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Evaluation of the effects produced by the addition of growth-promoting products to broiler feed*

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Abstract: The aim of this study was to determine the effects of feed additives on broiler productivity. Probiotics, oligosaccharides, organic acids, and avilamycin were used either alone or in combination to improve productivity in terms of body weight, feed intake, feed conversion ratio (FCR), and mortality rate. Broiler chicks (n = 900) were randomly divided into 9 groups. Group 1 was separated from the other groups and used as the control group; the chickens in this group were fed corn soybean until the end of the study. The other groups were fed corn soybean and the following food additives: probiotics (Group 2), oligosaccharides [mannan oligosaccharide (MOS)] (Group 3), organic acids (Group 4), probiotics + oligosaccharides (Group 5), probiotics + organic acids (Group 6), oligosaccharides + organic acids (Group 7), avilamycin (Group 8), and probiotics + oligosaccharides + organic acids (Group 9). The body weight and feed intake parameters were checked weekly, and the mortality rate was followed on a daily basis. The broilers were fed until they were 44 days old. Body weight and FCR were higher in the group given probiotics + oligosaccharides + organic acids (Group 9). Based on the results, we concluded that these growth-promoting products have positive effects that act synergistically, thereby leading to improved growth and feed conversion. The results of this study show that probiotics, oligosaccharides, and organic acid mixtures can be used as good alternative feed supplements to antibiotics.

Key words: Antibiotic, broiler, oligosaccharide, organic acid, probiotic

Introduction

The main objective in livestock production is to obtain high yields at a low cost. Good care and feeding of animals, improvement of their genetic structure, and the use of drugs and similar products to enhance growth are important strategies for achieving these goals. In particular, the use of yield-increasing materials in broiler production results in an increase in the yield over a short time period accompanied by lower feed consumption (1).

Feed additives are used for 2 purposes: to prevent the growth of pathogenic microorganisms that may cause digestive system diseases and to allow the animals to benefit from the higher levels of nutrients present by altering the microflora of their digestive systems in favor of beneficial bacteria. Antibiotics can provide these beneficial effects. However, due to the increased prevalence of antibiotic-resistant bacterial strains, the use of antibiotics as growth factors has been prohibited in many countries. This has led to

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the search for alternative materials that can increase the benefits of feed and positively affect the health of animals (2). At present, several substances such as probiotics, organic acids, and oligosaccharides are used as yield enhancers in broiler production. These yield-enhancing substances can be used either alone or in combination with other substances (3).

Probiotics are defined as live bacteria-yeast cultures or biological products that are added to drinking water or feed to regulate the ecological balance of microflora in the digestive tract of animals. These substances prevent the harmful effects of potentially pathogenic microorganisms and allow animals to derive increased benefits from the feed (4). Organic acids and oligosaccharides used as feed additives (for example, lactic acid, fumaric acid, propionic acid, citric acid, formic acid, and acetic acid) create an acidic environment by decreasing the pH in the digestive tract, which prevents the development of pathogenic microorganisms and increases enzyme activity. Moreover, this increases the digestibility and utility of minerals such as iron, calcium, phosphorous, magnesium, and zinc, as well as proteins and amino acids (5,6). Lately, there has been a great deal of research on the use of growth factors as alternatives to antibiotics in feed supplements.

Mannan oligosaccharide (MOS), obtained from the cell wall of *Saccharomyces cerevisiae* (also known as baker's yeast), is a natural alternative feed additive. The basic composition of MOS is 30% mannan, 30% glucagon, and 12.5% protein. MOS allows bacteria to be excreted with the feces without harming the animal. Through its terminal mannose units, this compound forms strong bonds with the adhesion regions of pathogenic bacteria, which are known as fimbria and contain lectins, in the small intestine. MOS action appears to involve acceleration of the growth of beneficial bacteria present in natural microflora and the strengthening of the immune system against pathogenic microorganisms. It has been reported that MOS can be used as an energy source by beneficial bacteria such as *Lactobacillus* and *Bifidobacterium*, but this oligosaccharide cannot be used by pathogenic bacteria (such as *Salmonella*, *E. coli*, and *Campylobacter*). Therefore, MOS has been used against pathogenic microorganisms (7).

In broiler production, it is important to compare substances used as feed additives in terms of their costs and benefits. It is also necessary to determine whether such products are actually useful and necessary in the broiler industry. Therefore, in this study, we investigated the effects of some products used to enhance broiler production in terms of the live weight gain and feed conversion ratio (FCR). Differences existed across the products used as yield enhancers. The most appropriate product was determined and its contribution to broiler production and the broiler industry was evaluated.

Materials and methods

Animals

In this study, 900 one-day-old broiler chicks (Ross 308), weighing 49-51 g (male/female mixed), were used.

Feed

The study was conducted over 4 feeding periods: initial broiler starter chicks (0-11 days), broiler chicks (11-21 days), broilers (21-37 days), and broilers before slaughter (37-44 days). The feed was purchased ready. The structures and compositions of the main rations used in the different feeding periods are shown in Table 1. Nutrient contents and energy value of the rations were determined by the supplier. Proximate composition was determined using the method of the AOAC (8). The metabolizable energy content of the diets was calculated from the chemical composition (9).

Yield-enhancing substance: In this study, probiotics (*Lactobacillus plantarum*, *L. delbrueckii*, *L. acidophilus*, *L. rhamnosus*, *Bifidobacterium bifidum*, *Streptococcus salivarius* subsp. *thermophilus*, *Enterococcus faecium*, *Aspergillus oryzae*, and *Candida pintolopesii*), oligosaccharides (MOS and beta-glucan from *S. cerevisiae*), and organic acids (orthophosphoric acid, fumaric acid, lactic acid, and natural orange oil) were used as yield-enhancing products, and an antibiotic with the active ingredient of avilamycin was used as the growth factor.

Experimental groups, ration design, and experimental design: In accordance with the decision of the Local Ethics Committee of Animal Experiments (Decree 2003/19 and Date 10.07.2003), the broiler chicks used in this study were initially

Table 1. Composition of the experimental diets.

Ingredients	Broiler starter feed (0-11 days)	Broiler chicks feed (11-21 days)	Broiler feed (21-37 days)	Broiler finishing feed (days 37-44)
Dry matter, %	88.59	88.43	88.61	88.56
Metabolizable energy (ME), kcal/kg	3050.00	3150.00	3250.00	3270.00
Crude protein, %	24.25	22.15	20.31	20.11
Ether extract, %	7.83	9.37	11.84	11.94
Crude fiber, %	3.13	3.10	3.11	3.16
Ash, %	5.95	5.58	5.32	5.30
Methionine, %	0.67	0.58	0.52	0.51
Lysine %	1.45	1.34	1.18	1.17
Methionine + cysteine, %	1.05	0.94	0.86	0.85
Calcium, %	1.00	0.95	0.90	0.90
Total phosphorus, %	0.50	0.45	0.42	0.43

divided into 9 groups by random selection (100 chicks in each group). Each group was further divided into 5 subgroups (20 chicks in each subgroup). The study was conducted at a commercial poultry in Ankara between 4 May 2006 and 19 June 2006. Yield-enhancing substances were added to the feed as shown in Table 2.

Feed and water were given to the chicks ad libitum. During the experiment, 24-h continuous illumination was provided. Ambient temperature was maintained at 34 °C between days 1 and 3, at 30 °C between days 4 and 14, and at 27 °C between days 15 and 44. Heating was provided with electric radiant heaters, and ventilation was achieved with windows and fans that were automatically controlled.

The live weight gain, feed consumption, and death ratios were investigated in the test. The weekly FCR was calculated by dividing the weekly feed consumption with the number of animals. The animals were weighed using balances that were sensitive to 1 g.

Statistics

The data obtained at the end of the study were statistically evaluated with SPSS 13.00. In this context, the mean, standard deviation, and lowest and highest values were determined. Differences between the groups were detected by one-way analysis of variance and Duncan's test.

Results

The number of deaths observed in the groups at the end of the experiment is shown in Table 3. The highest mortality rate (6%) was observed in Group 7, which was given oligosaccharides and organic acids, and the lowest death rate (1%) was observed in Group 4, which was given only organic acids.

The weekly live weight gain of the broilers is shown in Table 4. The highest live weight gain was observed in Group 9, which was given oligosaccharides, organic acids, and probiotics, and the lowest live weight gain was observed in the control group.

The FCRs are shown in Table 5. The highest FCR (1.70) was observed in Group 9, which was given oligosaccharides + organic acids + probiotics.

The feed consumption of the different groups is shown in Table 6. The highest feed consumption was observed in the control group (4762 g), and the lowest feed consumption was observed in Group 9, which was given oligosaccharides + organic acids + probiotics.

Discussion

In this study, when probiotics and oligosaccharides were used individually, they had no major effects on live weight gain, feed consumption, and FCR. Moreover, although the addition of these substances led to better activity until day 21, there was no

Table 2. Dietary treatments.

	Basal diet	Probiotics (0.5 kg/t)	Oligosaccharides (1 kg/t)	Organic acids (1.5 kg/t)	Probiotics (0.5 kg/t) + oligosaccharides (1 kg/t)	Probiotics (0.5 kg/t) + organic acids (1.5 kg/t)	Oligosaccharides (1 kg/t) + organic acids (1.5 kg/t)	Avilamycin (1 kg/t)	Probiotics (0.5 kg/t) + organic acids (1.5 kg/t)+ oligosaccharides (1 kg/t)
Group 1	+	-	-	-	-	-	-	-	-
Group 2	+	+	-	-	-	-	-	-	-
Group 3	+	-	+	-	-	-	-	-	-
Group 4	+	-	-	+	-	-	-	-	-
Group 5	+	-	-	-	+	-	-	-	-
Group 6	+	-	-	-	-	+	-	-	-
Group 7	+	-	-	-	-	-	+	-	-
Group 8	+	-	-	-	-	-	-	+	-
Group 9	+	-	-	-	-	-	-	-	+

Table 3. The number of deaths in the groups by weeks.

	The number of deaths						Total deaths (%)
	Day 7	Day 14	Day 21	Day 28	Day 35	Day 44	
Group 1	2	-	-	1	-	-	3
Group 2	-	-	-	1	1	-	2
Group 3	-	-	-	-	2	1	3
Group 4	-	-	-	-	1	-	1
Group 5	-	-	2	1	-	-	3
Group 6	-	-	-	2	2	-	4
Group 7	3	2	1	-	-	-	6
Group 8	2	-	-	-	-	-	2
Group 9	2	1	1	-	-	1	5

significant difference from the control group after that point. This indicates that the use of probiotics and oligosaccharides individually until day 21 is a good option. When organic acid was used alone, it was less effective than avilamycin; however, the former showed a significant difference from the control group in terms of live weight gain, feed consumption, and FCR. Similarly, a study conducted by Pelicano et al. (10) reported that the FCR was better in animals fed probiotics and MOS. It was reported that broilers that consumed MOS-enhanced feed had better live weight gain, especially between days 1 and 21. When MOS and organic acids were used together, this effect reportedly increased. The results obtained during the first 21 days were identical to those obtained by the addition of antibiotic growth factors, but in the case of antibiotics, growth appeared to further increase until the end of the 42-day period.

Although the studies with oligosaccharides yielded different results, it has been generally reported that oligosaccharides improve the FCR by reducing feed consumption, activating *Lactobacillus* and *Bifidobacterium*, increasing the lactic acid level, decreasing the *Salmonella* population in the ileum, and strengthening the immune system (11).

Positive results for poultry fed with probiotics have been reported by many researchers. Broilers that

Table 4. Weekly live weight gains of the broilers (g).

Groups	Day 7	Day 14	Day 21	Day 28	Day 35	Days 1-44
1	171.6 ± 1.26^{a}	477.5 ± 2.15^{a}	790.0 ± 1.03^{a}	1227.8 ± 1.42^{a}	1873.3 ± 1.83^{a}	2480.3 ± 2.92^{a}
2	175.1 ± 0.93^{b}	482.0 ± 1.44^{abc}	$803.3 \pm .97^{b}$	1229.6 ± 1.37^{a}	1875.2 ± 1.66^{a}	2486.9 ± 2.91^{a}
3	174.2 ± 0.99^{ab}	481.0 ± 1.67^{ab}	805.0 ± 0.54^{b}	1228.5 ± 1.26^{a}	1875.4 ± 1.43^{a}	2487.5 ± 5.22^{a}
4	174.2 ± 1.14^{ab}	482.6 ± 1.59^{abc}	815.0 ± 1.02^{c}	1234.2 ± 1.29^{b}	1890.3 ± 1.35^{b}	2504.8 ± 3.41^{b}
5	175.1 ± 0.94^{b}	485.6 ± 2.24^{bc}	828.2 ± 0.92^{d}	1241.7 ± 1.27^{c}	1905.4 ± 1.46^{c}	2527.9 ± 4.52^{c}
6	176.3 ± 1.00^{b}	485.3 ± 1.25^{bc}	834.1 ± 1.18^{e}	1245.1 ± 1.29^{c}	1921.2 ± 1.49^{d}	2553.6 ± 2.86^{d}
7	175.3 ± 1.13^{b}	487.2 ± 0.58^{cd}	841.6 ± 1.13^{f}	1250.3 ± 1.44^{d}	1927.4 ± 1.19^{e}	2573.6 ± 1.57^{e}
8	174.6 ± 1.01^{ab}	482.1 ± 1.41^{abc}	844.4 ± 3.18^{f}	1258.3 ± 1.30^{e}	1936.2 ± 1.21^{f}	2590.3 ± 4.31^{f}
9	176.8 ± 1.02^{b}	490.9 ± 0.59^{d}	850.8 ± 3.37^{g}	1260.2 ± 1.38^{e}	1940.1 ± 1.21^{f}	2597.4 ± 3.08^{f}
	$P < 0.05$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$

a, b, c, d, e, f, and g: Values in the same column marked with different superscripts were significantly different.

Table 5. Feed conversion ratio (FCR).
a, b, c, d, e, f, and g: Values in the same column marked with different superscripts were significantly different.

Group	Day 7	Day 14	Day 21	Day 28	Day 35	Days 1-44
1	0.85 ± 0.005^{a}	1.14 ± 0.007^{a}	1.34 ± 0.013^{ab}	1.56 ± 0.007^{a}	1.61 ± 0.014^{a}	1.92 ± 0.011^{a}
2	0.82 ± 0.005^{cde}	1.12 ± 0.010^{b}	1.33 ± 0.007^{ab}	1.53 ± 0.006^{b}	1.60 ± 0.010^{a}	1.89 ± 0.007^{b}
3	0.84 ± 0.003^{abc}	1.12 ± 0.003^{b}	1.34 ± 0.007^{a}	1.53 ± 0.005^{b}	1.57 ± 0.007^{b}	1.90 ± 0.006^{b}
4	0.84 ± 0.006^{ab}	1.11 ± 0.004^{bc}	1.33 ± 0.013^{ab}	1.51 ± 0.010^{c}	1.56 ± 0.008^{b}	1.79 ± 0.005^{c}
5	0.83 ± 0.005^{bcd}	1.11 ± 0.005^{bc}	1.31 ± 0.005^{bc}	1.48 ± 0.005^{d}	1.54 ± 0.005^{c}	1.78 ± 0.010^{cd}
6	0.83 ± 0.007^{bcde}	1.09 ± 0.008^{de}	1.32 ± 0.008^{abc}	1.45 ± 0.007^{e}	1.51 ± 0.007^{de}	1.75 ± 0.007^{d}
7	0.82 ± 0.005^{bcde}	1.09 ± 0.005^{de}	1.29 ± 0.003^{cd}	1.43 ± 0.008^{e}	1.53 ± 0.004^{cd}	1.75 ± 0.006^{d}
8	0.82 ± 0.004^{de}	1.08 ± 0.004^{de}	1.29 ± 0.006^{cd}	1.42 ± 0.005^{f}	1.51 ± 0.004^{de}	1.73 ± 0.006^{e}
9	0.81 ± 0.005^{e}	1.07 ± 0.004^{e}	1.27 ± 0.006^{d}	1.41 ± 0.007^{f}	1.49 ± 0.007^{e}	1.70 ± 0.005^{f}
	P < 0.001	P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001	P < 0001

were given feed and water with *S. faecium* showed better FCR and live weight gain than animals given antibiotics. It was reported that the live weight gain in broilers could increase from 5% to 9% upon addition of a 100 mg/kg probiotics mixture containing *L. acidophilus*, *L. casei*, *B. bifidum*, *Aspergillus oryzae*, and *Torulopsis candida* (12).

Similarly, Manickam et al. (13) and Yeo and Kim (14) reported that the addition of antibiotics, organic acids, and probiotics to feed have beneficial effects on the live weight and FCR.

Hayat et al. (15) and Iji and Tivey (16) showed that the addition of MOS to poultry feed increases productivity. Alp et al. (17) found that the addition of probiotics alone or in combination with various antibiotics (avoparcin, virginiamycin, and zinc bacitracin) to mixed broiler feed had no effect on live weight gain, FCR, carcass performance, abdominal fat, small intestine weight, and serum cholesterol level. However, these results contrast with those obtained in this study.

Jin et al. (18) proposed that many factors, such as the probiotic concentration, operating conditions, existing intestinal flora, health status of the animals, and feed composition, may affect the success of probiotic use.

Table 6. Feed consumption of the chickens (g).
a, b, c, d, e, f, and g: Values in the same column marked with different superscripts were significantly different.

Group	Day 7	Day 14	Day 21	Day 28	Day 35	Days 1-44
1	145 ± 1.140^{ab}	543 ± 0.894^{a}	1058 ± 5.147^{a}	1914 ± 1.685^{a}	3015 ± 4.743^{a}	4762 ± 6.615^{a}
2	143 ± 0.547^{bc}	539 ± 1.435^{b}	1067 ± 2.039^{b}	1880 ± 5.306^{b}	2981 ± 1.241^{b}	4725 ± 2.236^{b}
3	146 ± 0.663^{a}	538 ± 0.632^{bc}	1078 ± 1.720^{c}	1878 ± 1.965^{b}	2943 ± 3.310^{c}	4725 ± 1.631^{b}
4	145 ± 0.860^{ab}	535 ± 0.860^{cd}	1083 ± 1.964^{cd}	1863 ± 1.435^{c}	2948 ± 0.916^{c}	4482 ± 1.113^{e}
5	145 ± 1.000^{ab}	538 ± 1.095^{bc}	1092 ± 0.894^{ef}	1849 ± 1.595^{d}	2933 ± 1.000^{d}	4500 ± 4.017^{d}
6	143 ± 0.707^{bc}	533 ± 1.000^{de}	1100 ± 1.562^{g}	1817 ± 0.812^{e}	2900 ± 4.183^{f}	4495 ± 4.183^{d}
7	143 ± 0.678^{bc}	531 ± 1.356^{e}	1093 ± 1.827^{ef}	1800 ± 1.562^{f}	2948 ± 2.073^{c}	4530 ± 1.536^{c}
8	142 ± 0.735^{c}	520 ± 0.735^{f}	1097 ± 0.678^{fg}	1786 ± 2.097^{g}	2923 ± 0.510^{e}	4480 ± 1.720^{e}
9	142 ± 0.707^{c}	530 ± 0.871^{e}	1088 ± 0.800^{de}	1777 ± 0.860^{h}	2890 ± 1.788^{g}	4440 ± 1.414^{f}
	P < 0.005	P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001	P < 0.0001

In this study, we obtained better results with organic acids than with probiotics and oligosaccharides when used alone. Moreover, organic acids had positive effects when used in conjunction with other substances. The results of some earlier studies support the effects of organic acids observed in this study. For instance, studies conducted by Ceylan et al. (12) on broilers fed certain organic acids (citric acid, fumaric acid, propionic acid, sorbic acid, and tartaric acid) indicated that growth performance was positively affected by the presence of these acids in the ration. Patten and Waldroup (19) reported that the addition of 0.5% or 1% fumaric acid to broiler rations led to live weight gain but had no effect on feed consumption. These results support those obtained in this study.

In contrast, other studies reported that there was no significant increase in the live weight gain, FCR, or carcass performance of broilers with the addition of organic acids (6), essential oils, and/or humic acids (20) to broiler feed.

Vale et al. (21) suggested that the addition of organic acid to feed only altered feed consumption and did not lead to any change in live weight gain. However, when 2% organic acid was added, the live weight was reported to be approximately 80 g lower than that of the control group, with no change in the FCR and deaths. Moreover, feed consumption was reduced to approximately 240 g. The addition of 0.25% or 0.5% organic acid resulted in an increase in feed consumption per animal of 117 and 53 g, respectively. These results contradict those presented in this study.

Engberg et al. (22), Gunal et al. (5), Izat et al. (23), Lee et al. (24), and Panda et al. (25) reported that the addition of organic acids, probiotics, antibiotics, or organic acids + probiotics had no significant effect on feed consumption, FCR, and death rates.

Anderson et al. (26) suggested that the reason for not obtaining good results after the addition of growth factors such as antibiotics, probiotics, and organic acids may be related to environmental conditions. Therefore, they concluded that without healthy chicks, good feeding, and clean henhouses, the animals would not respond positively to the growth factors.

Another study suggested that the addition of antibiotics and probiotics to rations of poultry that were grown in environments where hygienic conditions already existed would not result in any added benefits (27).

Albuz (28) investigated the difference between groups given corn-soy-based commercial broiler ration (control group), antibiotics (flavomycin), MOS, and probiotics. The highest live weight gain was observed in the group that was given flavomycin, and this was followed by the group given probiotics, the control group, and the group given MOS. During the experiment, the highest average feed consumption was observed in the group given MOS, followed by the control group, and the groups given flavomycin and probiotics.

Fethiere and Miles (29) compared the effects of rations containing antibiotics (10 ppm virginiamycin), probiotics (1 kg/t *L. acidophilus*), and antibiotics + probiotics on broiler chicks in terms of live weight gain, FCR, and small intestine weight. At the end of the 21-day study, there were no significant differences among the groups in terms of the live weight gain of the broilers. However, better results were obtained in the groups that were given antibiotics and antibiotics + probiotics in terms of the FCR.

In our study, animals given probiotics + MOS, probiotics + organic acids, and MOS + organic acids showed better results than the control group; however, the results were not as good as those obtained with animals given antibiotics and the triple mixture. The best results were obtained with the probiotics + MOS + organic acids mixture, and these results were similar to those obtained with antibiotics (avilamycin) in terms of both live weight gain and FCR. Therefore, these products appear to have synergistic effects that lead to better growth and FCR. If our cost analysis is accurate, we can safely conclude that the triple combination of oligosaccharides + organic acids + probiotics can easily replace the use of antibiotics.

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