Effects of different raising systems on colour and quality characteristics of Turkish Pekin duck meats

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Abstract

The current trial was conducted to determine the influence of different raising systems on the meat quality properties of male Turkish Pekin ducks. Ninety male ducklings were randomly allocated to three experimental groups: an animal-fish integrated farming group (IG), a non-animal-fish integrated farming group (NIG) and a poultry house group (PHG). All ducklings were fed a starter diet from weeks 2 to 6 and a finisher diet from weeks 6 to 10. Feed and water were offered *ad libitum*. At the end of the trial all ducks were slaughtered and the carcasses were stored at 3 °C for 24 hours, after which L*, a* and b* values of the carcass skins were measured. After standard dissection of carcasses, pectoralis muscles were obtained on which pH, colour (L*, a*, b*, C and H), total aerobic mesophilic, total aerobic psychrotrophic, lactic acid bacteria, *Micrococcus/Staphylococcus*, yeast-mould and Enterobacteriaceae counts were determined. The different raising systems of the ducks had significant effects on the pH, total aerobic mesophilic, Enterobacteriaceae, and L* and b* values of the pectoralis muscle. The lowest pH, total aerobic mesophilic and Enterobacteriaceae counts were found in the PHG group. The lowest L* values for the pectoralis muscle were found in the IG group while the highest a* value was recorded in the IG group. Significant differences in skin colour were observed between the experimental groups. For all production groups, all microbial counts were found to be within acceptable ranges. However, pH, total aerobic mesophilic and Enterobacteriaceae results were found to be lower in the PHG group than in the other groups. Different raising systems were thus found to affect the meat and skin colour of ducks, which may influence the preference of consumers.

Keywords: Pekin duck, integrated farming, carcass and meat colour, microbial properties
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Introduction

The global increase in the cost of fish feeds and inorganic fertilisers has resulted in an increase in the cost of fish production. However, this can be lowered to some extent by introducing an integrated farming system (Essa *et al*., 1988). Energy and food crises are redirecting world attention to a wiser use of all resources, and integrated fish farming offers a partial solution to the problem. Integrated farming includes animal-fish farming and crop-fish farming. Livestock-fish integration maximises food production and economic return per unit area of land. The combination of duck and fish farming is considered an inexpensive way of fertilising ponds for the production of fish (Little & Muir, 1987). On the economics of duck-fish integrated farming, Soliman *et al*. (2000) reported that it was more profitable than non-integrated farming.

Fish-duck integration also promotes the recycling of nutrients in the pond ecosystem. It utilises the mutually beneficial biological relationship between fish and ducks (Anon, 1989). Ducks feed on a large variety of organisms such as snails and insects that are potential vectors of diseases. Fishponds provide ducks with a perfect disease-free environment. In shallow areas a duck dips its head to the pond bottom and turns the silt to search for benthos. Ducks also keep the water body clean and increase dissolved oxygen by swimming, playing and chasing each other (Kalita, 2006). Barash *et al*. (1982) and Lacin & Aras (2008) reported that compared to ducks raised in pens, the growth rate and feed conversion ratio of ducks raised in

fishponds were better. Fish species reared in integrated ponds exhibited better body weight and feed conversion ratios compared with those of fish species reared in non-integrated ponds (Soliman *et al*., 2000).

Although there has been a number of investigations related to the effect of integrated duck-fish farming on water quality, natural productivity and duck-fish growth performance (Barash *et al*., 1982; Mukherjee *et al*., 1992; Prinsloo *et al*., 1999), none of these studies investigated the effect of production system on skin colour, meat colour and microbiological counts of the duck meat.

The meat of ducks, being waterfowls, have a different composition than that of other poultry types e.g. duck meat has a higher fat content than chicken and turkey meat (Russell *et al*., 2004). Colour and variations in colour are important quality attributes that affect consumer selection and acceptability of many foods. The colour of the carcass skin, breast fillets, drumsticks and wings affects the acceptability of these products. Skin and meat colour are affected by numerous factors such as production system, method of slaughter, processing, handling and packaging (Froning, 1995; Petracci & Fletcher, 2002).

Integrated duck-fish raising systems have been practised for many years in countries such as China, Hungary, Germany and Malaysia, but little has been reported in the scientific literature on the colour and quality characteristics of meat from Pekin ducks reared in these type of systems. The present study was carried out to determine the effect of different raising systems on the meat quality properties of male Turkish Pekin ducks.

Materials and Methods

A total of 90 male two-week old ducklings were used as experimental material. The present study was carried out at the Research and Application Farm of the Department of Aquaculture, Agricultural Faculty, Ataturk University in Erzurum, Turkey. Ducklings were assigned to three production groups: an integrated group [IG = duck-fish (Mirror carps) integration]; non-integrated group (NIG = duck group raised only on ponds) and poultry house group (PHG = group raised in a poultry house without a pond). Each treatment group was replicated five times as subgroups comprising six ducklings each. Feed and water were offered *ad libitum*. All ducklings were fed a starter diet from weeks 2 to 6 and a finisher diet from weeks 6 to 10 (Table 1). The chemical composition of the feed such as dry matter, crude protein, crude cellulose, crude ash and ether extract was determined using the analysis methods of the AOAC (1984).

Table 1 Chemical composition of the experimental diets (dry matter basis) fed to the Pekin ducks

Composition	Duckling starter diet (g/kg)	Duckling finisher diet (g/kg)
Dry matter	940.0	930.3
Crude protein	220.0	190.0
Crude cellulose	72.6	59.8
Crude ash	65.5	57.7
Ether extract	26.5	42.4
Non-soluble ash in HCI	10.0	10.0
Calcium	8.0	8.3
Phosphors	3.9	4.0
Sodium	2.0	2.0
NaCI	3.5	3.5
Lysine	12.9	9.5
Methioine + Cystine	8.1	6.6
ME (MJ/kg)	11.30	11.92

At the end of the feeding period, the ducks were slaughtered. Prior to slaughtering, the ducks were kept without feed for 8 h, slaughtered by a neck cut, bled for 120 s and scalded at 60 °C (Barbut, 2002) for 30 s, before mechanical plucking in a rotary drum plucker. Subsequently, the birds were eviscerated manually, washed and allowed to drain for 10 min (Yalcin *et al*., 1999). After evisceration, the carcasses

were stored at 3 ± 0.5 °C for 24 h. The carcasses were dissected as described by Pingel *et al*. (1998) and Barbut (2002).

Colour (L*, a*, b*, C* and H*), pH, total aerobic mesophilic, total aerobic psychrotrophic, lactic acid bacteria, *Micrococcus/Staphylococcus*, yeast-mould and Enterobacteriaceae counts of the pectoralis muscles from the Pekin ducks were determined.

The ultimate pH values of the pectoralis muscles were measured at 3 ± 0.5 °C 24 h *post mortem*. Before measurement, the pH-electrode was calibrated, using three buffers with pH values of 4.01, 7.00 and 9.01. The samples were always measured at the same place. The stabilisation time of the pH value was defined by the device (SCHOTT L 6880, Lab Star pH). The pH readings were taken three times on the same muscle samples, and means are shown in Table 3.

The surface colour of both pectoralis muscle samples and skin was determined by using a chromameter (model CR-200, Minolta, Japan) after allowing a 30 min blooming period (Saucier *et al*., 2000). Expression of colour was characterised as Hunter colour indexes L*, a*, b*, C* and H*; where L* indicates the lightness, a* represents the colour axis from green to red and b* represents the colour axis from blue to yellow. C* and H* colour parameters were calculated. Chroma, $C^* = (a^{*2}b^{*2})^{0.5}$ and Hue, $H^* = \tan^{-1}$ (a*/b*). The colour values were measured five times at different points on the surface of each carcass and muscles. Before each measurement, the chromameter was standardised against a white tile. The measurements were always measured in the same region on the carcass surfaces for all the carcasses.

For microbiological analysis, sample solutions were prepared by homogenisating a 25 g meat sample with 225 mL physiological saline water (0.85 NaCl %) in a Stomacher (Lab Stomacher Blander 400-BA 7021, Seward Medical) for 1 min. Total aerobic mesophilic bacteria was enumerated aerobically on Plate Count Agar (Merck) at 30 °C for three days. Total aerobic psychrotrophic was enumerated aerobically on Plate Count Agar (Merck) at 10 °C for seven days. Lactic acid bacteria and Enterobacteriaceae were incubated anaerobically on De Man Rogosa Sharpe Agar (Merck) for three days and Violet Red Bile Dextrose Agar (Merck) for two days at 30 °C, respectively. *Micrococcus/Staphylococcus* was incubated aerobically on Mannitol Salt Phenol-Red Agar (Merck) at 30 °C for two days. Yeast-mould was enumerated on PDA at 20 °C for five days. All bacteria counts were expressed as colony-forming units per gram sample (CFU/g).

Statistical evaluations were performed by SPSS (the completely randomised design procedure; SPSS for Windows Release 10.01, SPSS Inc. 1996). Differences between data were tested using the Duncan's multiple range test (significance $P < 0.05$). The results of the statistical analysis are shown as mean values with standard error in the tables.

Results and Discussion

Muscle pH is a significant parameter in terms of preservation and stability of meat, as it is known that a high muscle pH results in shorter shelf life stability, especially as pertaining to microbial growth. Most microorganisms grow best at neutral pH (pH = 7.0), and only a few below 4.0. It is known that meat from fatigued animals spoils faster than meat obtained from rested animals. This is a direct result of the higher ultimate pH. In fatigued animals, most of the muscle glycogen has been utilised prior to slaughter, the pH drop is less pronounced and microorganisms can thus grow more easily (Barbut, 2002). The mean pH value of duck meat is generally between 5.90 (Fernandez *et al*., 2003) and 5.65 (Raj *et al*., 1998). In this investigation, treatment had an effect ($P < 0.01$) on pH values, with the lowest pH value determined in the PHG group (5.76) ($P < 0.05$) (Table 3). The results of this study are in agreement with other research findings for ducks reared in PHG environments (Raj *et al*., 1998; Mallia *et al*., 2000; Fernandez *et al*., 2003; Mazanowski *et al*., 2003).

Control of the growth rates of microorganisms that grow over a wide range of temperatures is one of the most important factors manipulated to prolong the shelf life of fresh meats and meat products. Of these factors, initial microbiological contamination is one of the most important. According to the results from the present study, the PHG group had an important advantage in terms of total aerobic mesophilic ($P < 0.05$) and Enterobacteriaceae counts (Table 2). While the highest total aerobic mesophilic bacteria count was encountered in the IG group, the lowest value was found in the PHG group. The Enterobacteriaceae counts of pectoralis muscles were determined to be 4.46 - 4.85 log (CFU/g), a count differing ($P < 0.01$) between the experimental groups. The Enterobacteriaceae counts in the PHG group were lower ($P < 0.05$) than in the NIG

group (Table 2). The Turkish Standard Regulation (Anon, 1997) for fresh poultry meat states that the tolerable upper limit for aerobic plate count (APC) is 5 x 10^6 CFU/g. Khalifa & Nassar (2001) determined that Enterobacteriaceae counts of breast meats of game ducks were 3.8 - 2.2 log CFU/g. Treatment did not affect (P >0.05) the total aerobic psychrotrophic, lactic acid bacteria, *Micrococcus/Staphylococcus* and yeast-mould counts (Table 2). Khalifa & Nassar (2001) reported that psychrotrophic counts of breast meat of game ducks were 5.1 - 2.2 log CFU/g.

Table 2 Microbiology of duck pectoralis muscle [mean, standard error of means (s.e.m.), (log_{10} CFU/g)]

Experimental Group†	TAM[1] *	TAP[2] Ns	M/S[3] Ns	LAB[4] Ns	E[5] **	Y–M[6] Ns
IG	5.99[a]	5.68	4.73	4.02	4.64[ab]	2.15
NIG	5.83[ab]	5.59	4.84	4.03	4.85[a]	2.47
PHG	5.66[b]	5.41	4.80	3.67	4.46[b]	2.33
s.e.m.	0.099	0.152	0.079	0.134	0.079	0.135

[a-b]:For each variable, any two means in the same column having different superscripts differ (** P <0.01, * P <0.05), Ns - Non significant.
[1] Total Aerobic Mesophilic, [2] Total Aerobic Psychrotrophic, [3] Micrococcus/Staphylococcus,
[4] Lactic Acid Bacteria, [5] Enterobacteriaceae, [6] Yeast-Mould ,
† IG - integrated group, NIG - nonintegrated group, PHG - poultry house group.

The L* (P <0.05), a* (P <0.05) and H* (P <0.01) values of the breasts were significantly affected by the different treatments (Table 3).

Table 3 Colour (L^*, a^*, b^*, C* and H^* values) and pH of duck pectoralis muscle [mean, standard error of means (s.e.m.)]

Experimental Group†	L* *	a* *	b* Ns	H* **	C* Ns	pH **
IG	33.06[b]	18.83[a]	-0.258	239.14[ab]	18.76	5.84[a]
NIG	35.46[a]	18.14[ab]	-0.097	371.14[a]	18.30	5.81[ab]
PHG	35.71[a]	17.93[b]	0.492	145.75[b]	18.01	5.76[b]
s.e.m.	0.759	0.298	0.306	70.60	0.299	0.018

[a-b] : For each variable, any two means in the same column having different superscripts differ (** P <0.01, *P <0.05), Ns - Non significant.
L* - lightness (0 = black; 100 = white), a* - redness (– = green; + = red), b* - yellowness (– = blue; + = yellow), H* - hue, C* - liveliness.
† IG - integrated group, NIG - nonintegrated group, PHG - poultry house group.

In the food industry colour measurements are used as important quality determinants. Producing poultry with a consistent skin colour is very important to consumers who have certain expectations regarding a wholesome product. Fibre type and myoglobin content have a strong effect on meat colour. Skin pigmentation is the result of melanin and xantophyll deposition obtained from plant material. In the present study it was determined that different raising systems affected the meat colour of ducks. Raising Pekin ducks in the IG group decreased the L* values (P <0.05) of the meat in comparison to the values in the NIG and

PHG groups. The highest a* value was recorded in the IG group. There are some studies that reported a high correlation between ultimate muscle pH and meat colour, in particular lightness. Normally muscles with a high pH (IG group) have a darker colour than those with a low pH (NIG and PHG groups) (Allen *et al*., 1997; Fletcher *et al*., 2000). The ducks in the IG group were more active than those in the PHG group. Muscle that works hard needs oxygen, and myoglobin binds oxygen, even better than haemoglobin. This facilitates the movement of oxygen from the blood to the muscle cells. Also, the iron content of duck meat is high and therefore, duck meat has a much darker appearance than chicken and turkey meat (Barbut, 2002). The pectoralis muscle of ducks was found to be significantly darker and redder but less yellow than the pectoralis of chicken (Smith *et al*. 1993). The redness ('a' value) was found to be higher for duckling than for chicken because the duck *M. pectoralis* contains 16% white and 84% red fibres while chicken *M. pectoralis* contains 100% white fibres (Smith *et al*., 1993). Several studies have published colour values of the raw pectoralis muscle of ducks. Values of L*, a* and b* for duck pectoralis were recorded as 36.45, 13.09 and 2.03, respectively (Smith *et al*., 1993); 38, 19 and 3, respectively (Raj *et al*., 1998); 39.6, 13.86 and 12.18, respectively (Baeza *et al*., 2002); and 40.5, 22.0 and 6.6, respectively (Fernandez *et al*., 2003).

Differences ($P < 0.01$) in skin colour were observed between the experimental groups. While the IG and NIG groups ($P < 0.05$) had the highest lightness value, the lowest redness values were also observed in these groups. On the other hand, the highest b* values were recorded for the IG group (Table 4). The highest C* value among the treatments was also determined in the IG group, while the highest H* value was calculated for the NIG group. C* values are related to a* and b* values and describe colour liveliness. Because of the low b* value in the PHG group, the calculated H* and C* values were lower than those found in the other groups.

Table 4 Skin colour (L^*, a^*, b^*, C^* and H^* values) of duck pectoralis muscle [mean, standard error of means (s.e.m.)]

Experimental Group[†]	L* **	a* **	b* **	H* **	C* **
IG	65.17[a]	4.63[b]	11.28[a]	67.55[a]	12.32[a]
NIG	65.56[a]	3.93[b]	9.16[b]	67.99[a]	10.40[b]
PHG	63.93[b]	5.46[a]	8.57[b]	57.56[b]	10.21[b]
s.e.m.	0.359	0.256	0.369	1.113	0.312

[a-b] For each variable, any two means in the same column having different superscripts differ (P** $P < 0.01$), L* - lightness (0 = black; 100 = white), a* - redness (– = green; + = red), b* - yellowness (– = blue; + = yellow), H* - hue, C* - liveliness.
[†] IG - integrated group, NIG - nonintegrated group, PHG - poultry house group.

Conclusions

In an integrated farming application, the pond water turns fertile with large multiplications of feeding organisms, and duck-fish production is enhanced. Integrated duck-fish raising systems have been practiced for many years in the world. However, insufficient attention has been given to food safety and quality. In this study some quality parameters (pH, microbial properties and colour) of duck meat are reported from the ducks raised in different production systems. In all these systems, microbial traits, examined by using pectoralis muscles, were found to be within acceptable limits. However, pH, total aerobic mesophilic and Enterobacteriaceae results were found to be lower in the PHG group than in the others groups. The different rearing systems were also found to have an effect on the meat and skin colour of the ducks. In the meat samples, the lightness (L*) was higher in the PHG group whilst the redness (a*) was higher in the IG group. For skin colour parameters, lightness (L*) and yellowness (b*) were higher in the IG and NIG groups, whereas redness (a*) was higher in the PHG group. It is concluded that different raising systems significantly influence the meat and skin colour of ducks. Numerous studies have shown that consumers commonly prefer

poultry skin and meat colour that is traditionally available in their region. It is thought that this situation may have an influence on consumer preferences. This aspect warrants further research.

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