Carcass Characteristics and Physical Meat Quality Properties of Spent Broiler Breeder Hens and Commercial Spent Layer Hens

Metin PETEK[1,a,*], Enver ÇAVUŞOĞLU[1,b]

[1]Department of Animal Science, Faculty of Veterinary Medicine, University of Bursa Uludag, Turkey.
[a]ORCID: 0000-0001-8789-3101, [b]ORCID: 0000-0002-9018-3511

Abstract: This study was conducted to investigate the carcass characteristics and physical meat quality properties of spent broiler breeder, commercial spent white, and commercial spent brown layer hens. Ten samples from each genotype were analyzed for muscle pH, meat colour characteristics, and carcass yield performance. Meat colour analyses were performed on skinned and skinless breast and thigh meat samples, while meat pH was measured on skinned meat samples. The percentage of the breast meat of carcass was significantly higher for broiler breeder hens than for white and brown layer hens (P<0.001), while wing meat percentage was significantly lower for these birds (P<0.005). There were significant differences in the lightness value of skinned layer breast meat (P<0.016). Skinned redness (P<0.001), skinned chroma (P<0.001), skinless lightness (P<0.001), and skinless chroma (P<0.002) values of thigh meat were significantly affected by the genotype of spent layer hens. The spent breeder hens had significantly lower pH levels for leg and breast meat (P<0.001). In conclusion, it seems that the carcass and meat quality characteristics of the spent laying hens differed. The spent layer meat might be an alternative meat for consumer as breast and leg meat or processed meat.
Keywords: *Carcass yield, laying hen, meat quality.*

Damızlık ve Ticari Yumurtacı Tavuklarda Karkas Özellikleri ve Et Kalitesi

Özet: Bu çalışma, etçi damızlık, ticari beyaz ve kahverengi yumurtacı tavuklarda karkas özellikleri ve fiziksel et kalitesi özelliklerini araştırmak amacı ile yapılmıştır. Her genotipten on örnek alınarak karkas özellikleri ile et pH ve renk özellikleri için analiz edilmiştir. Et rengi ölçümleri; derili ve derisiz göğüs ve but eti örneklerinde yapılırken, et pH'sı derili et örneklerinde ölçülmüştür. Damızlık tavuklarda göğüs eti randımanı; beyaz ve kahverengi yumurtacı tavuklara göre önemli ölçüde daha yüksek (P<0.001), kanat eti randımanı ise önemli ölçüde daha düşük bulunmuştur (P<0.005). Derisiz göğüs eti parlaklık değeri bakımından gruplar arasında önemli farklılıklar tespit edilmiştir (P<0.016). Derili but eti renk özelliklerinden kırmızılık (P<0.001), kroma (P<0.001) ile derisiz but eti parlaklık (P<0.001) ve kroma (P<0.002) değerleri genotipden önemli ölçüde etkilenmiştir. Etçi damızlık tavuk but ve göğüs etinde *pH* önemli düzeyde daha düşük bulunmuştur (P<0.001). Sonuç olarak, kasaplık yumurtacı tavuklarda karkas ve et kalitesi özellikleri birbirinden farklı olup, yumurtacı tavuk etleri, göğüs ve but eti veya işlenmiş et olarak tüketiciler için alternatif bir et olabilir.
Anahtar Kelimeler: *Et kalitesi, Karkas verimi, Yumurtacı tavuk.*

Introduction

The commercial value of end of lay hens as breeder or commercial has been considered negligible throughout the World, in general. There has been an increasing interest in taking spent layer meats into the consumption chain. Although some of the carcasses of the spent hens are offered for consumption in some countries, most of them are slaughtered and then sent for rendering to be converted into protein meals for animal feed (Hamm, 1976). Even if it is not consumed directly, using these hens after egg production to produce processed meat products or a special recipe for a large consumption scale could benefit to the poultry market (De Souza et al., 2011, Karakaya et al., 2010; Kadıoğlu et al., 2019). Polizer Rocha et al. (2019) showed that the substitution of up to 75% of chicken meat by spent laying hen meat did not

decrease consumers' sensory acceptance of the sausages. Bhaskar Reddy (2016) showed that spent breeder meat is superior for preparing processed and value-added chicken meat products than spent layer and broiler meat. In general, the meat quality of poultry has been mainly studied for commercial broiler, turkey, and quail (Dos Santos et al., 2020; Özbek et al., 2020; Zampiga et al., 2020). Muthulakshmi et al. (2016) reported significant differences in meat pH between larger and smaller weight groups due to differences in the body weight of culled layer hen. Since it does not have enough economic benefit, the meat quality of end of laying hens, neither breeder nor commercial, has not been studied in detail. Revealing more detail about the meat quality of spent hens will increase consumer demand and producer income. This study aims to

evaluate the carcass characteristics, and meat quality of spent broiler breeders and commercial layers raised and slaughtered under commercial conditions.

Material and Methods

The study was conducted in the carcass evaluation and meat quality analysis laboratory of the Faculty of Veterinary Medicine in the University of Bursa Uludag. The experimental procedures do not require ethical permission according to Animal Experiments Ethics Committees Regulation on Working Procedures and Principles, Article 8 19-k (Bursa Uludag University, 2020-07/03).

1. Layers, slaughter, and sample collection: Ten whole carcasses from each layer (broiler breeder, commercial brown and white layer flocks) were randomly collected after commercial slaughter (HSA, 2013; TS 5925, 2014; Nielsen, 2019). During the slaughter process, the birds were electrically stunned in a water bath and scalded with hot water (55-58 °C for 2.5-4 minutes) after bleeding. The birds' feathers were removed mechanically with a rotary drum for 4 minutes and advanced to an evisceration. The eviscerated carcass was chilled at 4 ºC for at least 30 minutes. The whole carcasses were kept in a box during transportation to the laboratory with a minimum delay time. Laboratory investigations started four hours after postmortem and comprised weighing the carcass parts and measuring of physical meat quality parameters.

2. Data: At first, the whole carcasses were weighed, and the carcass parts as necks, two wings, whole breast, and two skinned legs were removed from the whole carcasses (TS 5890, 2014). The cuts were weighed, and the yields were calculated as a percentage of carcass weight. Measured meat quality traits were consistent with meat pH and meat colour properties and were carried out on the medial surface, bone side, of the left breast meat and left leg muscle (Keskin et al., 2017). The pH was

taken with a pH meter from the direct surface of the skinned samples (ExStik PH100 pH-meter, Extech Instruments). Meat colour characteristics were performed on skinned and skinless breast and leg samples. After the pH and meat colour measurement, the visible skin was trimmed from the samples for the skinless evaluation of meat colour characteristics. The colour determination of the samples was performed with a colorimeter (PCE-XXM 20, PCE Instruments LTD) programmed with standards of the International Commission on Illumination (CIE *L*a*b** system, D65 illuminant, 10°) at an angle of 90° after the colorimeter was calibrated. The *L** value represents a degree of lightness component (0:black to 100; white). The redness (*a**) and the yellowness (*b**) both range from -60 to +60, with *a** ranging from green if negative to red if positive and *b** ranging from blue if negative to yellow if positive (Krallik et al. 2018). After that, the chroma, $C^*=(a^{*2}+b^{*2})^{0.5}$ and arctan values (hue angle, $h \circ =tan^{-1} (b^*/a^*).180/ \pi$) were calculated for each meat sample (Ingram ve ark. 2008).

3. Statistics: The statistical tests were performed by SPSS®, computer software 23.00 (IBM Corp Released., 2015). ANOVA test was used to analyse the effects of genotype on carcass characteristics, meat pH and colour parameters. Tukey test was used for post hoc analysis (Snedecor and Cochran, 1989).

Results

Mean values for the carcass characteristics of spent broiler breeder hens and spent layer hens were presented in table 1. Significant differences were observed in the carcass weight, leg weight, wing weight, breast weight, and neck weight of spent broiler and layer hens (P<0.001, P=0.006). The wing and breast meat percentages were significantly different among the groups (P=0.005, P<0.001).

Table 1. Means (±SEM) of carcass characteristics of spent broiler breeder hens, white and brown spent layer hens.

Parameters	Broiler Breeder	White Layer	Brown Layer	*P Values*
Carcass Weight, g	3545.6±78.5[a]	1432.8±27.4[c]	1880.4±60.8[b]	<0.001
Thigh Weight, g	1492.6±41.8[a]	587.0±31.1[c]	828.8±27.2[b]	<0.001
Wing Weight, g	323.8±5.5[a]	152.0±6.0[c]	201.6±6.3[b]	<0.001
Breast Weight, g	1394.6±31.1[a]	403.7±13.7[c]	675.0±23.2[b]	<0.001
Neck Weight, g	189.0±20.2[a]	113.7±17.0[b]	110.6±15.9[b]	0.006
[**]Thigh, %	42.1±1.0	41.16±2.4	44.08±0.4	0.417
[**]Wing, %	9.1±0.2[b]	10.6±0.5[a]	10.7±0.2[a]	0.005
[**]Breast, %	39.4±1.1[a]	28.2±1.1[b]	35.9±0.9[a]	<0.001
[**]Neck, %	5.3±0.5	7.8±1.2	5.8±0.7	0.411

*a–c ; means with different superscripts that vary significantly within the same row.
** Calculated as a percentage of cold carcass weight.

Table 2 shows the colour parameters of leg meat from the spent broiler and layers. There were significant differences for redness (P<0.001) and chroma (P<0.001) values of skinned leg meat and for skinless lightness (P<0.001), redness (P=0.044), and chroma (P=0.002) values of leg meat of spent broiler breeders and layers.

Table 2 : The average values (±SEM) for colour parameters of thigh meat of spent broiler and layers.

Factors	L*	a*	b*	C*	h⁰
Skinned meat					
Broiler Breeder	79.25±0.81	22.14±3.93[a]	0.32±0.67	23.80±3.41[b]	-0.00±0.07
Commercial White Layer	81.48±1.39	31.05±3.86[a]	2.32±1.02	32.14±3.53[b]	-0.05±0.09
Commercial Brown Layer	79.20±0.68	44.26±1.69[b]	1.55±0.73	44.42±1.67[a]	-0.04±0.01
P Value	*0.198*	*0.001*	*0.076*	*0.001*	*0.907*
Skinless meat					
Broiler Breeder	61.50±1.56[a]	22.45±4.80[b]	4.77±1.17	28.53±2.92[a]	0.17±0.11
Commercial White Layer	54.19±0.86[b]	9.00±2.62[a]	7.11±1.49	14.93±2.01[b]	0.56±0.15
Commercial Brown Layer	55.37±1.20[b]	14.75±3.27[ab]	6.84±1.56	19.24±2.75[b]	0.13±0.19
P Value	*0.001*	*0.044*	*0.458*	*0.002*	*0.119*

*a–c ; means with different superscripts that vary significantly within the same column
L*;Lightness*, **a***;Redeness, **b***;Yellowness, **C***; Chroma, **h⁰**;Hue.

The colour properties of layer breast meat are presented in table 3. There were no significant effects of layer type on skinned and skinless colour parameters of breast meat of spent broiler breeder, brown and white spent hen, except lightness (*L*) values *(*P=0.016*)*. The commercial white layer hens had significantly higher skinned breast meat lightness values than brown layer and broiler breeder hens.

Table 3. Means (±SEM) for the colour properties of breast meat, with/without skin, of spent broiler and commercial layers.

Factors	L*	a*	b*	C*	h⁰
Skinned meat					
Broiler Breeder	73.36±1.47[b]	25.17±5.78	0.75±0.68	25.53±5.64	0.09±0.06
Commercial White Layer	80.03±2.17[a]	29.98±8.08	0.33±1.42	31.56±7.43	0.20±0.13
Commercial Brown Layer	78.39±1.01[ab]	33.91±3.48	4.35±2.25	35.39±2.81	0.19±0.10
P Value	*0.016*	*0.576*	*0.073*	*0.440*	*0.075*
Skinless meat					
Broiler Breeder	55.33±1.26	17.62±3.54	7.96±1.04	20.05±3.24	0.50±0.11
Commercial White Layer	55.21±2.02	13.00±5.80	7.96±1.49	17.74±5.17	0.36±0.24
Commercial Brown Layer	58.33±1.88	27.93±4.32	4.12±1.76	29.00±4.11	0.18±0.10
P Value	*0.377*	*0.086*	*0.119*	*0.161*	*0.411*

*a–b ; means ± SEM with different superscripts that vary significantly within the same column
L*;Lightness*, **a***;Redeness, **b***;Yellowness, **C***; Chroma, **h⁰**;Hue.

The means for meat pH of skinless leg and breast layer meat are shown in table 4. There were significant differences in leg and breast meat pH between the groups. Broiler breeder hens had lower leg (P<0.001) and breast meat (P<0.001) pH compared to commercial laying hens.

Table 4. The meat pH values (±SEM) of thigh and breast meat of spent layers.

Genotype	Thigh	Breast
Broiler Breeder	6.09±0.03[b]	6.15±0.08[c]
Commercial White Layer	6.28±0.02[a]	6.60±0.03[a]
Commercial Brown Layer	6.35±0.06[a]	6.37±0.03[b]
P Value	<0.001	<0.001

*a–c ; means with different superscripts that vary significantly within the same column.

Discussion

Poultry meat quality is affected by several factors as genotype, housing condition, production system, slaughter age, nutrition, etc. (Del Bosque et al., 2020; Özbek et al., 2020; Semwogerere et al., 2018). As in commercial conditions, the slaughter age, nutrition, and housing condition of broiler breeder and commercial brown and white layer hens for carcass and meat quality analysis were different from each other in this study (Yalçın et al., 2020). In commercial conditions, the broiler breeder is slaughtered at 64 weeks of age, while layer hens are slaughtered after 72-95 weeks of age depending on performance and egg price (Lohman Tierzucht Management Guide 2019, 2020; Aviagen, 2021). The housing conditions and nutrition of breeder and commercial laying hens are different in practice. The broiler breeder was commonly housed in barn systems, while the commercial layers were housed in conventional battery cages.

There were significant differences in carcass and portion weights of layer hens in this study due to different body weights. As expected, broiler breeder hens' carcass weight was significantly greater than commercial brown and white layer hen. In commercial conditions, broiler chickens exhibit superior weight gain and have higher meat yields than laying hens. The body weight significantly affects the meat yield and some of the meat quality of culled layer hens (Kondaiah and Panda, 1992; Muthulakshmi et al., 2016). If we compare with commercial broiler, it can be said that broiler breeder carcass is above broiler marketing weight, brown ones are slightly below, and white ones are below the minimal marketing weight for broiler carcass (Aviagen, 2021). If a comparison is made with the carcass weight of the brown layer and hybrids are like that of slow-growing ones

(Ozbek et al., 2020). Therefore, marketing breeder meats as portioned or processed products would be more appropriate, whereas commercial layers as whole carcasses.

The poultry meat colour is one of the essential visual factors affecting consumers' decisions because it reflects the freshness of the meat (Wideman et al., 2016). Many factors such as genetic, age at slaughter, sex, indoor conditions, poultry diet, and pre-slaughter stress condition etc. affect poultry meat colour (Albrecht et al., 2019; Qamar et al., 2019; Siekman et al., 2018;). In this study, lightness values of skinned breast meat of commercial layers were significantly greater (lighter) than broiler breeder breast meat. Increased slaughter age is also characterized by a change in the colour attributes of meat being darker, redder, or yellower when compared to the younger hens (Yalçın et al., 2020).

The muscle type and skin are the main issues related to raw poultry meat colour; breast meat has a pale and pink colour, while the thigh meat expresses dark and red (Mir et al., 2017). If we compared to thigh and breast meat, the layer breast meat was found lighter than leg meat in all spent layers in our study. Cruz et al. (2018) showed that broiler thigh meat had a greater hue angle, chroma, brightness, and redness values than breast meat. Compared skinned and skinless meat lightness and yellowness colour parameters of breast and thigh meat, the skinned breast and thigh meat was lighter and yellower than skinless meat. The skinned thigh meat redness value was more remarkable in broiler breeder (Dunlop et al., 2016) while it was darkest in skinned spent layer meat (P<0.044).

The meat pH values of thigh and breast meat of the broiler breeder were significantly lower than commercial layers, which could be attributed to the

lower body weight of the commercial layers and pre-slaughter handling. The meat pH directly relates to the meat quality attributes such as tenderness, meat colour, and shelf life (Mir et al., 2017). Fletcher (1995) reported a correlation between the colour of the broiler breast fillets and the meat pH, and the pH of meat can be easily identified by meat colour (Anadon, 2002). Frizzel et al. (2018) reported strain differences for muscle meat pH and redness values of end of lay hens. Limpisophon et al. (2019) reported that the breast meat pH of spent layers was lower than commercial broiler meat.

Conclusion

The findings of this study provide baseline information for the carcass yields and meat quality of spent laying hens for the poultry industry and the consumers. Variability of meat quality characteristics were mainly related to genotype. However, it should be taken into account that the differences in terms of meat quality may have also been affected by the housing system, slaughter age, and nutrition, etc. If spent layer meat can be put into the consumption chain in any way, it can help compensate for some of the disadvantages of end of lay hens as lower economic values. In particular, free-range or organic spent laying hen meats may be evaluated in this way, and layer meats could be a good option for consumers looking for an alternative to broiler chicken meat.

Author contributions

MP planned this research, collected and analyzed the samples, and wrote the article. EÇ collected and analyzed the samples.

Competing interests

The authors declare that they have no conflict of interest for this paper.

Acknowledgement

We want to thank the slaughterhouse staff for their help with this study.

References

Albrecht A, Hebel M, Heinemann C, Herbert U, Miskel D, Saremi B, Kreyenschmidt J, 2019: Assessment of meat quality and shelf life from broilers fed with different sources and concentrations of methionine. *J. Food Qual,* 1, 1–10.

Anadon HLS, 2002: Biological, nutritional, and processing factors affecting breast meat quality of broilers, Ph.D. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA, 24061, USA, pp:181.

Aviagen, 2021: Parent Stock Ross 308 Parent Stock Performance Objectives. https://en.aviagen.com/assets/Tech_Center/Ross_P S/Ross308-ParentStock-PerformanceObjectives-2021-EN.pdf (last access 27.04.2021).

Bhaskar Reddy GV, Naga Mallika E, Obula Reddy B, Azad SAK, Maheswara Reddy, D, 2016: Comparison on meat quality characteristics of spent breeder, layer and broiler birds. *Int J Sci Environ Technol,* 5, 2590 – 2595.

Cruz FL, Silva AA, Machado IFM, Vieira LC, Estevez C, Fassani EJ, Faria PB, 2018: Meat quality of chicken of different crossing in alternative system. *Arq Bras Med Vet Zootec* 70, 254–262.

De Souza KMR, Araujo RB, Santos AL, Rodrigues CEC, Faria DE, Trinade MA, 2011: Adding Value to the Meat of Spent Laying Hens Manufacturing Sausages with a Healthy *Appeal Rev Bras Ciênc Avíc,* 13, 57–63 doi:10.1590/S1516-635X2011000100009.

Del Bosque CI, Altman BA, Ciulu M, Halle I, Jansen S, Nolte T, Weigend S, Mörlein D, 2020: Meat Quality Parameters and Sensory Properties of One High-Performing and Two Local Chicken Breeds Fed with Vicia faba. *Foods*, 9, 1052. doi:10.3390/foods9081052

Dos Santos TC, Gates RC, Tinoco FF, Estrada MM, Chizzotti ML, 2020: Meat quality traits of European quails reared under differentconditions of temperature and air velocity. *Poult Sci*, 99, 848-856 https://doi.org/10.1016/j.psj.2019.10.037

Dunlop MW, Moss AF, Groves PJ, Wilkinson SJ, Stuetz RM, Selle PH, 2016: The multidimensional causal factors of 'wet litter' in chicken-meat production. *Sci Total Environ,* 562, 766-776 doi: 10.1016/j.scitotenv.2016.03.147.

Fletcher DL, 1995: Relationship of breast meat color variation to muscle pH and texture, *Poult Sci*, 74(Suppl.), 120 (Abstr.).

Frizzell KM, Jendral MJ, Maclean IM, Dixon WT, Putman CT, 2018: Physicochemical determinants of pH in pectoralis major of three strains of laying hens housed in conventional and furnished cages. *Br Poult Sci*, 59, 286-300.

Hamm D, 1976: Use of Spent Laying Hens in Rendered Products. *Poult Sci*, 55, 399-402.

Ingram DR, Hatten LF, Homan KD, 2008: A Study on the relationship between eggshell color and eggshell quality in commercial broiler breeders. *Int J Poult Sci*, 7, 700–703.

Kadıoğlu P, Karakaya M, Unal K, Babaoğlu AS, 2019: Technological and textural properties of spent chicken breast, drumstick and thigh meats as affected by marinating with pineapple fruit juice. *Br Poult Sci,* 60 (4), https://doi.org/10.1080/00071668.2019.1621990

Karakaya M, Yetişir R, Aygün A, Yılmaz MT, Tiske SS, 2019: Effects of Proteolytic Enzymes of Plant Origin to the Carcass of White and Brown Egg Laying Chickens Completed Their Second Laying Cycle on Some Meat Quality Properties (*In Turkish with English abstract*) *Hayvansal Üretim*, 51(2), 44-49.

Kralik G, Kralik Z, Grcevic M, Hanzek D, 2018: Quality of chicken meat, in: Animal Husbandry and Nutrition, edited by: Banu Yücel, Book Chapter in Animal Husbandry and Nutrition, IntechOpen, https://doi.org/10.5772/intechopen.69938.

Keskin M, Setlek P, Demir S, 2018: Use of Color Measurement Systems in Food Sci. and Agriculture. Int. Adv.Res. & Engineering Congress. 16-18 November.

Kondaiah N, Panda B, 1992: Processing and utilization of spent hens. *World's Poult Sci J,* 48 (3). https://doi.org/10.1079/WPS19920020

Limpisophon K, E-tun S, Koeipudsa C, Charoensuk D, Malila Y, 2018: Characterization of Breast Meat Collected from Spent Lohmann Brown Layers in Comparison to Commercial Ross Broilers. *Rev Bras Cienc,* 21(3), https://doi.org/10.1590/1806-9061-2018-0941

Lohman Tierzucht Management Guide, 2019: Lohman Brown-Classic Layers Management Guide Cage Housing, 12/19. (Last Access 27.04.2021)

Lohman Tierzucht Management Guide, 2020: Lohman LSL-Classic Layers Management Guide Cage Housing, 02/20. (Last Access 27.04.2021)

Mir NA, Rafiq A, Kumar F, Singh V, Shukla V, 2017: Determinants of broiler chicken meat quality and factors affecting them: a review. *J Food Sci Technol*, 54, 2997–3009.

Muthulakshmi M, Muthukumar M, Rajkumar RS, Girish PS, Mooventhan P, 2016: Carcass characteristics and meat quality attributes of commercial culled layer hen. *Int J Sci Environ Technol*, 5, 3352-3361.

Özbek M, Petek M, Ardicli S, 2020: Physical quality characteristics of breast and leg meat of slow- and fast-growing broilers raised in different housing systems. *Arch Anim Breed*, 63, 337–344, https://doi.org/10.5194/aab-63-337-2020

Qamar A, Mohyuddin SG, Hamza A, Lartey KA, Shi CO, 2019: Physical and chemical factors affecting chicken meat color. *Pakistan J Sci*, 71, 82-88.

Polizer Rocha YJ, Lorenzo JM, Barros JC, Baldin JC, Trindade MA, 2019: Effect of chicken meat replacement by spent laying hen meat on physicochemical properties and sensorial characteristics of fresh sausage. *Br Poult Sci*, 60, 139-145, doi: 10.1080/00071668.2019.1568392.

Semwogerere F, Neethling J, Muchenje V, Hoffman LC, 2018: Effects of production systems on the carcass and meat quality characteristics of spent laying hens. *Poult Sci*, 6, 1990-1997.

Siekmann L, Meier-Dinkel L, Janisch S, Altmann B, Kaltwasser C, Sürie C, Krischek C, 2018: Carcass Quality, Meat Quality and Sensory Properties of the Dual-Purpose Chicken Lohmann Dual. *Foods*. 7, 156.

Snedecor GW, Cochran WG, 1989: *Statistical Methods*. Eighth Edition, Iowa State University Press.

IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

TS 5925, 2014: Poultry Rules for slaughtering and carcass preparation. Institute of Turkish Standards. Ankara, Turkey.

TS 5890, 2014: Poultry Carcass-Rules for carcass dissecting. Institute of Turkish Standards, Ankara, Turkey.

Wideman N, O'Bryan CA, Crandall PG, 2016: Factors affecting poultry meat colour and consumer perefenece-A Review. *World's Poult Sci J*, 72, 353-366. https://doi.org/10.1017/S0043933916000015

Yalçın S, Onbaşılar EB, Ramay MS, 2020: Effects of slaughter age and cage type on carcass and meat characteristics of laying hens. *Europ Poult Sci*, 84, DOI: 10.1399/eps.2020.310

Zampiga M, Soglia F, Baldi G, Petracci M, Strasburg GM, Sirri F, 2020: Muscle Abnormalities and Meat Quality Consequences in Modern Turkey Hybrids. *Front. Physiol*, https://doi.org/10.3389/fphys.2020.00554

*Correspondence: Metin Petek

Department of Animal Science, Faculty of Veterinary Medicine, University of Bursa Uludag, Turkey.

e-mail: petek@uludag.edu.tr