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The Effects of Feeding of Milk Protein Concentrate on Productivity and Meat Quality in Broiler Chickens

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Abstract

This study was aimed to evaluate the effect of milk protein concentrate (MPC) on the broiler chicken performance and meat quality. Two experiments were conducted to this study. In the first study 250 1-day old broiler chicks (VINITIP-1 cross bred) were assigned into 5 groups (control, 5% Fishmeal, 1% MPC, 3% MPC and 5% MPC) and placed in the separated cages for 7th weeks. By daily monitoring of the chickens and their feed intake and weighing of individual birds at the ages of 4th and 7th weeks of age, animal viability, feed efficiency, body weight (BW) and weight gain were evaluated. In the second experiment, 200 1-day old chicks were assigned into four groups (control, 5% fishmeal, 1% MPC and 3% MPC) and placed into the separated cages for 8 weeks. In order to we could not significantly found difference between the groups were fed 3% and 5% MPC, thus we eliminated the group was supplemented 5% MPC in this experiment. At the end of this experiment 5 chickens from each groups were slaughtered for meat quantitative and qualitative analysis of breast and drumstick meat. The current studies revealed that 3% MPC significantly improved the animal performance, viability, live weight and meat quality. Increment of MPC had no beneficial impacts on the chicken meat quality and their performances. In conclusion, MPC as a byproducts of milk processing is a good alternative source of protein in the chicken diet that can improve their body weights and the carcasses quality.

Keywords:- Milk Protein Concentrate, Broiler chicken, productivity, Meat quality

1. Introduction

Among the animal sectors, poultry production is widely developed in Afghanistan and the globe. According to Ministry of Agriculture, Irrigation and livestock of Afghanistan (MAIL, 2009), over 1,000 poultry farms are operating in this sector across the country and the poultry industry meet nearly 80% of the local markets. However, the poultry industries are still facing with the challenge such as ration preparation and selecting of profitable breeds for meat and egg. Most of the poultry rations were

imported from the neighboring countries with a high cost which is highly effect on the final product cost for the farmers.

In poultry feed formulation, after the energy-yielding materials, protein supplements constitute the biggest component and attention has been focused on the proper levels in the diets. These two components are not only quantitatively important, but also the sources and their availabilities are crucial for animals (Leeson & Summers, 2009). The usefulness of a protein source for poultry diet depends upon its digestibility as well as availability to supply sufficient amounts of the essential amino acids (EAA) for completion of the bird requirements(Beski et al., 2015; Leeson & Summers, 2009).

Plant protein are traditionally the main sources widely used in the poultry diets. The major sources for energy and protein are respectively maize and soyabean as well as cereals such as wheat, sorghum and some plant protein meal(Beski et al., 2015). However, some plant protein sources are directly used by human and the addition of the sources may increase the cost. Furthermore, generally plant protein sources are nutritionally imbalanced and poor in certain EAA (Saima et al., 2008). Lack of an amino acid in plant protein source further decreases their biological value as they may not furnish the required limited amino acid needed by birds for meat and egg production(Beski et al., 2015; Saima et al., 2008).

Animal by-products such as meat meal, blood meal, feather meal and fish meal are extensively used in poultry diets because of their high biological values, true metabolizable energy and available amino acids. Moreover, milk processing by-product are recently attracted as a source of protein especially for broiler chicken because of its high nutritional value.

Milk is an excellent food, the use of which is chiefly for humans. Off-quality milk powder and skim milk powder, unsuitable for human use, are often used as protein source in poultry feed formulation (Ravindran & Blair, 1993). Milk protein concentrates (MPC) are dairy protein powders with protein content in approximately 50–85% total solid range. They are manufactured by partially removing the lactose and minerals from skim milk using ultrafiltration(Havea, 2006). Some reports indicated that MPC has beneficial effects on poultry performance (Ravindran & Blair, 1993). However, the MPC effects on the growth performance, meat quality and its digestibility in broiler chicken is not known yet. Thus, the objectives of the current study is to quantify the use of MPC in broiler diet formulation; to determine the MPC digestibility and absorbance in broiler chickens, and to find its impact on broilermeat quantity and quality.

2. Materials and Methods

This study was carried out at the Zagorsk research institute of farming (All-Russian Research and Technological Institute of Poultry), Departments of animal Nutrition and animal product technology, Academy of Veterinary Medicine and Biotechnology (K.i. Skryabina).

2.1. MPC preparation

MPC was obtained from Nerchinsk dairy industry (Kostromskaya Russia) by processing and precipitation of casein and whey protein of skimmed milk with hydrochloric acid in 95ºC. MPC processing was done according to TY-49 specification of Russian federation and the chemical analysis of MPC was as follow: protein 83.98%, Lysine 6.43%, methionine 3.53; arginine 3.85%, valine 5.23%, isoleucine 4.05%; leucine 7.69%, glycine 1.58 and phenylalanine 4.27%.

2.2. Experimental design

Two experiments were conducted for determination of specific norm for MPC in the poultry diet and to investigate its effect on the productivity, clinical condition and viability of broiler chicken as well as meat quality.

For the first experiment 250 1-day-old broiler chicks (Cross type VINITIP-1) were randomly assigned into 5 groups and placed into the separated cage as shown in **table 1**. All the chicks were housed in a controlled environment and the birds had free access to standard commercial feed and water *ad libitum* (**table 2**). Based on the experimental procedures, ration for the control group didn't included animal originated protein, while the other groups; treatments I (positive control), II, III and IV had 5% fish meal, 1%, 3% and 5% MPC respectively (**table 1**). The chicks body weight (BW), weight gain (WG) and feed conversion ratio (FCR) were accounted by weighing of each individual at the ages of 4th and 7th weeks and monitoring daily feed intake calculation. Furthermore, the chickens' viability were obtained by daily monitoring of the experimental animal in each group.

Table 1. Research plan and addition of MCP to the diets of broiler chicken

Groups		Amounts in the feed components (%)	
		Fish meal	MCP
Control		-	-
Treatments	I.	5.0	-
	I.	-	1.0
	I.	-	3.0
	′.	-	5.0

The second experiment was aimed to evaluate meat quality of the broiler chicken. In this experiment 200 1-day old chicks (Cross type VINITIP-1) were randomly assigned into four groups (control, treatments [5% fish meal, 3% MPC and 5% MPC]). All experimental procedures in both experiments were performed in accordance with the guidelines approved by the Academy of Veterinary medicine and Biotechnology, Russia.

Table 2. Nutrients composition of the broiler diets (%).

Indexes	Animal groups				
	Control	Treatments			
		5% Fish meal	1% MPC	3% MPC	5% MPC

	Starter ration (1-4 weeks age)				
ME (MJ)	1.295	1.293	1.295	1.294	1.295
CP	21.5	22.00	22.00	22.30	22.50
CF	4.60	4.40	4.50	4.40	4.40
Ca	1.10	1.30	1.10	1.30	1.50
P	0.83	0.89	0.75	0.84	0.90
Na	0.24	0.28	0.24	0.24	0.24
Lysine	1.16	1.17	1.17	1.19	1.19
Met+sys	0.82	0.83	0.82	0.83	0.83
	Grower ration (5-7 weeks age)				
ME (MJ)	1.311	1.323	1.318	1.319	1.319
CP	19.60	19.10	19.0	19.10	19.60
CF	4.60	4.40	4.50	4.40	4.40
Ca	0.93	1.00	0.90	0.87	0.93
P	0.70	0.75	0.63	0.62	0.67
Na	0.25	0.26	0.26	0.25	0.26
Lysine	0.95	0.95	0.97	0.98	1.00
Met+Sys	0.82	0.82	0.82	0.83	0.83

Abbreviations: ME, Metabolizable Energy; CP, Crude Protein; CF, Crude Fiber; Met+Sys, Methionine+Cysteine.

2.3. Dietary and meat quality test

Meat quality of the broiler chickens in the first experiment were analyzed by anatomical dividing of carcasses at the age of 7th week's ages by using Vintip$_a$ method (Palivanova 1967). After anatomical separation of the body parts, samples were collected from breast and leg meat for biochemical analysis of moisture, crude protein (CP), crude fat (CF) and ash contents as previously described (Lebedov and Usovich, 1970; Masliev, 1976). The amino acid (AA) compositions of protein in the animal carcass, diets, remaining food and feces were analyzed quantitatively and qualitatively by using amino acid analyzer AAA-339 (Hitachi, Japan). Macro and micro mineral contents of the chicken diets and their meat were analyzed by using spectrophotometer.

2.4. Statistical analysis

Statistical analysis was performed using the software ESTAT 2.0 (1992), and means were compared by

Tukey's test. For comparing the chemical composition between white and red muscle and also between male and female in the same group, Two-Way analysis of variance (ANOVA) was performed. Data represented in the table shown by mean, mean ± standard division and percentage. $P<0.05$ was considered as significant difference.

3. Results

3.1. Abbreviations and Acronyms

No significant difference were found in the chicken viability between the groups. However, feeding of 3% MPC slightly improved the broiler chicken viability as compared to the control (**table 3**). Furthermore increment of MPC up to 5% didn't have positive effects on the chicken viability.

Table 3. Zoo technical indexes of broiler chicken

Indexes	Animal groups				
	Treatments				
	Control	5% Fish meal	1% MPC	3% MPC	5% MPC
Viability %	92.0	94.0	96.0	98.0	94.0
BW in 7th weeks (g)	1511.6 ± 10.1^{a}	1643.3 ± 11.7^{b}	1576.6 ± 6.6^{a}	1691.6 ± 5.8^{c}	1668.3 ± 10.1^{b}
Feed efficiency for 1kg BW (kg)	3.05	2.73	2.86	2.48	2.64
Protein digestibility (%)	88.55	89.96	89.00	90.44	89.77
Protein absorption rate (%)	38.3	48.8	45.9	50.4	49.2
Biological value of protein	47.0	54.22	54.47	55.74	54.85

b and c shown the significance $P<0.05$ and $P<0.01$ respectively

As illustrated in table 3, body weights of broiler chickens at the age of 7th weeks were significantly higher in positive control ($P<0.05$), Treatment III($P<0.01$) and treatment IV ($P<0.05$) as compared to the control group. Concomitantly, feed conversion ratio (FCR) was lower in the treatment III (2.4 kg feed/1kg gain) as compared to the groups of control (3.05 kg feed/1kg gain) and treatment I (2.73 kg feed/1kg gain). Protein digestibility was another factor which was analyzed in this study. The result shown that MPC digestibility was high in treatment III (90.44%) as compared to the control (88.0%) and treatment I (89.9%). Furthermore, the absorption rate of the amino acids (Lysine) was significantly high ($P<0.05$) in the treatment groups III and IV, 85.6% and 85.4% respectively as compared to control (79.6%). However, the absorption rate of amino acid threonine and glycine were better in treatment group I.

3.2. Carcass yield and characteristics

As represented in **table 4**, body weights before slaughtering of the chickens were significantly higher in the treatment I (P<0.01), treatment II (P<0.01), treatment III and treatment IV (P<0.01) as compared to control group. Moreover, the partial processed weights of the carcasses were also higher in all treatments (P<0.01) when compared to the control. Furthermore, processed weights of the carcasses were significantly higher in treatments groups (P<0.05) as compared to the control. Other parameters such as muscle and bone weights, muscle and bone ratio, edible and inedible parts of the carcasses were better in the chickens were fed MPC. The ratio between edible and inedible parts of the carcasses were higher in treatment III (2.28), while this factor was in control and treatment I 1.67 and 1.97 respectively. As similar trend was observed in muscle and bone ratio.

Table 4. Anatomical division of broiler chicken

Indexes	Animal groups				
		Treatment			
	Control	5% Fish meal	1% MPC	3% MPC	5% MPC
BW before slaughter (g)	1605.0±11.6	1693.3±10.1^{c}	1670.0±8.6^{b}	1745.0±10.4^{c}	1720.0±8.7^{c}
Partial processed carcass weight (g)	1303.0±8.8	1400.0±8.6^{c}	1370.0±8.7^{c}	1468.3±7.3^{c}	1435.0±6.9^{c}
Partial processed carcass product (%)	81.2	82.7	82.03	84.13	83.43
processed carcass weight (g)	1050.0±8.6	1124.0±8.1^{c}	1100.0±7.5^{b}	1168.0±7.2^{c}	1142.0±6.4^{c}
Slaughter product (%)	65.4	66.4	65.9	66.93	66.4
Muscle weight (g)	540.9	653.5	639.6	704.5	673.2
Bone weight (g)	300.3±2.1	293.0±2.8	290.0±3.2^{a}	300.6±1.9^{a}	291.3±1.7^{c}
Muscle and bone ratio	1.8	2.23	2.2	2.34	2.31
Edible parts weight (g)	817.8	947.2	913.7	1020.7	987.9
Inedible parts weight (g)	488.6	479.4	482.8	447.2	450.0
Edible and inedible parts ratio	1.70	1.97	1.90	2.28	2.19

a= P < 0.1; b =P <0.01; c = P < 0.001

3.3. Chemical composition of breast and drumstick meat

Different protein sources in broiler diet effects on the quality of breast (white) and drumstick (red) meat of the chickens. The chemical composition of breast and drumstick meats were evaluated within (male and female) and between the groups (treatments vs controls). A significant difference was observed in dry matter, protein and fat and ash contents between the control and treatment groups (**table 5**).

The chemical analysis revealed that protein content was slightly higher in white muscle when compared to red meat within the same group and the amounts were higher in female than male animals. However, fat content was higher in red muscle as compared to the white one within the same group. No significant difference was observed in ash contents between white and red muscle within the same animals and between two sexes in the same group.

Furthermore, taste analysis of the cooked meats (white and red meat) revealed that supplementation of the broiler diets with MPC improve the quality of chicken meat and the quality was similar to the OCT-49104-76 standard.

Table 5. Chemical composition of male and female broiler meat

Meat type	Male groups					Female groups				
	Control	5% Fish meal	1% MPC	3% MPC	5% MPC	Control	5% Fish meal	1% MPC	3% MPC	5% MPC
	Dry matter (%)									
White meat	26.25±0.08	26.71±0.06^{b}	26.33±0.09^{b}	26.83±0.04^{b}	26.86±0.02^{b}	26.74±0.1	27.63±0.10^{b}	27.10±0.10^{a}	28.42±0.06^{c}	27.52±0.03^{b}
Red meat	25.58±0.04	25.75±0.04^{a}	25.55±0.03	26.60±0.03^{c}	26.33±0.10^{b}	24.56±0.04	26.63±0.01^{c}	25.58±0.04^{c}	26.91±0.06^{c}	25.73±0.10^{c}
	Protein (%)									
White meat	19.83±0.01	20.03±0.04^{b}	19.85±0.05^{a}	21.00±0.03^{c}	20.82±0.04^{c}	20.13±0.04	21.15±0.03^{c}	20.18±0.04^{c}	21.85±0.03^{c}	21.23±0.04^{c}
Red meat	18.38±0.07	19.55±0.03^{c}	18.62±0.04^{c}	20.48±0.02^{c}	19.68±0.04^{c}	18.63±0.03	18.73±0.02^{a}	18.63±0.02	18.95±0.03	18.72±0.02^{a}
	Fat (%)									
White	1.10±0.01	1.52±0.07^{b}	1.35±0.05^{b}	1.92±0.04^{c}	1.65±0.03^{c}	1.85±0.03	2.26±0.02^{c}	1.95±0.03^{a}	2.61±0.02^{c}	2.30±0.03^{c}

meat										
Red meat	3.85±0.03	4.46±0.07[b]	4.00±0.03[a]	4.55±0.03[c]	4.16±0.04[b]	4.25±0.03	4.55±0.03[b]	4.35±0.03[a]	5.05±0.05[c]	4.44±0.03[b]
	Ash (%)									
White meat	0.87±0.003	0.88±0.009[a]	0.90±0.01[a]	0.92±0.003[a]	0.91±0.009[a]	0.87±0.003	0.89±0.005[a]	0.89±0.003[b]	0.90±0.003[c]	0.89±0.006[a]
Red meat	0.81±0.05	0.83±0.003[a]	0.82±0.00[a]	0.84±0.009	0.84±0.006[a]	0.82±0.003	0.83±0.003[a]	0.82±0.006	0.85±0.006[b]	0.84±0.003[b]

a = P < 0.1; b = P<0.01; c= P < 0.001

4. Discussion

This is the first report showing the beneficial effects of dietary supplementation of MPC on the broiler chicken performance. In the current study, treatments supplemented with 3% and 5% MPC improved viability of the broiler chickens compared with the birds in the groups control and treatment I (5% fish meal). Consequently, chickens in treatment III had higher body weight (11.2% and 3.2% higher than control and treatment I respectively) and better FCR than control animals. Moreover, protein digestibility, absorption rate and the biological values of protein was higher in treatment III compared to the control animals. Despite the low levels of protein in whey protein concentrate (WPC) than MPC, previous data support our results and shown that supplementation of WPC in the chicken (Nath et al., 2018; Pineda-Quiroga et al., 2018; Szczurek et al., 2013) and rabbit diet(Kishawy et al., 2018) significantly improved the animal growth performances. Ashour et al., (2019) reported the similar results and indicated that feeding WPC may improve absorption of nutrients by creating an appropriate environment in the intestine for useful microorganisms and increase the length of the intestinal villi. Feeding or WPC not only effects on protein digestibility, but also improved the absorption of some mineral such as calcium and phosphorus (Pineda-Quiroga et al., 2018).

Definite standards for proper identification of MPC still do not exist in the food industry worldwide (Patel and Patel 2014). Mistry (2013) reported a broad range of compositional contents and functional characteristics of various MPCs

As shown in table 4, dietary supplementation of MPC at the level of 3% and 5% significantly effects on the partial processed carcass weight, partial processed carcass product, processed carcass weight and slaughter products compared to the groups of control and treatment I. Moreover, muscle weights and the ratios between edible and inedible parts were somewhat higher in the above-mentioned groups compared to the control animals. This effects somewhat resemble those reported by Ashour et al., (2019) , who found that whey protein powder support muscle building with its essential amino acid content (Hoffman & Falvo, 2005). Moreover, the results of the current study are in agreement with those reported by (Gharahveysi et al., 2015), who reported that dried whey powder in broiler diet increases the relative

weights of carcass edible parts. These results are closely resemble to previous results found that supplementation of 4% whey powder improved the broiler performance and carcass traits (Gharahveysi et al., 2015). Improving the boiler performance and the carcass traits might affected by multiple factors such as better digestibility and absorption of MPC protein, existence of essential amino acids and making favorable intestinal environment for useful bacteria as reported previously (Pineda-Quiroga et al., 2018).

The current study revealed that MPC supplementation quantitatively and qualitatively improver the broiler meat. As presented in table 5, meat quality differences were observed between the experimental groups and between male and female in the same group. No previous result providing the mechanisms by which supplementation of protein source differently effect on male and female. However, Bahari et al. (2015) demonstrated that the addition of 4% whey powder to the broiler ration improved carcass weight, carcass percent, breast weight, drum stick weight and wings weight. MPC contains both whey protein and casein. Hoffman & Falvo, (2005) reported that casein has ability to form a gel or clot in the stomach and this clot makes it very efficient in nutrient supply. The clot is able to provide a sustained slow release of amino acids into the blood stream, sometimes lasting for several hours and provides better nitrogen retention and utilization by the body. Better nutrients digestion and growth performance in female boiler chicken than male within the same group probably be due to the animal behaviors. Male chickens are more aggressive and more active than females.

In conclusion, these results indicate that MPC is a beneficial protein supplement in poultry feeding because they improve chicken growth performances, protein digestibility and absorption rate, and modulate the broiler carcass quality. Supplementation of MPC at the levels of 3% of 5% not only improved the protein digestibility, but also may improve the digestion and utilization of all other nutrients in the chicken diet.

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