Brazilian Journal of Poultry Science
Revista Brasileira de Ciência Avícola

ISSN 1516-635X 2022 / v.24 / n.3 / 001-010

http://dx.doi.org/10.1590/1806-9061-2021-1615

Review

# Male Layer-Type Chickens – an Alternative Source for High Quality Poultry Meat: a Review on the Carcass Composition, Sensory Characteristics and Nutritional Profile

■Author(s)

Popova T[I] https://orcid.org/0000-0003-1561-5481
Petkov E[I] https://orcid.org/0000-0002-8386-6701
Ignatova M[I] https://orcid.org/0000-0002-0149-3658
Vlahova-Vangelova D[II] https://orcid.org/0000-0002-2027-504X
Balev D[II] https://orcid.org/0000-0002-9586-2361
Dragoev S[II] https://orcid.org/0000-0003-4817-6008
Kolev N[II] https://orcid.org/0000-0002-6964-5785

[I] Agricultural Academy, Institute of Animal Science-Kostinbrod, Bulgaria.
[II] University of Food Technologies should be corrected to University of Food Technologies, Plovdiv, Bulgaria.

■Mail Address

Corresponding author e-mail address
Teodora Popova
Agricultural Academy Institute of Animal Science- Kostinbrod, 2232, Kostinbrod, Bulgaria.
Phone: ++359 721 68 940
Email: tlpopova@yahoo.com

■Keywords

Male layer-type chickens, carcass quality, meat characteristics.



Submitted: 16/December/2021
Approved: 20/February/2022

## ABSTRACT

Male layer-type chickens are usually killed immediately after hatching. Despite the ethical debates and the sharp criticism against this practice, it is still widely applied. One of the possible alternatives for the culling of layer cockerels might be their use for meat production. Except for a small market niche, meat from male layer-type chickens is not currently popular among wider circles of consumers. However, although rather scarce, research on this type of bird shows that in comparison to fast or slow growing broilers, dual purpose, or indigenous breeds, the meat of male layers does not show any disadvantages in regards to sensory characteristics, chemical composition, and fatty acid profile, with its overall acceptability rating equally or even higher.

## INTRODUCTION

The poultry sector has been growing rapidly in many parts of the word, as poultry meat is among the most widely consumed foods. According to FAO, world poultry meat production increased dramatically from 9 million tons in 1961 to 134 million tons in 2020. Poultry meat is expected to represent 41% of all the protein from meat sources globally by 2030 (OECD/FAO, 2021). This increase in the production of poultry meat to respond to global demands is based on its affordable price and consumer preferences for healthier meat. As shown by Marangoni *et al.* (2015), the good nutritional profile of poultry meat enables its optimal incorporation into the diet at all ages, and adequate consumption can facilitate the control of body weight and reduce the risk of cardiovascular diseases, diabetes, and cancer. While modern hybrids for meat grow very fast, in recent years there is increased interest towards slow-growing chickens. The latter are reared free range or in organic systems (Fanatico *et al.*, 2007; Evaris *et al.*, 2019; Sarica *et al.,*2019), which positively influences meat quality (Popova *et al.,* 2018 a, b). However, despite their slow growth, male layer-type chickens are still not perceived by consumers as a meat chicken. These birds are not considered for meat production due to their poor performance and are usually killed right after hatching. This practice has been sharply criticized for years and, as a result, the European Union has started banning the culling of male chicks; with France and Germany being the first to stop this practice as of 2022. This makes it necessary to explore alternative uses of male layer-type chickens, such as adopting appropriate rearing strategies for these birds so that they are raised for meat production. There are already studies proving that male layer-type chickens have better quality characteristics as compared to male broilers; however, this depends on the age of slaughter and on rearing systems (Gerken *et al.*, 2003; Lichovníková *et al.*, 2009). Furthermore, Soisontes (2015) showed that male layer-type chickens are commonly used in Thailand for meat production and only a small part of them are further processed for animal feed. Hence, this review aims to summarise the existing knowledge about the meat quality characteristics of male layer-type chickens and to reveal the possible use of these birds for production of high quality meat products.

## Alternatives to culling male layer-type chickens - public awareness and perception regarding their use as meat

Alternatives to the culling of layer cockerels are schematized in Figure 1.

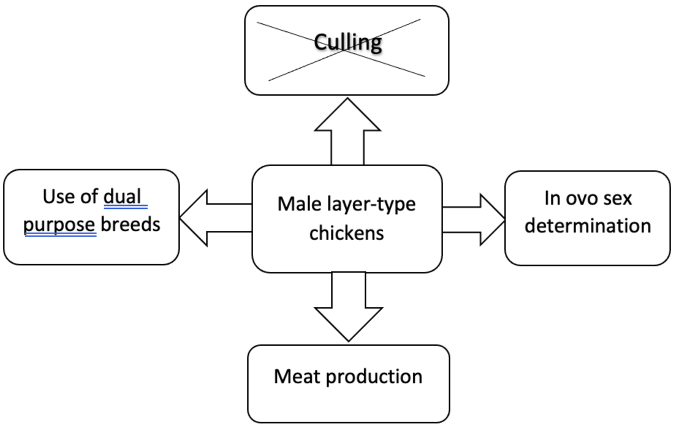


**Figure 1** – Alternatives to culling of male layer-type chickens.

Three approaches are generally applied to avoid culling: *in ovo* sex determination (Krautwald-Junghanns *et al.*, 2018; Fioranelli *et al.*, 2019; Reithmayer *et al.,* 2021), use of dual-purpose crossings (Damme *et al.*, 2015; Lambertz *et al.*, 2018; Reithmayer *et al.*, 2019; Baldinger & Bussemas, 2021), or use the male layer-type chickens for meat (Damme & Ristic, 2003; Konig *et al.*, 2010; 2012; Popova *et al.*, 2017; Murawska *et al.*, 2019). In recent years, due to the sharp criticism against the culling of male layers, several studies in Europe have been carried out to investigate the awareness of the population regarding alternatives for male layer-type chickens and their preferred ones (Leenstra *et al.*, 2011; Giersberg & Kemper, 2018; Gremmen *et al.,* 2018; Reithmayer & Musshoff, 2019; De Haas *et al.*, 2021). De Haas *et al*. (2021), summarized the results of 7 studies and showed that people prefer *in ovo* sex determination, followed by the use of dual purpose breeds. Rearing male layer-type chickens for meat was either not determined or the least preferred by the audience (6-10% vs. 51-57% for *in ovo* sex determination and 23-29 % for the use of dual purpose chickens, de Haas *et al.*, 2021). Only one of the studies (Gremmen *et al.*, 2018) reported that respondents preferred equally the use of dual purpose breeds and the rearing of male cockerels (41.3%). Although limited, positive consumer attitude towards rearing male layer-type chicks for meat has been shown. In a study from 2011 aiming to determine the suitability for fattening of male layer-type chickens, Kaufman & Andersson reported positive feedback from the consumers for the meat quality of this type of birds. However, the authors showed considerably higher operating costs for these birds reared in alternative system as compared to conventional broilers, which could place the meat from layer cockerels into a niche market. Later, Giersberg & Kemper (2018) presented the German perspective on the rearing of male layer chicks and also concluded that "fattening" male layer hybrids is not a suitable alternative for the mass or world market. However, the authors outline ways of marketing the meat of male chicks: it might be offered either under special brands or labels as whole carcasses or convenience product, or sold by retailers, usually not labelled but processed for traditional products.

## Carcass composition of the male layer-type chickens

Generally, male layer –type chickens produce lean carcasses. These type of birds need a much longer period than conventional broilers or dual purpose breeds to reach comparable slaughter weight (Table 1). The available literature includes studies reporting different ages of slaughter of male layer-type chickens ranging between 5 weeks (Popova *et al.,* 2017) and 28 weeks (Murawska *et al.,* 2019). Regardless of the age, the dressing percentage of the chickens varied between 59-69% and was within the range of values determined for slow growing chickens (Knight *et al.,* 2019). Higher dressing percentage was recorded by Murawska & Bochno, 2007 (73% in male layers at 8 and 10 weeks of age). On the other hand, Yigzaw *et al.,* (2020) presented slightly lower dressing percent in males from three different breeds slaughtered at 16 weeks of age (50.5%-53.6%). Such discrepancies might be attributed to the different breeds, as well as to processing conditions. It should be mentioned that in some cases the dressing percentage of the male layer cockerels did not differ substantially from that of broilers, however achieved after a much longer rearing period. In a study comparing male layer-type chickens with broilers, Murawska & Bochno (2007) showed that the carcass weight of Messa male chickens was 4.6 times lower than that of broilers at 6 weeks, and their dressing percentage was also lower (68.7% vs. 77.6%). However, at an older age (8-10 weeks), the dressing percentage of males increased to 73 %. Choo *et al*. (2014) reported 64.47% carcass yield in layer males at 51 days of age, which did not differ from

**Table 1** – Carcass characteristics of male layer-type chickens.

| Reference | N[1] | Breed | Age | Production system | Live weight, g | Dressing percentage, % | Breast, % | Legs, % | Abdominal fat, % |
|---|---|---|---|---|---|---|---|---|---|
| Damme & Ristic (2003) | 200 | Meister hybrid | 80 d | Floor pens | 1243 | 64.2 | 22.4 | 34.6 | NR[2] |
| Murawska & Bochno (2007) | 100 | Messa 445 | 6w | Straw litter | 665.8 | 68.68 | 24.9 | 33.7 | 0.41 |
| | | | 8w | | 1049.2 | 73.05 | 25.95 | 34.22 | 0.41 |
| | | | 10w | | 1485.0 | 73.06 | 25.43 | 35.45 | 1.14 |
| Jaturasitha *et al.* (2008) | 80 | Bar Plymouth Rock | 16 w | Commercial farm | 1640 | 63.8 | 15.7 | 19.9 | NR |
| | 80 | Shanghai | 16w | | 1700 | 65.8 | 14.8 | 20.5 | |
| Ahn *et al.* (2009) | 100 | Hy Line | 49d | Pens | 763.1±21.48 | 59.1±1.61 | 26.10±0.39 | 34.98±0.46 | NR |
| Lichovníková*et al.* (2009) | 50 | ISA Brown | 49d | Free range | 721.4±12.0 | 60.6±1.1 | 14.2±0.4 | 24.1±0.8 | 0.1±0.1 |
| | | | 90d | | 1769.0±15.9 | 63.3±0.6 | 15.6±0.3 | 25.4±0.5 | 0.7±0.1 |
| Choo *et al.* (2014) | 120 | Hy Line | 51d | Pens | 830.00 | 64.47 | 8.11 | 18.62 | NR |
| Popova *et al.* (2017) | 150 | Lohmann Brown Classic | 5w | Controlled microclimate/pens | 358±0.022 | 56.97±0.1 | NR | NR | NR |
| | | | 12w | | 1657±0.132 | 61.32±0.2 | | | |
| Mueller *et al.* (2018)[3] | 9 | Lohmann Brown Plus | 63 d | Pens | 1227 | 62.9 | NR | NR | NR |
| Murawska *et al.* (2019)[3] | 112 | Leghorn | 12 | NR | 1170.00±21.76 | 62.24±0.81 | NR | NR | NR |
| | | | 16 | | 1597.00±20.90 | 66.43±1.01 | | | |
| | | | 20 | | 1753.88±63.19 | 68.80±0.52 | | | |
| | | | 24 | | 2034.00±85.97 | 68.59±0.42 | | | |
| | | | 28 | | 2308.00±60.16 | 70.82±1.95 | | | |
| Yigzaw *et al.* (2020) | 150 | Novo Brown | 16 w | Pens | 1690±173 | 50.55±0.35 | 23.8±0.21 | 17.1±0.36 | NR |
| | 150 | Lohmann Brown | 16 w | | 1540±20 | 53.65±0.31 | 23.4±0.63 | 18.2±0.03 | |
| | 150 | Dominant Sussex | 16 w | | 1543±490 | 53.5±1.67 | 23.3±1.03 | 17.2±0.3 | |

[1]Number of chickens in the study; [2] NR-not reported; [3] Authors have provided data in absolute values.

White mini broilers (65.17%, 28 d) and commercial broilers (64.85%, 21 d). The muscle deposition and distribution in male layers also differs from that in broilers. The percentage of the breast shown in the studies varied from 14% to 26 %, whereas that of legs ranged between 24%-35 %. Lower percentage for both parts was reported by Choo *et al.* (2014) (8.11% and 18.62 for the breast and thigh respectively). Some of the studies comparing layer cockerels to broilers reported different distribution of the meat in layer-type chickens, with less meat located in the breast and more in the legs (Murawska & Bochno, 2007; Lichovníková *et al.,* 2009; Mueller *et al.,* 2018). On the other hand, Damme & Ristic (2003), Ahn *et al.* (2009) and Choo *et al.* (2014) did not observe dramatic differences in the distribution of the meat among breast and legs between male layers and broilers. Both authors reported lower percentages of meat in the two carcass parts in the layer cockerels than in the broilers, confirming that layer-type chickens have less meat than broilers (Murawska *et al.,* 2005). Additionally, Mueller *et al.* (2018) showed that the carcasses of the male layer-type chickens had considerably thinner breast muscles (18.8 mm) and legs (29.4mm) when compared to fast and slow-growing broilers (breast:41.0 mm-23.4mm; leg:41.7mm-38.7mm), and dual purpose breeds (breast: 25.7mm-20.6mm; leg: 39.2mm-34.6mm). The lower deposition of meat, especially in breast, might be responsible for the less attractive appearance of the carcass of male layer-type chickens when compared to commercial broilers and hens. The lower meat content of male layer-type chickens is accompanied by low deposition of abdominal fat. In male layer-type chickens at the age of 49 days and 90 days, Lichovníková *et al*. (2009) reported respectively 0.1% and 0.7% abdominal fat, whereas Murawska & Bochno (2007) determined 0.41% for 6 and 8 week old cockerels, and a slightly higher percentage (1.14%) for layer males at the age of 10 weeks. These values were considerably lower than those observed in broilers: 2.0%-2.7% (Lichovníková *et al.*, 2009) and 2.73% (Murawska & Bochno, 2007). Increased abdominal fat deposition in modern fast growing broilers is a result of the intensive selection for improved feed conversion and higher breast yield, but is also one of the major problems in the poultry industry. The excessive fat in poultry carcasses is a concern for producers, since parts of it are lost during carcass evisceration, thus impairing carcass quality and yield (Duarte *et al*., 2014). Moreover, it is considered wasted food energy and a waste product with low economic value (Emmerson *et* *al.,* 1997, Wang *et al*., 2017). In this regard, low fat deposition in the carcass of layer cockerels might be considered a positive trait.

## Meat colour and tenderness

Meat colour is consumers' major criterion to choose meat (Ripoll *et al*., 2019). Poultry meat colour can be affected by different factors; some of which depend on the bird itself, while others are related to environment and processing (Wideman *et al.*, 2016). Meat colour was measured in a limited number of studies (Table 2). The lightness of the meat (L*) was determined within the range of 50.8-59.51. These values have been measured for breast meat; however, most of the studies report L* values between 53-58 in both breast and leg muscles. According to Qiao *et al.* (2001), meat with a value higher than 53 is considered light. The a* values presented in the studies indicate higher redness in the leg meat than breast (3.47-4.69 vs. 1.22-1.86). Much redder breasts are presented by Lichovníková *et al.* (2009) and Ahn *et al.* (2009) (3.0; 3.87, respectively). It should be mentioned that, although not comparing them, Lichovníková *et al*. (2009) reported very different values in the red component of breast in male layer-type chickens aged 49 and 90 d (3.0 vs. -0.34), which indicates strong influence of age on meat colour components. This study also presented the highest values of yellow component b* in breast, which differed again in both ages (19.3 vs. 13.6 respectively for the chickens ages 49 and 90 days). As opposed to Lichovníková *et al.* (2009), Mueller *et al.* (2018) reported very low values of yellowness in both breast and legs (0.72). The rest of the studies reported b* values for male layer-type chickens within the range of 5.13-11.9. Most of the studies presenting meat colour in male layer-type chickens compare it to that of commercial fast and slow growing broilers, or traditional dual-purpose breeds. The results from the comparisons are not consistent and there is not a uniform trend in meat colour components between the different genotypes. When comparing layer cockerels with broilers, Lichovníková *et al.* (2009), Ahn *et al.* (2009), and Choo *et al.* (2014) showed that the latter had lighter meat than layer-type cockerels. This is not surprising, since the selection of broilers towards higher weight and breast yield leads to lighter meat, as shown by previous studies (Le Bihan- Duval *et al.* 1999; Le Bihan-Duval *et al*., 2001). This can be partly explained by lower content of heme pigments in selected broilers (Berry *et al.*, 2001) or rapid pH decline. In contrast, in a study comparing commercial fast growing broilers, slow growing broilers, indigenous lines, and layer males, Mueller *et al.* (2018) showed that commercial broilers had the darkest colour of all the genotypes, and male layers were in the middle position among the slow growing broiler and indigenous breeds. The lighter colour of the male layer-type chickens compared to the broilers corresponded to the lower pH values in their meat (5.90 vs. 6.25). Jaturasitha *et al.* (2008) also showed that Bar Plymouth Rock and Shanghai layer males had lighter meat in both breast and leg cuts than indigenous breeds. Only two of the studies (Lichovníkováe*t al*., 2009 and Mueller *et al*., 2018) presented colour of the skin in male layer-type chickens. Lichovníková *et al.* (2009) reported slightly darker skin in layer males regardless of the age, with considerably higher yellowness than broilers. The opposite was reported by Mueller *et al.* (2018). The yellow colour of the skin observed by Lichovníková *et al.* (2009) and the highest values of b* component in the meat might be attributed to the free range rearing of the birds the and accumulation of carotenoids from the diet.

Tenderness has been described as probably the single most critical quality factor that associated with end consumers' satisfaction with poultry meat (Fletcher, 2002). Methods for evaluation of poultry meat tenderness include instrumental analyses,

**Table 2 –** Instrumental colour and tenderness of meat from male layer-type chickens.

| Reference | N[1] | Breed | Age | Production system | Muscle | L* | a* | b* | Shear force |
|---|---|---|---|---|---|---|---|---|---|
| Jaturasitha *et al.* (2008) | 80 | Bar Plymouth Rock | 16 w | Commercial farm | Breast | 55.8 | 1.86 | 9.9 | 30.9 N |
| | 80 | Shanghai | 16w | | Legs | 54.3 | 3.47 | 5.13 | 35.8N |
| Ahn *et al.* (2009) | 100 | Hy Line | 49d | Pens | Breast | 54.14±0.58 | 3.87±0.25 | 7.18±0.25 | 2.30kgf[2] |
| | | | | | Legs | 55.51±0.51 | 4.69±0.27 | 7.03±0.44 | 22.55N |
| Lichovníkováe*t al*. (2009) | 50 | ISA Brown | 49d | Free range | Breast | 55.2±0.78 | 3.0±0.5 | 19.3±0.65 | NR |
| | | | 90d | | | 50.8±0.47 | -0.34±0.30 | 13.6±0.53 | |
| Choo *et al*. (2014) | 120 | Hy Line | 51d | Pens | Breast | 59.51 | 1.22 | 6.96 | 2.42 kgf[2] |
| | | | | | | | | | 23.63N |
| Mueller *et al.* (2018) | 9 | Lohmann Brown Plus | 63 d | Pens | Breast | 54.6 | 1.35 | 0.72 | 12.1N |
| | | | | | Leg | 53.1 | 4.56 | 0.72 | |

[1]Number of chickens in the study; [2] The study originally reports shear force in kgf.

descriptive analyses, consumer sensory evaluation, or combinations of such tests (Owens *et al.*, 2004). The tenderness of meat in male layer-type chickens has been determined through measurement of the shear force, and mainly for the breast. The values of shear force were quite different among the studies. In cooked samples, the shear force measured in breast varied among 12.1 N in Lohmann Brown Plus (Mueller *et al.*, 2018), 22.55N-23.63N (2.30 kgf -2.41 kgf) in brown layer chickens Hy line (Ahn *et al.*, 2009; Choo *et al.,* 2014), 30.9 N-21.9N in Bar Plymouth Rock and Shanghai, respectively (Jaturasitha *et al.*, 2008). Again, as comparedto commercial broilers or slow growing ones and indigenous lines, Mueller *et al.* (2018) found significant effect of the genotype ($p$<0.001) on meat tenderness, with male layer chickens having less tender meat when compared to broilers (12.1N vs. 8.7N, respectively); which might be due to the older age of male layer-type chicks. However, in comparison with other slow growing broiler and dual purpose lines, the differences in shear force were not significant. Neither Ahn *et al.* (2009) nor Choo *et al*. (2014) observed significant differences in the shear force of meat obtained from male layer chicks as compared to White mini broiler and commercial broiler. On the other hand, Jaturasitha *et al*. (2008) found that the tenderness of breast meat of both layer-type lines was higher than in the indigenous Thai breed, and tended to be higher in the thigh muscles. Both layer-types had less tender meat than the birds crossbred between the Thai indigenous and Bar Plymouth Rock.

## Chemical composition and fatty acid profile

The moisture content reported varied between 71.1% (Mueller *et al*., 2018) and 84.4% (Yigzaw *et al*., 2020) in breast, and 73.2% (Jaturasitha *et al*., 2008) and 75.7 % (Popova *et al*., 2017). The chemical composition of the breast and leg meat has been found to differ among the various genetic types and breeds. The comparison between genotypes (Mueller *et al*., 2018) showed significant difference between fast growing broilers and male layers regarding moisture, which was more evident in breast. Male layer-type chickens had lower moisture content than broilers, but values of this parameter did not differ significantly between indigenous breeds and slow growing broilers. As opposed to Mueller *et al.* (2018), Jaturasitha *et al*. (2008) found that moisture content varied among breeds in thigh muscle, with significant differences observed between Bar Plymouth Rock and Thai indigenous breed. Choo *et al.* (2014) found significantly lower moisture in breast of layer-type male chickens as compared to two broiler breeds. Such results were later confirmed by Lichovníková *et al*. (2009), but only at a later bird age. When comparing three breeds of layer males, Yigzaw *et al*. (2020) observed significantly lower moisture content in Lohmann Brown than in Novo Brown and Dominant Sussex. Age was also responsible for the difference in moisture content in meat. In a study by Popova *et al.* (2017) comparing the quality of meat in male layer-type chickens aged 5 and 12 weeks, it was shown that moisture content was higher in the breasts of younger birds, but lower in their thighs ($p$<0.001). Moisture in meat affects its shelf life and has strong impact on sensory parameters (Ahmad *et al.,* 2018). According to Jo *et al.* (2012), moisture contents depends on intramuscular fat contents. Such relationship was found by Mueller *et al.* (2018), Popova *et al.* (2017), and Lichovníková *et al*. (2009) in breast meat. The fat content in the meat of layer cockerels varied stronglybetween studies (Table 3), between 0.43% (Jaturasitha *et al*., 2008) – 0.68% (Mueller *et al*., 2018; Lichovníková *et al*., 2009) in breast. Relatively high fat content in breast was reported by Choo *et al.* (2008) (1.77%) and Yigzaw *et al*. (2020) (2.01%-2.09%), resembling the fat content in broilers' meat. The fat content of male layers was generally lower when compared to broilers; however, Choo *et al.* (2008) did not find any difference. In leg meat, the fat content was higher and varied within the range of 2.47% (Popova *et al*., 2017) to 5.55% (Jaturasitha *et al.*, 2008). The latter reported significant difference in that parameter between breeds. Fat content of breast and thigh meat in male layers also varied between age groups, as is well documented by Popova *et al.* (2017). The authors found that fat content was higher in both breast (0.61% vs. 0.44 %) and thigh meat (3.85% vs. 2.47%) in chickens at 5 weeks of age as compared to 12 weeks.

The protein content in the meat of male layer-type chickens was reported in five of the studies. As with the rest of the chemical components of the meat, protein was found to be different among genotypes, breeds, and age (Table 3). Mueller *et al.* (2018) and Choo *et al.* (2014) found that male layer-type chickens had higher protein content in comparison to broilers in both breast and legs. Additionally Mueller *et al.* (2018) also reported significantly higher protein content (20.8%) in layer cockerels' legs when compared to slow growing broiler Sasso + and dual purpose Belgian Malines (20.2%). Yigzaw *et al.* (2020) reported significant differences in protein content in three layer

**Table 3 –** Chemical composition of meat in male layer-type chickens.

| Reference | N[1] | Breed | Age | Production system | Muscle | Moisture, % | Fat, % | Protein, % | Ash, % |
|---|---|---|---|---|---|---|---|---|---|
| Jaturasitha *et al.* (2008) | 80 | Bar Plymouth Rock Shanghai | 16 w | Commercial farm | Breast | 73.3 | 0.56 | 24.2 | NR[2] |
| | | | 16w | | Legs | 73.2 | 3.83 | 21.3 | |
| | 80 | | | | Breast | 73.3 | 0.59 | 23.9 | |
| | | | | | Legs | 74.5 | 5.55 | 19.8 | |
| Lichovníkováet *al.* (2009) | 50 | ISA Brown | 49d | Free range | Breast | 25.1±0.06 | 0.49±0.08 | NR | NR |
| | | | 90d | | | 26.6±0.06 | 0.68±0.11 | | |
| Choo *et al.* (2014) | 120 | Hy Line | 51d | Pens | Breast | 72.77 | 1.77 | 25.19 | 0.27 |
| Popova *et al.* (2017) | 150 | Lohmann Brown Classic | 5w | Controlled microclimate/ pens | Breast | 74.69±0.1 | 0.61±0.04 | 21.54±0.15 | 1.16±0.01 |
| | | | 12w | | Legs | 74.98±0.18 | 3.85±0.15 | 18.11±0.10 | 1.13±0.01 |
| | | | | | Breast | 73.46±0.09 | 0.44±0.08 | 22.98±0.09 | 1.12±0.01 |
| | | | | | Legs | 75.70±0.11 | 2.47±0.13 | 18.77±0.09 | 1.11±0.01 |
| Mueller *et al.* (2018) | 9 | Lohmann Brown Plus | 63 d | Pens | Breast | 71.1 | 0.68 | 25.1 | NR |
| | | | | | Leg | 74.8 | 2.67 | 20.8 | |
| Yigzaw *et al.* (2020) | 150 | Novo Brown | 16 w | Pens | Breast | 84.4±0.06 | 2.01±0.25 | 44.05±1.5 | 3.8±0.54 |
| | 150 | Lohmann Brown | 16 w | | | 83.7±0.00 | 2.09±0.11 | 48.8±0.6 | 3.8±0.65 |
| | 150 | Dominant Sussex | 16 w | | | 84.4±0.00 | 2.06±0.23 | 42.9±1.8 | 3.21±0.3 |

[1]Number of chickens in the study, [2]NR-not reported.

breeds, the highest being Lohmann Brown (48.8%) in comparison to Nova Brown and Dominant Sussex (44.05%-42.09%, respectively). Popova *et al.* (2017) found that layer cockerels at the age of 5 weeks had lower protein content than those at the age of 12 weeks for both breast and thigh meat. On the other hand, the authors found that older birds had lower ash content than younger birds. Cholesterol content in the meat of male layers was reported only by Jaturasitha *et al.* (2008). The content of total cholesterol in breast was 15 mg/100 g, while in legs it was 76.5 mg/100g-86.4 mg/100g, for both layer-type chickens Bar Plymouth Rock and Shanghai, respectively. These values were significantly higher than those determined in the legs of Thai (58.7 mg/100g) and the crossbred birds (68.4 mg/100g). The values of the cholesterol content in the breast of male layer-type chicks were considerably lower than in broilers (23.51 mg/100g in organic broilers, 36.78 mg/100g in antibiotic free broilers, Giampietro-Caneco *et al*., 2020), turkey (27.0 mg/100g, Baggio *et al*., 2002), and duck (Ishmoyowati & Sumarmono, 2011).

## Fatty acid profile

The fatty acid profile of meat is an important quality characteristic that is strongly related to its health value. Studies reporting fatty acid composition in male layer-type chickens are quite scarce (Table 4). When comparing male layer-type chickens to White mini broiler and commercial broiler, Choo *et al.* (2014) found significant effects of the genotype on the content of MUFA ($p<0.001$), PUFA ($p<0.001$), n-6 ($p<0.001$), and n-3 ($p=0.018$) in breast meat. Layer-type cockerels had considerably lower MUFA when compared to the commercial broiler (30.81% vs. 38.88%), but higher PUFA (34.11%vs 27.48%). The higher PUFA was due mainly to the higher percentage of n-6 PUFA (32.59 %vs. 24.54%). In regard to n-3, however, male layer-type chicks had lower content when compared to both broiler breeds (1.51% vs.3.00% and 2.93%, for the White mini broiler and commercial broiler respectively).

Jaturasitha *et al.* (2008) showed that differences in the fatty acid composition in breast and thigh meat of male chickens were more pronounced between the two layer-type breeds than when compared to the indigenous or crossbred chickens. This might be used to show certain advantages of both layer breeds in regard to the fatty acid profile.

When compared to Bar Plymouth Rock, the breast meat of Shanghai male chickens had higher SFA content (39.39 % vs. 36.94%), lower MUFA (27.44%-32.65%), and higher PUFA (33.17 % vs. 30.42%). The

**Table 4 –** Fatty acids in meat of male layer-type chickens.

| Reference | N[1] | Breed | Age | Muscle | SFA[2], % | MUFA[3], % | PUFA[4], % | n-6, % | n-3, % |
|---|---|---|---|---|---|---|---|---|---|
| Jaturasitha *et al.* (2008) | 80 | Bar Plymouth Rock | 16 w | Breast | 34.94 | 32.65 | 30.42 | 29.02 | 1.32 |
| | | | | Legs | 36.72 | 29.70 | 33.57 | 31.50 | 2.00 |
| | | Shanghai | 16w | Breast | 39.39 | 27.44 | 33.17 | 30.32 | 2.71 |
| | 80 | | | Legs | 39.96 | 27.71 | 32.33 | 30.04 | 2.24 |
| Choo *et al.* (2014) | 120 | Hy Line | 51d | Breast | 35.09 | 30.81 | 34.11 | 32.59 | 1.51 |

[1]Number of chickens in the study; [2] SFA-saturated fatty acids, [3]MUFA –monounsaturated fatty acids, [4] PUFA-polyunsaturated fatty acids.

latter was due to the significantly higher content of n-3 PUFA (2.71 % vs. 1.32%). The higher n-3 PUFA determined the lower n-6/n-3 PUFA in Shanghai birds (14.29 vs.22.80). The leg meat of Shanghai chickens also showed higher SFA content than that of Bar Plymouth Rock (39.96% vs. 36.72%). Due to the limited number of studies showing the fatty acid profile of the meat from male layer-type chickens, and the fact that the fatty acids are mainly affected by the feeding, it is difficult to conclude on certain advantages of layer cockerels regarding this trait. However, different feeding or rearing strategies (e.g. free range rearing with pasture access) might be applied in order to make their fatty acids profile more favourable for a healthy and balanced human diet.

### Sensory evaluation and overall acceptance of the meat from male layer-type chickens

The sensory evaluation of the meat is critical for its acceptance by consumers. The meat from male layer-type chickens has been subjected to sensory evaluation in three of the studies (Jaturasitha *et al.*, 2008; Lichovníková *et al*., 2009 and Ahn *et al*., 2009). In the study of Jaturasitha *et al.* (2008), the sensory evaluation was carried out on roasted meat from breast and thigh, using a scale from 1 to 9 pts. (1 very unfavourable and 9 very favourable). There were no significant differences in the sensory evaluation including tenderness, juiciness, and flavor, between the meat from layer-type chickens and those from the indigenous breed and crossbreed. The overall acceptability of the breast was 5.75-6.00, and thighs were rated 6.92-7.17. Similarly, using the 9 pts hedonic scale, Ahn *et al.* (2009) found no significant difference in the flavor, tenderness, and juiciness of the grilled meat of Hy-Line male chickens when compared to broilers. However, the colour of the meat from the male layer-type chickens was rated lower than broilers (7.67 vs. 8.11 and 8.33 respectively for the Ross broiler and White mini broiler). The overall acceptability of the meat was 8.00, which was similar to that of the broiler meat (8.11-8.22).

Using an unstructured scale from 0 to 100, Lichovníková *et al.* (2009) reported that, regardless of the age, male layer-type chickens had significantly darker colour of the breast meat in comparison to broilers ($p<0.001$). At the age of 49 days, male layers displayed tougher meat ($p<0.01$), and the overall acceptability of the meat from ISA Brown chicks was higher than from Ross broilers.

Though limited, these findings testify that the meat from male layer-type chickens does not show any significant disadvantages when compared to fast and slow growing broilers, and in some cases even excels it and might be well accepted by consumers as a high quality poultry meat.

## CONCLUSIONS

The review focused on male layer-type chickens, particularly on carcass characteristics and meat quality in terms of sensory traits, and chemical, and fatty acid composition. These parameters were presented in a very limited number of studies and often in comparison to commercial or slow growing broilers, indigenous breeds, dual purpose breeds, and crossbreeds. Age was also considered as a factor affecting meat quality traits. Male layer-type chickens produced lean carcasses with lower deposition of meat, especially on breast, and low abdominal fat content. The sensory characteristics, and chemical, and fatty acid profile of the meat of male layer-type chickens did not show disadvantage when compared to the other chicken genotypes or breeds, with its overall acceptability being the same and even higher. The results of the studies suggest that, instead of being culled, male layer-type chickens might be used as a source of high quality meat. However, further research is needed on different rearing strategies or dietary manipulations to develop best rearing practice for this type of birds, so that their meat is popular not only to a small market niche but to wide circles of consumers.

## ACKNOWLEDGEMENTS

The authors would like to thankfully acknowledge the funding provided by the Bulgarian National Science Fund, Ministry of Education and Science in Bulgaria (Project INOVAMESPRO, Contract Nº КП06-Н56/10, 12.11.2021).

## REFERENCES

Ahmad RS, Imran A, Hussain BM. Nutritional composition of meat. In: Arshad MS, editor. Meat science and nutrition. London: IntechOpen Limited; 2018.

Ahn BK, Kim JY, Kim JS, Lee BK, Lee SY, Lee WS, et al. Comparisons of the carcass characteristics of male white mini broilers, Ross broilers and Hy Line brown chicks under the identical rearing condition. Korean Journal of Poultry Science 2009;36:149-55.

Baggio SR, Vicente E, Bragagnolo N. Cholesterol oxides, cholesterol, total lipid, and fatty acid composition in turkey meat. Journal of Agricultural and Food Chemistry 2002;50(21):5981–6.

Baldinger L, Bussemas R. Dual-purpose production of eggs and meat — Part 1: cockerels of crosses between layer and meat breeds achieve moderate growth rates while showing unimpaired animal welfare. Organic Agriculture 2021;11:489–98.

Berri C, Wacrenier N, Millet N, Le Bihan-Duval E. Effect of selection for improved body composition on muscle and meat characteristics of broilers from experimental and commercial lines. Poultry Science 2001;80(7):833–8.

Choo Y-K, Oh S-T, Lee K-W, Kang C-W, Kim H-W, Kim C-J, et al. The growth performance, carcass characteristics, and meat quality of egg-type male growing chicken and white-mini broiler in comparison with commercial broiler (Ross 308). Korean Journal for Food Science of Animal Resources 2014;34(5):622–9.

Damme K, Ristic M. Fattening performance, meat yield and economic aspects of meat and layer-type hybrids. World's Poultry Science Journal 2003;59:50-53.

Damme K, Urselmans S, Schmidt E. Economics of dual-purpose breeds—A comparison of meat and egg production using dual purpose breeds versus conventional broiler and layer strains. Lohmann Information 2015;50 (2):4–9.

De Haas EN, Oliemans E, van Gerwen MAAM. The need for an alternative to culling day-old male layer chicks:a survey on awareness, alternatives, and the willingness to pay for alternatives in a selected population of dutch citizens. Frontiers of Veterinary Science 2021;8:662197.

Duarte KF, Junqueira OM, Borge LL, Rodrigues E, Filardi R da S, Praes MFFM, et al. Performance, carcass traits, and body composition of broilers fed different linseed oil levels between 21 and 56 days of age. Revista Brasileira de Ciência Avícola 2014;16(1):55–60.

Emmerson DA. Commercial approaches to genetic selection for growth and feed conversion in domestic poultry. Poultry Science 1997;76:1121–5.

Fanatico AC, Pillai PB, Emmert JL, Owens CM. Meat quality of slow- and fast-growing chicken genotypes fed low-nutrient or standard diets and raised indoors or with outdoor access. Poultry Science 2007;86(10);2245–55.

Faustin Evaris E, Sarmiento Franco L, Sandoval Castro C. Slow-growing male chickens fit poultry production systems with outdoor access. World's Poultry Science Journal 2019;75(3):429-44.

Fioranelli M, Sepehri A, Roccia MG, Rossi C, Vojvodic P, Lotti J, et al. In ovo sexing of chicken eggs by virus spectroscopy. Open Access Macedonian Journal of Medical Sciences 2019;7(18):3106-9.

Fletcher D L. Poultry meat quality. World's Poultry Science Journal2002;58(2):131–45.

Gerken M, Jaenecke D, Kreuzer M. Growth, behavior and carcass characteristics of egg-type cockerels compared to male broilers. World's Poultry Science Journal 2003;59:46–9.

Giampietro-Ganeco A, Boiago MM, Mello JLM, De Souza RA, Ferrari FB, Souza PA, et al. Lipid assessment, cholesterol and fatty acid profile of meat from broilers raised in four different rearing systems. Anais da Academia Brasileira de Ciencias 2020;92(Suppl. 1):e20190649.

Giersberg MF, Kemper N. Rearing male layer chickens: a german perspective. Agriculture 2018;8:176.

Gremmen HGJ, Bruijnis MRN, Blok V, Stassen EN. A public survey on handling male chicks in the Dutch egg sector. Journal of Agricultural and Environmental Ethics 2018;31:93–107.

Ismoyowati, Sumarmono J. Fat and cholesterol contents of local Duck (*Anas platyrhynchos platyrhynchos*) meat fed mash, paste and crumble feeds. Asian Journal of Poultry Science 2011;5:150-4.

Jaturasitha S, Kayan A,Wicke M. Carcass and meat characteristics of male chickens between Thai indigenous compared with improved layer breeds and their crossbred. Archiv Tierzucht, Dummerstorf 2008;51 (3):283-94.

Jo C, Cho SH, Chang J, Nam K C. Keys to production and processing of Hanwoo beef: a perspective of tradition and science. Animal Frontiers 2012;2:32–38.

Kaufmann F, Andersson R. Eignung männlicher legehybriden zur mast. Hochschule Osnabrück, Research Report; 2011. Available from: https://opus.hs-osnabrueck.de/files/10/Report_Kaufmann_Andersson.pdf.

Knight C, Anderson G, Hatley J. Generating data-based recommendations for pastured broiler producers. Journal of the NACAA 2019;12(1):1-7.

Koenig M, Hahn G, Damme K, Schmutz M. Utilization of laying type cockerels as "coquelets":influence of genotype and diet characteristics on growth performance and carcass composition. Archiv fur Geflugelkunde 2012;76 (3):197–202.

Koenig M, Hahn G, Damme K, Schmutz M. Utilization of laying type cockerels as coquelets - growth performance and carcass quality. Fleischwirtschaft 2010;90:92–4.

Krautwald-Junghanns M-E, Cramer K, Fischer B, Förster A, Galli R, Kremer F, et al. Current approaches to avoid the culling of day-old male chicks in the layer industry, with special reference to spectroscopic methods. Poultry Science 2018;97:749–57.

Lambertz C, Wuthijaree K, Gauly M. Performance, behavior, and health of male broilers and laying hens of 2 dual-purpose chicken genotypes. Poultry Science 2018;97:3564–76.

Le Bihan-Duval E, Millet N, Remignon H. Broiler meat quality:beffect of selection for increased carcass quality and estimates of genetic parameters. Poultry Science 1999;78(6):822–6.

Le Bihan-Duval E, Berri C, Baeza E, Millet N, Beaumont C. Estimation of the Genetic Parameters of Meat Characteristics and of Their Genetic Correlations with Growth and Body Composition in an Experimental Broiler Line. Poultry Science 2001;80(7):839–43.

Leenstra F, Munnichs G, Beekman V, Van den Heuvel-Vromans E, Aramyan L, Woelders H. Killing day-old chicks? Public opinion regarding potential alternatives. Animal Welfare 2011;20:37.

Lichovníková M, Jandásek J, Jùzl M, Draèková E. The meat quality of layer males from free range in comparison with fast growing chickens. Czech Journal of Animal Science 2009;54:490–7.

Marangoni F, Corsello G, Cricelli C, Ferrara N, Ghiselli A, Lucchin L, Poli A. Role of poultry meat in a balanced diet aimed at maintaining health and wellbeing:an Italian consensus document. Food and Nutrition Research 2015;59:27606.

Mueller S, Kreuzer M, Siegrist M, Mannale K, Messikommer RE, Gangnat ID. Carcass and meat quality of dual-purpose chickens (Lohmann dual, Belgian malines, Schweizerhuhn) in comparison to broiler and layer chicken types. Poultry Science 2018;97:3325–36.

Murawska D, Bochno R, Michalik D, Janiszewska M. Age-related changes in the carcass tissue composition and distribution of meat and fat with skin in carcasses of laying-type cockerels. Archiv fur Geflügelkunde 2005;69(3):S135–9.

Murawska D, Bochno R. Comparison of the slaughter quality of layer-type cockerels and broiler chickens. The Journal of Poultry Science 2007;44:105-10.

Murawska D, Gesek M, Witkowska D. Suitability of layer-type male chicks for capon production. Poultry Science 2019;98(8):3345-51.

OECD/FAO. OECD-FAO Agricultural Outlook 2021-2029. Rome: OECD Publishing; 2021.

Owens CM, Cavitt LC, Meullenet J-FC. Tenderness evaluation in poultry meat. Proceedings of the 57th American Meat Science Association, Reciprocal Meat Conference; 2004 Jun 20-23; Lexington, Kentucky. p.115-121.

Popova T, Petkov E, Ignatova M, Lukic M. Fatty acid composition of thigh meat in two lines of slow-growing chickens as affected by the access to pasture. International Journal of Innovative Approaches in Agricultural Research 2018b;2(2):123-132.

Popova T, Petkov E, Ignatova M. Carcass and meat quality of male layer-type chickens at different age. Proceedings of the 11th International Symposium Modern Trends in Livestock Production; 2017 Octr 11-13**.** Belgrade-Zemun: Institute for Animal Husbandry; 2017. p.220-8.

Popova T, Petkov E, Ignatova M. Fatty acid composition of breast meat in two lines of slow-growing chickens reared conventionally or on pasture. Food Science and Applied Biotechnology 2018a;1(1):70-6.

Qiao M, Fletcher DL, Smith DP, Northcutt JK. The effect of broiler breast meat color on pH, moisture, water-holding capacity, and emulsification capacity. Poultry Science 2001;80:676–80.

Reithmayer C, Danne M, Mußhoff O. Societal attitudes towards in ovo gender determination as an alternative to chick culling. Agribusiness 2021;37(2);306-23.

Reithmayer C, Mußhoff O, Danne M. Alternatives to culling male chicks. The consumer perspective. British Food Journal 2019;122:753–65.

Reithmayer C, Mußhoff O. Consumer preferences for alternatives to chick culling in Germany. Poultry Science 2019;98:4539–48.

Ripoll G, Alcalde MJ, Argüello A, Panea B. Web-based survey of consumer preferences for the visual appearance of meat from suckling kids. Italian Journal of Animal Science 2019;18:1284–93.

Sarica M, Yamak US, Boz MA, Erensoy K, Cilavdaroglu E, Noubandiguim M. Performance of fast, medium and slow growing broilers in indoor and free-range production systems. South African Journal of Animal Science 2020;49(6):1127–38.

Soisontes S. An alternative use of one day-old male layer chicks: the case of Thailand. 2015. Available from: http://www.wing-vechta.de/pdf_files/themenenglisch/male-layer-chicks_for-poultry-international.pdf.

Wang G, Kim W K, Cline M A, Gilbert E R. Factors affecting adipose tissue development in chickens:A review. Poultry Science 2017;96(10):3687-99.

Wideman N, O'Bryan CA, Crandall PG. Factors affecting poultry meat colour and consumer preferences - A review. World's Poultry Science Journal 2016;72(2):353–66.

Yigzaw M, Demeke S, Hassen W. The meat quality of layer males from three exotic chickens. Global Journal of Animal Scientific Research 2020;8(1):12-9.