Differences in poultry meat properties depending on species, muscle, and cooking method

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Introduction

In poultry, the effects of age, gender and preparing on meat properties within species have been repeatedly investigated. Studies on species differences simultanously obtained at similar conditions are lacking. Particularly, it remains uncertain, if the level of these differences is higher or lower than effects of different factors within species. Therefore, several characteristic parameters of meat quality were compared between poultry species and related to the effects of gender, meat preparing and location within muscle.

Materials and Methods

24 Broilers (origin Cobroed Cobb) were fattened in a common manner for 37 days and fed starter (23.4 % protein, 13.3 MJ AME), fattening (21.4 % protein, 12.2 MJ AME) and finisher feeds (22.7 % protein, 13.2 MJ AME). Average live and slaughter weights of the broilers were 1671 g (std. 171 g) and 1220 g (std. 129 g), respectively. Final live weights of male and female broilers were 1776 g (std. 86 g) and 1496 g (std. 125 g). 32 Muscovy ducks (Cairina moschata, origins Grimaud R51 and Gourmaud compact) were reared, separated by gender, on a commercial farm up to 70 days and fed starter (20.9 % protein, 10.2 MJ AME) and fattening feed (18.1g protein, 11.1 MJ AME), respectively. Average live weight of the ducks was 3318 g (std. 237 g) with the male and female ducks weighing 3994 g (std. 581 g) and 2842 g (std. 2[illegible] g), respectively. Slaughter weight was 2027 g (std. 165 g).18 geese were fattened on straw litter in an intensively manner with starter feed for 3 weeks (23.0 % protein, 12.2 MJ AME) and finishing feed (18.5 % protein, 12.0 MJ AME). Body weights of 15 weeks old males and females were 7,7 kg (std. 1,0 kg) and 7,0 kg (std. 1,2 kg), and average weight of carcasses was 5,0 kg (std. 0,8 kg). 19 male turkeys (Big 6) were fattened in a conventional way using protein graded feeds (27 to 14 %). After 21 weeks, the turkeys had average live weights of 17,3 kg (std. 0.9 kg) and slaughter weights of 14,9 kg (std. 0,8 kg).

All animals were transported from the stables directly to the slaughter room. After recording the live weight, animals were always slaughtered by the same persons. Slaughter weight was calculated from live weight minus weight of feathers, head, shanks, and intestines. 45 min and 24 h p.m., pH was measured (Portamess 651, Knick, Berlin; Ingold-electrode, Steinbach) in breast muscle (M. pectoralis). After storing for 24 h at 4°C, carcasses were weighed to determine cooling loss and were dissected afterwards (right and left part of leg as well as breast; of turkeys upper thigh were separated) and percentage of breast and leg were calculated. Samples were vacuumized in polyethylen bags and frozen at -20°C, and thawed in a refrigerator. Freezing losses were calculated after drying the surface with professional wipes (Kleenex®). Afterwards breast muscle (without skin) of broilers and ducks as well as geese (with skin) of one side and 2 cm thick slices of one breast muscle of turkeys (without skin) were grilled (CycloJet, TTI TechTronik Industries Co. Ltd., USA) at about 170°C until an internal temperature between 75 to 80°C was reached, which was controlled using a NiCr-Ni-thermo-sensor (Therm-Gerät 3280-6, Ahlborn Meß- und Regelungstechnik, Holzkirchen, Germany). Thigh of broilers, ducks, geese and turkeys were prepared with skin in the same manner like breast. Breast muscles of the individual ducks were either grilled or fried at the same air or oil temperature (around 170°C) until the same internal (75°-80°) temperature was reached. In order to measure tenderness of the prepared breast muscles, cylindric cores (Ø 1,27 mm) were obtained cutting along to the alignement of the muscle fibres. The cores were cut by the Instron (Typ 2830-130, USA, Modell 4301, Buckinghamshire) equipped with a Warner-Bratzler shear blade recording shear force and extension. Fat content was analyzed in the prepared breasts according to the standard method (1). The remaining breast half of 8 of the turkeys was cut into caudal and cranial parts. Each slice of 2 cm thickness was treated as described above. pH was measured, afterwards samples were grilled and tenderness was recorded. Statistical evaluation was carried out using analysis of variance and tukey or LS-Means test for multiple comparison among means.

Results and Discussion

Differences between species

There were significant species differences in pH, storage and preparing losses, and tenderness (Tab. 1). Regardless of the muscle type, broiler meat showed about 0.3 to 0.4 higher pH-units at 45 min p.m. as well as at 24 h p.m., as compared with ducks and turkeys whereas pH_{24} was highest in geese. The species differences in pH were accompanied by respective differences in weight losses during storage and preparing as well as shear force and extension with the more favourable values for meat with high pH. Duck meat was intermediate to broiler and turkey whereas goose meat showed the smallest freezing losses but the highest cooking losses. The species, broilers, Muscovy ducks, geese, and turkeys, highly differed in age (5, 10, 15 and 21 weeks) as well as in final live weight (1.7, 3.3, 7.3, and 17.0 kg). Members of all three species were fattened in a common manner and, in this respect, reflected the usual meat offered in retail shops. Generally, pH was higher in thigh than in breast which might be a result of different distribution of muscle fibre types (2). Water-holding-capacity was lower with lower pH, and shear values decreased with increasing cooking losses. One possible reason for the high inital pH in broilers (over or equal to 6.00) could be a result of an insufficient energy supply in muscle cells (3). This might not be solely caused by species differences but also by a higher stress susceptibility of the strains which led to a higher rate of glycogen expenditure previous to slaughter (4). Ducks and turkeys had similar meat pH in breast and thigh but the weight losses during storage and preparing were significantly higher in turkeys. The insignificantly higher cooking losses of turkey meat as compared with duck meat might be a result of species differences in muscle fiber types as can be seen in meat colour. Darker colour is mainly caused by more oxidative cell types which contain more myoglobin for oxidative glycolysis. Even under similar processing conditions, light and dark meat of broilers exhibit different cooking yields (5). Furthermore,the higher cooking loss may be based on the different sample shape: breast muscles of the ducks were prepared as a whole with intact connective tissue membranes whereas samples of the turkeys were slices of the breast muscle which possessed therefore cut surfaces on both sides probably causing a higher release by inter- as well as intracellular liquid. Geese meat showed extraordinarily high cooking losses which might be partially explained in breast by cooking with skin in contrast to the other species and by the subcutanous fat in breast and leg, which is particularly high in geese (6). For storage losses species differences are probably the most important factor since differences in sample size as well as chemical composition are high (7). Weight losses during cooling and after freezing and thawing mainly depends on these factors.

Differences between genders

In broilers, there were no significant differences between male and female animals whereas almost all parameters of meat property were significantly different between the genders in the ducks (Tab. 2). Generally, species differences were much higher than differences between male and female animals within species. In broilers, both genders are usually reared together. During the short fattening periods, both genders showed similar weight gain and, therefore, could be slaughtered at the same day with relatively similar live weight. As broilers, like ducks and turkeys, reach slaughter without being sexual mature, influence of sexual hormons can be neglected. Results of broilers clearly show that, in spite of certain differences in weight, as in previous studies (8) quite similar values of meat properties were measured. On the other hand, meat properties were different between genders in ducks. At the same slaughter age, male ducks were about 30 % heavier than female ducks. At this time, females were fatter than males, which could be seen from the abdominal fat percentage of 4.6 % to 2.3 % of the males (9). Consequently, intramuscular fat contents of the meat of the females should have been higher. Howerver, this might have had no or even a favourable influence on cooking losses.

Differences between preparing techniques

Preparing method of duck breast muscle led to significant differences with higher cooking losses and lower shear force in fried samples whereas fat content (2 %) was nearly the same as in grilled samples (1.9 %) (Tab. 3). Frying caused higher cooking losses followed by lower tenderness. The reason for this most likely is that the heat by contact with oil has a stricter effect than the hot air using the grilling technique. The lower cooking losses in grilled breast samples were accompanied by higher shear force. This is contradictory to the usual result that with extracellular liquid losses muscle fibres become narrower and shear force increases as results showed comparing belt-grill oven with water bath technique (10). Also the small but significantly longer distance to maximum force (= extension) is not easy to explain as after loosing liquid, more fibres are concentrated in the same area and should lead to a contrary direction. But a propable explanation may be, that the stronger heat conductivity of oil led to a higher cooking loss only in the area directly beneath the surface whereas the center of the samples reached the same temperature in each method. This had been controlled by the temperature sensors. The cores for shear force measurement had been taken from the center of the meat samples.

Differences between location within muscle

Differences caused by the two locations within breast muscle (Tab. 4) were quite pronounced reaching (pH) or even exceeding the differences to the other species (cooking losses). Muscles widely differ in structure and distribution of fibres as well as in chemical composition. But also within muscle, different properties exist which could be especially seen in big skeleton muscles which are edged by connective tissue binding them to the bones. These binding areas are different to the middle area which is characterized by a larger diameter and lower connective tissue content. In contrast to the results of other authors (11), in broiler breast muscles, decreasing pH and shear force from anterior to posterior location was found, probably accompanied by decreasing sarcomere length. But these differences, estimated as negligible in broiler breast muscle, could be more important in turkey meat which is received of heavier and older birds.

Conclusion

Species differences in meat properties could be regarded as more important than the effects of gender and cooking method whereas the effects of location within muscle were of similar extent.

Tab 1: Species differences in meat properties

	Broiler mean	std. err.	Duck mean	std. err.	Goose mean	std. err.	Turkey mean	std. err.
Breast, pH_{45min}	6.18 ^{a}	0.05	5.83 ^{b}	0.05	-*		5.87 ^{b}	0.06
Breast, pH_{24h}	6.00 ^{a}	0.04	5.76 ^{b}	0.04	5.85 ^{b}	0.04	5.55 ^{c}	0.05
Thigh, pH_{24h}	6.39 ^{b}	0.04	6.13 ^{c}	0.03	6.51 ^{a}	0.03	6.05 ^{c}	0.04
Cooling losses, % of carcass	0.63 ^{c}	0.10	1.45 ^{b}	0.09	-*		1.81 ^{a}	0.11
Freezing losses, %								
Thigh	-*		0.7 ^{b}	0.1	0.2 ^{c}	0.1	1.7 ^{a}	0.1
Breast	1.5 ^{c}	0.4	2.9 ^{b}	0.4	1.3 ^{c}	0.5	4.6 ^{a}	0.5
Cooking losses, %								
Thigh	19.6 ^{c}	1.0	22.7 ^{b}	0.7	32.3 ^{a}	1.8	24.5 ^{b}	0.9
Breast[1)]	18.6 ^{c}	0.8	23.2 ^{b}	0.7	36.5 ^{a}	0.9	29.2 ^{b}	0.9
Shear values, breast								
Force, N	18.1 ^{b}	0.8	23.9 ^{a}	0.7	-*		25.3 ^{a}	1.3
Extension, mm	12.4 ^{b}	0.2	15.6 ^{a}	0.2	-*		11.7 ^{b}	0.3

*no data available, mean values with different superscripts are significantly different at p<0.05

Tab. 2: Effects of gender in meat properties of different poultry species

	Broiler male mean	std.	Broiler female mean	std.		Muscovy duck male mean	std.		Muscovy duck female mean	std.
Breast, pH_{45min}	6.20	0.45	6.15	0.29		5.87	0.11		5.79	0.14
Breast, pH_{24h}	6.01	0.12	5.98	0.20		5.79	0.05	*	5.72	0.08
Thigh, pH_{24h}	6.44	0.17	6.32	0.22		6.23	0.18	*	6.04	0.12
Cooling losses, % of carcass	0.60	0.15	0.69	0.15		1.08	0.16	*	1.81	0.31
Cooking losses, %										
Thigh	18.5	1.7	19.6	1.7		22.3	3.0	*	24.2	4.1
Breast	19.0	1.4	20.4	1.6		21.9	5.5	*	23.6	3.1
Shear values										
Force, N	17.5	1.9	19.0	4.0		23.4	3.1		24.3	5.6
Extension, mm	12.3	0.5	12.5	1.1		15.9	0.9		15.4	1.3

+p<0.1;*p<0.05

References **1)** Naumann, C., Bassler, R., 1983. Methodenbuch. VDLUFA-Verlag.-**2)** Seemann, G., Kozlowski, G., 1982. Arch. Geflügelk. 46, 228-231.-**3)** Ristic, M. 1975. Arch. Geflügelk. 3, 108-111.-**4)** Chen, M.T., Lin, S.S., Lin, L.C., 1991. Br. Poult. Sci. 32, 997-1004.-**5)** Xiong, Y.L., Pescatore, A.J., Cantor, A.H., Blanchard, S.P., Straw, M.L., 1993. Int. J. Food Sci. Technol. 28, 429-434.-**6)** Wittmann, M., 1997. 11th European Symposium on Waterfowl, Nantes, September 8-10 (accepted).-**7)** Rizk, M.A., 1975. Diss. Bonn.-**8)** Kirchgessner, M., Kreuzer, M., Ristic, M., Roth, F.X., 1993. Züchtungsk. 65, 138-159.-**9)** Lemme, A., Wittmann, M., 1996. in: Sutter, F., Wenk, C., Kreuzer, M., Hrsg., Schriftenreihe Institut für Nutztierwissenschaften, 15, 67-70.-**10)** Lyon, B.G., Lyon, C.E. 1993. Poult. Sci. 72, 2157-2165.-**11)** Dunn, A.A., Kilpatrick, D.J., Gault, N.S.F., 1993. Poult. Sci. 34, 663-676.

Tab. 3: Effects of preparing on duck breast muscle traits

Preparing technique	grilled mean	std.		fried mean	std.
Inital pH	5.75	0.07		5.73	0.05
Cooking losses, %	23.7	3.8	*	26.5	6.3
Shear values					
Force, N	24.0	4.2	*	21.9	3.7
Extension, mm	15.6	1.1	*	16.1	1.1
Fat content, %	1.9	0.6		2.0	0.5

*p<0.05

Tab. 4: Effects of location within turkey breast on meat traits

Part of brest	cranial mean	std.		caudal mean	std.
Inital pH	5.72	0.11	*	5.84	0.07
Cooking losses, %	28.6	1.3	*	20.8	2.6
Shear values					
Force, N	26.4	3.7		31.3	6.1
Extension, mm	10.4	5.8	*	12.4	1.6

*p<0.05