Meat performance and metabolism of broiler ducklings on diets with different protein levels

D G Pogosyan, R N Tyurdenev, E N Varlamova and E A Zueva
Penza State Agrarian University, 30 Botanicheskaya St., Penza, 440014, Russia

E-mail: pogosyan.d.g@pgau.ru

Abstract: When feeding broiler ducklings of the Agidel 343 breed, the most optimal raw protein level in the pre-start (0-10 days old), start (11-21 days old) mixed fodder of the first phase of fattening can be considered 22 and 21% and the second phase 21% (22-49 days old). It was found that at the end of fattening with increasing the protein level in mixed fodder of the second phase from 17 to 19 and 21%: increase in live weight of young ducklings by 4.5-8.8%; decrease in feed expenses per 1 kg of live weight gain of ducklings by 4.4-9.5%; increase in preservation of young animals by 5.3%; stimulation of protein and carbohydrate exchange in ducklings body by increasing total protein content in blood serum by 3.1-9.2% and glucose by 5.5-8.5%; improvement in nitrogen exchange by increasing total nitrogen absorbed in body by 6.8-18.7%; increasing slaughter yield from 68 to 68.5-69.8%, increasing muscle yield from 46.7 to 47.5-49.1% and edible body parts from 55.7 to 56.2-58.0%; increasing European fattening efficiency from 233 to 277 and 300 units and increasing economic efficiency by increasing the profitability of duck meat production from 29.2 to 39.1-41.4%.

1. Introduction

At present, the Russian Federation is experiencing a revival of industrial duck breeding, which involves the use of broiler technology for fattening young chickens. In intensive fattening, the main factor determining meat productivity is the full protein diet of the young, which depends on the level and quality of crude protein in the bird's diet. The use of modern meat breeds and crosses of waterfowl requires revision of the existing norms of consumption of crude, digestible protein, limiting essential amino acids, metabolizable energy and, accordingly, the search for optimal parameters of their content, taking into account the age-specific characteristics and technology of broiler fattening. An insufficient amount of protein reduces the growth rate and metabolism, slows down the development, worsens the quality and nutritional value of carcasses, which prevents the realization of the high genetic potential of meat productivity of young fattening animals. At the same time, both excess and deficiency of protein in bird diets contributes to fat deposition in internal organs and subcutaneous tissue, leads to digestive disorders and reduces productivity [1]. Feed with high protein content, especially of animal origin, is expensive, so when increasing their input, feed conversion and costs associated with increased protein in feed must be taken into account [2]. In our understanding, high productivity of young fattening animals is possible at maximum feed intake with optimum protein and metabolizable energy content, provided that the profitability of poultry meat production is increased.

If the level of protein in the diet is increased by 30%, so called protein poisoning can occur due to protein toxicity. Protein overfeeding disrupts the acid-base balance in the body towards acidosis,
resulting in the destruction of vitamin A, the lack of which contributes to damage to the mucous membranes, especially the cloaca in ducks. A short-term increase in protein level in the diet increases the concentration of pancreatic enzymes, which increases the digestibility of feed protein in the digestive tract. With prolonged exposure to this factor, adaptation mechanisms are impaired and protein digestibility decreases [3]. Consequently, poultry feeds should contain an optimum level of protein. In 1982, an article was published in the Australian Journal of Agricultural Research investigating the effect of protein on the performance of white Peking ducks, in which it was suggested that the application of 19% protein was sufficient to meet the protein requirements of ducklings from 0 to 2 weeks of age [4].

Existing domestic and foreign standards for crude protein content in feed for fattening ducklings have certain discrepancies [5,6]. Therefore, the search for the optimum level of protein in the fodder of broiler ducklings by main fattening periods is considered to be an urgent task in industrial duck breeding.

2. Materials and Methods
The experiment was conducted in the conditions of the farm "Tyurdenev" on ducklings of the meat cross Agidel 345 staffed into five groups of 100 animals each. Fattening was conducted according to two age phases of fattening: from 1 to 21 days and from 22 to 49 days. In the control group the ducklings were fed with mixed fodders developed in the state enterprise "Blagovarsky Poultry Breeding Farm". In the 1st group mixed fodders corresponding nutritiveness recommendations of VNIITIP (All-Russian Scientific and Practical Research Institute of Poultry Farming) were used. Group 2 used mixed fodder used for broiler fattening of young ducks in OOO (LLC) "New Duck Farms" (OOO "Donstar"). Groups 3 and 4 were fed with experimental mixed fodders with high protein levels (Table 1).

| Group | Fattening phase | 0-21 days | 22-49 days |
|-------|----------------|-----------|------------|
|       | crude protein, | exchange energy, | crude protein, | exchange energy, |
|       | %              | kcal      | %          | kcal        |
| control | 22             | 285       | 18         | 305         |
| 1     | 21             | 275       | 17         | 295         |
| 2     | 22 /21         | 295 /300  | 19         | 300         |
| 3     | 23             | 300       | 21         | 310         |
| 4     | 25             | 300       | 22         | 310         |

Note: – a Crude protein and exchange energy content for 0-10 days of age; b – 11-21 days.

The ducklings were housed on deep bedding and fed from group feeders.

Based on the ducklings' survival, live weight, fattening period and feed consumption per 1 kg of live weight gain, the European Duck Meat Performance Index (EPI) was calculated using the formula:

\[
EPI = \frac{Lw \times P \times 100}{F \times Fe}
\]

where, Lw – the live weight of ducklings at slaughter, kg; P – the preservation of young animals, %; Fe – the feed expenses per 1 kg of growth, kg; F – the fattening period, days.

To study physiological processes, the balance of nitrogen in ducklings was determined in balance experiments at the end of the experiment and average blood samples were taken to obtain serum in which the total indices were determined. At 49 days, a control slaughter of 10 ducklings of similar live weight from each group was carried out and the slaughter and anatomical carcass cutting parameters were determined.

3. Results and Discussion
When studying the dynamics of live weight of ducklings at 21 days of age, it was found that the maximum intensity of growth in the first phase of fattening was observed in the young of the 2nd group.
The average live weight of the ducklings in this group was 1,295 g, which was 2.9 (P<0.05) and 6.3% (P<0.001) higher than that of the control and the 1st group, accordingly (Table 2).

**Table 2.** Dynamics of live weight and feed consumption for fattening ducklings.

| Indicator                        | Control      | Group | Group | Group |
|----------------------------------|--------------|-------|-------|-------|
|                                  | Live weight, g: |       |       |       |
| 1 day old                        | 50.80±0.68   | 1,258±8.9 | 3,290±19.4 | 3,239±18.9 |
| 21 days old                      | 1,221±12.1c  | 1,295±11.4c | 3,250±18.2 | 3,199±18.7 |
| % to the control                 | 100          | 97.0  | 102.9 | 100   |
| 49 days old                      | 3,438±20.0b  | 3,578±19.8b | 98.8      | 104.5  |
| % to the control                 | 100          | 102.9 | 108.7 | 103.3 |
| Increase, g                      | 3,386±19.8b  | 3,526±20.6b | 3,386±19.8b | 3,386±19.8b |
| average daily                    | 66.11±0.77   | 69.10±0.92a | 71.96±1.01b | 68.32±0.78a |
| % to the control                 | 100          | 98.8  | 104.5 | 108.8 |
| Feed consumption per 1 kg of increase, kg | 2.63 | 2.65 | 2.51 | 2.40 |
| % to the control                 | 100          | 100.7 | 95.4 | 91.2 |

Note: * P<0.01; * P<0.001; c P<0.05 – in relation to control

Consequently, the feeding scheme practiced at New Duck Farms when ducklings are fed mixed fodder with 22% protein in the first 10 days and then switched to 21% protein until they are 21 days old proved to be the most effective. The results of our studies are consistent with the findings of Chinese scientists who, when feeding Peking ducks until 21 days of age with mixed fodder with protein content of 15, 17, 19, 21, 23 and 25%, found that high growth rate and feed conversion were observed at protein levels of 21 and 23% [7]. In studies conducted in India on Campbell ducklings, it was found that by increasing protein content in duckling diets from 18 to 20 and 22% in the starter period, there was an increase in live weight of young animals up to 8 weeks of age with decreased feed intake [8]. Feeding Peking ducklings to 21 days old with 20.5% crude protein with 12.6 MJ/kg or 300 kcal/kg of exchange energy increased the average daily gain in live weight and improved feed conversion [9].

The increase in protein content in the feed of the first phase of fattening from 22% in the control to 23 and 25% prepared according to the developed experimental formulas in groups 3 and 4 was accompanied by a slight increase in live weight of young animals by 1.4 and 1.8% compared to the control. This is probably due to the lack of exchangeable energy which resulted in an increase in protein intake not stimulating the growth and development of the growing organism.

In studies by a number of authors, it was found that increasing the level of protein in pre-starter feed for broiler chickens from 23.1 to 26.7% resulted in increased relative growth of the chickens only during the first 5 days [10]. According to other scientists, the efficiency of protein use in the organism of fattened young chickens decreases with an increase in its content above the accepted normative values in the diet [11,12].

During the second phase of fattening (21-49 days of age), the highest growth rate was detected in the 3rd group, where live weight was 3,578 g, which was 8.7% higher than control (P<0.001). Increasing crude protein levels in the 2nd, 3rd and 4th experimental groups to 19, 21 and 22% with exchange energy of 300 and 310 kcal resulted in a disproportionate increase in live weight of ducklings by 4.5; 8.8 (P<0.001) and 3.3% (P<0.01) by increasing the average daily gain by 5.4; 13.2 (P<0.001) and 4.2% (P<0.01) respectively. Consequently, in the compound feed of the second phase of the intensive fattening technology for ducklings of the Agidel breed, the level of crude protein of 21% and exchange energy of 310 kcal can be considered the optimum content.
The best overall performance during the whole fattening period was obtained when fattening the 3rd experimental group, although the average daily gain in this group was inferior to the 2nd group during the first phase of fattening. The low protein values in the fodder of the 1st and 2nd experimental groups did not allow the growth potential of the ducklings to be realised. Although, in studies conducted on Peking ducks aged 15 to 35 days, the best live weight gain and feed conversion ratio were obtained when feeding ducks with high exchange energy of 28 kcal/kg and average crude protein and lysine levels of 19 and 1.21% [13]. In turn, the high protein level in the feeds of the 4th group of ducklings did not result in a correspondingly expected increase in meat productivity of the poultry. Increasing protein content in the first phase of fattening from 21 to 23% and in the second phase from 17 to 21% resulted in decreasing feed expenses per 1 kg of live weight gain of ducklings by 4.4-9.5%. In studies by Egyptian scientists, the best results in fattening moscow ducks were obtained by using mixed fodder during the first 6 weeks of fattening with a protein content of 22%, then at 18% [14]. The results of our studies are consistent with those obtained by other scientists in experiments on broiler chickens at the beginning of fattening [15,16].

An analysis of the biochemical parameters in the blood serum of the experimental ducklings showed that increasing the protein content in feed resulted in a significant increase in the serum total protein content in ducklings of groups 2, 3 and 4 compared to control and the 1st experimental group by 3.2-5.9% (P <0.05), 6.5-9.2% (P <0.001) and 8.3-11.1% (P <0.001) (Table 3).

### Table 3. Biochemical blood indicators.

| Indicator          | Control      | Group 1 | Group 2 | Group 3 | Group 4 |
|--------------------|--------------|---------|---------|---------|---------|
| Total protein, g/l | 43.4±0.50    | 42.3±0.93 | 44.8±0.64 | 46.2±0.64 | 47.0±0.79 |
| Glucose, mmol/l    | 9.12±0.21    | 9.02±0.28 | 9.28±0.18 | 9.79±0.19 | 9.36±0.28 |
| Calcium, mmol/l    | 4.03±0.10    | 3.99±0.14 | 3.77±0.18 | 3.83±0.15 | 3.95±0.14 |
| Phosphorus, mmol/l | 1.74±0.09    | 1.69±0.08 | 1.67±0.11 | 1.75±0.06 | 1.74±0.09 |

Note: * P <0.05 – to the 1st group; ** P <0.001 – to the control and the 1st groups

Consequently, the use of high-protein mixed fodder in the diets of young birds stimulates protein metabolism in growing broiler ducklings. In the 3rd experimental group, there was a significant increase in blood glucose content by 7.3-8.5% (P<0.05) compared with the control and 1st experimental group, indicating the stimulation of carbohydrate metabolism. Different levels of protein in the feed had no effect on calcium and phosphorus metabolism.

In a study conducted by CARI Regional Centre, it was found that by increasing the protein content in the diets of ducklings from 18 to 20 and 22%, there was an increase in apparent dry matter digestibility. At the same time, there was a slight increase in blood glucose, total protein, albumin, globulin, albumin/globulin ratio, total cholesterol and creatinine concentration [17].

Nitrogen metabolism is a criterion for assessing protein metabolism in the body, by which the productivity of poultry can be judged. In balance experiments conducted at the end of the second phase of fattening, it was found that with an increase in protein level in the diet from 17 to 23%, there was an increase of 5.1-24.8% in the amount of nitrogen taken in with feed compared to group 1 (Table 4). Differences in the amount of nitrogen ingested with feed influenced its excretion with the manure, which in turn resulted in changes in digestibility, protein digestibility in the poultry body.

It was found that an increase in nitrogen flow into the poultry body, was accompanied by an increase in nitrogen content in manure. The lowest nitrogen concentration in manure was found in group 1 and the highest in group 4, with a difference of 15.9% (P<0.001). However, total digested nitrogen increased in groups 2, 3 and 4 with increasing levels of protein in feed by 5.6-11.9% (P<0.05), 12.8-18.7% (P<0.001), 3.8-9.4% respectively, compared to group 1 and the control. There was an inversely proportional relationship with total nitrogen ingested with feed. With an increase in protein intake to 21%, there was little change in the amount of assimilated nitrogen from feed intake between the groups. However, further increasing the protein level in feed in group 4 where ducklings were fed mixed feed
with 23% crude protein led to a significant decrease in assimilated nitrogen from the amount taken in with feed by 9.0%. Consequently, the capacity of the proteolytic enzymes of the digestive tract is limited and has age-related features, as a result of which the excessive protein intake may not be digested and may transit into manure and a certain proportion of the nitrogenous substances intake will remain unclaimed for synthetic, productive purposes. The results of our research are consistent with those of other scientists [3,17], who found that during fattening of the Star 53 HY cross, the highest digestibility of protein, fat, fibre and NFES was found in ducklings fed compound feed in the first and second fattening periods with 22 and 20% of crude protein, respectively.

Table 4. Nitrogen metabolism in the digestive tract of ducklings.

| Indicator                        | Control     | Experimental |
|----------------------------------|-------------|--------------|
| Nitrogen taken with feed, g      | 6.83±0.15   | 6.50±0.13 a  |
| Nitrogen excreted with manure, g | 1.89±0.10   | 1.81±0.09    |
| Absorbed in the body, g          | 4.94±0.11   | 4.69±0.17    |
| Absorbed from ingested food, %   | 72.3        | 72.2         |

Table 5. Indicators of young ducks control slaughter.

| Indicator                        | Control     | Experimental |
|----------------------------------|-------------|--------------|
| Number of animals                | 15          | 15           |
| Pre-slaughter weight, g          | 3,285       | 3,252        |
| Weight of gutted carcasses, g    | 2,251       | 2,212        |
| % to the control                 | 100         | 98.5         |
| Slaughter yield, %               | 68.5        | 68.0         |

The results of the control slaughter of the ducklings conducted at the end of fattening showed that the gutted carcass weights were high in group 3 ducklings, which were 11.1 and 12.6% higher than those of control and group 1 (Table 5).

Table 6. Anatomical dissection of the ducklings.

| Indicator                        | Control     | Experimental |
|----------------------------------|-------------|--------------|
| Number of animals                | 15          | 15           |
| Pre-slaughter weight, g          | 3,285       | 3,252        |
| Weight of gutted carcasses, g    | 2,251       | 2,212        |
| % to the control                 | 100         | 98.5         |
| Slaughter yield, %               | 68.5        | 68.0         |
feed in group 4, there was an increase of 0.3-0.5% in fat yield. During deboning of carcasses, it was found that with an increase in the level of protein in the feed there was a decrease in bone mass in the carcasses from 27.4% in the 1st group to 29.1% in the 3rd group. At the same time, there was an increase in the yield of muscle tissue from 46.7 to 49.1% mainly due to the muscles of the thoracic part of the carcasses. This resulted in an increase in the ratio of muscle tissue to bone mass from 1.58 to 1.79%. Increasing the protein content in the feed for the second phase of fattening from 17 to 21% was accompanied by an increase in the yield of edible body weight from 55.7% to 58.0% of the live weight of ducklings before slaughter. The high protein content in the mixed fodder of the 4th group of ducklings at 23% resulted in obtaining carcass anatomical cut scores at the level of the control and 2nd groups where ducklings were fed mixed fodder with a lower protein content of 18% and 19%.

Table 6. Indicators of the anatomical carcass dissection.

| Indicators                             | Control     | Group 1 | Group 2 | Group 3 | Group 4 |
|---------------------------------------|-------------|---------|---------|---------|---------|
| Live weight, g                        | 3,285       | 3,252   | 3,431   | 3,583   | 3,382   |
| Weight of gutted carcasses, g          | 2,251       | 2,212   | 2,378   | 2,501   | 2,336   |
| Skin with subcutaneous fat, g          | 488         | 487     | 518     | 543     | 504     |
| yield, %                              | 21.7        | 22.0    | 21.8    | 21.7    | 21.6    |
| Inner fat, g                          | 38.2        | 39.8    | 40.4    | 45.0    | 51.4    |
| yield, %                              | 1.7         | 1.8     | 1.7     | 1.8     | 2.2     |
| Total muscle tissue, g                | 1,069       | 1,033   | 1,149   | 1,228   | 1,111   |
| including chest muscles               | 47.5        | 46.7    | 48.3    | 49.1    | 47.6    |
| including thigh muscles               | 608         | 568     | 651     | 710     | 633     |
| Bone weight, g                        | 461         | 465     | 493     | 518     | 488     |
| yield, %                              | 29.1        | 29.5    | 28.2    | 27.4    | 28.6    |
| Weight of edible body parts, g         | 1,846       | 1,811   | 1,956   | 2,078   | 1,931   |
| yield, %                              | 56.2        | 55.7    | 57.3    | 58.0    | 57.1    |
| Ratio of muscle tissue to bone mass, % | 1.63        | 1.58    | 1.71    | 1.79    | 1.66    |

Thus, the results of the control slaughter and anatomical cutting of carcasses show that increasing the crude protein content in the feed for ducklings during the second phase of fattening from 17 to 21% leads to increasing the slaughter yield from 68 to 69.8%, the yield of muscular tissue and edible body parts by 2.4 and 2.3%, respectively, and increasing the ratio of muscular tissue to bone mass from 1.58 to 1.79%. An objective criterion for evaluating the zootechnical efficiency of fattening young poultry for meat can be the European fattening efficiency index, which combines several final fattening parameters. It is stated that increasing the protein level in feed from 21 to 23% in the first phase of fattening and from 17 to 21% in the second phase increases the European fattening efficiency from 233 to 300 units or by 28%. A further increase in protein content in feed during the first phase of fattening from 23 to 25% and during the second phase from 21 to 22% is accompanied by a reduction in this index to the level of the protein content of the 1st test group.

The efficiency of fattening under production conditions is determined by economic efficiency indicators. The conducted calculations show that the greatest amount of poultry meat was obtained in the 2nd and 3rd experimental groups, by 12.4-14.1 and 17.18.7% compared to the control group and the 1st experimental group. The minimum amount of meat was obtained in the 4th experimental group, which was due to the high mortality of young animals of 12%. Despite the high cost of fodder, due to the high weight gain the cost of meat in the 3rd and 4th groups was the lowest and as a result the profitability level in these groups was 10-12.3% higher than in the control and by 25.5-27.8% higher than in the 4th experimental group. The level of profitability in the control and in the 1st experimental group was the same and amounted to 29%. Thus, the highest European fattening efficiency and profitability level of meat production was established in the 3rd experimental group, where the ducklings were fed the experimentally developed high-protein mixed fodder.
References

[1] Greenhalgh S, McInerney B V and McQuade L R 2020 Capping dietary starch: protein ratios in moderately reduced crude protein, wheat-based diets showed promise but further reductions generated inferior growth performance in broiler chickens *Animal Nutrition* **6** (2) 168–178

[2] Pogosyan D, Zimnyakov V, Zueva E and Varlamova E 2020 The use of unconventional feed for broiler chickens *Univ agricultural sciences & veterinary medicine** 63** 124–128

[3] Balanchuk N 2013 Digestibility of nutrients and nitrogen balance in ducks depending on the levels of protein and lysine nutrition *Almanac of Modern Science and Education** 11** (78) 26–29

[4] Siregar A, Cumming R and Farrell D 1982 The nutrition of meat-type ducks. 1. The effects of dietary protein in isoenergetic diets on biological performance *Australian Journal of Agricultural Research** 5** 857

[5] Egorov I A, Egorov V A, Manukyan T M and Okolelova I A 2015 Methodological guide to feeding poultry (Sergiev Posad: VNITIP) p 119

[6] GOST 18221-2018 Interstate standard 2018 Compound feeds are full-fledged for poultry. General technical conditions (Moscow: Standartinform)

[7] Cho H M, Samiru S W and Shemil P M 2020 Evaluation of crude protein levels in White Pekin duck diet for 21 days after hatching *Journal of Animal Science and Technology** 5** 628–637

[8] Joshi S K, Sahoo S K, Babu L K and Mondal Debabrata 2015 Effects of feeding different levels of proteins on the performance in Khaki Campbell ducks during starter stage *Indian Journal of Animal Research** 1** 70

[9] Lü W, He J H and Li's J B 2013 Effects of different supplemental levels of cassava on growth performance and nutrient utilization of meat ducks *Journal of huan human agricultural university** 1** 78–82

[10] Everaert N et al 2010 The effect of the protein level in a pre-starter diet on the post-hatch performance and activation of S6K1 in muscle of neonatal broilers *British Journal of Nutrition** 103** 206–211

[11] Collin A et al. 2003 Effects of dietary macronutrient content on energy metabolism and uncoupling pro-tein mRNA expression in broiler chickens *British Journal of Nutrition** 90** 261–269

[12] Swennen Q, Janssens G P J, Decuyper E and Buyse J 2004 Effects of substitution between fat and protein on feed intake and its regulatory mechanisms in broiler chickens: energy and protein metabolism and diet-induced thermogenesis *Poultry Science** 83** 1997–2004

[13] Zeng Q F, Cherry P and Doster A 2015 Effect of dietary energy and protein content on growth and carcass traits of Pekin ducks *Poultry Science** 3** 384–394

[14] Abdel-Hamid S E and Abdelfattah E M 2020 Effect of Different Dietary Protein Levels on Some Behavioral Patterns and Productive Performance of Muscovy Duck *Advances in Animal and Veterinary Sciences** 6** 661–667

[15] Sergeevskaya I A 2015 Productivity and use of nutrients in broiler chickens of different crosses with two- and three-phase feeding with different levels of metabolic energy and raw protein *Collection of articles Multifunctional adaptive feed production* (Moscow: Ugreshskaya printing house) pp 324–329

[16] Fisinn V I, Egorov I A, Osmanyan A K, Mahdavi R and Malorodov V V 2017 The effectiveness of broiler cultivation depending on the levels of metabolic energy and protein in pre-starter diets *Poultry and poultry products** 6** 30–33

[17] Kyrylv B and Gunchak A 2016 Intensity of protein metabolism in the body of ducks of meat productivity in ontogenesis *Stiinta zootehnica – factor important pentru o agricultură de tip european* (Maximovca: Print Caro) pp 703–708