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RESULTS OF SELECTION FOR BREAST MUSCLE PERCENTAGE AND FEED CONVERSION RATIO IN PEKIN DUCKS

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Review paper

Abstract: Increasing breast muscle percentage by selection for breast layer thickness (muscle and skin) of living ducks by needle probe improves carcass quality as could be demonstrated by experiments and by applied breeding programs. In addition direct selection for individual feed conversion ratio can increase the efficiency of duck meat production. Divergent selection for feed conversion ratio from the age of 4 – 7 weeks over 11 generations has differentiated the feed efficiency by about 25 %. Causes for the reduction in feed conversion ratio are lower fat content of carcass, lower locomotor activity, higher enzymatic activity (alkaline phosphatase and creatinkinase in blood plasma) and better feed protein utilization. Because of lower feed consumption in the line selected for lower feed conversion ratio the emission of nitrogen and phosphorus via manure was reduced by about 39 and 26 %, respectively. That means, selection for better feed efficiency is not only an important economical but also an important ecological factor.

Key words: duck meat, percentage of breast muscle, feed efficiency

Development of duck meat production

Ducks were known in ancient China and they had already achieved considerable status at that time. The use of meat of duck goes back to very early times in the history. It belongs to the food with high nutritional quality and is marketed at relatively low prices. Therefore, there is a sharp rise in the production of duck meat in the world during the last decades. The duck meat production was 1.27 million tons in 1991 and 3.85 million tons in 2010. Production of duck meat accounts for 4.08 % of the total world poultry meat production..

France, Malaysia, Vietnam, Myanmar, Thailand, Germany and South Korea are the leading countries in duck production after China (Table 1).

Table 1. Leading countries in duck meat production in 2009, *(FAO STATISTICS, 2011)*

Country	Total duck meat, Mt	Duck meat/head, kg	Of poultry meat, %
China	2,644	1.9	16.1
France	238	3.8	14.0
Malaysia	108	4.0	10.2
Vietnam	81	0.9	13.5
Myanmar	81	1.6	9.2
Thailand	77	1.1	6.7
Germany	62	0.7	4.8
Rep. Korea	55	1.1	9.9
Hungary	52	5.2	13.4
USA	50	0.16	0.26
India	46	0.04	6.4
Egypt	39	0.5	5.3
UK	30	0.5	1.8
Indonesia	26	0.11	1.8
Bangladesh	23	0,14	12.8
Mexico	21	0.2	0.8
Philippines	14	0.15	1.8

With regard to duck production per head Hungary, Malaysia, France and China are leading, but with regard to percentage of duck production of total poultry meat China with 16 %, followed by France, Vietnam and Hungary with about 14 % are the leaders. In some Asian countries duck meat production per head is relatively low like in India, Indonesia and Phillppines, because it is only a by-product of duck egg production.

Meat yield

Peking ducks are very fast growing birds. They reach about 80 % of the final weight at the age of 7 weeks. But there are definite limits for the reduction of slaughter age for ducks because of late breast muscle growth as shown in table 2. The volume of breast and leg muscle were determined by magnetic resonance-imagine (MRI) from 4 to 10 weeks of age at intervals of two weeks.

The intensive growth of breast muscle starts relatively late at the age of 5 to 6 weeks along with development of wing feathers to reach the ability to fly at the age of 8 weeks.

It is possible to grow Peking ducks to satisfactory weights as early as 5 weeks. However, at this age the ducklings do not meet the requirements of consumers due to insufficient breast muscle development. The maximum gain of breast muscle is reached in males and females of Peking ducks at the age of 45 and 43 days. For carcass quality, it is important to utilize the growth capacity of the meat rich parts. If waterfowl is slaughtered too early, muscles at the breast are missing and the ratio of muscles to skin is unfavourable.

The growth of leg muscle volume agrees with growth of body weight. The maximum gain of leg muscle is reached in males and females of Peking ducks at the age of 19 and 17 days,

Table 2. Growth parameters of body weight (g) and breast muscle volume (cm³) of Peking ducks *(Wiederhold, 1996)*

Body weight	Final body weight (g)	Maximum daily. gain (g)	At body weight (g)	At the age (d)	Body weight at 2nd turning point (g)	Age at 2nd turning point. (d)
Drakes	2950	129	1085	17	2014	25
Ducks	2621	128	964	16	1789	24
Breast muscle volume	Final volume (cm³)	Maximum gain per day	At volume of	At age of (d)	Volume at 2nd turning point	Age at 2nd turning point (d)
Drakes	472.5	10.6	173.8	45	322.5	60
Ducks	404.2	8.6	148.7	43	275.9	59
Leg muscle volume						
Drakes	205.8	8.2	75.9	19	140.5	28
Ducks	174.9	7.5	6.3	17	119.4	25

The late start of breast muscle growth is a limit for the reduction of slaughter age and an indirect improvement of feed efficiency. Therefore, the main objective of successful duck breeding is to increase the percentage of breast muscle and to improve feed efficiency by direct selection for feed conversion ratio.

Meat yield is a difficult trait to assess. It can only be measured accurately after the bird has been slaughtered. Fortunately, the yield of breast meat is positively correlated with the thickness of breast meat. Therefore, selection for higher breast meat yield is possible by measuring the thickness of breast meat in living ducks (Figure 1). As shown in table 3 the relationship between breast meat thickness (measured by a needle probe) and the percentage of breast muscle to carcass with 0.73 is high enough for practical selection. The high accuracy of determining the percentage of breast muscle in live ducks is due to the cylindrical form of the trunk.

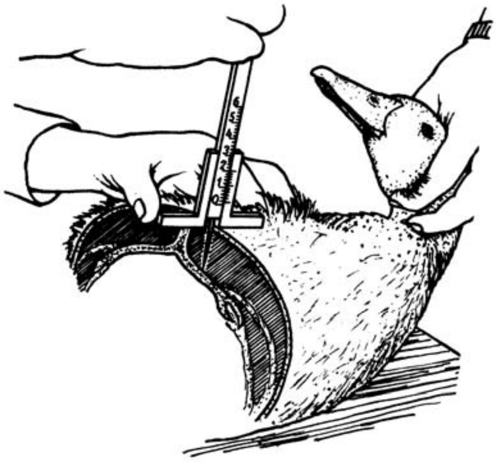

Figure 1. Measure of breast meat thickness by a needle probe

Table 3. Relationship of breast meat thickness (BMT) and body weight (BW) with amount and percentage of breast muscle in ducks

	Amount of breast muscle	Percentage breast muscle
BMT	0.68	0.73
BW	0.48	-0.04
BMT+BW (multiple correlation)	0.81	0.73
BMT-BW (partial correlation)	0.75	0.73

In a breeding experiment with Peking ducks over 7 generations a synthetic line was selected for body weight and breast meat thickness at the age of 8 weeks and compared with an unselected control (Table 4).

Table 4. Body weight, breast meat thickness and percentage breast muscle of carcass after 7 generations

	Selected line	Control line	Difference (%)
N	675	689	-
Body weight (g)	3287	2782	+18.2
Breast meat thickness (cm)	1.98	1.69	+17.2
Breast muscle (%)	13.0	11.9	+9.4

The cumulative selection differences for body weight and for breast meat thickness were 1288 g and 0.91 cm, respectively. These results had been adjusted for the number of offspring per breeding duck. The realized heritability for both traits in this series of experiments had been 0.39 and 0.32, respectively, thus confirming the estimated values.

Feed conversion ratio (FCR). Selection for rapid growth rate means that ducklings reach slaughter weight at younger ages and thus feed conversion will be improved by the reduction of maintenance requirement. A reduction of one day in reaching a certain body weight reduces feed consumption of Peking ducks by 100-120 g and reduces feed conversion ratio by 0.04 kg. However, the marketing of waterfowl at younger age results in lowered breast muscle percentage and increased subcutaneous fat deposition as was shown above. Therefore, direct selection for feed conversion ratio was investigated with an experimental population created by crossing of flyable dwarf ducks with heavy Peking ducks. Each line consisted of 20 pens of 1 male and 2 female. The initial population was used as a control population with random mating. Two lines were selected divergenrly for feed conversion ratio, low FCR and high FCR. FCR was defined as the quotient of food consumption and body weight gain. The individual feed consumption was measured during a test period from the age of 4-7 weeks. In that time the offspring were kept in single cages (0.4 by 0.6 m) by individual feeding. About 10-15 % sons and 20-30 % daughters were selected in each line.

Table 5 shows results of estimation of genetic parameter of body weight and feed conversion ratio based on 2189 tested ducks (with pedigree) from the control line.

Table 5. Phenotypic (rp) and genetic (rg) correlations and heritability (diagonal) of body weight (BW) and feed conversion ratio (FCR) in the control line (n = 2189) ***(Klemm, 1995)***

rp rg	BW (21^{st} d)	BW (49^{th}d)	BW-Gain	Feed Consumption	FCR
BW (21^{st} d)	*0.40*	+ 0.58	+ 0.35	+ 0.35	+ 0.29
BW (49^{th} d)	+ 0.57	*0.47*	+ 0.83	+ 0.70	- 0.28
BW-Gain	+ 0.03	+ 0.85	*0.50*	+ 0.63	- 0.55
Feed cons.	+ 0.21	+ 0.65	+ 0.64	*0.58*	+ 0.25
FCR	+ 0.34	- 0,27	- 0.54	+ 0.59	*0.52*

It was found that body weight gain and body weight at the age of 49 days have a negative relationship to feed conversion ratio and a positive correlation to feed consumption. Body weight and feed conversion ratio have moderately high heritability. The heritability for FCR amounts to 0.52.

The response of selection for feed conversion ratio is shown in table 6 after 11 generations.

Table 6. Effect of selection for feed conversion ratio (FCR) in Peking ducks after 11 generations

Line	Body weight at the age of 7 weeks, g	FCR 4-7 weeks, kg	Skin of breast and leg, % of carcass
Low FCR	2649	2.847	11.7
High FCR	2306	3.710	16.1
Control	2145	3.305	14.4

There was a significant differentiation with strong effects on skin percentage and fat content. The percentage of skin with subcutaneous fat was markedly reduced. The reduction of carcass fat is an important reason for differences in feed conversion ratio.

The significant genetic differentiation for feed conversion ratio leads to the question, which factors apart from carcass composition and fat content are responsible for the differences in feed conversion ratio. Ducks with low and high feed conversion ratio were compared for utilization of protein and energy. Ducks of the low feed conversion line had a better protein utilization, but the energy utilization was poorer (Table 7).

Table 7. Effect of divergent selection for feed conversion ratio after 6 generations on protein and energy utilization *(Pahle et al., 1989)*

	Low FCR	High FCR
Number of ducks tested	16	16
Intake of dry matter (g)	6117	6137
Body weight gain (g)	1909	1619
Intake of dry matter/gain (g/g)	3.2	3.8
g protein retention/100 g protein intake	26.0	23.2
MJ energy retention/MJ energy intake	0.345	0.361

Improvements in feed efficiency cause differences in metabolism and physiological parameters..The activity of alkaline phosphatase in plasma was much higher in ducks of the low feed conversion line than in ducks of the high feed conversion line *(Müller, 1986)*. Despite reduction of fat content in the strain with low feed conversion ratio there was no negative effect on sensorial traits. There was no disadvantage in tenderness, juiciness and taste for breast meat of ducks with low feed conversion ratio.

Additional investigations were conducted to find out the emission of Nitrogen and Phosphorus of the low and high FCR lines. In two replications 16 birds of each line were kept in single cages from day 22 to day 48. The manure was collected daily, dried and analyzed.

Table 8 shows that there was no difference in excrements (dry matter) per kg feed intake. The reduction of emission of N and P in the low FCR-line was mainly caused by the decreased feed intake.

Table 8. Emission of nitrogen and phosphorus of ducks with high and low FCR (n=16) from day 22 to 49 of age

	Low FCR	High FCR
Gain, g	1450	1307
Feed consumption, g	4362	5209
Kg feed/kg gain	3.046	3.989
Excrements (dried), g	980	1140
Excr. (dried)/kg feed intake, g	225	219
N-intake, g	129.1	154.2
N-emission, g	61.6	77.2
N-emission/kg gain, g	42.8	59.4
P-intake, g	39.3	46.8
P-emission, g	24.9	31.0
P-emission/kg gain, g	17.3	23.7

Improvement or reduction of FCR results in lower pollution of environment. The emission of N and P via manure related to 1 kg gain of body weight is in the low FCR-line reduced by 28 and 27 %, respective. That means selection for feed efficiency is not only an important economical but also an important ecological factor.

Causes for the reduction in feed conversion ratio are lower fat content of carcass, lower locomotor activity, higher enzymatic activity (alkaline phosphatase in blood plasma) and better feed protein utilization

Rezultati selekcije na procenat mišića grudi i konverziju hrane pekinške patke

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Rezime

Povećanje procenta grudnih mišića selekcijom na debljinu slojeva grudi (mišići i koža) kod živih pataka, poboljšava kvalitet trupa, što bi se moglo dokazati eksperimentima i primenom odgajivačkih programa. Direktnom selekcijom na individualnu konverziju hrane može se povećati efikasnost proizvodnje pačijeg mesa. Divergentnom selekcijom na konverziju hrane u uzrastu od 4-7 nedelja tokom 11 generacija, diferencirano je efikasnije korišćenje hrane za oko 25%. Razlozi za redukciju konverzije hrane su niži sadržaj masti u trupu, manja lokomotorna aktivnost, veća enzimska aktivnost (alkalna fosfataza i keratin kinaza u krvnoj plazmi) i bolje iskorišćavanje proteina iz hrane.

Zbog manje konzumacije hrane u liniji selekcionisanoj na nižu konverziju hrane, emisija azota i fosfora iz stajnjaka je redukovana za oko 39, odnosno 26%. Što znači da selekcija na bolju efikasnost korišćenja hrane nije važna samo kao ekonomski već i kao važan ekološki faktor.

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