ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF POULTRY SCIENCE

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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
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International Journal of Poultry Science 12 (7): 390-395, 2013
ISSN 1682-8356

Effect of Probiotic and Population Density on the Growth Performance and Carcass Characteristics in Broiler Chickens

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Abstract: In order to assess the effect of a probiotic and population density on the growth performance and the carcass characteristics in broiler chickens, an experiment was conducted involving 208 1-day-old Peterson brand chicks. They were fed a corn and soy paste diet with 23 and 20 percent crude protein at the first and last stage respectively and 3.2 Mcal ME/kg. A completely randomized design with a 2 x 2 factorial arrangement, with two probiotics levels: 0 y 0.1% and two population density levels: 10 and 16 birds/m^2, with four repetitions per treatment. The evaluation centered on growth performance: weight gain, feed consumption, food conversion and carcass variables: hot and chilled carcass weight, as well as breast, leg and thigh output. The growth performance was not affected (P>0.05) by probiotic and population density. The greatest yields (P<0.05) in the hot carcass weight was reported from the interaction between 0.1% probiotic and 10 birds/m^2. The probiotic increased (P<0.05) the lean leg meat. The density of 16 birds/m^2 showed the highest yield (P<0.05) in leg fat versus 10 birds/m^2. The results of this study indicated that, 0.1% probiotic increased the lean leg meat yield and the population density of 16 birds/m^2 generates a higher fat deposit in broiler chickens.

Key words: Probiotic, population density, carcass, yield, broiler chickens

INTRODUCTION

In the last few years there has been an increase in the number of poultry farms due to the high demand for white meat on the part of the consumer who has shown a marked preference towards meat that is low in cholesterol, leaner and with the right mix of nutrients. As the number of flocks has grown year after year, so too has the prevalence of poultry diseases which in turn encourage massive antibiotic use to eliminate undesirable bacteria and improvement the feed conversion ratio (Thomke and Elwinger, 1998). However, its continued use may lead to increasing the resistance of pathogens to antibiotics (Collignon, 1999) and to the presence of antibiotic residuals in poultry products.

An alternative approach to solve this problem is the use of live microbial feed supplements and their metabolites, known as a whole as probiotics (Patterson and Burkholder, 2003; Isolauri *et al.*, 2004) which confer a degree of protection against pathogen micro-organisms (Menconi *et al.*, 2011; Rocha *et al.*, 2012) since they modify conditions in the gastrointestinal tract (Tsirtsikos *et al.*, 2012) and reduce the entry of pathogen micro-organisms and susceptibility to disease, improving intestinal tract health and feed efficiency (Tortuero, 1973; Fuller, 1989; England *et al.*, 1996; Douglas *et al.*, 2003; Xu *et al.*, 2006; Mountzouris *et al.*, 2010), increasing productivity and improving meat quality (Endo and Nakano, 1999; Kabir *et al.*, 2004) without secondary effects and bacterial resistance. However, the response to probiotics is more efficient under commercial conditions or in stress conditions: sub-par management conditions, high population density and/or low nutrient-concentration on the diet (Angel *et al.*, 2005).

In a controlled environment, lactic acid producing beneficial bacteria and pathogenic bacteria, in the gastrointestinal tract, keep each other in balance which benefits good bacteria. Under stress situations, or under certain farm management conditions the concentration of pathogenic bacteria increase and competing with good bacteria; this situation generate unbalance of the metabolism, decreasing growth performance (Weaver *et al.*, 1982; Craverner *et al.*, 1992) and to cause a change in the carcass structure and composition (Puron *et al.*, 1995).

A study based on these facts was set out with the following objective: to evaluate the effect of probiotic in two levels of population density on growth performance and carcass characteristics in broiler chickens.

MATERIALS AND METHODS

The research was conducted in the non-ruminant metabolic unit and the meat industrialization workshop

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at the School of Animal Husbandry at the Autonomous University of Chihuahua, state of Chihuahua in México.

A total of 208 1-day-old chicks were used, all chicks were weighed on Day 1 and distributed randomly to experimental units in a completely randomized design with a 2 x 2 factorial arrangement, with two probiotics levels: 0 y 0.1% and two density levels: 10 and 16 birds/m^2 and four repetitions per treatment. The chicks were raised in floor pens; each repetition was equipped with a stove, a linear drinking and feeding trough. The ambient temperature at the start of the experiment was 33°C and gradually reduced to 21°C as the birds reached maturity. Feed and water were offered *ad libitum*, with a twenty-four hours light program.

Their diets were corn and soy paste-based according to National Research Council (1994), with 23 and 20% crude protein content at the initial stages (1 to 21 days) and end stages (22 to 42 days), respectively and 3.2 Mcal ME/kg (Table 1). The chemical composition of the feed was analyzed according to AOAC (1990). The probiotic used in the diet was Pioneer® brand probios 180-12 with 1 x 10^7 cfu/g of *Lactobacillus acidophilus*, *Lactobacillus plantarum*, *Lactobacillus casei* and *Streptococcus faecium*.

In order to assess carcass characteristics, a selection of 4 chickens per repetition of each treatment was made, with a subsample of 16 chickens per treatment for a total of 64 chickens.

For growth performance the evaluated variables were: feed consumption, weight gain and feed conversion which were recorded weekly.

During the experimental period, the weight of chickens and feed consumed were recorded weekly for each replicate pen.

To evaluate the carcass yield, the live weight at slaughter was registered before proceeding to desensitize via electric shock and a lengthwise cut, making incisions on the carotid arteries for bleeding-out. The birds were then plucked and eviscerated. Hot carcass weight was obtained by removal of shanks, neck and head and recording of their respective weight. The carcasses were kept at -4°C for the next evaluation. The main commercial cuts: wings, breast, leg, thigh, back and hip were separated and weighed. Later, the main cuts: breast, leg and thigh were dissected and separated into lean meat, skin-fat and bone to obtain components' weight.

The yield was estimated based on weight reached: Carcass yield = Chilled carcass weight x 100/Live weight; Part yield = Weight of the piece x 100/Chilled carcass weight; Component yield = Component weight x 100/Piece weight.

Data were evaluated through variance analysis with a linear method that included probiotic and population density levels as the main effects and the interactions between them. Data were analyzed with a SAS (1999) program. The means were compared using the Tukey Test (P<0.05) (Steel and Torrie, 1988).

Table 1 Composition of the basal diet (%)

Ingredients	Starter	Finisher
Corn	55.80	62.00
Soy paste	30.00	23.75
Meat flour	8.00	8.00
Oil	5.00	4.90
Methionine	0.15	0.06
Salt	0.20	0.20
Calcium carbonate	0.21	0.20
Premix [1]	0.50	0.50
Calculated analysis		
Energy, Mcal ME/kg	3.2	3.2
Crude protein (%)	23.00	20.00
Lysine (%)	1.16	1.01
Methionine (%)	0.50	0.38
Tryptophan (%)	0.39	0.36
Calcium (%)	1.00	0.90
Available phosphorus (%)	0.50	0.50

[1]Supplied the following per kilogram of diet: A (Retinyl acetate), 4,500 UI; D (Cholecalciferol), 1,000 UI; E (DL-α-tocopheryl acetate), 25 UI; K (Menadione), 1.5 mg; B_{12}, 0.02 mg; riboflavin, 3mg; pantothenic acid, 5mg; niacin, 20mg; folic acid, 0.5mg; tiamin, 1.5mg; biotin, 0.5mg and pyridoxine, 2.5mg

RESULTS AND DISCUSSION

Growth performance: Feed intake, accumulated weight gain and feed conversion were not affected (P>0.05) by the treatment (Table 2), similar results were reported by Watkins and Kratzer (1984); Goodling *et al.* (1987) and Mutus *et al.* (2006). By contrast, Owings *et al.* (1990); Edens *et al.* (1992); Jin *et al.* (1998); Zulkifli *et al.* (2000); Mountzouris *et al.* (2010), reported that adding probiotic to poultry diet increased growth rate and in some cases it also increased feed conversion. This inconsistency may be due to several factors affecting probiotic response as shown by Angel *et al.* (2005) where probiotics were shown to act efficiently in productive behavior but only if low nutrient-concentration is present on the diet which did not occur in the present study.

Table 2: Effect of probiotic and population density on the feed intake, body weight gain and conversion ratio, at starter and finisher stages in broiler chickens

	Probiotic (%)			
	0.0		0.1	
Population density(birds/m^2)	10	16	10	16
Feed intake(g):				
Starter	1650.7	1515.6	1602.5	1620.2
Finisher	2110.6	2037.8	2055.8	2138.8
Conversion ratio:				
Starter	1.52	1.451	1.48	1.44
Finisher	2.24	2.12	2.20	2.16
Cumulative weight gain (g):				
Starter	1080.7	1043.2	1078.6	1118.7
Finisher	942.1	961.4	916.2	988.1

Standard error of starter: feed intake 27.4 g, conversion ratio 0.03, cumulative weight gain 19.2 g

Standard error of finisher: feed intake 52.7 g, conversion ratio 0.03, cumulative weight gain 26.4 g.

Other factors for consideration in response to probiotic use are the stability of the product and its viability (Pollman, 1986; Foster, 1977), the type and dose of preparation, flora composition in the host, the adherence to the epithelial tissue of the gastrointestinal tract and the specificity for the living host (Fuller, 1989).

Carcass yield, its parts and components: In hot carcass yield, the probiotic x density interaction was significant (P<0.05) and it was visible with an increase in carcass yield (Table 3). The treatment with probiotic and 10 birds/m^2 achieved the highest yield which can be associated to a lower percentage of viscera in this group (Table 3). The reduction in entrails weight can be considered one of the mechanisms by which absorption of nutrients improves (Izat *et al.*, 1990) and can be linked to a better absorption of nutrients. Khaksefidi and Rahimi (2004) working with probiotics in heat-related stress conditions, conclude that the inclusion of 0.1% probiotic improved significantly the carcass yield. Similarly, Endo and Nakano (1999) and Falaki *et al.* (2010) report that birds fed with probiotics show an increase in carcass yield.

Feather production dropped (P<0.05) in the confined bird group without probiotics, compared with the rest of the treatment groups (Table 3) and probiotic-population density interaction was shown (P<0.05). In high density, birds are confined, with greater humidity due to higher evaporation of droppings which shows that a movement of restricted air among birds causes abnormal feathering. Considering that a feather is composed of protein, results might indicate that probiotics favor nitrogen retention (Mohan *et al.*, 1996).

No chilled carcass yield of wings, back, breast, leg and thigh was seen (P>0.05) on probiotic and stocking density (Table 4). Kabir *et al.* (2004) in a study of birds supplemented with probiotic found significant difference between the control groups and probiotic-treated groups in carcass, breast and leg yields. Research into densities of 10, 13 and 16 birds/m^2 did not find any significant differences in carcass yield (Moreira *et al.*, 2004). Dossier *et al.* (2005) and Thaxton *et al.* (2006), found that equivalent stocking densities in the 20-55 Kg/m^2 range did not cause any physiological stress that may be reflected in lesser carcass and breast yield; but, however affect the animal welfare.

As show in Table 5 the probiotic and population density had no effect on the components of the main poultry parts: breast, thigh and leg (P>0.05). Similar information was registered when yeast culture, combined with other feed additives (Gomez and Angeles, 2011).

At the point of leg dissection, an effect from the probiotic was detected and an improvement on the yield of lean meat was detected (P<0.05) with the following reduction of (P<0.05) in hips and shanks (Table 6). The most likely cause was the supplemented probiotic on the diet which generated lactic acid which turned the medium more acid, with this acidity kept the gastric pH at low levels, with the subsequent result of higher retention of nitrogen and other nutrients (Vargas-Rodríguez *et al.*, 2002), this

Table 3: Effect of probiotic and population density on hot carcass weight and non-carcass components (%) in broiler chickens of forty two days old

Population density (birds/m^2)	Probiotic (%) 0.0		0.1		
	10	16	10	16	SE
Hot carcass	70.3^b	71.7^{ab}	72.0^a	70.4^b	0.4
Viscera	10.4	10.1	9.8	10.4	0.1
Blood	3.2	3.5	2.8	3.3	0.1
Feathers	5.9^a	5.1^c	5.3^b	5.8^{ab}	0.1
Head-neck	7.0	6.9	6.7	6.5	0.2
Shanks	4.3	4.4	4.2	4.0	0.1

^{a,b,c}Different superscripts within rows indicate statistical differences (P<0.05). SE: Standard error

Table 4: Effect of probiotic and population density on the cold carcass yield and main commercial breaks (%) in broiler chickens of forty two days old

Population density (birds/m^2)	Probiotic (%) 0.0		0.1		
	10	16	10	16	SE
Cold carcass	68.2	70.0	70.8	69.3	0.6
Wings	11.6	11.4	11.6	11.5	0.1
Back	12.4	11.8	11.9	12.6	0.2
Hip	16.0	16.8	15.3	16.1	0.2
Breast	28.5	28.2	29.4	27.9	0.4
Leg	16.0	16.2	16.2	16.5	0.2
Thigh	14.7	14.7	15.1	14.5	0.3

SE: Standard error

Table 5: Effect of probiotic and population density on the components of main cuts (%) in broiler chickens of forty two days old

Population density (birds/m^2)	Probiotic (%) 0.0		0.1		
	10	16	10	16	SE
Breast:					
Fat	12.3	12.8	12.3	13.3	0.5
Bone	14.6	14.6	15.0	13.5	0.6
Lean	72.8	71.3	71.8	72.8	0.7
Thigh:					
Fat	11.0	11.3	10.6	12.7	0.6
Bone	27.4	27.4	28.4	27.9	0.9
Lean	61.1	60.4	60.5	58.6	0.8
Leg:					
Fat	16.1	16.4	13.9	16.8	0.8
Bone	18.5	17.5	16.4	16.7	0.6
Lean	65.0	64.9	68.9	66.0	0.7

SE: Standard error

Table 6: Main effects (%) of probiotic level in broiler chickens of forty two days old

	Probiotic (%)		
	0	0.1	SE
Lean leg	64.9[b]	67.4[a]	0.5
Hip	16.4[a]	15.7[b]	0.1
Shanks	4.4[a]	4.1[b]	0.8

[a,b]Different superscripts within rows indicate statistical differences ($P<0.05$). SE: Standard error

Table 7: Main effects (%) of population density in broiler chickens of forty two days old

	Population density (birds/m^2)		
	10	16	SE
Fat leg	15.0[b]	16.6[a]	0.4
Hip	15.6[b]	16.5[a]	0.1
Blood	3.0b	3.4[a]	0.1

[a,b]Different superscripts within rows indicate statistical differences ($P < 0.05$). SE = Standard error.

acidity facilitate the conversion of pepsinogen to pepsin promoting a higher pepsin activity (Chapman, 1988) which result in an increase of protein digestibility.

Nahashon *et al.* (1993); Mohan *et al.* (1996) and Kim *et al.* (2001) worked with broilers supplemented with probiotics and they observed greater digestibility of dry matter and raw protein than the control group. In addition, Angel *et al.* (2005) point out that adding probiotics improves the retention of nitrogen, calcium and phosphorus but its effect is greater if there is a low concentration of nutrients on the diet. On the other hand, Jin *et al.* (2000) report that poultry supplemented with probiotics show more amylolytic activity, the addition of *L. acidophilus* increases the levels of amylase significantly 40 days after the feed has been supplemented. Probiotics produce a balance in the intestinal flora as they create the ideal conditions in the intestinal tract making the digestive process in the animal more efficient and allows the best absorption of nutrients (Pollman, 1986; Jayakumar *et al.*, 1986). A greater retention of nutrients is reflected in a greater deposit of lean meat in the present study.

Leg fat yield was affected ($P<0.05$) by density levels (Table 7). Birds with higher population density developed a greater percentage of fat probably due to more confined quarters which means a reduced mobility range on the part of the birds that leads to more fat deposit on the legs, as opposed to birds in a wider range. Moreira *et al.* (2001), working with densities of 10, 13 and 16 birds/m^2, found an effect in the abdominal fat in birds exposed to a higher population density. Ozdogan and Aksit (2003) found a negative relationship between fat and humidity content in the carcass and they argue that low levels of humidity result in an increase of fat which in turns negatively affects the quality of the carcass.

The treatment with probiotic and 10 birds/m^2 achieved the lowest percentage of fat ($P>0.05$) (Table 5). Khaksefidi and Rahimi (2004) worked with probiotic in heat-stress conditions, found no difference in abdominal fat; however Kalavathy *et al.* (2003) reported that 0.1% levels of probiotic in broilers, reduce abdominal fat compared with the control group.

Conclusion: The results indicate that using probiotics in different population density levels had no effect in general growth performance. Density level of 16 birds/m^2 generates higher fat deposits. The addition of 0.1% of probiotic increases the yield of lean meat in legs.

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