to be poultry meat (Ahmad et al., 2010). The poultry industry has been one of the most productive and quickly expanding global industries during the last 20 years. The global population's growing need for high-quality protein is mostly met by this industry(van den Bogaard & Stobberingh, 2000). Poultry flesh offers vital lipids, minerals, and vitamins in addition to protein(Grashorn & Clostermann, 2002). Hens are renowned for their effective conversion of grain into protein. The feed that broiler chicks consume has a major impact on the makeup of their muscular tissue (Abdul, 2020).Demand for high-quality, virus-free protein sources that are safe is rising(Opalinski et al., 2007). This rising demand has led to an expansion in the poultry business worldwide. Global meat consumption increased by 55% between 1997 and 2020, and by 2050, meat production is expected to reach 455 million tons (Alexandratos & Bruinsma, 2012). Up to 90% of the market value is made up of demand for poultry and chicken. According to estimates, India's per capita consumption of chicken meat will rise by 12.5 kg by the year 2050 (Hellin et al., 2014). The poultry industry is expanding faster than 5% a year (Wirsenius et al., 2010).

Poultry production has increased dramatically in developing countries, especially in Asia. Presently, more than 25% of the world's poultry is produced in Asia (Manning & Baines, 2004). India is notable for being the fifth-largest producer of poultry meat worldwide and one of the biggest producers of poultry meat in Asia (Mitra & Bose, 2005). India's poultry industry accounts for 80% of the nation's total poultry production, with about 60,000 operational farms producing chicken (Pfeifer et al., 2005). Africa's top producer of chicken meat is South Africa, which is followed by nations like Egypt, Morocco, Nigeria, and Algeria. As the largest sector of all agricultural segments, the poultry business plays a major role in South Africa's agricultural sector (Bednarski et al., 2015). The poultry business in Pakistan has grown significantly in the last several years, accounting for 16.8% of the nation's total meat production (Dousa et al., 2017). Pakistan's internal market demand is driving a 45% annual increase in the country's consumption of poultry meat (Sadiq & Rodriguez, 2004). With a 1.26% GDP contribution to the national economy and a 5.76% contribution to the agricultural sector, the poultry business is also essential to the nation's economy. Pakistan, poultry meat is thought to be the most reasonably priced meat choice (Botha et al., 2015).

Pakistan has produced more poultry meat than any other country over the previous fifty years. In 1971, the market proportions of mutton and beef were 37% and 61%, respectively, while poultry meat made up only 2-2.25% of the total. By 2010, the proportion of meat from poultry had increased to 25%, while the proportions of beef and mutton had dropped to 55% and 20%, respectively. Pakistan sells chicken products to Afghanistan, Bahrain, Hong Kong, Iran, Turkey, and Vietnam, among other nations (Hussain et al., 2015).It has been demonstrated that probiotics, which are living microorganisms that help the host species' health (Organization, 2001), accelerate the growth of birds. They are thought to promote intestinal absorption and serve a critical role in maintaining the proper balance of intestinal microorganisms, which in turn

improves broiler development performance (Sohail et al., 2012). Two common probiotic species that are employed are lactobacilli and enterococci (Patterson & Burkholder, 2003). Research has shown that giving broilers probiotics can help these birds grow more successfully (Gadde et al., 2017).

Antibiotics have long been used to treat illnesses and strengthen birds' immune systems. Antibiotic resistance mechanisms may arise as a consequence of extended antibiotic use (Fahlman et al., 2018). In the early years of the twenty-first century, the European Union made a huge step forward when it outlawed these antibiotics in 2006 (Castanon, 2007). The FDA is one of the US government agencies that has made it mandatory for antibiotics to not be used for the purpose of promoting animal growth (Stephany, 2010). Probiotics are used to promote growth, however the Food and Drug Administration has not formally recognized this usage, despite the fact that probiotics have not yet been the target of any legal action (Al-Khalaifah, 2018).Supplementing with Bacillus bacteria has been shown to suppress pathogenic microorganisms, boost immunity, control gut microbiota, and positively impact productivity (La Ragione et al., 2001). It has also been demonstrated that this species of bacteria improves the sensory qualities and quality of broiler meat (Y. Wang et al., 2017). When broiler chicks are given probiotics, there is an increase in macrophage phagocytic activity and the generation of peptides against pathogenic microorganisms (Pender et al., 2017).

Probiotics have been demonstrated to lower death rates by competitively eliminating pathogenic microorganisms from the gastrointestinal system. However, research has shown mixed results regarding the impact of Lactobacillus probiotics on mortality (Zulkifli et al., 2000). It has been discovered that multispecies probiotics (MSPB) are superior to monospecies probiotics in terms of enhancing broiler performance (Elmenawey & Gharib, 2013). Broiler performance has improved when Lactobacillus probiotics, lactic acid bacteria, are used during the starting stage (Zulkifli et al., 2000)After 21 days, it has been demonstrated that Saccharomyces cerevisiae, another probiotic product, improves broiler growth (Bai et al., 2013).Both directly and indirectly, vitamin E affects living cells through changes to metabolic parameters and endocrine function (Leshchinsky & Klasing, 2001). Because of the detrimental effects of free radicals in high-stress situations like heat stress, the use of synthetic antioxidants to alleviate oxidative stress has become standard practice (Hassan et al., 2017). Vitamin E's antioxidative properties have been investigated in order to comprehend its function in disease prevention, specifically in relation to preventing protein oxidation and lipid peroxidation (Gianazza et al., 2021).

Numerous factors that interact with vitamin E and may affect physiological processes and the dietary needs of broilers limit the isolated demand for vitamin E supplementation (Kuttappan et al., 2012). Due to variations in absorption, disease interactions, elevated metabolic demands, and vitamin E breakdown in the gastrointestinal tract, the requirements for vitamin E can change among genotypes of broilers. To address the needs of poultry, using vitamin E in central feed components is usually sufficient.The current study aims to evaluate the effect of probiotics on

broiler chicks' growth performance and to assess how probiotics and vitamin E together affect broiler chicks' ability to grow(Pompeu et al., 2018).

II. MATERIALS AND METHODS

The study was carried out at the University of Agriculture, Faisalabad's Postgraduate Agricultural Research Institute. Strict hygiene and safety protocols were continuously applied for the duration of the study. Throughout the entire investigation, the welfare of the animals was the top focus. Adequate ventilation and temperature control mechanisms were employed to provide ideal circumstances for broiler chicks. There was access to filtered drinking water, and water bottles needed to be cleaned every day. During the research period, lighting was given to the broiler chicks constantly throughout their 24-hour cycle.

The aim of the research was to assess the impact of probiotics and vitamin E supplementation on the body composition and growth performance of broiler chicks. The investigation took place over the course of forty days. For the purpose of the study, twenty-one broiler chicks were divided into three treatment groups at random (identified as 11, 12, and 13). Every treatment group had seven chicks in it. Treatment 12 was supplemented with 500 mg of Protexin probiotics per liter of water, whereas Treatment 11 was used as the control group. Treatment 13 was administered protexin probiotics (500 mg per liter of water) along with vitamin E supplementation (180 mg per kilogram of diet).*Lactobacillus plantarum, Lactobacillus rhamnosus, Lactobacillus delbrueckii, Lactobacillus acidophilus, Lactobacillus bulgaricus, Bifidobacteriumbifidum, Enterococcus faecium and Streptococcus thermophilus* are among the strains of beneficial live microbes present in protexin, a probiotic formulation. These probiotic strains were chosen with care since they may improve the health and performance of broiler chicks.

Table 1: Number of Treatments

No. of Treatments	Diet
T_I	Control diet
T_2	Control diet+ Protexin Probiotics (500 mg Litre)
T_3	Control diet+ Protexin probiotics (500 mg/Litre) Vitamin E supplement (180 mg/kg)

2.1 Vaccination Program

The immunization schedule for Newcastle and bursal illnesses was adhered to by the broiler chicks, as advised by veterinary specialists.

2.2 Feeding trial:

The feeding trial for the chicks was divided into multiple phases

2.3 Phases:

Initial phase

In the initial phase, commercial feed was provided to the chicks. This phase commenced on day 1 and concluded on day 26 of the trial.

Table 2: Feeding trail for the first phase

Days	Treatments	Feed Types
1-12 Acclimatization)	All	Only commercial feed
12-26	T1	Commercial diet
	T2	Commercial diet + Protexin (Probiotics)
	T3	Commercial diet+Vitamin E+Protexin (Probiotics)

Second phase

In the Second phase, commercial feed was provided to the chicks. This phase commenced on day 26 and concluded on day 40 of the trial.

Table 3Feeding trail for the Second phase

Days	Treatments	Feed Types
26-40	T1	Formulated diet
	T2	Formulated diet
	T3	Formulated diet + Protexin (Probiotics)+ Vitamin E

Data for the subsequent growth indicators were recorded.

2.4Body mass

Body weight was recorded once a week for the duration of the study. The purpose of the scale was to measure the weight of developing chicks.

2.5Food intake:

Feed refused was subtracted from the total amount of feed supplied to determine the Total feed Ingest. By putting the values in the formula below, it was measured.

Food intake = Quantity of feed given (g) - Refused feed (g)

2.6 Feed conversion ratio:

The FCR was used to assess the broiler chicks' feed efficiency.FCR was computed using a predetermined formula.

FCR = Feed intake (g) - FCR Gain in weight (g)

2.7 Specific growth rate:

The following calculation was used to get the chicks' Specific Growth Rate (SGR):

SGR = Final weight (g) − Initial weight (g) equals SGR. / Days of the experiment

2.8 Economic parameters:

Based on input and output analysis, the economics of each treatment were determined at the end of the experiment, taking into account differences in growth performance and feeding costs. For every treatment, the same amounts were spent on litter, chicks, drugs, nutrition, and immunizations (Rojo-Gimeno et al., 2016).

III. RESULTS

At the Postgraduate Agricultural Research Station, University of Agriculture, Faisalabad, a study was carried out to find out how probiotics called Protexin and vitamin E supplements affected the growth and body composition of broiler chicks. Twenty-one broiler chicks, with seven chicks in each cage, were bought from a nearby farm and randomized into three treatment groups (T1, T2, and T3). T1 was the control group; T2 had 500 mg/litre of Protexin probiotics; and T3 got 500 mg/litre of Protexin probiotics in addition to 180 mg/kg of vitamin E supplement. Throughout the research trial, weekly records of the broiler chicks' body weight, weight gain, feed intake, feed conversion ratio (FCR), and specific growth rate (SGR) were made. Following a body composition examination, the amounts of crude protein, crude fat, moisture, and ash content were also ascertained.

3.1Growth Performance of Broiler Chicks

A number of metrics, including body weight, weight gain, feed intake, feed conversion ratio (FCR), and specific growth rate (SGR), were used to evaluate the broiler chicks' growth performance. Throughout the trial, these variables were closely watched every week to assess the impact of probiotics called Protexin and vitamin E supplements. The gathered data provide insightful information about the various treatment groups' growth trends and nutrient use efficiency. The findings showed that, in comparison to the control group (T1) and the group getting only Protexin probiotics (T2), broiler chicks receiving both a vitamin E supplement and Protexin probiotics (T3) showed significantly greater body weights and weight growth. As indicated by the lower feed conversion ratios (FCR) and greater specific growth rates (SGR) throughout the study, the T3 group's feed intake was also seen to be more efficient. These results imply that a vitamin E supplement and Protexin probiotics may work in concert to improve broiler chick development performance.

3.2 Weight gain:

In all research weeks, T3 broiler chicks consistently demonstrated the highest average body weight and weight gain, while T1 broiler chicks consistently displayed the lowest values for these parameters. Specifically, the average body weight and weight for T3 were recorded as 672.07±150.05 and 154.39±75.64, respectively.

Table 4: Effect of vitamin E supplement and protexin probiotics on weight gain of broiler chicks during all research weeks

Duration	T1 (Control diet without vitamin E supplement and probiotics)		T2 (Control diet with 500 mg/Litreprotexin probiotics)		T3 (Control diet with 180 mg/kg vitamin E supplement and 500 mg/Litreprotexin probiotics)	
	Average weight (g)	Weight gain (g)	Average weight (g)	Weight gain (g)	Average weight (g)	Weight gain (g)
Week 1	338.57	163	397.86	185.86	431.43	213.29

Week 2	543.16	204.56	625	227.14	675.86	244.43
Week 3	587.5	44.34	677.14	52.14	745.29	69.43
Week 4	651.83	64.33	753	75.86	835.71	90.42
Mean±S.D.	530.27 117.23	119.06±66.74	613.25 132.42	135.25 73.21	672.07+150.05	154.39+75.64

Table 4: Represents that average body weight and weight gain was highest in T3 broiler chicks during all research weeks and lowest in T1 broiler chicks during all research weeks. Average body weight and weight of T3 were 672.07±150.05 and 154.39±75.64 respectively.

3.3Feed intake:

Treatment 3 exhibited the highest trend in feed intake, with an average of 278.75±129.56, while Treatment 1 showed the lowest trend at 219.5±117.6. Throughout all research weeks, Treatment 3 consistently demonstrated the highest feed intake trend, whereas Treatment 1 consistently exhibited the lowest feed intake trend.

Table5: Effect of vitamin E supplement and protesin probiotics on feed intake of broiler chicks during all research weeks

DURATION	TI (Control diet without vitamin E supplement and probiotics)		12 (Control diet with 500 mg/Litreprotexin probiotics)		T3 (Control diet with 180 mg/kg vitamin E. supplement and 500 mg/Litreprotexin probiotics)	
	feed given (g)	Feed intake (g)	feed given (g)	Feed intake (g)	feed given (g)	feed intake (g)
Week 1	.04	299	504	337	504	383

Week 2	504	368	504	404	504	429
Week 3	504	84	504	98	504	128
Week 4	504	127	504	147	504	174
Mean±S.D.	504	219.5±117.6	504	246.5±127.43	504	278.75±129.56

Table5: represents that highest trend regarding feed intake was observed in Treatment 3 which was 278.75±129.56 and lowest trend regarding feed intake was recorded in T1 which was 219.5±117.6. T3 expressed highest trend in all research weeks and T1 expressed lowest trend in all research weeks.

3.4FCR

Treatment 1 for broiler species showed the highest trend in feed conversion ratio, with a value of 1.87, while Treatment 3 for broiler chicks exhibited the lowest trend with an FCR of 1.83 throughout all research weeks.

Table 6: Effect of vitamin E supplement and protexin probiotics on FCR of broiler chicks during all research weeks

DURATION	TI (Control diet without vitamin E supplement and probiotics)		T2 (Control diet with 500 mg/Litreprotexin probiotics)		T3 (Control diet with 180 mg/kg vitamin E supplement and 500 mg/Litreprotexin probiotics)	
	Feed intake (g)	FCR	Feed intake	FCR	Feed intake (g)	FCR
Week 1	299	1.89	337	1.81	383	180

Week 2	358	1.80	404	1.78	429	1.76
Week 3	84	1.89	98	1.88	128	1.84
Week 4	127	1.97	147	194	174	1.92
Mean±S.D.	219.5±117.6	1.87±0.065	246.5±127.3	1.85±0.062	278.75±12956	1.83±0059

Table 6: Represents that highest trend related to feed conversion ratio was observed in Treatment I broiler species and lowest trend related to feed conversion ratio was recorded in 13 broiler chicks during all research weeks. FCR of treatment 3 was 1.83 and FCR of treatment 1 was 1.87.

3.5Specific growth rate

In the first week, the specific growth rate (SGR) of the broiler chicks in treatment 1 was 0.73; by the last week, it had dropped to 0.64. Treatment 3 broiler chicks consistently had the highest SGR over the course of all research weeks, while Treatment 1 broiler chicks consistently displayed the lowest SGR. The SGR value for Treatment 2 was 0.68±0.09.

Table 7: Effect of vitamin E supplement and protexin probiotics on SGR of broiler chicks during all research weeks

DURATION	T1 (Control diet without vitamin E supplement and probiotics)	T2 (Control diet with 500 mg/Litreprotexin probiotics)	T3 (Control diet with 180 mg/kg vitamin E supplement and 500 mg/Litreprotexin probiotics)

	Specific growth rate	Specific growth rate	Specific growth rate
Week 1	0.73	0.75	0.77
Week 2	0.76	0.78	0.79
Week 3	0.54	0.56	0.61
Week 4	0.59	0.62	0.64
Mean S.D	0.66±0.09	0.68±0.09	0.70±0.07

Table 7: Represents that SGR of T1 broiler chicks in 1 week was 0.73 and in last week, SGR of broiler chicks was 0.64. SGR of T3 broiler chicks was highest in record and SGR of T1 broiler chicks was lowest in record during all research weeks. T2 expressed 0.68±0.09 value regarding specific growth rate

IV. DISCUSSION

Probiotics, live microorganisms that provide health advantages to their host species (Organization, 2001). It is used to enhance growth amd produced immunity (Butel, 2014).They boost the quantity of T lymphocytes and aid in preserving the equilibrium of intestinal microorganisms(Al-Khalaifa et al., 2019). Probiotics Probiotics are being utilized as an alternative because the use of antibiotics in birds is restricted in many countries(Abiuso, 2016).Vitamins are necessary nutrients, and vitamin E is one of them. Increased vitamin E levels lessen oxidative stress by providing defense against reactive oxygen species (Panda & Cherian, 2014). Studies have indicated that adding more vitamin E to broiler feed has positive outcomes (Khatun et al., 2020).

A study from the University of Agriculture, Faisalabad's Postgraduate Agricultural Research Station looked at the impact of probiotics called Protexin and vitamin E supplementation on the growth and body composition of broiler chicks. Weight increase, specific growth rate, feed intake, feed conversion ratio, and body composition in terms of moisture, ash content, crude protein, and crude fat were all assessed in the study.The group receiving both

Protexin probiotics and a vitamin E supplement (T3) had the greatest weight growth, according to the data, whereas the group receiving no supplements (T1) experienced the lowest weight gain. Because of their antibacterial qualities and ability to increase intestinal absorption, probiotics may have contributed to the improvement in weight gain. It's possible that protexin probiotics stimulated particular immune cells to fight off dangerous microbes in the broiler gut. Furthermore, the vitamin E pill may have caused weight gain by activating antioxidant enzymes to combat oxidative stress.

The results of this investigation are consistent with earlier studies showing the beneficial effects of probiotics on broiler chick weight gain. Probiotics may enhance weight gain, according to studies by (Alkhalf et al., 2010; Samli et al., 2007; Zulkifli et al., 2000). Similar results were found in studied that supplemented with probiotics and vitamin E led to increased weight gain. Probiotics and vitamin E have been linked to enhanced weight growth (G. Wang et al., 2017). According to (Min et al., 2018), particular vitamin E supplementation controlled gene expressions to protect against oxidative stress, which improved the broiler chicks' ability to grow.The findings showed that Treatment 3, which got probiotics and vitamin E supplementation, had the maximum feed intake, whereas Treatment 1, which did not receive any supplementation, had the lowest feed consumption. The capacity of the probiotics to improve intestinal absorption in broiler chicks and consequently feed utilization may be the cause of this increase in feed intake. The results which showed that probiotic treatment enhanced feed intake(Ryu & Chang, 2013; Willis et al., 2007).

In terms of feed conversion ratio (FCR), the group receiving probiotics and vitamin E had the lowest FCR, whereas Treatment 1, which did not get any supplements, had the highest FCR. The beneficial microorganisms in the digestive system that increase nutrient absorption and digestibility may be the cause of this improvement in FCR. Probiotics may help gut flora, encouraging growth and eventually improving FCR. By preventing oxidative stress, vitamin E may potentially play a role in this improvement. These findings align with earlier research by which demonstrated enhanced FCR with probiotic and vitamin E administration(Giannenas et al., 2010; Jayaraman et al., 2013).

Treatment 3 (protexin probiotics and vitamin E supplementation) had the highest specific growth rate, while Treatment 1 (no supplementation) had the lowest. The probiotics' improved ability to aid in digestion and absorption in the digestive system, as well as the beneficial role that intestinal microorganisms play in the development of broiler chicks, may be the cause of this growth rate improvement. Supplementing with vitamin E may also contribute to an increase in the specific growth rate by enhancing cell development and lowering free radicals. These results are consistent with studies by Edens (2003) and Palmidi et al. (2016) that showed probiotics improved broiler chick development performance(Edens, 2003; Makled et al., 2019).

Regarding the composition of the body, Treatment 3, which was administered probiotics and vitamin E supplements, showed the highest trend in crude protein content. This rise might be the

result of probiotics facilitating nutritional absorption and vitamin E stimulating particular enzymes, both of which have a beneficial effect on crude protein concentration. Treatment 1 had the highest crude fat trend, while Treatment 3 had the lowest. Treatment 1 had the highest moisture content, whereas Treatment 3 had the lowest. For Treatments 1, 2 and 3 the ash content was 1.22, 1.30 and 1.19, in that order. (Abdulla et al., 2017)on water and fat contentbut they are consistent with the findings of Pietras (2001) on protein content and Davies et al. (1975) on body composition.

Conclusion:

This study used a multi-strain probiotic and vitamin E supplementation to improve the growth performance of broiler chicks. The chicks were given a favorable environment, with daily temperature monitoring, filtered drinking water, and proper sanitation. Three treatment groups were established: T1, T2, and T3. The study assessed growth performance and body composition, with T2 showing the highest growth performance. The combined effect of vitamin E supplementation and probiotics showed the highest impact on growth performance, with T2 exhibiting the highest growth performance. Feed intake and specific growth rate were highest in T3 and lowest in T1, with crude protein and ash content highest in T3.

References:

Abdul, M. (2020). effects of climatic variations on the spread and outbreak of newcastle disease. a critical literature review. *Animal Health Journal*, *1*(1), 1-14.

Abdulla, N. R., Mohd Zamri, A. N., Sabow, A. B., Kareem, K. Y., Nurhazirah, S., Ling, F. H., Sazili, A. Q., & Loh, T. C. (2017). Physico-chemical properties of breast muscle in broiler chickens fed probiotics, antibiotics or antibiotic–probiotic mix. *Journal of Applied Animal Research*, *45*(1), 64-70.

Abiuso, C. (2016). Influence of different prebiotics and mode of their administration on growth, carcass traits and meat quality in broiler chickens.

Ahmad, P., Jaleel, C. A., Salem, M. A., Nabi, G., & Sharma, S. (2010). Roles of enzymatic and nonenzymatic antioxidants in plants during abiotic stress. *Critical reviews in biotechnology*, *30*(3), 161-175.

Al-Khalaifa, H., Al-Nasser, A., Al-Surayee, T., Al-Kandari, S., Al-Enzi, N., Al-Sharrah, T., Ragheb, G., Al-Qalaf, S., & Mohammed, A. (2019). Effect of dietary probiotics and prebiotics on the performance of broiler chickens. *Poultry science*, *98*(10), 4465-4479.

Al-Khalaifah, H. (2018). Benefits of probiotics and/or prebiotics for antibiotic-reduced poultry. *Poultry science*, *97*(11), 3807-3815.

Alexandratos, N., & Bruinsma, J. (2012). World agriculture towards 2030/2050: the 2012 revision.

Alkhalf, A., Alhaj, M., & Al-Homidan, I. (2010). Influence of probiotic supplementation on blood parameters and growth performance in broiler chickens. *Saudi journal of biological sciences*, *17*(3), 219-225.

Bai, S., Wu, A., Ding, X., Lei, Y., Bai, J., Zhang, K., & Chio, J. (2013). Effects of probiotic-supplemented diets on growth performance and intestinal immune characteristics of broiler chickens. *Poultry science*, *92*(3), 663-670.

Bednarski, M., Dudek, M., Knutelska, J., Nowiński, L., Sapa, J., Zygmunt, M., Nowak, G., Luty-Błocho, M., Wojnicki, M., & Fitzner, K. (2015). The influence of the route of administration of gold nanoparticles on their tissue distribution and basic biochemical parameters: In vivo studies. *Pharmacological Reports*, *67*(3), 405-409.

Botha, H., Duffy, J. R., Whitwell, J. L., Strand, E. A., Machulda, M. M., Schwarz, C. G., Reid, R. I., Spychalla, A. J., Senjem, M. L., & Jones, D. T. (2015). Classification and clinicoradiologic features of primary progressive aphasia (PPA) and apraxia of speech. *Cortex*, *69*, 220-236.

Butel, M.-J. (2014). Probiotics, gut microbiota and health. *Médecine et maladies infectieuses*, *44*(1), 1-8.

Castanon, J. (2007). History of the use of antibiotic as growth promoters in European poultry feeds. *Poultry science*, *86*(11), 2466-2471.

Dousa, J., Vaclavovic, P., & Elias, M. (2017). Tropospheric products of the second GOP European GNSS reprocessing (1996–2014). *Atmospheric Measurement Techniques*, *10*(9), 3589-3607.

Edens, F. (2003). An alternative for antibiotic se in poultry: probiotics. *Brazilian Journal of Poultry Science*, *5*, 75-97.

Elmenawey, M., & Gharib, H. (2013). Effects of monospecies and multispecies probiotics on productive performance, intestinal histomorphological parameters and immune response in broilers. *Egyptian Journal of Animal Production*, *50*(2), 93-102.

Fahlman, A., McHugh, K., Allen, J., Barleycorn, A., Allen, A., Sweeney, J., Moore, M. J., & Wells, R. (2018). Resting metabolic rate and lung function in wild offshore common bottlenose dolphins, Tursiops truncatus, near Bermuda. *Frontiers in Physiology*, *9*, 393807.

Gadde, U., Kim, W., Oh, S., & Lillehoj, H. S. (2017). Alternatives to antibiotics for maximizing growth performance and feed efficiency in poultry: a review. *Animal health research reviews*, *18*(1), 26-45.

Gianazza, E., Brioschi, M., Martinez Fernandez, A., Casalnuovo, F., Altomare, A., Aldini, G., & Banfi, C. (2021). Lipid peroxidation in atherosclerotic cardiovascular diseases. *Antioxidants & redox signaling*, *34*(1), 49-98.

Giannenas, I., Pappas, I., Mavridis, S., Kontopidis, G., Skoufos, J., & Kyriazakis, I. (2010). Performance and antioxidant status of broiler chickens supplemented with dried mushrooms (Agaricus bisporus) in their diet. *Poultry science*, *89*(2), 303-311.

Grashorn, M., & Clostermann, G. (2002). Performance and slaughter characteristics of broiler breeds for extensive production.

Hassan, W., Noreen, H., Rehman, S., Gul, S., Amjad Kamal, M., Paul Kamdem, J., Zaman, B., & BT da Rocha, J. (2017). Oxidative stress and antioxidant potential of one hundred medicinal plants. *Current topics in medicinal chemistry*, *17*(12), 1336-1370.

Hellin, J., Erenstein, O., Krishna, V. V., & Boeber, C. (2014). The rapid growth of the poultry industry in Asia: implications for research and development. *Maize for Food, Feed, Nutrition and Environmental Security*, *75*.

Hussain, J., Rabbani, I., Aslam, S., & Ahmad, H. (2015). An overview of poultry industry in Pakistan. *World's poultry science journal*, *71*(4), 689-700.

Jayaraman, S., Thangavel, G., Kurian, H., Mani, R., Mukkalil, R., & Chirakkal, H. (2013). Bacillus subtilis PB6 improves intestinal health of broiler chickens challenged with Clostridium perfringens-induced necrotic enteritis. *Poultry science*, *92*(2), 370-374.

Khatun, J., Loh, T. C., Foo, H. L., Akit, H., & Khan, K. I. (2020). Growth performance, cytokine expression, and immune responses of broiler chickens fed a dietary palm oil and sunflower oil blend supplemented with L-Arginine and varying concentrations of vitamin E. *Frontiers in Veterinary Science*, *7*, 619.

Kuttappan, V., Brewer, V., Apple, J., Waldroup, P., & Owens, C. (2012). Influence of growth rate on the occurrence of white striping in broiler breast fillets. *Poultry science*, *91*(10), 2677-2685.

La Ragione, R. M., Casula, G., Cutting, S. M., & Woodward, M. J. (2001). Bacillus subtilis spores competitively exclude Escherichia coli O78: K80 in poultry. *Veterinary microbiology*, *79*(2), 133-142.

Leshchinsky, T., & Klasing, K. (2001). Relationship between the level of dietary vitamin E and the immune response of broiler chickens. *Poultry science*, *80*(11), 1590-1599.

Makled, M., Abouelezz, K., Gad-Elkareem, A., & Sayed, A. (2019). Comparative influence of dietary probiotic, yoghurt, and sodium butyrate on growth performance, intestinal microbiota, blood hematology, and immune response of meat-type chickens. *Tropical animal health and production*, *51*, 2333-2342.

Manning, L., & Baines, R. (2004). Effective management of food safety and quality. *British Food Journal*, *106*(8), 598-606.

Min, Y., Niu, Z., Sun, T., Wang, Z., Jiao, P., Zi, B., Chen, P., Tian, D., & Liu, F. (2018). Vitamin E and vitamin C supplementation improves antioxidant status and immune function in oxidative-stressed breeder roosters by up-regulating expression of GSH-Px gene. *Poultry science*, *97*(4), 1238-1244.

Mitra, S., & Bose, D. (2005). Supply chain issues in the Indian poultry-meat industry: the case of a vertically-integrated farm. *Indian Institute of Management Calcutta, Working Paper Series*.

Opalinski, M., Maiorka, A., Dahlke, F., Cunha, F., Vargas, F., & Cardozo, E. (2007). On the use of a probiotic (Bacillus subtilis-strain DSM 17299) as growth promoter in broiler diets. *Brazilian Journal of Poultry Science*, *9*, 99-103.

Organization, W. H. (2001). The World Health Report 2001: Mental health: new understanding, new hope.

Panda, A. K., & Cherian, G. (2014). Role of vitamin E in counteracting oxidative stress in poultry. *The Journal of Poultry Science*, *51*(2), 109-117.

Patterson, J., & Burkholder, K. (2003). Application of prebiotics and probiotics in poultry production. *Poultry science*, *82*(4), 627-631.

Pender, C. M., Kim, S., Potter, T. D., Ritzi, M. M., Young, M., & Dalloul, R. A. (2017). In ovo supplementation of probiotics and its effects on performance and immune-related gene expression in broiler chicks. *Poultry science*, *96*(5), 1052-1062.

Pfeifer, P. E., Haskins, M. E., & Conroy, R. M. (2005). Customer lifetime value, customer profitability, and the treatment of acquisition spending. *Journal of managerial issues*, 11-25.

Pompeu, M. A., Cavalcanti, L. F., & Toral, F. L. (2018). Effect of vitamin E supplementation on growth performance, meat quality, and immune response of male broiler chickens: A meta-analysis. *Livestock Science*, *208*, 5-13.

Rojo-Gimeno, C., Postma, M., Dewulf, J., Hogeveen, H., Lauwers, L., & Wauters, E. (2016). Farm-economic analysis of reducing antimicrobial use whilst adopting improved

management strategies on farrow-to-finish pig farms. *Preventive Veterinary Medicine*, *129*, 74-87.

Ryu, E. H., & Chang, H. C. (2013). In vitro study of potentially probiotic lactic acid bacteria strains isolated from kimchi. *Annals of microbiology*, *63*, 1387-1395.

Sadiq, R., & Rodriguez, M. J. (2004). Disinfection by-products (DBPs) in drinking water and predictive models for their occurrence: a review. *Science of the total environment*, *321*(1-3), 21-46.

Samli, H. E., Senkoylu, N., Koc, F., Kanter, M., & Agma, A. (2007). Effects of Enterococcus faecium and dried whey on broiler performance, gut histomorphology and intestinal microbiota. *Archives of animal nutrition*, *61*(1), 42-49.

Sohail, M., Hume, M., Byrd, J., Nisbet, D., Ijaz, A., Sohail, A., Shabbir, M., & Rehman, H. (2012). Effect of supplementation of prebiotic mannan-oligosaccharides and probiotic mixture on growth performance of broilers subjected to chronic heat stress. *Poultry science*, *91*(9), 2235-2240.

Stephany, R. W. (2010). Hormonal growth promoting agents in food producing animals. *Doping in sports: Biochemical principles, effects and analysis*, 355-367.

van den Bogaard, A. E., & Stobberingh, E. E. (2000). Epidemiology of resistance to antibiotics: links between animals and humans. *International journal of antimicrobial agents*, *14*(4), 327-335.

Wang, G., Kim, W. K., Cline, M. A., & Gilbert, E. R. (2017). Factors affecting adipose tissue development in chickens: A review. *Poultry science*, *96*(10), 3687-3699.

Wang, Y., Sun, J., Zhong, H., Li, N., Xu, H., Zhu, Q., & Liu, Y. (2017). Effect of probiotics on the meat flavour and gut microbiota of chicken. *Scientific Reports*, *7*(1), 6400.

Willis, W. L., Isikhuemhen, O. S., & Ibrahim, S. A. (2007). Performance assessment of broiler chickens given mushroom extract alone or in combination with probiotics. *Poultry science*, *86*(9), 1856-1860.

Wirsenius, S., Azar, C., & Berndes, G. (2010). How much land is needed for global food production under scenarios of dietary changes and livestock productivity increases in 2030? *Agricultural systems*, *103*(9), 621-638.

Zulkifli, I., Abdullah, N., Azrin, N. M., & Ho, Y. (2000). Growth performance and immune response of two commercial broiler strains fed diets containing Lactobacillus cultures and oxytetracycline under heat stress conditions. *British poultry science*, *41*(5), 593-597.