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PRODUCTIVE AND PHYSIOLOGICAL EFFECTS OF PROBIOTICS AND APPLE VINEGAR ON BROILER CHICKENS UNDER HIGH STOCKING DENSITY

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ABSTRACT: This study aimed to assess the effect of watery supplementation of probiotic and/or apple vinegar on productive and physiological performances of broiler chickens (Ross 308) reared under high stocking density. Three hundred thirty-six unsexed one-day-old broiler chicks were randomly distributed to eight different treatments (3 replicates each) as follow: T_1: Negative control (low stocking density (LSD) 12 birds/m^2; basal diet with no studied additives in drinking water), T_2: LSD + probiotic, T_3: LSD + apple vinegar, T_4: LSD + probiotics + apple vinegar, T_5: Positive control (high stocking density (HSD), 16 birds/m^2 ; basal diet with no studied additives in drinking water), T_6: HSD + Probiotics, T7: HSD + apple vinegar and T_8: HSD + probiotics+ apple vinegar. Probiotic mixture or/and apple vinegar were provided at a dose of 0.5% in drinking water. The body weight (BW), body weight gain (BWG), feed intake (FI) and feed conversion ratio (FCR) were measured every growth phase until the end of the study at 35 day of age. Also 6 birds of each treatment were used to evaluate carcass traits. Results revealed that administration of probiotics individually or in combined with apple vinegar significantly increased BW, BWG and FI, with a decreased FCR at grower (21 days of age) phase and market age (35 days of age), while apple vinegar additive groups had the lowest BW, BWG and FI, with increased FCR in both tested stocking density. In addition, enhanced carcass yield, some carcass parts (breast and thigh), blood constituents and beneficial bacteria count in small intestine of broilers provided by additives suggested. In conclusion, this study proves valuable effects of probiotic and apple vinegar on growth performance, carcass traits, and microbiological measurements at grower and finisher phases of broilers raised under high stocking density.

Keywords: Broiler, probiotic, apple vinegar, performance, stocking density, microbial count

1. INTRODUCTION

Recent decades, poultry research, especially broiler research has been devoted to genetic selection and enhancing feed formulations (Havenstein *et al.,* 2003; Neveling and Dicks, 2021). Efficient feed for livestock depends on low price ingredients and good nutritional quality, feed quality is not only resulted from the interpolation of nutrients, but also the ability to digest and absorb nutrients into animal's body. In order to achieve high digestion and absorption of nutrients feed additives have been used.

Antibiotics considered one of the most commonly feed additives used in broilers feed (Cruz *et al*., 2019) to enhance growth, efficiency and livability of birds. However, scientist discovered that excessive use of antibiotics brings about many problems such as pathogenic contamination, bacterial resistant in the end product and add effort to create sustainable poultry farming (Ardiansah *et al*., 2020). In addition, the use of antibiotics in therapeutic doses causes residual veterinary drugs in final products (Jeong *et al*., 2010). In response to this situation, administration of antibiotics in animal feed as growth promoters has been prohibited as animal feed supplements in Europe since 2006, in the United States since 2014 and in China since 2020 (Ahmat *et al.,* 2021). Consequently, the establishment of nutritional feed additives has become the focus of the poultry industry, including probiotics, prebiotics, synobiotics, organic acids, phytogenic, antimicrobial peptides, feed enzymes and algae (Gadde *et al*., 2017).

In poultry, regulating gut health is the main aspect to ensure best bird's performance and health as unbalanced microbiota may induce inflammation, or other gut-related disorders (Tellez and Latorre, 2017). For instance, using probiotics or organic acids in managing the intestinal microbiota are well summarized by numerous previous studies (Ramlucken *et al*., 2020; Ahmat *et al*., 2021; Zhang *et al*., 2022).

Probiotic are mono or mixed cultures of live microorganisms which can be administrated via different routes to broiler chickens, confer an improvement in intestinal microbiota, structure and mucosal immunity (Li *et al*., 2020; Wang *et al*., 2021). Moreover, a lot of previous studies illustrated the affirmative effects of probiotics in ameliorating digestibility and absorption of nutrients (Zhang *et al*., 2022), insulating harmful microorganisms (Gao *et al*., 2019; Biswas *et al*., 2022), enhancing growth performance (Arteaga *et al*., 2020; Zou *et al*., 2022), improving carcass characteristics and raising health parameters of broilers (Li *et al*., 2020; Khochamit *et al*., 2020).

As mentioned, attention has been shifted to natural growth promoters as alternatives to antibiotics, which include organic acids (Elnesr *et al*., 2021). Apple vinegar, is made from apple fermentation and acetic acid is the predominant acid in apple vinegar (less than 5 %), also contains polyphenols, vitamins (B1, B2, B6, biotin, Vit C., folic acid and pantothenic acid) and trace amounts of minerals (like, sodium, phosphorus, potassium and magnesium) (Tripathi and Mazumder, 2020). Previous studies have shown that organic acids have a great ability to eliminate toxic substances and harmful bacterial compounds present in the digestive system of poultry (Mohanad *et al*., 2019). Furthermore, Jahantigh *et al*. (2021) found that administration of apple vinegar led to an improvement in the intestinal morphology of broilers and this might be the reason for enhancing nutrients digestion and absorption. Also, organic acids reduce the intestinal tract pH (3.5-4), which encourages the growth of Lactobacilli and Bacilli spp. (Galli *et al*., 2021). According to Mohanad and Salem (2018), adding apple cider vinegar in drinking water (1 ml vinegar/1 L water) increased weight gain of broilers. In addition, Awad *et al*. (2009) reported that organic acids supplementation improved broiler chicken's performance. Antecedent study made by Adeleye *et al*. (2021) stated that carcass yield and meat quality of broilers could be improved due to the additive of apple vinegar in drinking water.

Broiler production is known to be affected by environmental factors such as stocking density (18 birds/m^2), which can lead to oxidative stress and adverse effects on physiological status and meat quality of broiler chickens (Son *et al*., 2022; Goo *et al*., 2019). One of the possible approaches employed to avoid harmful effects happened is adding probiotic and organic acids. Shabani, *et al*. (2012) stated that using probiotic enhanced growth performance and carcass quality of broilers reared under high stocking density. Also, Dai *et al*. (2022) demonstrated the important role of organic acids in prohibiting intestinal inflammation and ameliorating growth performance of broilers experiencing high stocking density (17 birds/m^2 of Arbor Acres broilers).

In this respect, our study was designed to determine productive and physiological effects of supplementing probiotic and apple vinegar on broiler chickens raised under high stocking density.

2. MATERIALS AND METHODS

The Animal Ethics Committee at the Research Ethics Unit of Animal Production Research Institute confirmed all experimental procedures and techniques, including animal handling and husbandry.

2.1. Birds, experimental design, diets and management

A total of 336 mixed sex one-day-old broiler chicks (Ross 308) with an average initial body weight 42.18±1.3 g were used in the current study. All chicks were randomly distributed in the 24 littered pens (1x1m) with eight treatments (3 replicates each) included 2 stocking density, low stocking density (LSD, 12 birds/m^2) and high stocking density (HSD, 16 birds/m^2). The experimental treatments were T_1: Negative control (LSD), T_2: LSD + probiotic, T_3: LSD + apple vinegar, T_4: LSD + probiotics + apple vinegar, T_5: Positive control (HSD), T_6: HSD + probiotics, T_7: HSD + apple vinegar and T_8: HSD + probiotics + apple vinegar. Watery supplementation dose of probiotic and apple vinegar was 0.5%. The probiotic used in our study is a bacterial probiotic (Lacto produced by Brandvet Company, Egypt and contained mixture of Bacillus spp. and Lactobacillus acidophillus (10^{12} CFU/g^{-1})). The vinegar used in this experiment was commercial apple vinegar with 4% acetic acid concentration. Chicks were raised for 35 days at 33°C of room temperature and gradually reduced to 24°C (with 60% humidity). Feed and fresh water were provided to chicks *adlibitum* throughout the entire trial period. All birds were fed commercial basal diets formulated to contain 23% CP and 3000 Kcal, ME/Kg as starter from 0 to 10 d old; 21% CP and 3100 Kcal. ME/Kg as grower from 11 to 21 d old and 19% CP and 3150 Kcal ME/Kg as finisher from 22 to 35 days old. Manually feeding and drinking systems were equipped in all pens. The birds were vaccinated according to the routine vaccination routine followed at the farm without any addition of antibiotics. The birds were exposed to 24 h light on day one, then 1 hour less each day until they had 18 hours of light, which was maintained until the completion of the experiment.

2.2. Growth performance, characteristics of carcass and relative organs weight

Live body weight (BW) of individual birds and feed intake (FI) of each replicate were recorded for each growth phase and calculated body weight gain (BWG) and feed conversion ratio (FCR) were evaluated. Mortality rate were calculated during the experimental periods. At 35 days of age after fasting for 8 h before slaughtering, 2 birds per replicate were randomly selected (6 birds for each treatment) and individually weighed, slaughtered followed by bleeding, de-feathering and eviscerated. Carcass, cut parts (breast, thighs, wings and neck), giblets (liver, heart and gizzard) and abdominal fat were weighed and calculated as percentages proportioned to the live body weight of birds upon slaughtering.

2.3. Serum metabolites

At 35 days of age during slaughtering, blood samples were collected in vacuum blood collection tubes and centrifuged at 3,000 rpm for 15 min to obtain the serum, then samples were stored frozen at -20C° until analyzed. Total protein, albumin, alanine aminotransferase (ALT), aspartate aminotransferase (AST), urea, creatinine, glucose, total cholesterol, triglyceride and total lipids were determined by a colorimetric method using the kits purchased from Egyptian Company for Biotechnology (S.A.E.), Egypt.

2.4. Collection of samples and enumeration of bacteria

For *Lactobacillus* and *Escherichia coli (E. coli)* enumeration in the intestinal contents, at 35 days of age, 6 birds from each treatment were randomly selected, slaughtered and 1 g of their ileal contents were collected and diluted with 9mL of 0.9% saline solution and mixed in a vortex for 15 min (Zhang *et al*., 2021). The population of *Lactobacillus* bacteria was counted on the *lactobacilli* MRS agar that was incubated in an anaerobic incubator at 37°C for 48 hours (h) (Baurhoo *et al*., 2007). *E. coli* was cultured on the Eosin-methylene blue agar medium. Plates were incubated at 37°C for 24 h (Dziuk and Duck, 1972). *Lactobacilli* bacteria as white colonies and *E. coli* bacteria as green sheen colonies were seen and identified on the culture surface. Formed colonies were expressed as log10 colony-forming units (CFU) per gram of ileal digesta (Ghasemi-Sadabadi *et al.*, 2019).

2.5. Statistical analysis:

Statistical analysis was carried out using a general linear model (G.L.M) of the SAS (2013) program. The significant differences between treatment means were tested by Duncan Multiple Range Test (Steel and Torrie, 1980). All percentages were subjected to arcsine transformation to approximate normal distribution before analysis. The data are presented as means and SEM. Probability values of less than 0.05 ($p < 0.05$) were considered to be significant. Two-way analysis of variance (ANOVA) was used to evaluate the effect of different treatments and their interactions on different measured parameters. Statistical analysis using the following mode:

$$Y_{ijk} = \mu + D_i + T_j + D_i{*}T_j + e_{ijk}$$

where; Y_{ijk}= observed value; μ = the population mean; D_i= fixed effect of stocking densities (LSD and HSD); T_j= treatment effect (control, probiotics, apple vinegar and probiotics + apple vinegar); $D_i{*}T_j$ = the interaction between stocking densities and treatments; e_{ijk}= experimental error.

3. RESULTS AND DISCUSSION

3.1. Broiler performance

Current situation of preventing the use of antibiotics as growth promoters in poultry feeds because of their aforementioned harms had encouraged scientists to find nutritional alternatives, such as probiotics and acidifiers made us think about trying to find a combination that may improve bird's performance in general and provides consumer needs and desires of white meat in particular. That's why we suggested using probiotic, apple cider vinegar and the aspiring combination between both of them and studying their effects on production performance, carcass traits and intestinal microbial profile of broilers chickens, especially when breeding them under high stocking density.

Results of broiler BW, BWG, FI and FCR presented in Tables (1 and 2) shown that there were no significant differences (P>0.05) at starter period and highly significant differences (P≤0.05) between all treatments at grower (21 days of age) phase and market age (35 days of age). It was interested in our study, despite of no significant differences found on broilers performance at starter phase, watery supplementation of probiotic individually or in combined with apple vinegar significantly increased BW, BWG and FI, with a decreased FCR, while apple vinegar additive groups had the lowest BW, BWG and FI, with increased FCR of broilers in both tested stocking density when compared with other supplemented groups at the same growth phases mentioned above. The positive effect of probiotic supplementation may be due to the competitive elimination of pathogenic bacteria in the intestine (Patterson and Burkholder, 2003) and improving the bioavailability of nutrients and minerals (Khaksefidi, 2005). On the otherwise, the decrease happened in apple vinegar supplementary groups could be a result of the strong taste associated with the apple vinegar, which would have reduced the bird's appetite, thereby decreasing feed intake, and accordingly, BW, BWG and impairment feed conversion ratio.

Our findings are in line with Jacquier *et al.* (2019), who reported same delayed response of probiotic supplementation on growth performance of broilers which started at 21 d of age. In addition, Wahyudi *et al.* (2021) mentioned that administration of liquid probiotics had no significant effect on BWG, FI and FCR up to 4 weeks of age. Karaalp *et al.* (2018) and Chabalala, (2022) stated that adding apple vinegar had no effect on growth performance of laying hens and broilers. In contrary, Allahdo *et al.* (2018) found that supplementation of probiotic and apple vinegar had no significant differences during grower and finisher phases, but beneficial effects were noticed at 1-10 d of age of broilers. Moreover, Jahantigh *et al.* (2021) summarized that dietary supplementation with apple cider vinegar had beneficial effects on broiler performance.

These dissimilarities in results obtained by researchers may be attributed to the differences in probiotic strains used, probiotic and apple vinegar manufacturing methods, feeds composition and rearing conditions.

3.2. Carcass characteristics:

In our experiment, supplementation effects of probiotic, apple vinegar and the combination between both of them on some carcass characteristics are summarized in table (3). Significant differences were observed between treatments in dressing percentage, breast, thigh and abdominal fat percentages. Moreover, no significant differences found in wings, neck and giblets weight percentages between all groups. Percentages of carcass yield, breast and thigh had increased according to watery additive treatments except for apple vinegar treatments, affirming the findings of Arteaga *et al.* (2020) who summarized that probiotic mixture supplementation had significant effects on relative weight of the carcass. Also, Parsa *et al.* (2018) and Ardiansah *et al.* (2020) noticed that the inclusion of probiotic and their combination had no significant effect on the giblets weight. Probiotic supplementation might be enhanced the availability of protein likewise, nutrient content such as metabolic energy, crude fibre and crude protein in the basal diet. Moreover, several studies mentioned that carcass yield improved by increasing the protein content of broiler basal feeds.

In contrast with our findings, some previous studies reported that the addition of probiotic and/ or apple vinegar didn't affect carcass traits (Yadav *et al.*, 2018; Allahdo *et al.*, 2018). As well as, Adeleye *et al.*, (2021) found that the administration of apple vinegar increased significantly carcass yield and some cut part variables.

According to results of abdominal fat (AF) as a percentage of live body weight at market age, we discovered that adding apple vinegar to drinking water decreased AF % in both stocking density suggested. Different compounds in apple vinegar specifically acetic acid and polyphenolic compounds are suggested to have beneficial effects on lipid metabolism (Ousaaid *et al.,* 2020). The decrease in abdominal fat percentage that observed in our experiment is consistent with results mentioned by Agboola *et al.* (2016) and Allahdo *et al.* (2018).

3.3. Blood constituents:

As presented in Table (4), watery supplementation with probiotic, apple vinegar and combination between both of them had a significant effect on all blood parameter tested except for globulins and creatinine levels. Significant increase in total protein and albumin levels was observed in additive treatments especially, probiotic and combination groups when compared with control groups in both stock density breeding. Furthermore, we noticed that adding apple vinegar had increased liver enzymes and urea levels; however probiotic supplementation had decreased them.

Our results are in agreement with Gong *et al.* (2018) and Derakhshan *et al.* (2023), who stated that supplementation of probiotic in broiler feeds increased serum total protein, albumin levels and liver enzymes. The increase in serum total protein and albumin could be explained by the inhibition exclusion mechanism, in which probiotic and apple vinegar improves dietary protein utilization by inhibiting pathogen growth via the secretion of antibacterial substances and reducing protein breakdown into nitrogen, while also increasing the surface area for nutrient absorption (Mohanad *et al.,* 2019; Ahmat *et al.,* 2021).

Adding probiotic to birds in both stock density breeding had increased blood glucose level while, apple vinegar administration had no effects on it. In the current study, when examining the results of cholesterol, triglyceride, and total lipids levels, we found that there was a decrease happened due to whether adding probiotic or apple vinegar in individual forms or as a combination between both of them in both stock densities suggested. Similar, Pourmozaffar *et al.* (2019) reported that apple cider vinegar reduced cholesterol and triglyceride levels in white shrimp. Also, Adeleye *et al.* (2021) indicated that probiotic and apple vinegar possess a hypotriglyceridemic effect. The underlying mechanism behind this observation might be due to a reduction in hepatic lipogenesis (Bardos and Bender, 2012), or increased oxidation of fatty acids by the animals (Shishehbor *et al.,* 2008), thereby preventing hypertriglyceridemia.

3.4. Microbiological measurements

Data presented in table (5) shows the effect of supplemented probiotic and/ or apple vinegar on pathogenic and beneficial bacteria counts (mean $\log^{10}$cfu/g) in small intestine of broilers. Monitoring results obtained, we found that pathogenic bacteria counts were higher in birds reared under high stock density, and the opposite of this happened for beneficial bacteria counts. Also, we noticed that watery supplementation groups of probiotic and/or apple vinegar increased beneficial bacteria (*Bacilli spp.*) and decreased pathogenic bacteria (*Salmonella and E coli*).

Our results are consistent with some previous studies, which summarized that probiotic and organic acids had a positive effect on intestinal health via suppression of the growth and proliferation of undesirable opportunistic pathogenic bacteria such as *Salmonella, E coli and clostridium*, and fortify the beneficial microorganisms like *Lactobacillus* and *Bacillus* spp. (Nguyen *et al*., 2018; Gao *et al.,* 2019; Bilal *et al.,* 2021; Biswas *et al.,* 2022).

Against with our findings, Konstantinov *et al.* (2006) observed that the concentration of *E coli* improved after weaning, but the quantity of Lactobacillus was reduced in the intestinal flora of weaned piglets.

4.CONCLUSION

Based on our findings, it could be concluded that probiotic, especially when supplemented with apple vinegar in drinking water enhanced growth performance, carcass yield, beneficial bacteria count in small intestine and some blood constituents of broilers reared in both stocking densities proposed, which consequently translated into great products quality and superior resistance to diseases. Eventually, Research on the field of antibiotics nutritional alternatives deserve to further investigations.

Table (1): Body weight and body weight gain of different experimental groups

Items		Groups								SEM	P-Value
		LSD				HSD					
		Nig. Control	Pro	Vin	Pro + Vin	Pos. Control	Pro	Vin	Pro + Vin		
BW (g)	Initial	42.14	42.22	42.09	42.24	42.17	42.23	42.30	42.06	0.13	0.89
	Starter	307	303	306	306	304	308	309	313	3.10	0.40
	Grower	949^{b}	985^{a}	916^{c}	973^{ab}	917^{c}	966^{ab}	902^{c}	958^{ab}	10.08	<.0001
	Market age	2043^{b}	2268^{a}	2046^{b}	2206^{a}	2025^{b}	2202^{a}	2041^{b}	2221^{a}	26.12	<.0001
BWG (g)	Starter	265	260	263	263	262	266	267	271	3.07	0.38
	Grower	642^{b}	683^{a}	610^{c}	668^{ab}	614^{c}	659^{ab}	593^{c}	644^{b}	9.26	<.0001
	Market age	1087^{b}	1279^{a}	1132^{b}	1225^{a}	1108^{b}	1231^{a}	1132^{b}	1260^{a}	28.4	<.0001
	All BWG	2001^{b}	2225^{a}	2004^{b}	2163^{a}	1983^{b}	2159^{a}	1998^{b}	2179^{a}	26.12	<.0001

LSD: low stocking density, HSD: high stocking density, Nig. control: negative control, Pos. control: positive control, Pro: probiotics, Vin: apple vinegar, Pro + Vin: probiotics + apple vinegar. $^{a--c}$ Means within row followed by different superscripts are significantly different (P≤0.05).

Table (2): Feed intake and feed conversion ratio of different experimental groups

Items		Groups								SEM	P-Value
		LSD				HSD					
		Nig. Control	Pro	Vin	Pro + Vin	Pos. Control	Pro	Vin	Pro + Vin		
FI (g)	Initial	401	423	425	423	405	428	425	427	7.58	0.415
	Starter	763^{b}	831^{a}	821^{a}	827^{a}	758^{b}	815^{a}	805^{a}	809^{a}	9.93	0.001
	Grower	1738^{d}	1898^{a}	1785^{bcd}	1845^{ab}	1765^{cd}	1829^{abc}	1788^{bcd}	1838^{abc}	19.52	0.003
	Market age	2901^{c}	3152^{a}	3031^{b}	3094^{ab}	2927^{c}	3071^{ab}	3018^{b}	3073^{ab}	25.77	0.001
FC (gFI/gG)	Starter	1.51	1.63	1.62	1.61	1.55	1.61	1.59	1.58	0.06	0.6054
	Grower	1.19^{a}	1.22^{a}	1.35^{a}	1.24^{a}	1.23^{a}	1.24^{a}	1.36^{a}	1.26^{a}	0.04	0.0035
	Market age	1.60^{a}	1.48^{ab}	1.58^{ab}	1.51^{ab}	1.59^{a}	1.49^{ab}	1.58^{ab}	1.46^{b}	0.08	0.1121
	All FC	1.45^{abc}	1.42^{bc}	1.51^{a}	1.43^{bc}	1.48^{ab}	1.42^{bc}	1.51^{a}	1.41^{c}	0.02	0.0062

LSD: low stocking density, HSD: high stocking density, Nig. control: negative control, Pos. control: positive control, Pro: probiotics, Vin: apple vinegar, Pro + Vin: probiotics + apple vinegar. $^{a--d}$ Means within row followed by different superscripts are significantly different (P≤0.05).

Table (3): Carcass characteristics of different experimental groups

Items		Groups								SEM	P-Value
		LSD				HSD					
		Nig. Control	Pro	Vin	Pro + Vin	Pos. Control	Pro	Vin	Pro + Vin		
Carcass yield (%)		71.35^{b}	75.33^{a}	71.19^{b}	75.17^{a}	71.14^{b}	75.11^{a}	71.18^{b}	75.24^{a}	0.88	0.0479
Carcass cuts (%)	Breast (%)	17.83^{b}	21.06^{a}	18.55^{b}	20.28^{a}	17.86^{b}	20.56^{a}	18.06^{b}	21.19^{a}	0.37	0.0015
	Thighs (%)	13.33^{b}	15.44^{a}	13.63^{b}	15.13^{a}	13.68^{b}	15.11^{a}	13.55^{b}	15.28^{a}	0.30	0.0074
	Wings (%)	5.08	5.16	5.06	5.08	5.20	5.36	5.27	5.20	0.08	0.3716
	Neck (%)	3.15	3.40	3.15	3.17	3.15	3.18	3.12	3.42	0.06	0.2172
Giblets weight (%)	Liver (%)	1.83	1.73	1.79	1.86	1.82	1.93	1.82	2.02	0.08	0.7152
	Heart (%)	0.55	0.56	0.57	0.51	0.57	0.56	0.52	0.56	0.03	0.2387
	Gizzard (%)	1.20	1.21	1.26	1.22	1.28	1.31	1.27	1.24	0.03	0.6901
	All giblets (%)	3.59	3.50	3.62	3.59	3.67	3.80	3.61	3.82	0.10	0.4607
Abdominal fat (%)		2.75^{ab}	3.01^{a}	2.21^{c}	2.12^{c}	2.31^{bc}	2.71^{ab}	2.02^{c}	2.31^{bc}	0.11	0.0050

LSD: low stocking density, HSD: high stocking density, Nig. control: negative control, Pos. control: positive control, Pro: probiotics, Vin: apple vinegar, Pro + Vin: probiotics + apple vinegar. $^{a-c}$ Means within row followed by different superscripts are significantly different ($P \leq 0.05$).

Table (4): Blood constituents of different experimental groups

Items	Groups								SEM	P-Value
	LSD				HSD					
	Nig. Control	Pro	Vin	Pro + Vin	Pos. Control	Pro	Vin	Pro + Vin		
Total protein (g/dl)	3.11^{bc}	3.54^{a}	3.22^{abc}	3.50^{a}	3.03^{c}	3.28^{abc}	3.13^{bc}	3.48^{ab}	0.10	0.0310
Albumin (g/dl)	1.75^{ab}	1.87^{a}	1.82^{a}	1.82^{a}	1.66^{b}	1.81^{a}	1.78^{a}	1.79^{a}	0.03	0.0353
Globulin (g/dl)	1.36	1.50	1.49	1.58	1.37	1.30	1.35	1.38	0.05	0.3096
ALT (u/ml)	17.15^{abc}	15.62^{bc}	20.35^{a}	16.55^{bc}	19.36^{ab}	13.68^{c}	14.71^{c}	14.83^{c}	0.95	0.0108
AST (u/ml)	270^{b}	253^{b}	304^{a}	298^{a}	269^{b}	267^{b}	312^{a}	310^{a}	5.43	<.0001
Urea (mg/dl)	27.37^{abc}	21.82^{c}	29.50^{ab}	24.80^{bc}	31.50^{a}	26^{abc}	30.54^{ab}	27.20^{abc}	1.52	0.0241
Creatinine (mg/dl)	0.37	0.36	0.34	0.36	0.36	0.34	0.36	0.34	0.01	0.9210
Glucose (mg/dl)	105^{e}	158^{a}	104^{e}	120^{c}	91^{f}	145^{b}	90^{f}	115^{d}	1.03	<.0001
Cholesterol (mg/dl)	72^{b}	66^{b}	70^{b}	67^{b}	86^{a}	68^{b}	69^{b}	69^{b}	2.21	0.0036
Triglyceride	80.94^{ab}	67.27^{c}	71.20^{c}	70.98^{c}	82^{a}	73.08^{b}	74.37^{bc}	72.43^{c}	2.07	0.0046
Total lipids (mg/dl)	750^{a}	638^{b}	658^{b}	658^{b}	755^{a}	630^{b}	641^{b}	627^{b}	11.69	<.0001

LSD: low stocking density, HSD: high stocking density, Nig. control: negative control, Pos. control: positive control, Pro: probiotics, Vin: apple vinegar, Pro + Vin: probiotics + apple vinegar. $^{a-d}$ Means within row followed by different superscripts are significantly different ($P \leq 0.05$).

Table (5): Microbiological measurements of different experimental groups

Items	Groups								SEM	P-Value
	LSD				HSD					
	Nig. Control	Pro	Vin	Pro + Vin	Pos. Control	Pro	Vin	Pro + Vin		
Pathogenic bact.										
Salmonella bact.	5.62^{b}	4.89^{cd}	4.72^{d}	4.83^{cd}	6.99^{a}	4.99^{c}	4.98^{c}	5.06^{c}	0.06	<.0001
E coli (log^{10} CFU/g)	6.63^{b}	5.47^{cd}	4.57^{e}	5.28^{cd}	6.98^{a}	5.55^{c}	4.78^{e}	5.25^{d}	0.08	<.0001
Beneficial bact.										
Bacilli spp.	3.70^{b}	6.33^{a}	3.72^{b}	5.53^{a}	3.30^{b}	6.27^{a}	3.70^{b}	5.42^{a}	0.28	<.0001

LSD: low stocking density, HSD: high stocking density, Nig. control: negative control, Pos. control: positive control, Pro: probiotics, Vin: apple vinegar, Pro + Vin: probiotics + apple vinegar. $^{a–e}$ Means within row followed by different superscripts are significantly different (P≤0.05).

5. REFERENCE

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الملخص العربى

التأثيرات الإنتاجية والفسيولوجية لإضافة البروبيوتك وخل التفاح على دجاج اللحم تحت ظروف الكثافة العددية العالية

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تهدف هذه الدراسة لتقييم تأثير البروبيوتك وخل التفاح كمكمل غذائي في مياه الشرب علي الأداء الإنتاجي والفسيولوجي لدجاج التسمين تحت تحت ظروف الكثافة العالية. تم تقسيم 336 كتكوت تسمين (روص 308) عشوائيا إلي 8 معاملات مختلفة (3 مكررة/ معاملة) كالآتي: (T_1) مجموعة المقارنة (-) تتلقي فيها الطيور ماء الشرب بدون أي إضافات وبكثافة 12 طائر/ متر^2، (T_2) يضاف البروبيوتك لماء الشرب وبكثافة 12 طائر/ متر^2، (T_3) يضاف خل التفاح لماء الشرب وبكثافة 12 طائر/ متر^2، (T_4) يضاف البروبيوتك + خل التفاح لماء الشرب وبكثافة 12 طائر/ متر^2، (T_5) مجموعة المقارنة (+) تتلقي فيها الطيور ماء الشرب بدون أي إضافات وبكثافة 16 طائر/ متر^2، (T_6) يضاف البروبيوتك لماء الشرب وبكثافة 16 طائر/ متر^2، (T_7) يضاف خل التفاح لماء الشرب وبكثافة 16 طائر/ متر^2، (T_8) يضاف البروبيوتك + خل التفاح لماء الشرب وبكثافة 16 طائر/ متر^2. يتم إضافة البروبيوتك وخل التفاح لماء الشرب بنسبة 0.5 ٪.

تم قياس وزن الجسم، معدل الزيادة في وزن الجسم، معدل إستهلاك العليقة ومعدل التحويل الغذائي كل فترة نمو لكل طائر طول مدة التجربة. كما تم تسجيل النافق اليومي. وعند عمر35 يوم، تم تقييم لمواصفات الذبيحة المختلفة، تقدير بعض صفات الدم والمحتوي البكتيري بالأمعاء. أظهرت النتائج أن إضافة البروبيوتيك بشكل فردي أو مع خل التفاح أدي إلي تحسن في وزن الجسم، معدل الزيادة في وزن الجسم ومعدل إستهلاك العليقة مع تدهور في معدل التحويل الغذائي خلال مرحلة النمو (عمر21 يوم) وعمر التسويق (عمر35 يوم) لكلا الكثافتين، في حين أنه عند إضافة خل التفاح منفردا أدي إلي إنخفاض في وزن الجسم، معدل الزيادة في وزن الجسم ومعدل إستهلاك العليقة مع تحسن معدل التحويل الغذائي في كلا الكثافتين (المنخفضة والعالية). أظهرت إضافة البروبيوتك تحسن في صفات الذبيحة مقارنة بباقي المعاملات في كلا الكثافتين (المنخفضة والعالية)، بالإضافة إلي تحسن في بعض صفات الدم وكذلك المحتوي البكتيري بالأمعاء عند إضافة البروبيوتك وخل التفاح لماء الشرب سواء في الكثافة العالية أو المنخفضة. في الختام، أثبتت هذه الدراسة التأثيرات الإيجابية للبروبيوتيك وخل التفاح على معدلات النمو وصفات الذبيحة وتقديرات الميكروبيولوجي خلال فترتي النامي والناهي لدجاج التسمين والتي يتم تربيتها بكثافة عالية.