The quality of quail meat upon crossbreeding

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Abstract. The growing consumer demand for safe food offers great prospects for the production of quail meat. The progress in poultry farming is based on the use of hybrid breeds. This study was carried out at the Siberian Research Institute of Poultry (Omsk Region). Studied were the productivity and quality of quail meat of Japanese and Pharaoh breeds and their hybrid combinations (♂Japanese×♀Pharaoh and ♂Pharaoh×♀Japanese). Hybrid combinations had lower body weight than the Pharaoh breed (by 7.78-16.30%, p<0.05), but larger body weight than the Japanese breed (by 11.33-22.66%, p<0.05). The discrepancies in body weights are due to the weight of the pectorals, the share of which is 19.43-21.63% for males and 18.34-19.45% for females. The superficial pectoral muscle accounts for the bulk of the weight of the pectoral muscles (74.09-78.22%). The deep pectoral muscle accounts for 21.78-25.91%. The area of muscle fibers of the superficial pectoral muscle is 226-299 μm², the area of deep pectoral muscle is 409-443 μm². For hybrid combinations, the area of fibers of the superficial and deep pectorals depends on the male breed. The protein content in the pectoral muscles of the Pharaoh breed was higher than that of the Japanese by 1.01-1.02 g, but the fat content was lower by 0.24-0.96 g. In hybrids, the paternal form has an impact on the protein content in the pectoral muscles, and the maternal form has an impact on fat content.

1. Introduction

Poultry is characterized by a vast variety of species raised for meat, which are intensively selected. The dominant directions in the development of poultry farming use hybrid breeds. It is based on the presence of a large number of breeds and lines of poultry, which have undergone intensive selection over a large number of generations. Divergent selection of poultry for meat and egg production resulted in a great difference between the poultry lines in terms of productivity as well as growth and development patterns. Artificial directional selection of poultry by body weight led to a change in the quantitative and qualitative indicators of meat, which depend on the breed and line [1-4]. Analysis of the profitability of quail meat production confirms that this direction has great potential. Raising quail is relatively less expensive in terms of keeping, feeding, and veterinary protection compared to other types of poultry. Quail meat is a premium product that complements the market for other poultry meat [5-9].

The combination of paternal and maternal forms in crosses affects the proportion of muscle in the total carcass weight of hybrid crosses. The influence of parents on the meat productivity of offspring has been established. These patterns are the basis for the selection of the crossing scheme to effectively obtain poultry meat [10].
To meet the growing demand for pectoral meat, breeding programs include poultry lines with rapid pectoral muscle development. Selection by this characteristic may be associated with changes in the anatomical structure of the pectoral muscles. The superficial pectoral muscle increased significantly. It is assumed that selection for an increase in the growth rate of the pectoral muscles led to a change in the area of the muscle fibers of the pectoral muscles and the content of protein and fat in them [11-16].

This work aims to study the influence of the quail breed on the productivity and quality of meat of hybrid combinations upon reciprocal crossing.

2. Materials and methods

The study was carried out at the Siberian Research Institute of Poultry, branch of Omsk Agricultural Scientific Center (Omsk region, Russia). The test control included 100 day-old quails of breeds Pharaoh (Ph), Japanese (J) and hybrid combinations: Japanese×Pharaoh (JPh) and Pharaoh × Japanese (PhJ). The meat quality of the carcasses was determined based on the control slaughter of ten heads of each group (10 males and 10 females) at the age of 42 days. The nutritional value of quail meat was determined based on muscle biochemical analysis. Material for histological examination of the superficial and deep pectoral muscles of quail was fixed in a 10% buffered formalin solution, compacted by embedding in paraffin. The obtained histosections were stained with hematoxylin and eosin. Microscopy was performed using the microscope "LOMO Mikmed-5". Micrometry analysis was carried out using the screw eyepiece micrometer MOV - 1-16x. Statistical processing was carried out using the SPSS 20.0 software package. The first threshold of significance was considered statistically significant (p <0.05). The obtained data on the area of muscle fibers of the superficial and deep pectoral muscles of quail of the original breeds and hybrids were used to construct a dendrogram. The degree of convergence of the clusters was judged by the Euclidean distance.

3. Results and discussion

Quails of all four groups significantly differed in body weight. The difference in body weight was 33.54% for males, and 33.00% for females. The hybrids showed additive inheritance of the trait: the considered indicator was less than for the Pharaoh breed, but higher than for the Japanese breed. While the body weight of the JPh hybrid and the original breeds are comparable (compared with Pharaoh Δ♂=-13.95%, Δ♀=-16.30%; compared with Japanese Δ♂=14.91%, Δ♀=11.33%), the PhJ hybrids showed a deviation of this indicator towards the parental breed (compared with Pharaoh Δ♂=-10.23%, Δ♀=7.78%; compared with Japanese Δ♂=19.88%, Δ♀=22.66%). The reciprocal crossing showed, that when the males of the heavy breed (Pharaoh) are used as paternal form and females of the lightweight breed (Japanese) are used as maternal form, the body weight of the hybrids increased compared to the option when the lightweight breed is used as paternal form with the heavy breed as maternal form. PhJ hybrids had a higher body weight compared to JPh hybrids (Δ♂= 4.32%, Δ♀= 10.18%). Revealed was the dominant influence of the paternal breed (in comparison with the maternal one) in crosses on the body weight of the hybrids (η2♂ = 0.78, η2♀ = 0.20, p <0.001) (Table 1).
The inheritance of the pectoral muscle weight of the hybrids was additive and tended towards the heavier Pharaoh breed. A tendency common for males and females was noted: with an increase in pectorals weight (Japanese → JPh → PhJ → Pharaoh), the ratio of weight of the superficial and deep muscles decreases.
Micromorphological analysis of the pectoral muscles indicates that the superficial and deep muscles of the chest have various structures of muscle fibers and depend on the direction of the breed productivity. The average area of the muscle fibers of the deep pectoral muscle is 1.5-1.8 times larger than that of the superficial pectoral muscle. The maximum difference was noted for the Japanese quail of the egg production direction, the minimum - for the Pharaoh breed of the meat production direction. A general pattern was revealed: with an increase in live weight, the ratio of the weight of the superficial and deep pectoral muscles and the difference in the average area of their muscle fibers decreases.

The breeds having polar productivity directions (Pharaoh and Japanese) showed the greatest difference in the area of the superficial ($\Delta^\phi = 27.23\%$, $\Delta^\gamma = 29.20\%$) and deep pectoral muscles ($\Delta^\phi = 6.55\%$, $\Delta^\gamma = 8.31\%$). Males and females of both hybrid combinations significantly differed from the original breeds in the average area of fibers of the superficial pectoral muscle, which had a greater weight in comparison with the deep pectoral muscle. Differences in the area of the fibers of the deep pectoral muscle were registered only for hybrid females with females of both breeds. The area of muscle fibers of both pectoral muscles was larger for the PhJ hybrid than for the JPh hybrid, but these differences were not significant. The analysis of correlations made it possible to establish that the body weight and the area of muscle fibers had a high interrelation. A slightly greater correlation was noted between the live weight and the area of muscle fibers of the deep pectoral muscle ($r = 0.991-0.999$, $p < 0.01$) than that for the superficial pectoral muscle ($r = 0.985-0.995$, $p < 0.01$).

According to the average fiber area of the superficial and deep pectoral muscles, the original breeds are combined into one cluster with hybrids based on the common parental breed belonging. The location of the clusters on the Euclidean distance scale indicates that the Pharaoh breed and the PhJ hybrid have a greater similarity than the Japanese and JPh hybrid (Fig. 1).

![Figure 1. Dendrogram of the muscle fiber area of breeds and hybrids.](image)

Pharaoh quails with a higher growth rate had more protein (1.01-1.02 g) and less fat (0.24-0.96 g) in the pectoral muscles compared to Japanese quails. PhJ hybrids were close in muscle protein content to their paternal Pharaoh breed. The protein content in the pectoral muscles of the JPh hybrid was comparable to that of the Japanese breed. It was found that for both hybrids the fat content in the pectoral muscles exceeded that of the parent breeds.

The protein-quality indicator (PQI) quantitatively characterises the consumer properties of meat. The pectoral muscles of the Pharaoh quail had the highest PQI. The muscles of both hybrids contained more tryptophan than that of the Pharaoh breed. As a result, the PQI of the pectoral muscles of hybrids was higher (Table 2).
Table 2. Biochemical composition and biological values of quail pectoral muscles

| Characteristics                  | Japanese Males | Females | Pharaoh Males | Females | J×Ph♂ Males | Females | J×Ph♀ Males | Females | Ph×J♂ Males | Females | Ph×J♀ Males | Females |
|----------------------------------|----------------|---------|---------------|---------|-------------|---------|-------------|---------|-------------|---------|-------------|---------|
| Content per 100 of product, g:   |                |         |               |         |             |         |             |         |             |         |             |         |
| protein                          | 21.50          | 21.53   | 22.52         | 22.54   | 21.43       | 21.52   | 21.84       | 21.91   |             |         |             |         |
| fat                              | 2.89           | 2.54    | 2.65          | 1.58    | 2.95        | 3.26    | 3.03        | 4.33    |             |         |             |         |
| Fat:Protein                      | 1:7.44         | 1:8.48  | 1:18.50       | 1:14.27 | 1:7.26      | 1:6.60  | 1:7.21      | 1:5.06  |             |         |             |         |
| Tryptophan, %                    | 1.22           | 1.45    | 1.59          | 1.60    | 1.35        | 1.61    | 1.42        | 1.55    |             |         |             |         |
| Oxyproline, %                    | 0.234          | 0.291   | 0.251         | 0.227   | 0.221       | 0.263   | 0.245       | 0.274   |             |         |             |         |
| PQI                              | 5.21           | 4.98    | 6.33          | 7.05    | 6.11        | 6.12    | 5.80        | 5.66    |             |         |             |         |

The protein-quality indicator of the pectoral muscles has a close negative relationship with the average fiber area of the superficial and deep pectoral muscles (respectively $r_s=-0.976$ to $-0.982$ and $r_d=-0.897$ to $-0.988$, $p<0.01$).

Reciprocal crossing of quails of two breeds of different productivity directions made it possible to establish the proportion of the influence of the paternal and maternal forms on the studied parameters of productivity and quality of meat. It was found that the influence of the paternal form prevailed over the maternal in relation to the weight of the pectoral muscles, the area of their muscle fibers and their protein content. Interestingly, it is manifested for the superficial pectoral muscle to a greater extent than the deep pectoral muscle. In terms of muscle protein content, on the contrary, the influence of the paternal form was stronger for the deep pectoral muscle than for the superficial one. The fat content in the pectoral muscles was more influenced by the maternal form.

Table 3. Proportion of influence of the parent form ($\eta^2$).

| Characteristics                  | Males Parental | Maternal | Females Parental | Maternal |
|----------------------------------|----------------|----------|------------------|----------|
| Weight of pectoral muscles:      |                |          |                  |          |
| Total                            | 0.71*          | 0.28*    | 0.69*            | 0.28*    |
| superficial                      | 0.74*          | 0.24*    | 0.75*            | 0.22*    |
| deep                             | 0.66*          | 0.33*    | 0.64*            | 0.35*    |
| Area of muscle fibers:           |                |          |                  |          |
| superficial                      | 0.66*          | 0.27*    | 0.67*            | 0.31*    |
| deep                             | 0.58*          | 0.19*    | 0.55*            | 0.21*    |
| Protein content in pectoral muscles|                |          |                  |          |
| superficial                      | 0.68*          | 0.22*    | 0.70*            | 0.19*    |
| deep                             | 0.71*          | 0.25*    | 0.72*            | 0.22*    |
| Fat content in pectoral muscles  |                |          |                  |          |
| superficial                      | 0.25*          | 0.62*    | 0.20*            | 0.59*    |
| deep                             | 0.22*          | 0.74*    | 0.19*            | 0.68*    |

Note: * – $p<0.05$

4. Conclusion
The hybrids showed additive inheritance of the trait: yielding to the Pharaoh breed, they were superior to the Japanese breed. PhJ hybrids had higher live weights compared to JPh hybrids ($\Delta\bar{x}=4.32\%$, $\Delta\bar{y}=10.18\%$). The differences in body weight are explained by the weight of the pectoral muscles, the weight of which was 31.28-46.5 g for males and 37.23-52.10 g for females. The superficial pectorals (74.09-78.22%) accounted for the bulk of the weight of pectoral muscles. The deep pectoral muscle weight accounted for 21.78-25.91%. The average area of the muscle fibers of the deep pectoral muscle is 1.5-1.8 times larger than that of the superficial pectoral muscle. Males and females of hybrids significantly differed from the parent breeds in the average area of fibers of the superficial pectoral...
muscle. PhJ hybrids were close in muscle protein content to their paternal Pharaoh breed. The protein content in the pectoral muscles of the JPh hybrid was comparable to that of the Japanese breed. The influence of the paternal form prevailed over the maternal in terms of pectoral muscle weight, muscle fiber area, and muscle protein content. The fat content in the pectoral muscles was more influenced by the maternal parental form.

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