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Effects of Housing System, Swimming Pool and Slaughter Age on Duck Performance, Carcass and Meat Characteristics

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Abstract: The aim of this study was to determine the effects of different housing systems, swimming pool and slaughter age on performance, carcass and meat characteristics of ducks. A total of 420 (212 male, 208 female) one day old ducklings (Star 52-Grimaud Freres) were obtained from a commercial hatchery. The ducklings were randomly divided into four treatment groups; two Intensive Systems (IS) (one without pool and the other with swimming pool) and two intensive systems with outside activity (IOS) (one with swimming pool and the other without pool). Each group included 105 (53 male and 52 female) ducklings. European Efficiency Factor (EEF), feed efficiency and livability rate were affected by the housing system, swimming pool and age. Housing system and slaughter age significantly affected the slaughter weight and cold carcass yield. Breast, legs and wings percentages were significantly affected by slaughter age. PH_{24}, cooking loss, ash, protein and lipid contents of leg muscle were significantly altered by age. PH_{24}, ash, protein and lipid contents increased while, the cooking loss decreased with age. Housing system had no effect on the carcass chemical composition. From the point of EEF the market age of Pekin ducks at 6 weeks is more beneficial due to the better feed efficiency, lower feed intake and lower feed cost. Open sided area and swimming pool enhanced the EEF.

Key words: Duck, housing system, carcass, meat characteristics, swimming pool, slaughter age

INTRODUCTION

Ducks are among the most versatile of animals. They live happily under a wide range of climatic conditions and they are free from common poultry diseases such as leukosis, Marek's disease, infectious bronchitis and other respiratory troubles (Ensminger, 1992).

The best slaughter age of ducks was found between 7 and 8 weeks of life. Within this range, the meat content of carcass was the highest and meat to fat ratio proved the most favorable (Bochno *et al*., 1988). When, the age of the ducks exceeds 8 weeks the muscles no longer gain in weight, while, the gain of skin with subcutaneous fat increases (Gorski, 1990, 1997a, b).

The tissue composition of carcasses changes with age, because particular components show different growth rates. The percentage of meat and skin fat increases, whereas the percentage of bones decreases, as birds grow older. These changes are more radical in ducks than in chickens (Bochno and Lewczuk, 1986).

Duck production may partly compensate the increasing demand for animal protein. Ducks are able to adapt to wide range of environmental and natural conditions, which may be the reason for the increasing importance and popularity of the duck production (Solomon *et al*., 2006).

There is a paucity of information about effects of different housing systems and slaughter age on carcass traits in ducks. The present study was therefore, carried out to determine the effects of different housing systems, swimming pool and slaughter age on performance, carcass and meat characteristics of ducks.

MATERIALS AND METHODS

Animals, housing systems and diets: A total of 420 (212 male and 208 female) one-day-old ducklings (Star 52-Grimaud Freres) were obtained from a commercial hatchery. The ducklings were randomly divided into four treatment groups; two Intensive Systems (IS) (one without pool (Fig. 1a) and the other with swimming pool (Fig. 1b)) and two intensive systems with outside activity (IOS) (one with swimming pool (Fig. 1c) and the other without pool (Fig. 1d)). Each pen area for the IS was 30 m^2

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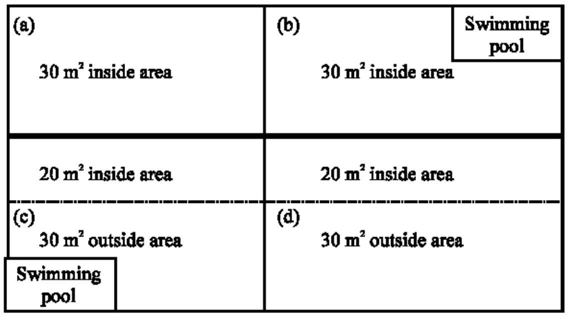

Fig. 1: Schematic drawing of pens. a): Intensive system without pool, b): Intensive system with pool, c): Intensive system with outside activity and pool and d): Intensive system with outside activity without pool

and for the IOS was 50 m^2 (20 m^2 inside area and 30 m^2 outside area). The size of each swimming pool was $1\times2\times0.5$ m in width x length x depth, respectively (Fig. 1a-d). Each group included 105 (53 male and 52 female) ducklings.

Litter was used in inside area of all pens. Within each pen, water was provided via a bell drinker and feed via a hanging bell feeder. Feeder space was 5 cm per duck and drinker space was 2.5 cm per duck. Ducks received natural daylight during daytime and artificial light during the night. All ducks consumed *ad libitum* two commercial diets (first 3 weeks 22% CP, 2950 kcal kg^{-1} ME and last 3 weeks 18% CP, 3050 kcal kg^{-1} ME). All animal-use protocols were in accordance with the regulations outlined by the Ethical Committee on Laboratory Animals of the Faculty of Veterinary Medicine at the University of Ankara. The experimental period lasted for 9 weeks.

Parameters: Records of feed consumption in each group were kept and birds were weighed individually at 6-9 weeks of age in order to calculate feed efficiency (kg of feed intake per kg of body weight gain). Then, European Efficiency Factor (EEF) was calculated (g gained/day X% livability rate/feed efficiency). Ten ducks (5 male and 5 female) chosen at random were weighed and slaughtered at a commercial slaughter house 12 h after their last meal at 6-9 weeks of age. Each carcass was weighed and was expressed as percentage of slaughter weight. The carcasses were stored at 4°C for 24 h. Then cold carcass weight and weights of breast, wing and legs (thigh and shank) with skin and bone were recorded. Cold carcass percentage was calculated as the ratio between cold carcass weight and slaughter weight. Weight of breast, leg and wing with skin and bone was expressed as a percentage of the cold carcass weight. Leg meats were used for analysis of pH, protein, fat, ash and cooking loss. The pH of meat samples at 24 h after the slaughter (pH_{24}) was measured. Samples from each meat were analyzed for protein, fat and ash by the standard procedures of AOAC (2002).

Statistical analysis: Because there were no differences using ANOVA in male and female carcasses, sex of the samples was not considered in the analysis. Analysis were carried out using ANOVA with general linear model procedure of SPSS 11.0 (SPSS, 2001) and differences were determined with Duncan test. Correlation coefficients between parameters were calculated. Livability rate was evaluated using the Chi-square (χ^2) test (Snedecor and Cochran, 1989).

RESULTS AND DISCUSSION

The main and interactive effects of different housing systems, swimming pool and slaughter age on duck performance are presented in Table 1. Initial body weight was not different among groups. EEF, feed efficiency and livability rate were affected by the housing system, swimming pool and age (Fig. 2 and 3). Livability rate was not statistically significant in groups at different weeks. Housing system and slaughter age significantly affected the slaughter weight and cold carcass yield. The mean slaughter weight of ducks in Intensive System with Outside (IOS) activity was better than Intensive System (IS). Also, swimming pool and age enhanced the slaughter weight. In all age groups, slaughter weight of ducks was higher in IOS with swimming pool. There were no interactions between housing system and swimming pool, housing system and slaughter age, swimming pool and slaughter weight, while, an interaction among housing systems, swimming pool and slaughter age was detected.

Cold carcass percentages were significantly higher in ducks of IS and also, at 8 weeks of age. Breast, legs and wings percentages were significantly affected by slaughter age. Breast increased while, legs decreased with age. Percentage of wing was higher in ducks at 8 weeks of age.

There were significantly positive correlations among cold carcass percentage, breast and wing percentages whereas negative correlation between cold carcass and leg percentages (Table 2).

PH_{24}, cooking loss, ash, protein and lipid contents were significantly altered by age. PH_{24}, ash, protein and lipid contents increased while, the cooking loss decreased with age. Housing system had no effect on the carcass chemical composition (Table 3).

Table 1: The effects of housing systems, swimming pool and slaughter age on slaughter weight, cold carcass, breast weight, leg weight and wing weight

Housing system	Swimming pool	Slaughter age (week)	Slaughter weight	Cold carcass (%)	Breast weight (%)	Leg weight (%)	Wing weight (%)
IOS	-	-	2903 ± 26^{y}	67.8 ± 0.2^{x}	27.9±0.2	20.9±0.2	12.8±0.1
IS	-	-	2779 ± 26^{x}	68.5 ± 0.2^{y}	28.4±0.2	20.6±0.2	13.1±0.1
-	-	-	0.001	0.019	NS	NS	NS
-	SP	-	2927 ± 26^{n}	67.9±0.2	28.5±0.2	20.6±0.2	12.8±0.1
-	NSP	-	2755 ± 26^{m}	68.4±0.2	27.9±0.2	20.8±0.2	13.1±0.1
-	-	-	0.000	NS	NS	NS	NS
-	-	6	2338 ± 37^{a}	65.1 ± 0.3^{a}	23.6 ± 0.3^{a}	23.2 ± 0.2^{c}	12.4 ± 0.2^{a}
-	-	7	2776 ± 37^{b}	67.7 ± 0.3^{b}	28.0 ± 0.3^{b}	20.6 ± 0.2^{b}	12.9 ± 0.2^{b}
-	-	8	2921 ± 37^{c}	70.6 ± 0.3^{d}	29.0 ± 0.3^{c}	20.1 ± 0.2^{b}	13.7 ± 0.2^{c}
-	-	9	3330 ± 37^{d}	69.2 ± 0.3^{c}	32.1 ± 0.3^{d}	19.0 ± 0.2^{a}	12.8 ± 0.2^{ab}
-	-	-	0.000	0.000	0.000	0.000	0.000
Interactive effects							
IOS	SP	6	2592±74	61.7±0.6	23.9±0.7	23.3±0.5	12.2±0.3
IOS	SP	7	2871±74	67.9±0.6	28.2±0.7	20.4±0.5	12.8±0.3
IOS	SP	8	3009±74	70.3±0.6	29.2±0.7	20.5±0.5	13.4±0.3
IOS	SP	9	3595±74	68.2±0.6	31.6±0.7	19.3±0.5	12.4±0.3
IOS	NSP	6	2266±74	65.8±0.6	22.3±0.7	24.4±0.5	12.3±0.3
IOS	NSP	7	2782±74	67.7±0.6	27.0±0.7	20.5±0.5	12.8±0.3
IOS	NSP	8	2968±74	70.3±0.6	29.0±0.7	19.8±0.5	13.7±0.3
IOS	NSP	9	3138±74	70.3±0.6	32.3±0.7	19.0±0.5	13.1±0.3
IS	SP	6	2228±74	67.5±0.6	24.3±0.7	22.4±0.5	12.6±0.3
IS	SP	7	2793±74	67.7±0.6	28.6±0.7	20.3±0.5	12.9±0.3
IS	SP	8	3001±74	70.2±0.6	29.6±0.7	20.2±0.5	13.6±0.3
IS	SP	9	3331±74	69.3±0.6	32.3±0.7	18.6±0.5	12.9±0.3
IS	NSP	6	2266±74	65.5±0.6	23.9±0.7	22.8±0.5	12.3±0.3
IS	NSP	7	2659±74	67.4±0.6	28.2±0.7	21.1±0.5	13.3±0.3
IS	NSP	8	2704±74	71.6±0.6	28.3±0.7	20.1±0.5	14.3±0.3
IS	NSP	9	3254±74	68.9±0.6	32.0±0.7	19.1±0.5	13.0±0.3
Housing system x Swimming pool		-	NS	0.006	NS	NS	NS
Housing system x Slaughter age		-	NS	0.003	NS	NS	NS
Swimming pool x Slaughter age		-	NS	NS	NS	NS	NS
Housing system x Swimming pool x Slaughter age			0.004	0.000	NS	NS	NS

IS: Intensive System, IOS: Intensive System with Outside activity, SP: Swimming Pool, NSP: Without Swimming Pool. Values are expressed as Mean±SEM, NS = Not Significant. $^{a-d}$, $^{x-y}$, $^{m-n}$: Significant difference between groups

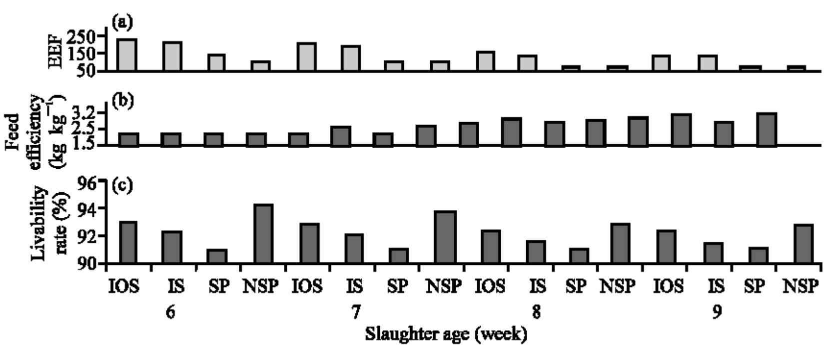

Fig. 2: The effect of slaughter age, housing system and swimming pool on EEF (a), feed efficiency (b), livability rate (c). IS: Intensive System, IOS: Intensive System with Outside activity, SP: Swimming Pool, NSP: Without Swimming Pool

EEF was higher in IOS than IS. This result could be explained by the higher slaughter weight, livability rate and better feed efficiency. Live weight at slaughter in IOS (2903 g) was higher than in IS (2779 g). Because IOS differs from IS in having outside activity and having more space, the body weight of ducks in this system was significantly higher than that in the IS. Also, in this study, swimming pool enhanced the EEF. This result could be explained by the fact that in this system slaughter weight and feed efficiency were better than the other system. Live weight at slaughter was higher in ducks in swimming pool. It could be due to access to water and therefore, this

Table 2: The correlation coefficient among cold carcass, leg weight, breast weight and wing weight

Variables (%)	Leg weight (%)	Breast weight (%)	Wing weight (%)
Cold carcass	-0.486^{**}	0.444^{**}	0.265^{**}
Leg weight	-	-0.644^{**}	-0.053
Breast weight	-	-	0.274^{**}

$^{**}p<0.01$

Table 3: The effects of housing systems, swimming pool and slaughter age on cooking loss, lipid, protein, ash and pH_{24}

Housing system	Swimming pool	Slaughter age (week)	Cooking loss (%)	Lipid (%)	Protein (%)	Ash (%)	pH_{24}
IOS	-	-	21.7±0.5	8.9±0.4	15.1±0.6	1.6±0.07	5.9±0.03
IS	-	-	20.8±0.5	8.2±0.4	15.6±0.6	1.8±0.07	5.9±0.03
-	-	-	NS	NS	NS	NS	NS
-	SP	-	21.1±0.5	8.8±0.4	15.3±0.6	1.7±0.07	5.9±0.03
-	NSP	-	21.4±0.5	8.4±0.4	15.4±0.6	1.7±0.07	5.9±0.03
-	-	-	NS	NS	NS	NS	NS
-	-	6	$24.2±0.7^a$	$6.0±0.6^a$	$12.0±0.8^a$	$1.0±0.1^a$	$5.5±0.04^a$
-	-	7	$22.5±0.7^a$	$9.2±0.6^b$	$15.0±0.8^b$	$1.7±0.1^b$	$5.8±0.04^b$
-	-	8	$19.6±0.7^b$	$9.6±0.6^b$	$17.7±0.8^c$	$2.0±0.1^c$	$6.2±0.04^c$
-	-	9	$18.7±0.7^b$	$9.5±0.6^b$	$16.7±0.8^{bc}$	$2.0±0.1^c$	$6.2±0.04^c$
-	-	-	0.000	0.000	0.000	0.000	0.000
Interactive effects							
IOS	SP	6	22.7±1.3	7.7±1.2	13.3±1.6	0.7±0.2	5.4±0.09
IOS	SP	7	22.7±1.3	11.0±1.2	15.5±1.6	1.7±0.2	5.6±0.09
IOS	SP	8	18.3±1.3	10.6±1.2	20.5±1.6	2.7±0.2	6.2±0.09
IOS	SP	9	17.6±1.3	10.6±1.2	17.1±1.6	2.8±0.2	6.2±0.09
IOS	NSP	6	25.6±1.3	5.1±1.2	12.1±1.6	1.4±0.2	5.2±0.09
IOS	NSP	7	23.2±1.3	9.0±1.2	12.2±1.6	0.9±0.2	6.1±0.09
IOS	NSP	8	21.7±1.3	10.0±1.2	14.4±1.6	1.4±0.2	6.1±0.09
IOS	NSP	9	21.6±1.3	7.4±1.2	16.1±1.6	1.4±0.2	6.2±0.09
IS	SP	6	22.5±1.3	7.1±1.2	11.3±1.6	0.7±0.2	5.5±0.09
IS	SP	7	23.3±1.3	9.9±1.2	15.7±1.6	1.2±0.2	5.7±0.09
IS	SP	8	20.8±1.3	6.3±1.2	16.3±1.6	1.8±0.2	6.2±0.09
IS	SP	9	20.5±1.3	6.8±1.2	13.1±1.6	1.8±0.2	6.2±0.09
IS	NSP	6	25.8±1.3	4.2±1.2	11.4±1.6	1.1±0.2	5.9±0.09
IS	NSP	7	20.7±1.3	7.0±1.2	16.7±1.6	3.0±0.2	5.7±0.09
IS	NSP	8	17.7±1.3	11.3±1.2	19.7±1.6	2.3±0.2	6.2±0.09
IS	NSP	9	15.1±1.3	13.3±1.2	20.4±1.6	2.2±0.2	6.3±0.09
Housing system x Swimming pool		-	0.001	0.004	0.000	0.000	NS
Housing system x Slaughter age		-	NS	NS	NS	0.003	0.000
Swimming pool x Slaughter age		-	NS	0.003	NS	0.000	NS
Housing system x Swimming pool x Slaughter age			NS	0.005	NS	0.000	0.002

IS: Intensive System, IOS: Intensive System with Outside activity, SP: Swimming Pool, NSP: Without Swimming Pool. Values are expressed as Mean±SEM, NS = Not Significant. a-c: Significant difference between groups

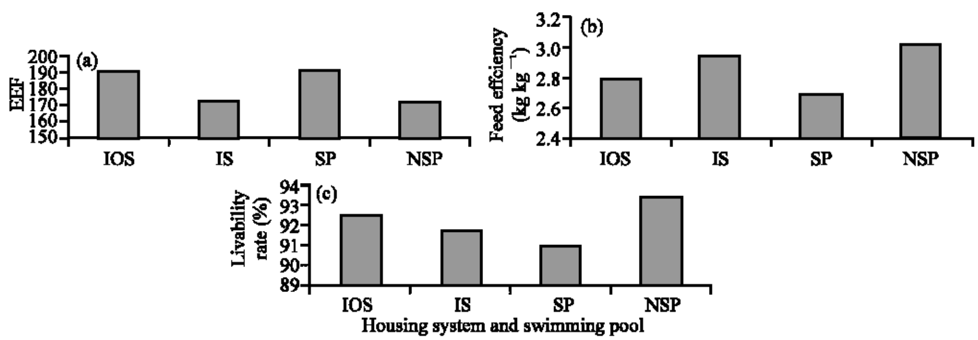

Fig. 3: The effect of housing system and swimming pool on EEF, a): Feed efficiency, b): Livability rate, c): IS: Intensive System, IOS: Intensive System with Outside activity, SP: Swimming Pool, NSP: Without Swimming Pool

increased the plumage condition and this system was more natural for ducks. EEF was better at 6 weeks of age. As expected, slaughter weight increased with age. The values for slaughter weight of ducks at 6-9 weeks were 2338, 2776, 2921 and 3330 g, respectively. These results were in agreement with the reports by Bochno *et al.* (2005). Solomon *et al.* (2006) reported that slaughter weight of Pekin hens at 8 week was 2290 g. This value was lower than our finding, which may be explained by differences in sex and genotype.

Zhou *et al.* (2000) reported that from the view point of feeding efficiency, the market age of meat type ducks at 6 weeks was more beneficial than that of at 8 or 10 weeks to reduce the feeding cost. Also in this study feed efficiency was better at 6 weeks of age than the others.

Cold carcass percentages were higher in IS. This may be due to the lower plumage when compared to the IOS. Cold carcass percentage in IOS was 68%, while in IS it was 69%. Slaughter age affected the cold carcass percentage which was the highest at 8 weeks of age. However, slaughter weight was the highest at 9 weeks of age, cold carcass percentage was the highest at 8 weeks of age. After the 8 weeks, the increase of the body weight had no effect on carcass weight.

In ducks major changes related with age occurred in percentage of the breast (increase) and legs (decrease). Wing percentage increased till 8 weeks of age and then decreased. Similarly, Zhou *et al.* (2000) reported that the weights of breast with skin, bone and wing in proportion to carcass weight increased with age in meat type growing ducks.

Carcass percentage was correlated negatively ($p<0.01$) with leg percentage, while, it was correlated positively ($p<0.01$) with breast percentage and wing percentage.

In the present study, average pH_{24} of leg meat was 5.9. Similarly, Mazanowski *et al.* (2003) stated that the average pH_{24} at post-mortem was 6.0 and 6.4 in meat from A44 and A55 strains of ducks. Pingel and Birla (1981) showed that in 8 weeks old Pekin ducks, the pH_{24} was found between 5.8 and 5.9. Values of pH_{24} increased with age, but outside activity and swimming pool had no effect on the pH_{24}.

Lipid, protein and ash content of leg muscles were significantly ($p<0.01$) lower at 6 weeks of age than the other weeks. Chartrin *et al.* (2006) showed that lipid level in breast muscle of 14 weeks old Pekin ducks was 4.81%. Mazanowski *et al.* (2003) reported that the fat, protein and ash contents in duck leg meat were 4.5, 18.6 and 1.4%, respectively. Smith *et al.* (1993) reported that duckling breast meat contained significantly more lipid, but lower protein, ash and calories than chicken breast meat. Cooking loss was the greatest at 6 weeks of age but then it decreased while, the age increased. Cooking loss at 6 weeks of age was found 24.2%. Chartrin *et al.* (2006) reported that cooking loss (percent of raw meat weight) was 18.38% in Pekin ducks. Cooking loss was greater in leg muscle containing high lipid levels.

Value of ash increased with age. At 6 weeks of age, ash was 1.0%, while, at 9 weeks of age it was 2.0%. Mazanowski *et al.* (2003) showed value of ash was 1.4% in their study.

CONCLUSION

From the point of EEF, the market age of Pekin ducks at 6 weeks is more beneficial due to the better feed efficiency, lower feed intake and lower feed cost. Open sided area and swimming pool enhanced the EEF. However, swimming pool was not suitable for first 3 weeks for livability rate due to the fact that homeothermic system was not developed at this age.

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