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Research Article

Prebiotic Supplementation in Broiler Diet During Starter Period: Effect on Growth Performance, Carcass Characteristics and Meat Quality

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Abstract

The aim of this work was to investigate the effect of inclusion of a prebiotic "AVIATOR®" (Arm and Hammer) based on yeast culture and enzymatically hydrolyzed yeast products (*Saccharomyces cerevisiae*) as a potential substitute of antibiotics growth promoters (AGPs) in poultry industry. The methodology consisted to incorporate increasing dose of prebiotic in broiler diet which did not contain AGPs or coccidiostats during starter period (14 d). A total of 224 days old chicks (Arbor Acres) were divided into four groups and were housed in cages (8 birds/cages). The birds were fed basal diet without prebiotic (P0), diet with 1g of prebiotic (P1), diet with 1.5g of prebiotic (P2) and diet with 2g of prebiotic (P3). Performances: Average weight (AW), Daily Weight Gain (DWG), FI (Feed Intake), Feed Conversion Ratio (FCR), Mortality Rate (MR) were measured. Carcass parameters: hot and cold carcass weight, hot and cold carcass yield and muscles weights were also studied. Meat quality was evaluated by determining pH and color values of CIE Lab Color System of meat. A sensory analysis was performed. Results showed no significant difference on growth performance between control and experimental groups (P>0.05). Similar results were observed regarding pH 30 min and pH ultime (P>0,05). However, a significant difference was occurred on meat color CIE Lab. Thus, meat quality showed no alteration when the control group was compared to birds fed with prebiotic during starter period. It was concluded that the prebiotic "AVIATOR®" added in broiler diet at doses up to 2g/kg during starter period did not promote performance, but could maintain meat quality.

Keywords: Prebiotic; Growth Performance; Organoleptic Characteristics; Broiler

Introduction

For many decades, the poultry industry has been looking for improvement of health and performance of birds with inclusion of sub-therapeutic levels of antibiotics in feeds [1,2]. However, human health has been threatened due the development of antimicrobial resistance and contamination of poultry products with antibiotic residues [3-5]. Therefore, the use of antibiotics as growth promoters (AGPs) was banned by the European Union since 2006 [6]. Supplementing the ratio with AGPs could increase growth performance of animals through various mechanisms: (a) the nutrients are more efficiently absorbed and less are utilized by the gut, (b) more nutrients are available to the host, (c) there is a reduction in harmful gut bacteria, (d) production of growth suppressing toxins or metabolites is reduced, (e) microbial de-conjugation of bile acids is decreased [7]. Many researchers look for alternatives to AGPs to maintain efficient poultry production [8,9]. Prebiotics have been defined as non-digestible substances that beneficially affect the host by selectively altering the composition and metabolism of the gut microbiota [2,9]. They are proposed as a potential substitute to improve growth performance, modulate the intestinal microbiota by providing energy for the growth of endogenous favorable bacteria in the gut such as *Lactobacillus* and *Bifidobacterium* [10] and reducing intestinal colonization gut of pathogenic bacteria such as *Escherichia coli* [11]. Many studies reported the positive effects of prebiotics administration on growth performance [12, 13]. A preliminary study conducted by Askri., *et al.* [14] indicated that the administration of prebiotic in broilers diet could ameliorate growth performances, but has altered meat sensory quality. Therefore, the aim of this study was to determine the efficacy of administering a prebiotic strain of *Saccharomyces cerevisiae* in promoting growth performance, carcass characteristics and meat quality in broiler chickens.

Materials and Methods

Birds and diets

A total of 224 one day old chicks (Arbor Acres) with an average weight of 45.82 ± 3.13 g distributed randomly into four groups of 56 chicken in each. Subsequently, the chicks in each group were dis-

tributed to 7 replicates with eight chicks in each. The chicks were placed on one of the four dietary treatments. These treatments were a basal diet (control) and three other diets which were same in composition as based diet but supplemented with prebiotic *Saccharomyces cerevisiae* to provide 1; 1.5 and 2 g per kg diet. All the chicks were allowed to have free access to starter diet during the first two weeks. They also had free access to water.

Housing and management

This study was conducted in the Poultry Experimental Unit of National Agronomic Institute of Tunisia. It was carried out during the period from March to April 2017. Minimum and maximum temperatures during the experimental period were 14 and 21°C, respectively. Chickens were vaccinated against Gumboro, Infectious Bronchitis (IB) and Newcastle Disease (ND). All birds received starter feed from 1 to 14 d and grower-finisher feed from 15 to 42 d. Feed and water were provided *ad libitum* throughout the experimental trial. The feeders and waterers were adjusted, according to the progressive growth of the chicks. During the first week, temperature was fixed at 35°C and then was gradually reduced to 24°C until the end of the experiment and continuous light was provided 24h/d by the use of fluorescent lights.

Measurement

Birds were weighed individually and the average weight (AW), feed intake (FI), daily weight gain (DWG) and feed conversion ratio (FCR) were determined for each group. Average weight and feed intake were measured weekly. Daily weight gain calculated as the difference between the final and initial body weight. Feed intake was calculated as the difference between the amount of feed supplied to the birds and the amount of feed refused. The feed conversion ratio was calculated as the ratio of feed intake to body weight gain. Mortality was recorded daily. At the end of trial, birds had fasted for a period of 12h with only water allowed. Birds were individually weighed and manually slaughtered. All eviscerated carcasses were refrigerated at 4°C for 24 h and weighed individually to calculate the eviscerated carcass yield (CY). After cutting, chicken muscles (breast and thigh) were also weighed.

Meat quality

The physical analysis was carried out as follows: The pH was determined in the breast muscle at 2 cm depth using a calibrated pH meter (Hanna HI- 99163) as described in Olivo., *et al.* [15]. The color for the samples of the various treatments were measured at 24h postmortem using a Minolta Chromameter (CR410 Konica Minolta Sensing Inc., Osaka, Japan). (L), (a) and (b) measures determined, where (L) measures lightness, (a) measures redness and (b) measures yellowness. The sensory analysis was determined by Hedonic scale based on a 9-points scale [16], each panelist was asked to evaluate cooked breast samples for color, aroma, flavor, tenderness, juiciness, overall appreciation.

Data analysis

Experimental data were analyzed using the GLM-general factorial ANOVA procedure using the SPSS for Windows statistical package program, version 23 (SPSS Inc., Chicago, IL). The statistical assumption of residual normality was evaluated using the Shapiro-Wilk while Levene's test was used for homogeneity of variances. Means difference were determining using the Dunnet test. Significance was considered at $P<0.05$. The data were expressed as a mean ± standard error. The statistical model was:

$$yij= \mu+ Xi+ + eij$$

Where: yij = response variable of broilers fed or not with probiotics (i) in replication j. μ = overall mean value for y. Xi = fixed effect of prebiotics. and eij = error term.

Results and Discussion

Effect of prebiotic on growth performances

In this study, we evaluated the growth performance of broilers using body weight (BW), daily weight gain (DWG), feed intake (FI), feed conversion ratio (FCR), and mortality. The mean values of BW, FI, FCR, and mortality are presented in Table 2. We observed that control group (1927g) had higher BW compared with treatments P1 (1862 g), P2 (1832 g) and P3 (1803 g). Moreover, broiler DWG did not differ ($P>0.05$) between the experimental treatments and control. Similarly, there were no significant differences between treatments regarding FI, FCR and mortality ($P>0.05$) that were generally low and averaged 0 and 0.5% for the whole experiment. The overall mortality during the experimental period was low in the control group (0%) compared to prebiotic group (0.2%). The variation in mortality among different treatments might be due to the seasonal influence and cannot be ascribed as treatment effect. The mortality observed in the present study was lower than (3%) reported by Awad., *et al*. [17] in Ross 308 commercial broilers. Our findings showed that the incorporation of increasing dose of prebiotic during starter period had not been any significant improvement on growth performance. In agreement with our result, other researchers reported that supplementation of prebiotic did not affect productive performance [18,19]. Also, Yalcınkaya., *et al.* [19] and Waldroup., *et al.* [20] affirmed that the dietary prebiotic supplementation did not affect ($P>0.05$) body weight and body gain. Similarly, Rehman., *et al.* [21] observed that the supplementation of a prebiotic at 1g/ kg diet had no effect on the final BW of broilers. Also, Alzueta., *et al.* [22] showed that the addition of inulin (from

5 to 20 g/kg) to a maize-soybean meal-based diet did not improve the growth performance of broiler chickens. However, this research has different result with Utami and Wahyono [23] who showed that supplementation of prebiotic in feed increase feed consumption of laying hens. Likewise, Mateova [24] reported that broiler increase body weight significantly with prebiotics. Moreover, Toghyani., *et al.* [25] found that adding 1 mg/kg mannanoligosaccharide (MOS) in broiler chicks' diets results in significantly (P<0.05) higher feed intake and body weight over 14-28 d. The feed conversion ratio describes the relation of feed intake and body weight gain. More precisely, it is the animal's overall efficiency in converting feed mass into body mass over a specific period of time. Konca., *et al.* [26] found that 1 mg/kg mannan oligosaccharide increased feed intake and feed conversion ratio significantly (P<0.05) in turkey during 10 to 20 weeks of age. Also, Sohail., *et al.* [27] demonstrated that adding MOS to broiler chicks' diet had gave higher (P<0.05) body gain, feed intake and better feed conversion ratio compared with the control group. Interestingly, our results showed that prebiotic should be present in broiler diet during the whole entire period in order to promote growth performance. This result could be explained by the fact that the length of time for adaptation and the exposure of gastro-intestinal tractus (GIT) microbes to the supplemented prebiotic plays inevitable role in enhancing growth performance. Correspondingly, Hanning., *et al.* [28] found a better result with villi height and crypt depth of intestine when FOS was added for a longer duration.

Ingredients (%)	Starter (d1-14)	Grower-Finisher (d15-42)
Corn	64	69
Soybean meal	32	27
Mineral[1] and vitamin[2] mixture	4	4
Anticoccidial	Non	Non
Total	100	100
Calculated nutrient Content		
ME[3] (Kcal/Kg)	2900	2970
Crude Protein %	20.5	19.5
Crude fiber %	3	3
Ash %	6.5	6.5
Fat %	3	4
Calcium %	1	0.9
Available Phosphorus %	0.67	0.66
Methionine %	0.5	0.44
Threonine %	0.8	0.78
Tryptophan %	0.3	0.25

Table 1: Composition and nutrient content of starter and grower basal diets for broilers

1Mineral mixture supplied (mg·kg-1 of diet): CF1 : Mn. 80 ; Fer. 50 ; Cu. 25 ; Zn. 65 ; Co. 0.2 ; Se. 0.3 ; I. 1.2/ CF2 : Mn. 70 ; Fer. 40 ; Cu. 20 ; Zn. 52 ; Co. 0.16 ; Se. 0.24 ; I. 0.69. 2Vitamin mixture supplied per kg of diet: CF1 : Vit A. 13000 IU ; Vit D3. 3500 IU ; Vit E. 40 mg/ CF2 : Vit A. 10400 IU ; Vit D3. 2800 IU ; Vit E. 32 mg. 3ME: metabolizable energy.

		AW (g)	DWG (g/d)	FI (g/b/d)	FCR (g/g)	Mortality rate (%)
Dietary group	P0	1927.81 ± 235	44.83 ± 43	78.86 ± 9	1.73 ± 0.2	0
	P1	1862.08 ± 71	43.21 ± 41	83.17 ± 12	1.85 ± 0.2	0
	P2	1832.25 ± 210	42.53 ± 41	74.21 ± 8	1.68 ± 0.3	0
	P3	1803.41 ± 246	41.85 ± 40	80.38 ± 13	1.89 ± 0.3	0.59 ± 1.5
Level of significance	P0 P1	0.88	0.89	0.62	0.5	1
	P0 P2	0.72	0.88	0.57	0.93	1
	P0 P3	0.55	0.56	0.96	0.31	0.4
P0: Control group; P1. P2. P3: Experimental groups						

Table 2: Performance of broiler chickens fed diets containing different dose of prebiotic at the starter phase.

Effect of prebiotic on carcass characteristics

The effect of prebiotic supplementation on carcass characteristics are shown in table 3. The hot carcass yields ranged, respectively, from 74 for P3 to 74.25% for control group which was in the line with results of Sarangi., *et al.* [29] who reported carcass yield (%) in the ranged from 73.77 to 76.04% after 42 days of age, and more than the value observed by Abdel-Raheem and Abd-Allah [30] who reported 64.45 to 70.68% in Avian -48 broilers of 42 days of age. There were no significant differences observed in the carcass traits with respect to carcass yields, breast muscle and thigh weights (P>0.05). Likewise, the present findings were in agreement with the report of Sahin., *et al.* [31] and Chumpawadee., *et al.* [32] who reported that the prebiotic had no significantly (P>0.05) positive effect on carcass yields of quails and broilers. The present findings were not in agreement with Abdel-Raheem and Abd-Allah [30] who reported a significant increase (P<0.05) in the carcass weight. Thus, Maiorano and Bednarzyck [33] showed that in ovo prebiotic injection into the chicken embryo did not affect carcass and yield. Corroborating with our results on growth performance, the prebiotic incorporation in broiler diet during starter period did not significantly improve carcass quality. The findings of this study are in line with previous studies [34] which not indicated positive effect on carcass parameters when prebiotic was added in broiler diet. In another report, Wang., *et al.* [35] reported that prebiotic supplementation did not affect breast as well as thigh weight.

Parameters		Hot Carcass weight (g)	Hot Carcass Yield (%)	Cold carcass weight (g)	Cold carcass Yield (%)	Thigh weight (g)	Breast weight (g)
Dietary group	P0	1598.5 ± 144	74.25 ± 3	1542.1 ± 143	71.63 ± 3	440.57 ± 69	502.6 ± 48
	P1	1602.6 ± 196	74.31 ± 3	1517 .8 ± 209	70.31 ± 4	470.12 ± 61	516.86 ± 75
	P2	1573.9 ± 269	74.8 ± 2	1503.2 ± 255	71 ± 2	446.5 ± 77	516.83 ± 86
	P3	1539.8 ± 236	74 ± 4	1497.1 ± 243	72 ± 4	454.5 ± 73	508.7 ± 81
Level of significance	P0 P1	1		0.9		0.4	0.8
	P0 P2	0.9		0.9		0.9	0.8
	P0P3	0.4		0.8		0.8	0.9
P0: Control group; P1. P2. P3: Experimental groups							

Table 3. Effect of prebiotic supplementation on carcass quality of broiler

Effect on meat quality

The pH post-mortem values of different groups are shown in table 4. The pH value of the broiler breast muscle reached at 30 mn ranged from 5.8 to 5.9 was not significantly different (P > 0.05) between control group and groups received prebiotic (P1, P2 and P3). Thus, the prebiotic supplementation had not a significant effect regarding pH value after 24 hours, there were no significant difference (P>0.05) between control and treated groups. It could be concluded that the incorporation of increasing doses of prebiotic in broiler diet during the starter period could not affect the meat pH (P>0.05). Differently, Park and Park [36] reported a significant decrease on pH of chicken meat by the dietary inclusion of the inulo-prebiotic. Additionally, in the study by Juśkiewicz., *et al.* [37] carried on turkeys for 8 weeks, reduction of the intestinal pH was noted in case of FOS administration at the concentration of 2%. Supplementation of broiler chickens' diet with prebiotics results in reduction of gastrointestinal pH [38]. On the other hand, Cheng., *et al.* [39] showed that the dietary supplementation with synbiotic increased significantly the pH 24h of breast muscle in Arbor Acres Plus. Our results suggested that this supplementation did not eventually modulate the level of muscle energy reserves.

Parameters		pH 30 min	pH ul time
Dietary group	P0	5.8 ± 0.11	5.5 ± 0.09
	P1	5.8 ± 0.13	5.6 ± 0.08
	P2	5.9 ± 0.17	5.5 ± 0.08
	P3	5.8 ± 0.17	5.5 ± 0.1
Level of significance	P0P1	1	0.39
	P0P2	0.11	1
	P0P3	0.89	0.99
P0: Control group; P1. P2. P3: Experimental groups			

Table 4: Effect of prebiotic supplementation on meat pH.

According to the table 5, Lightness (L) value of breast from group P3 was significantly lower in comparison with control group and there was no significant difference between Lightness value of breast from control group and other treated groups (P1 and P2). Lightness (L) value of thigh was not significantly different when compared control group with experimental groups. Likewise, for the redness (a) value, no significant difference (P > 0.05) was occurred on breast and thigh between control and experimental groups. Regarding yellowness value (b), breast from control group (14.74) was more yellow than breast from experimental groups (P1=12.87; P2=12.29; P3=12.42) but significant difference has been registered only between control group and P2 and control group and P3. Thus, yellowness thigh value of control group was significantly higher compared to group P2 (P=0.03). Our results revealed that the incorporation of different dose of prebiotic during starter period could affect meat color which is in line with those found by Pelicano., *et al.* [40] who reported that the Lightness value was affected with probiotics supplementation both to the drinking water and to the diet. In another study, breast meat redness value was greater in broilers receiving prebiotic diets whereas, L and b values of breast meat were not affected (P > 0.05) [40]. However, Zhao., *et al.* [41] indicated no significant effect of prebiotic supplementation on breast color. Furthermore, Pelicano., *et al.* [42] demonstrated that the addition of prebiotic in broiler diet had no significant effect on meat color. Sensory profile analysis (Figure 1) revealed that aroma of samples from control group was more intense in comparison with experimental groups, particularly in samples from groups P2 and P3. Regarding color, samples from experimental groups was darker than samples from control group confirming results of instrumental measurement CIE Lab in particular for group P2. Also, group fed the higher dose of prebiotic had more juicer meat than control group. Moreover, control samples were perceived more tough and less tasty compared to prebiotic samples, it was therefore the least appreciated by the panel. In terms of flavor, no remarkable difference was recorded between control and prebiotic samples. Globally, meat from group P2 was the most appreciated in comparison with meat from other groups and this may account by the fact that prebiotic based on *Saccharomyces cerevisiae* could edit the profile of fatty acids in muscle. The results of current study are in line with study of Saleh., *et al.* [43] that investigated effect of prebiotics on meat quality of chicken broilers. Interestingly, meat quality showed no alteration when the control group was compared to birds fed with prebiotic during starter period observed by Askri., *et al.* [14]. Our results revealed that the incorporation of increasing dose of prebiotic during starter period leads to improve sensory meat quality.

		Breast color			Thigh color		
Parameters		**L**	**a**	**b**	**L**	**a**	**b**
Dietary group	P0	61.91 ± 2	6.74 ± 1	14.74 ± 1	59.29 ± 3	8.9 ± 1	13.03 ± 1
	P1	60.48 ± 2	7.09 ± 0.9	12.87 ± 1	59.03 ± 3	8.47 ± 1	12.09 ± 1
	P2	60.37 ± 3	7.05 ± 1	12.29* ± 3	57.69 ± 3	9.42 ± 1	11.49* ± 2
	P3	57.13* ± 7	7.5 ± 1	12.42* ± 2	58.87 ± 2	8.77 ± 1	12.57 ± 1
Level of significance	P0P1	0.72	0.72	0.07	0.99	0.71	0.3
	P0P2	0.67	0.76	0.01	0.34	0.55	0.03
	P0P3	0.01	0.06	0.02	0.93	0.9	0.79
P0: Control group; P1. P2. P3: Experimental groups							

Table 5. Effect of prebiotic supplementation on meat color

Figure 1: Sensory profile.

Conclusion

The findings of this study showed that supplementation of increasing dose of prebiotic AVIATOR® during starter period had no significant effect on zootechnical performance but allowed to improve meat quality. Therefore, our results and those published by Askri., *et al.* indicated that prebiotic should be present in broiler diet during the whole period for optimum growth performance but it should be removed one week before slaughter to avoid any alteration of sensory quality. This study has highlighted that duration of prebiotic incorporation is an influencing factor that must be considered in poultry industry.

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Conflict of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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