ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF POULTRY SCIENCE

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International Journal of Poultry Science 9 (3): 264-272, 2010
ISSN 1682-8356

Effect of Dietary Supplementation of Mannan Oligosaccharides and Acidifier Calcium Propionate on the Performance and Carcass Quality of Japanese Quail (*Coturnix japonica*)

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Abstract: The effect of the dietary supplementation of Mannan Oligosaccharides (MOS) and the acidifier Calcium Propionate (CP) on the performance and carcass quality of the Japanese quail (*Coturnix japonica*) was investigated in this experimentation. Three hundred, one-day old Japanese quail divided into four groups with three subgroups each were fed a basal diet that served as control, or a basal diet containing 6 g/kg CP, or 1 g/kg MOS or 1 g/kg MOS plus 6 g/kg CP. The body weight, feed consumption, feed conversion ratio and mortality of the birds were calculated at weekly intervals. On last day of the growing period (day 42) the birds were slaughtered, the carcasses were processed and the carcass weight, carcass dressing percentage and carcass parts percentage were calculated. Furthermore, the breast meat composition and its fatty acid profile were analyzed. The results of the experimentation showed that the addition of MOS in the feed of growing quail significantly ($p \leq 0.050$) increased the body weight on second week and the feed consumption on second and fourth weeks, while it decreased the liver to live weight percentage and the palmitic acid content of the breast meat. Moreover, the addition of CP in the feed significantly ($p \leq 0.050$) decreased the feed consumption on fifth week and the heart to live weight percentage. Significant ($p \leq 0.050$) interaction between the examined supplements was observed on the feed consumption, the FCR and the liver to live weight percentage. No adverse effects from the dietary addition of MOS or CP or both were observed on the performance or the carcass quality of the growing quail.

Key words: Mannan oligosaccharides, acidifiers, calcium propionate, performance, meat quality, fatty acids

INTRODUCTION

Since 1950 antibiotic growth promoters have been included in animal feeds to increase the performance of farm animals and lower the feeding cost (Jukes *et al.*, 1956). However, in recent years there have been concerns over the use of these substances, due to the emergence of antibiotic resistant microorganisms and the adverse effects of their residuals that can be found in animal products (Greko, 2001; Spais *et al.*, 2001). Presently, the inclusion of these substances in the feed of farm animals has been banned in the European Union since 2006 (EU, 2005), while their use is under scrutiny in other countries around the world. Nowadays, the research for alternative and safe feed additives, has gained considerable interest, in order to alleviate the problems associated with the withdrawal of antibiotic growth promoters from the farm animal feed. Among these additives, two promising substances are the Mannan Oligosaccharides (MOS) and the acidifiers.

The MOS are natural substances that can be found in plant and animal cells such as the yeast *Saccharomyces cerevisiae* (Spring *et al.*, 2000; Hooge, 2004; Kogan and Kocher, 2007). When included in the feed, they can adhere to the type-I fimbriae of many different bacterial strains and so limit their ability to adhere to the mucosa of the digestive tract and multiply. In addition, MOS can benefit the intestinal function by improving the height, the uniformity and the integrity of the intestinal villi. Also, they can exert a positive effect on the immune response of the animal and the production of IgA antibodies. Due to their effects, the replication of many pathogens is being limited and the health of the gut improves (Hooge, 2004; Ferket, 2004; Kogan and Kocher, 2007; Rehman *et al.*, 2009).

The acidifiers - organic acids or their salts - are naturally occurring substances, many of which play an important role in the cell metabolism (Kirchgessner and Roth, 1998; Lückstädt *et al.*, 2004). Some acidifiers have been used for the sanitation of animal feed for decades. When they are included in the feed, they can modify the pH of both the feed and the digestive tract of the animal. Also, the organic acids in their un-dissociated form are able to pass through the bacterial cell membrane inside the cell, where they dissociate in H^+ ions which lower the pH of the cell and $RCOO^-$ ions that can disrupt the normal cell function and protein synthesis. As a result, the affected microorganisms are unable to replicate efficiently and the microflora of the digestive tract is modified (Lückstädt *et al.*, 2004; Freitag, 2007; Lückstädt, 2008).

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The purpose of this investigation was to study the effect of the dietary supplementation of MOS and acidifier Calcium Propionate (CP) on performance and carcass quality of growing Japanese quail (*Coturnix japonica*).

MATERIALS AND METHODS

Animals and diets: A total of three hundred, 1-day-old Japanese quail (*Coturnix japonica*) as hatched were used in this study. The birds were individually weighted and assigned randomly to four treatment groups with three subgroups (replicates) of twenty five birds each. All 12 subgroups were housed in separate wire suspended cages.

To meet the nutrient requirements of growing quail, a complete basal diet based on maize, soybean meal and wheat was formulated, in order to satisfy the nutrient requirements of growing quail, according to Florou-Paneri (1989) and NRC (1994). Table 1 presents the ingredients and the composition of this basal diet, in mash form, which was analyzed according to AOAC (2005) for crude protein, crude fat, crude fiber, moisture and ash content. Also the calcium, total phosphorus, lysine, methionine plus cystine and metabolizable energy content were calculated from the composition of the feed ingredients, according to Novus (1992), NRC (1994) and Spais *et al.* (2002).

The basal diet was given to one of the groups that served as control (Group A). The other three groups were given the same diet supplemented further with additional 6 g/kg CP (Group B) or additional 1 g/kg MOS (Group C) or both 6 g/kg CP and 1 g/kg MOS (Group D). The CP supplement used was the "Calcium propionate granules 99%" from Dr. Paul Lohmann, Emmerthal, Germany. The MOS supplement used was the "MOS 500" from Ultra Bio-logics Inc., Ragaud, QC, Canada.

Feed and drinking water were offered to birds *ad libitum* and the feed consumption was recorded daily. Conventional breeding and management procedures were applied throughout the feeding period that lasted 42 days. The quail were handled according to the principles of the Greek Directorate General of Veterinary Services for the care of animals in experimentation.

Measurements: All birds were individually weighted at days 7, 14, 21, 28, 35 and 42, whereas the sex of each bird was also recorded in the last three measurements. The feed intake per bird per day and the Feed Conversion Ratio (FCR) were calculated at weekly intervals. Mortality was recorded daily.

At day 42 of age, one male and one female bird from each replicate were randomly selected, weighted and slaughtered under commercial conditions. After dressing the carcass weight was measured and the dressing percentage was calculated. The carcass was chilled at 1°C for 12h and then it was separated into different parts, such as breast, back, neck, legs and wings, their weight was recorded and their percentage to carcass weight was calculated. The weight of liver and heart was also recorded and their percentage to live weight was calculated. All these parts were sealed in polyethylene bags and frozen at -20°C for further analysis.

Table 1: Composition of basal diet

Ingredients	g/kg
Maize	452.6
Soybean meal	320.0
Wheat	100.0
Corn gluten meal	79.7
Calcium carbonate	14.3
Dicalcium phosphate	11.4
Soybean oil	10.8
Lysine	3.7
Vitamin and trace mineral premix[1]	3.5
Salt	2.1
Sodium bicarbonate	1.9
Chemical analysis	
Dry matter	914
Crude protein	238
Crude fat	28
Crude fiber	36
Ash	62
Calculated analysis	
Calcium	8.5
Total phosphorus	6.5
Lysine	13
Methionine and Cystine	8.7
Metabolizable energy, kcal/kg	2950

[1]Supplying per kg feed: 14000 IU vitamin A, 5000 IU vitamin D_3, 30 mg vitamin E, 13 mg vitamin K, 3 mg vitamin B_1, 8 mg vitamin B_2, 3 mg vitamin B_6, 20 μg vitamin B_{12}, 85 mg vitamin niacin, 20 mg pantothenic acid, 2 mg folic acid, 200 μg biotin, 10 mg vitamin C, 960 mg choline cloride, 100 mg Zn, 116 mg Fe, 120 mg Mg, 20 mg Cu, 0.2 mg Co, 1 mg I, 0.3 mg Se

From the frozen breasts, the meat was removed from the bones, it was homogenized and it was analyzed for crude protein, crude fat, moisture and ash, according to the guidelines of AOAC (2005).

The fatty acid composition of the breast meat was also determined according to Folch *et al.* (1957) and AOAC (2005). Separation and quantification of the methyl esters of the fatty acids was carried out with a gas chromatographic system (TraceGC model K07332, ThermoFinnigan, ThermoQuest, Milan, Italy) equipped with a flame ionization detector, a model CSW 1.7 chromatography station (CSW, DataApex Ltd, Prague, Czech Republic) and a fused silica capillary column, 30 m x 0.25 mm i.d., coated with cyanopropyl polysiloxane (phase type SP-2380) with a film thickness of 0.20 μm (Supelco, Bellefonte, PA, USA). The chromatographic conditions were:

- Carrier: N_2 , Flow: 1 ml/min
- Oven: Temperature 70°C for 0,5 min, increase 30°C/min to 180°C for 10 min, increase 5°C/min to 225°C for 10 min
- Inlet temperature: 250°C, Detector temperature: 250°C
- Injection: 2 μl, with split 1/40

Statistical analysis: The statistical analysis was performed using the General Linear Model function of the SPSS (2007) Ver. 16.0.1 statistical package (SPSS Inc., Chigaco, IL, USA). The one-way analysis of variance for the four groups of the experimentation was performed. Also, the two-way analysis of variance and three-way analysis of variance (when applicable) was performed, using as main effects the inclusion of MOS in the feed (two levels), the inclusion of CP in the feed (two levels) and the sex of the birds (two levels, when applicable). A value of $p \leq 0.050$ was considered significant. Levene's test was applied to test the homogeneity of the variances. Tukey's test was applied to determine statistical differences between the means.

RESULTS AND DISCUSSION

Table 2 presents the effect of the supplementation of MOS and CP in the feed of growing quail on the body weight. There were no significant ($p>0.050$) differences in body weight among the four groups, during the 6 weeks of the experimentation. The addition of MOS resulted in significantly ($p \leq 0.050$) higher body weight on day 14 of age and in a tendency to have higher body weight on the last day of the experimentation (day 42). In previous studies by Guclu (2003), Parlat *et al.* (2003) and Oguz and Parlat (2004) higher body weight for birds that consumed MOS was observed, whereas Ghosh *et al.* (2007) and Sarica *et al.* (2009) did not observe any significant differences. In contrast, the addition of CP resulted in a tendency for the birds to have lower body weight at day 35 of age but this effect was not significant at $p \leq 0.050$. Sacakli *et al.* (2006) and Çakir *et al.* (2008) did not find any significant difference in the body weight of birds fed acidifiers, whereas Ghosh *et al.* (2007) and Ocak *et al.* (2009) found higher body weight for birds fed acidifiers. Furthermore, the female birds had significantly ($p \leq 0.001$) higher body weight than the male birds on days 35 and 42 of age, which is to be expected since female quail are normally heavier than males (Yannakopoulos and Tserveni-Gousi, 1986; Shim, 2005). Finally, no significant ($p>0.050$) interaction between the main effects was observed, which is similar to the findings of Loddi *et al.* (2002) and Pelicano *et al.* (2004), whereas Ghosh *et al.* (2007) reported improved body weight for birds fed a combination of MOS and sodium butyrate.

The effect of the supplementation of MOS and CP in the feed of the growing quail on the daily feed consumption is presented in Table 3. During the second week of the experimentation significantly ($p \leq 0.010$) higher feed consumption was observed for group D compared to group B. Also, during the fourth week significantly ($p \leq 0.001$) higher feed consumption was observed for group D compared to groups B and C and for groups A and C compared to group B. Furthermore, during the fifth week significantly ($p \leq 0.010$) higher feed consumption was observed for group C, compared to group D. The addition of MOS resulted in significantly ($p \leq 0.010$) higher feed consumption during the second and the fourth weeks. There is considerable variation in the results reported by other researchers, since Rosen (2007a; 2007b) in two comparative studies reported on average lower feed consumption for birds fed MOS versus controls, whereas Oguz and Parlat (2004) reported higher feed consumption for birds fed MOS and Ghosh *et al.* (2007) and Sarica *et al.* (2006) reported no significant differences. The addition of CP resulted in significantly ($p \leq 0.050$) lower feed consumption during the fifth week. Ao *et al.* (2009) reported lower feed consumption for birds fed acidifiers, whereas other researchers (Ghosh *et al.*, 2007; Parlat *et al.*, 2003; Sacakli *et al.*, 2006; Çakir *et al.*, 2008) did not find difference in feed consumption due to the dietary supplementation of acidifiers in the feed of birds or reported (Ocak *et al.*, 2009) increase in feed consumption. Finally, significant interaction between MOS and CP was observed during the first ($p \leq 0.050$), second ($p \leq 0.010$), fourth ($p \leq 0.001$), fifth ($p \leq 0.010$) and sixth ($p \leq 0.050$) weeks. During the first, fifth and sixth weeks the combined addition of MOS and CP resulted in decreased feed consumption compared to each separate addition, whereas during the second and fourth weeks the combined addition resulted in increased feed consumption compared to each separate addition. Ghosh *et al.* (2007) and Brzóska *et al.* (2007) did not report any significant interaction between MOS and acidifiers.

The results concerning the FCR are presented in Table 4. Significantly ($p \leq 0.050$) higher FCR was observed for group D compared to group B for the fourth week but not for the other weeks. Also, the addition of MOS resulted in a tendency for higher FCR during the fourth week which was not significant ($p>0.050$). Guclu (2003), Parlat *et al.* (2003) and Ghosh *et al.* (2007) found lower FCR for birds fed MOS. Moreover, the addition of CP in the feed did not result in any significant ($p>0.050$) difference which is similar to the reports of other researchers (Sacakli *et al.*, 2006; Çakir *et al.*, 2008; Ocak *et al.*, 2009) who found no significant difference in birds fed acidifiers, whereas Ghosh *et al.* (2007) and Senkoylu *et al.* (2007) observed lower FCR. Also, significant ($p \leq 0.050$) interaction between MOS and CP was noticed during the fourth week which shows that the combined addition of MOS and CP resulted in higher FCR than the addition of each substance separately. Contrary to these findings, Pelicano *et al.* (2004), Ghosh *et al.* (2007) and Brzóska *et al.* (2007) did not find any significant interaction between MOS and acidifiers. Finally, mortality was not affected significantly ($p>0.050$) throughout the experimental period in all groups.

The growth promoter effect of MOS and acidifiers is attributed to their ability to limit the growth of potential

Table 2: Effect of MOS, CP and sex on body weight of Japanese quail (mean±s.d.)

	Body weight (g) of quail on day of age					
Quail groups*	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42
Group A	19.33±0.38	48.28±2.04	67.77±0.58	122.25±3.66	154.57±4.63	171.95±13.40
Group B	20.27±1.22	48.02±1.26	63.86±9.06	120.23±7.47	152.26±7.39	175.55±21.29
Group C	20.87±1.20	51.72±2.09	65.15±8.08	123.80±5.83	159.45±6.90	179.57±16.89
Group D	20.34±2.23	50.40±2.06	65.38±10.63	119.16±8.88	154.26±7.38	177.07±18.59
Significance of F Value	0.628	0.123	0.944	0.644	0.316	0.900
Effect of MOS						
0 g/kg	19.80±0.96	48.15±1.52[a]	65.81±6.12	121.24±5.71	153.42±6.00	173.75±17.06
1 g/kg	20.60±1.63	51.06±1.99[b]	65.27±8.44	121.48±7.56	156.85±7.33	178.32±16.98
Significance of F Value	0.357	0.029	0.910	0.934	0.118	0.059
Effect of CP						
0 g/kg	20.10±1.16	50.00±2.64	66.46±5.32	123.03±4.71	157.01±6.16	175.76±15.07
6 g/kg	20.31±1.61	49.21±2.01	64.62±8.87	119.70±7.84	153.26±7.12	176.31±19.07
Significance of F Value	0.806	0.493	0.704	0.261	0.090	0.810
Effect of sex						
Male	-	-	-	119.10±9.61	150.73±4.91[a]	160.67±5.28[a]
Female	-	-	-	123.62±6.33	159.54±5.47[b]	191.40±6.93[b]
Significance of F Value	-	-	-	0.133	0.001	0.000
Interaction						
Significance: MOS x CP	0.396	0.642	0.669	0.652	0.499	0.193
Significance: MOS x Sex	-	-	-	0.861	0.748	0.867
Significance: CP x Sex	-	-	-	0.904	0.804	0.076
Significance: MOS x CP x Sex	-	-	-	0.839	0.663	0.193

MOS = Mannan Oligosaccharides, CP = Calcium Propionate, s.d. = standard deviation. Values in the same column with a superscript in common do not differ significantly at p≤0.050. *Groups: A = control; B = 6 g/kg CP; C = 1 g/kg MOS; D = 6 g/kg CP + 1 g/kg MOS

Table 3: Effect of MOS and CP on daily feed consumption of Japanese quail (mean±s.d.)

	Daily feed consumption (g) on week of age					
Quail groups*	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Group A	3.04±0.17	9.66±0.36[ab]	9.64±0.26	23.01±0.61[bc]	13.59±1.67[ab]	18.73±4.09
Group B	3.16±0.10	8.98±0.24[a]	8.50±0.49	20.37±0.15[a]	15.25±2.16[ab]	21.05±1.87
Group C	3.47±0.03	9.61±0.19[ab]	9.64±0.17	21.90±0.55[b]	17.41±0.78[a]	22.80±2.56
Group D	3.05±0.31	10.12±0.23[b]	9.91±1.46	23.53±0.62[c]	11.57±1.29[b]	16.17±1.86
Significance of F Value	0.063	0.005	0.205	0.000	0.010	0.079
Effect of MOS						
0 g/kg	3.10±0.14	9.32±0.46[a]	9.07±0.71	21.69±1.50[a]	14.42±1.95	19.89±3.11
1 g/kg	3.26±0.30	9.87±0.34[b]	9.77±0.94	22.72±1.03[b]	14.49±3.34	19.49±4.15
Significance of F Value	0.169	0.007	0.157	0.009	0.941	0.807
Effect of CP						
0 g/kg	3.26±0.26	9.64±0.26	9.64±0.20	22.46±0.80	15.50±2.40[a]	20.77±3.78
6 g/kg	3.11±0.21	9.55±0.66	9.20±1.24	21.95±1.78	13.40±2.57[b]	18.61±3.15
Significance of F Value	0.197	0.584	0.363	0.126	0.049	0.211
Interaction						
Significance: MOS x CP	0.032	0.004	0.160	0.000	0.003	0.023

MOS = Mannan Oligosaccharides, CP = Calcium Propionate, s.d.= standard deviation. Values in the same column with a superscript in common do not differ significantly at p≤0.050. *Groups: A = control; B = 6 g/kg CP; C = 1 g/kg MOS; D = 6 g/kg CP + 1 g/kg MOS

pathogens in the digestive tract of animals (Lückstädt *et al*., 2004; Lückstädt, 2008; Bozkurt *et al*., 2008). Thus, the digestive tract remains healthy, functions more efficiently and more nutrients are available for absorption. The lack of significant improvement in the performance of the birds that was found in our experimentation may be the result of the proper feed composition and the optimum rearing conditions. It is generally accepted that the positive effect of feed growth promoters is more pronounced when animals are not offered good quality feed or are reared in non-optimum conditions (Miguel *et al*., 2002; Sims *et al*., 2004; Hernández *et al*., 2006; Baurhoo *et al*., 2007; Bozkurt *et al*., 2008).

Table 5 presents the effect of the supplementation of MOS and CP in the feed of the growing quail on their carcass quality. No significant (p>0.050) effect was observed for the parameters measured between the four experimental groups. The addition of MOS resulted in significantly (p≤0.050) lower liver percentage, but had no (p>0.050) effect on the other measured parameters. In analogous experimentations, Ghosh *et al*. (2008), Bozkurt *et al*. (2008), Konca *et al*. (2009) and Sarica *et al*. (2009) reported no significant difference in birds fed MOS concerning carcass weight, carcass dressing percentage or carcass parts percentage. The birds that consumed CP had significantly (p≤0.050) lower heart percentage, but the addition of CP in the feed had no significant (p>0.050) effect on the other measured parameters. Ocak *et al*. (2009) reported higher carcass weight, Leeson *et al*. (2005) reported higher breast percentage, whereas Sacakli *et al*. (2006), Çakir *et al*.

Table 4: Effect of MOS and CP on feed conversion ratio of Japanese quail (mean±s.d.)

	FCR of quail on week of age					
Quail groups*	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Group A	1.64±0.17	2.12±0.09	2.55±0.03	2.68±0.03[ab]	2.74±0.11	3.22±0.22
Group B	1.75±0.17	2.08±0.05	2.59±0.41	2.51±0.14[a]	2.69±0.16	3.23±0.16
Group C	1.75±0.15	2.04±0.07	2.72±0.34	2.61±0.11[ab]	2.80±0.12	3.38±0.25
Group D	1.54±0.13	2.06±0.07	2.73±0.31	2.83±0.11[b]	2.70±0.02	3.00±0.04
Significance of F Value	0.372	0.599	0.836	0.036	0.685	0.168
Effect of MOS						
0 g/kg	1.69±0.16	2.10±0.07	2.57±0.26	2.60±0.13	2.72±0.12	3.22±0.17
2 g/kg	1.65±0.17	2.05±0.06	2.73±0.29	2.72±0.15	2.75±0.09	3.19±0.26
Significance of F Value	0.620	0.251	0.394	0.084	0.620	0.760
Effect of CP						
0 g/kg	1.69±0.16	2.08±0.08	2.63±0.24	2.65±0.08	2.77±0.11	3.30±0.23
6 g/kg	1.65±0.18	2.07±0.06	2.66±0.33	2.67±0.21	2.70±0.10	3.12±0.16
Significance of F Value	0.636	0.758	0.871	0.701	0.317	0.123
Interaction						
Significance: MOS x CP	0.118	0.572	0.914	0.013	0.725	0.099

MOS = Mannan Oligosaccharides, CP = Calcium Propionate, s.d.= standard deviation. Values in the same column with a superscript in common do not differ significantly at $p \leq 0.050$. *Groups: A = control; B = 6 g/kg CP; C = 1 g/kg MOS; D = 6 g/kg CP + 1 g/kg MOS

Table 5: Effect of MOS, CP and sex on carcass quality of Japanese quail (mean ± s.d.)

Quail groups*	Carcass weight (g)	Carcass dressing (%)	Breast % of carcass	Back % of carcass	Legs % of carcass	Neck % of carcass	Wings % of carcass	Liver % of live weight	Heart % of live weight
Group A	124.75	76.37	34.37	27.02	22.00	7.58	8.20	2.60	1.11
	±14.62	±3.10	±3.63	±3.75	±1.30	±1.49	±1.31	±0.86	±0.21
Group B	128.15	72.66	34.08	27.63	22.67	7.88	7.15	2.56	0.97
	±12.55	±3.92	±1.90	±1.56	±0.97	±0.92	±0.50	±0.60	±0.11
Group C	131.15	74.10	33.87	26.50	22.35	8.22	7.95	2.30	1.23
	±6.14	±4.69	±2.69	±2.67	±0.89	±0.61	±1.64	±0.32	±0.05
Group D	132.47	75.29	34.93	26.88	21.22	8.43	8.40	2.12	1.07
	±16.39	±6.58	±3.09	±1.90	±1.14	±0.94	±1.67	±0.33	±0.22
Significance of F Value	0.742	0.576	0.927	0.898	0.150	0.526	0.428	0.435	0.075
Effect of MOS									
0 g/kg	126.45	74.52	34.23	27.33	22.33	7.73	7.68	2.58	1.04
	±13.11	±3.88	±2.77	±2.75	±1.15	±1.19	±1.10	±0.71[a]	±0.18
1 g/kg	131.81	74.69	34.40	26.69	21.78	8.33	8.18	2.21	1.15
	±11.82	±5.48	±2.81	±2.22	±1.14	±0.78	±1.60	±0.32[b]	±0.17
Significance of F Value	0.177	0.922	0.890	0.590	0.260	0.169	0.420	0.027	0.101
Effect of CP									
0 g/kg	127.95	75.24	34.12	26.76	22.18	7.90	8.08	2.44	1.17
	±11.20	±3.97	±3.06	±3.11	±1.08	±1.14	±1.42	±0.64	±0.16[a]
6 g/kg	130.31	73.98	34.51	27.26	21.94	8.16	7.78	2.34	1.02
	±14.10	±5.34	±2.48	±1.70	±1.26	±0.94	±1.35	±0.51	±0.17[b]
Significance of F Value	0.543	0.480	0.756	0.670	0.627	0.538	0.626	0.472	0.031
Effect of sex									
Male	120.59	77.11	34.76	26.71	22.03	7.80	7.65	2.06	1.13
	±8.90[a]	±1.97[a]	±3.74	±3.30	±1.18	±0.96	±1.33	±0.34[a]	±0.14
Female	137.67	72.10	33.87	27.31	22.08	8.26	8.20	2.72	1.05
	±9.43[b]	±5.25[b]	±1.08	±1.26	±1.18	±1.09	±1.40	±0.58[b]	±0.21
Significance of F Value	0.000	0.011	0.483	0.610	0.917	0.281	0.376	0.001	0.195
Interaction									
Significance: MOS x CP	0.787	0.178	0.594	0.921	0.074	0.920	0.232	0.680	0.858
Significance: MOS x Sex	0.349	0.717	0.727	0.391	0.862	0.418	0.665	0.030	0.338
Significance: CP x Sex	0.378	0.898	0.567	0.989	0.627	0.265	0.957	0.308	0.126
Significance: MOS x CP x Sex	0.283	0.577	0.296	0.887	0.247	0.148	0.892	0.032	0.646

MOS = Mannan Oligosaccharides, CP = Calcium Propionate, s.d.= standard deviation. Values in the same column with a superscript in common do not differ significantly at $p \leq 0.050$. *Groups: A = control; B = 6 g/kg CP; C = 1 g/kg MOS; D = 6 g/kg CP + 1 g/kg MOS

(2008) and Ghosh *et al.* (2008) did not report any significant ($p > 0.050$) difference on the carcass characteristics of birds fed acidifiers. Furthermore, the sex of the birds had significant effect on the carcass weight and carcass dressing percentage, since the female birds had significantly ($p \leq 0.001$) higher carcass weight but significantly ($p \leq 0.050$) lower carcass dressing percentage. Also, the female birds had significantly ($p \leq 0.001$) higher liver percentage. These results can be attributed to the anatomical differences

Table 6: Effect of MOS and CP on carcass meat composition of Japanese quail (mean±s.d.)

Quail groups*	Crude protein (g/kg)	Crude fat (g/kg)	Moisture (g/kg)	Ash (g/kg)
Group A	219±4	31±17	719±11	15±1
Group B	213±3	46±14	731±9	14±1
Group C	219±3	27±16	737±13	15±1
Group D	220±4	21±6	725±8	14±1
Significance of F Value	0.385	0.269	0.220	0.587
Effect of MOS				
0 g/kg	216±4	38±16	725±11	15±1
1 g/kg	220±5	24±12	731±12	14±1
Significance of F Value	0.278	0.133	0.341	0.662
Effect of CP				
0 g/kg	219±5	29±15	728±15	15±1
6 g/kg	217±5	33±17	727±8	14±1
Significance of F Value	0.378	0.622	0.991	0.233
Interaction				
Significance: MOS x CP	0.299	0.231	0.068	0.680

MOS = Mannan Oligosaccharides, CP = Calcium Propionate, s.d.= standard deviation. Values in the same column with a superscript in common do not differ significantly at $p \leq 0.050$. *Groups: A = control; B = 6 g/kg CP; C = 1 g/kg MOS; D = 6 g/kg CP + 1g/kg MOS

Table 7: Effect of MOS and CP on fatty acid composition of the breast meat of Japanese quail (mean ± s.d.)

	Myristic acid	Palmitic acid	Palmitoleic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid	Erucic acid	Total SFA	Total MUFA	Total PUFA
Quail groups*	C14:0 %	C16:0 %	C16:1 %	C18:0 %	C18:1 %	C18:2 %	C18:3 %	C22:1 %	(%)	(%)	(%)
Group A	5.54	18.69	5.19	9.83	31.95	22.52	1.36	4.94	34.05	42.08	23.87
	±2.58	±1.03	±1.77	±2.95	±5.56	±0.60	±0.12	±1.65	±4.49	±5.00	±0.66
Group B	2.56	19.56	4.86	7.99	36.03	24.58	1.52	2.86	30.14	43.76	26.10
	±0.97	±1.23	±1.15	±0.38	±1.39	±4.06	±0.27	±1.02	±1.28	±3.09	±4.33
Group C	4.30	17.63	5.80	7.28	36.27	23.57	1.49	3.67	29.21	45.74	25.05
	±3.96	±0.71	±1.63	±2.73	±6.69	±2.26	±0.27	±2.94	±6.67	±4.41	±2.51
Group D	3.06	18.01	5.71	7.66	37.32	23.43	1.33	3.49	28.73	46.51	24.76
	±2.16	±0.88	±1.71	±2.72	±5.49	±0.77	±0.28	±2.42	±4.32	±4.62	±0.51
Significance of F Value	0.550	0.161	0.869	0.606	0.621	0.771	0.734	0.692	0.516	0.612	0.761
Effect of MOS											
0 g/kg	4.06	19.13	5.02	8.91	33.99	23.55	1.44	3.90	32.09	42.92	24.99
	±2.38	±1.12[a]	±1.35	±2.13	±4.26	±2.83	±0.21	±1.68	±3.65	±3.83	±3.03
1 g/kg	3.68	17.82	5.76	7.47	36.79	23.50	1.40	3.58	28.97	46.13	24.91
	±2.93	±0.75[b]	±1.49	±2.44	±5.51	±1.51	±0.26	±2.41	±5.03	±4.06	±1.63
Significance of F Value	0.810	0.050	0.447	0.335	0.378	0.974	0.812	0.799	0.274	0.237	0.526
Effect of CP											
0 g/kg	4.92	18.16	5.49	8.55	34.11	23.04	1.42	4.31	31.63	43.91	24.46
	±3.07	±0.98	±1.56	±2.90	±5.99	±1.59	±0.20	±2.24	±5.73	±4.67	±1.76
6 g/kg	2.82	18.79	5.28	7.83	36.67	24.00	1.43	3.17	29.43	45.13	25.43
	±1.52	±1.28	±1.38	±1.75	±3.65	±2.69	±0.27	±1.69	±2.95	±3.82	±2.85
Significance of F Value	0.207	0.301	0.824	0.620	0.417	0.504	0.944	0.386	0.433	0.638	0.526
Interaction											
Significance: MOS x CP	0.590	0.671	0.905	0.452	0.626	0.445	0.298	0.464	0.537	0.860	0.415

MOS = Mannan Oligosaccharides, CP = Calcium Propionate, s.d.= standard deviation, SFA = Saturated Fatty Acids, MUFA = Monounsaturated Fatty Acids, PUFA = Polyunsaturated Fatty Acids. Values in the same column with a superscript in common do not differ significantly at $p \leq 0.050$. *Groups: A = control; B = 6 g/kg CP; C = 1 g/kg MOS; D = 6 g/kg CP + 1 g/kg MOS

between male and female birds (Yannakopoulos and Tserveni-Gousi, 1986; Shim, 2005). In addition, significant ($p \leq 0.050$) interaction between MOS and sex was observed on the liver percentage which shows that the addition of MOS lowered the liver percentage of the female birds but did not affect that of the male birds. Furthermore, significant ($p \leq 0,050$) three-way interaction between MOS, CP and sex was observed on the liver percentage. According to Ferket (2004), the positive effect of growth promoters on carcass quality may be attributed to the improvement of the animal's health and the more efficient utilization of the feed nutrients. The effect of the supplementation of MOS and CP in the feed of the growing quail on the composition of their breast meat is presented in Table 6. No significant ($p > 0.050$) difference between the four groups was observed. Neither the addition of MOS, nor the addition of CP had any significant ($p > 0.050$) effect on the measured parameters. Ghosh *et al.* (2008) reported lower crude fat percentage in the meat of quail fed MOS. Also, Lessard *et al.* (1993) and Ghosh *et al.* (2008) found lower crude fat percentage for birds fed acidifiers, while Samanta *et al.* (2010) noticed higher ash percentage in their meat. Furthermore, no significant ($p > 0.050$) interaction between MOS and CP was observed. Ghosh *et al.* (2008) reported interaction between MOS and sodium butyrate on the crude fat percentage of quail meat, whereas Brzóska *et al.* (2007) did not find any interaction between MOS and fumaric acid.

The results concerning the fatty acid composition of breast meat are presented in Table 7. No significant (p>0.050) differences were observed among the four experimental groups. The addition of MOS resulted in lower ($p \leq 0,050$) palmitic acid percentage but did not affect (p>0.050) the other fatty acids. The addition of CP did not have any significant (p>0.050) effect on the fatty acid composition of the breast meat and no significant (p>0.050) interaction between the main effects was observed. According to Furuse *et al.* (1992), the fatty acid composition of the consumed feed and of the animal tissues can be modified as a result of the action of the gut microflora, because the gut microorganisms are able to hydrogenise unsaturated organic acids to more saturated ones, or even to desaturate some organic acids.

Conclusion: The addition of MOS in the feed of growing quail significantly ($p \leq 0.050$) increased the body weight on second week and the feed consumption on second and fourth weeks, while it decreased the liver to live weight percentage and the palmitic acid content of the breast meat. Moreover, the addition of CP in the feed significantly ($p \leq 0.050$) decreased the feed consumption on fifth week and the heart to live weight percentage. Significant ($p \leq 0.050$) interaction between the examined supplements was observed on the feed consumption, the FCR and the liver to live weight percentage. No adverse effects from the dietary addition of MOS or CP or both were observed on the performance or the carcass quality of the growing quail.

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