

## Review

# Broiler meat quality: Proteins and lipids of muscle tissue

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**Proteins and lipids of muscle tissue are important meat quality parameters. They contribute substantially to the nutritional characteristics of meat. A number of studies has been conducted on the effect of different factors on the protein and lipid content of broiler meat. Given the above, the subject matter of the present paper was to provide a review of latest research results on the said quality traits as affected by the most commonly tested factors. The results were grouped and presented in terms of the effect of nutrition, genotype, sex, age and rearing system. The objective of the paper was to review major previous studies on the subject in an attempt to define a future research pathway and facilitate the promotion of scientific findings towards wider practical implementation.**

**Key words:** Broilers, meat quality, proteins, lipids.

## INTRODUCTION

The quality of meat in general and hence poultry meat is an extremely complex notion that can be assessed from different points of view. From the standpoint of consumer interests and the slaughter industry, broilers should have not only high slaughter yields and desirable carcass conformation scores but also good aesthetic, sensory and nutritional characteristics. Nutritionally speaking, poultry meat is a valuable source of proteins, vitamins and minerals, and has a relatively low fat content. In that respect, the chemical composition of muscle tissue of major primal cuts is an important element of broiler meat quality (Demby and Cunningham, 1980; Ristić, 1999; Bogosavljević-Bošković, 2003; Grashorn and Closterman, 2002).

The above quality traits are dependent upon a number of factors. Genotype, sex and age stand out among biological factors (Lewis et al., 1997; Bokkers and Koene, 2003; Hellmeister et al., 2003). Among numerous non-genetic factors that substantially affect certain meat

quality traits, broiler nutrition plays an important role. Diet composition and feed consumption can affect the chemical composition of muscle tissue to a greater or lesser extent. Particular importance has been attached to broiler rearing system in the last years (Ristić, 2003; Holcman et al., 2003; Bogosavljević-Bošković et al., 2006a, 2011). Broiler rearing system is gaining importance along with the fact that the modern broiler meat market dominated solely by price competitiveness is undergoing radical transformation into a market equally dominated by both price and quality competitiveness.

Given the above, the objective of this work was to provide a review of latest research results on the chemical composition of broiler meat, protein and lipid content in particular, in terms of the effect of major genetic and non-genetic factors.

## PROTEINS AND LIPIDS IN MUSCLE TISSUE OF BROILERS AS DEPENDENT UPON MAJOR REARING FACTORS

As regards the anatomic region, origin, structure and function of muscle tissue of broilers, most authors

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emphasize differences in the chemical composition of breast, thigh and drumstick muscles. Žlender et al. (1995) report that the protein content of leg muscles and breast muscle-plus-skin ranges from 15.8 to 17.9% and 21.9 to 23.5%, respectively. The fat content of thigh muscle, as determined by the same authors, was within the 10.6 to 15.6% range and that of breast muscle ranged from 3.9 to 8.4%. Similar data were reported by Bogosavljević-Bošković et al. (1999). Breast muscle contains about 22% proteins. Apart from having more fat, thigh muscles have a somewhat lower protein content—about 17.20% (Simeonova, 1999). In commercial hybrids (Ross 308, Cobb, Hybro), the protein content of breast muscle is on the average of 3.6 to 4.2% higher than that of thigh muscles (Suchu et al., 2002). Most of the total body fat is found under the skin, as well as in the abdomen (Simeonova, 1999). A comparison of the fat content of main muscle groups of poultry meat reveals even greater differences than in protein content. Diaz (2010) relates the differences to the very structure of these organs, breast being mostly composed of white fibres, as opposed to drumsticks made up of muscles that contain red fibres having different metabolic functions. The fat and protein content of muscles is a complex trait simultaneously affected by a large number of genetic and non-genetic factors.

Nutrition, as one of the most important external factors in broiler production, can have a crucial effect on the chemical composition of broiler meat. Factors that can have a highly variable effect on the chemical composition and quality of poultry meat include the following: choice of raw materials to be used in feed formulation, their characteristic chemical composition, different protein and energy values of formulated rations, different degrees of nutrient utilisation, different mutual (synergistic and antagonistic) effects of feed components. Higher protein diets induce a higher meat protein content, while reducing the fat content of the muscles. The effect of nutrition on body fat percentage is primarily reflected in abdominal fat. The accumulation of fat in the abdomen is generally due to an imbalance between energy intake and energy expenditure (Skrivan et al., 1990). Marcu et al. (2009) studied Ross 500 commercial broilers fed diets containing different protein levels, and reported that the broilers receiving rations having a 2% higher crude protein content (during all fattening stages) gave a 0.48, 0.74 and 0.64% higher protein content of breast, thighs and drumsticks, respectively. Similar findings were obtained by Thim et al. (1997) who fed broilers on feed containing 16 to 24% proteins, and reported statistically significant differences in the total meat protein content, with higher protein intake resulting in a higher protein content in broiler meat (broilers fed 16 and 24% protein feed were found to have the meat protein content of 15.2 and 16.97%, respectively).

Ghahri et al. (2010) attribute the results to the fact that an increase in protein intake induces a decrease in the

protein calory ratio that is a reduction in energy intake relative to the protein intake, resulting in decreasing body fat percentage. Rezai et al. (2004) reported that a 2% reduction in the protein content of broiler feed induced an increase in the abdominal fat content from 16.4 to 22.2%. Similar data were obtained by Aletor et al. (2000) and Furlan et al. (2004). Zelenka et al. (2006) observed that the above-optimal fat content in broiler feed (in an experiment involving different dietary flaxseed oil concentrations) had a negative effect on the meat protein content, but no significant effect on the fat content of breast and thighs. The effect of fat provided through dietary intake on adipose tissue composition of certain organs is far higher than on meat fat content, suggesting that broiler feed can be used to easily modify the adipose tissue of reared animals (Crespo et al., 2002), due to the fact that fatty acids present in the feed undergo slight modifications to be incorporated into the body fat (Scaife et al., 1994).

Sanz et al. (1999a) evaluated the effect of different fat sources in broiler feed on body fat composition. Each of the three test groups of broilers received 8% suet, fat and sunflower oil in the diet and the results obtained showed highest variations in the level of polyunsaturated fatty acids. Sunflower oil (rich in polyunsaturated fatty acids) induced an almost threefold increase in the content of these acids in abdominal fat and neutral intramuscular fat (triglycerides) as compared to the diet containing suet as a source of fatty acids, whereas the difference in the polar fraction of intramuscular fat (phospholipids) was considerably lower (about 30%). Similar results were obtained by Betti et al. (2009). El Hachemi et al. (2007) studied the effect of different concentrations of olive oil (highly rich in unsaturated fatty acids, particularly monounsaturated oleic acid C18:1) in broiler nutrition. Feeding on diets containing increased concentrations of olive oil also led to a statistically significant increase in the total breast fat concentration as well as to a change in the content of unsaturated and polyunsaturated fatty acids, whereas the content of monounsaturated oleic acid did not undergo any substantial change. No total fat increase was observed in broiler thighs. The composition of all categories of fatty acids changed statistically significantly or even highly significantly. Significant changes were not observed only in the percentage of linoleic acid in both breast and thighs. The same authors reported that the abdominal fat percentage decreased with increasing concentrations of saturated fatty acids and that the percentage of oleic and linoleic acids increased, which is an important finding in both nutritional and health terms. Panda et al. (2010) achieved substantially better fattening performance when common maize was substituted by high-protein maize having 15 to 20% more crude proteins than the control group (fed common maize).

Apart from the dietary protein requirements, special consideration should be given to the feed content of essential amino acids, primarily lysine and methionine.

Higher amounts of these amino acids are needed (a minimum of 1.20% lysine and 0.90% of methionine + cystine) during the first stage of fattening (0 to 21 days), and somewhat lower amounts (a minimum of 0.90% lysine and 0.70% methionine+cystine) during the second stage (21 to 42 days). A higher amount of these amino acids in the diet consequently leads to their higher content in broiler meat. In their study on the effect of different methionine and lysine levels in broiler feed, Muhtar et al. (2007) suggested that an increased level of the two essential amino acids in broiler diet improved some broiler characteristics (total body weight and meat yield), and implied the existence of differences, though statistically non-significant, in protein content as dependent upon the level of these amino acids. A study by Ghahri et al. (2010) suggested that the optimal lysine level of 1% in broiler feed contributes not only to increased live weight at slaughter and reduced feed conversion, but also to elevated levels of the amino acid in broiler meat, through an increase in the yield of breast as the richest source of lysine in chicken meat. In addition, a number of researchers have associated the use of inorganic feed supplements with the protein and fat level in broiler carcass. Toghiani et al. (2008) observed that the addition of 1000 µg of chromium chloride statistically significantly increased the breast protein level from 20.72 to 22.98%, whereas an increase in the thigh protein content was not statistically significant. Kim et al. (1996) obtained a reduction in abdominal fat through the use of chromium picolinate feed supplement which was found to show an inhibitory effect on lipogenesis in broiler tissues under *in vitro* conditions. Breast fat percentage was statistically significantly reduced through the addition of 200 ppm organically bound chromium (Tolimir et al., 2005). This was attributed by Sakhari et al. (1992) to the ability of chromium to facilitate insulin secretion which enhances protein synthesis, contributes to the transport of amino acids to the site of synthesis and substantially reduces protein degradation in broilers.

Another factor to consider in broiler rearing is providing adequate microclimate rearing conditions in view of their great effect on meat quality. Higher temperatures induce a reduction in protein content and an increase in fat content of broiler meat. Thim et al. (1997) suggested that meat protein content is significantly affected by environment temperature, as broilers reared at a temperature of 26.6°C had a higher protein content (16.77%) than those reared at 35°C (14.35%). Gu et al. (2008) reported that excess high temperatures can substantially reduce meat protein content. Conversely, high temperatures can increase the carcass content of fat, abdominal fat in particular, while low temperatures have the opposite effect (Gordon and Charles, 2002; Baziz et al., 1996). Thim et al. (1997) reported 16.52 and 17.35% of total body fat at 26.6 and 35°C, respectively. Broiler rearing system has attracted the attention of a number of researchers in the last years who have, however, obtained differing results

on the effect of rearing system on the chemical composition of muscle tissue in broilers. Grashorn and Bros (1997) suggested that different rearing systems lead to different meat quality, with greater differences, though, being observed only for broilers reared under extensive systems in accordance with controlled ecological production, as opposed to label broilers (less intensive fattening following the label concept) which performed similarly to conventional commercially reared animals. Muriel and Pascual (1995) found no significant differences in muscle protein content between extensive male broilers slaughtered at 85 days of age and free range broilers slaughtered at 81 days of age. Protein content was lower in extensive broiler meat than in free range broiler meat.

Castellini et al. (2002) studied the effect of rearing system on the chemical composition of broiler meat in conventional broilers (8 birds/m<sup>2</sup>) and organic broilers (8 birds/m<sup>2</sup>+4m<sup>2</sup>free range/bird) and observed minimum differences in protein content and substantial differences in fat content in different muscle groups. Namely, at 56 days of age, organic broilers had a fat content of 0.72% in the breast, and conventional broilers – 1.46%. At 81 days of age, the respective values were within a wider range of 0.74 and 2.37%. The fat content of drumsticks was as follows: 2.47:4.46% after 56 days of fattening and 2.83:5.01% after 81 days, respectively. As for the effect of rearing system on fat composition i.e. content of fatty acids, organic broilers were found to have a higher content of saturated and polyunsaturated fatty acids but a lower content of monounsaturated fatty acids in both breast and drumsticks as compared to conventional broilers (Castellini et al., 2002). Organic broilers also gave a higher omega-3 and omega-6 fatty acid content, being attributed to a certain extent to different feeding conditions, as these broilers were allowed free access to grass paddock. Free range broilers had a 1.2 to 1.7 % higher breast proportion and a 0.1 to 0.5% higher share of drumstick. Holcman et al. (2003) suggested that fattening practiced in accordance with EU regulations on extensive and free range production systems did not affect the chemical composition of breast and leg muscles in broilers aged 56 days. Contrary to the above authors, a study conducted by Ristić (2003) on meat quality of 5 different broiler genotypes reared under ecological conditions revealed that the chemical composition of breast and drumstick meat was affected by the production system. The effect of rearing system on protein and fat content of breast and leg muscles was also reported by Bogosavljević-Bošković et al. (2006b, 2008). The results obtained were attributed to the fact that extensive indoor and free range production systems, with the latter involving access to natural environment (fresh air and sunlight), resulted in differences in terms of the structural manifestations of tissues and organs, as well as in terms of the biochemical processes involved in the metabolism.

Dou et al. (2009) studied 3 rearing systems (indoor-floor, indoor-net and free range) but observed no statistically

significant differences in meat protein and fat content between the broilers raised in confinement and those allowed access to free range. The same authors reported the abdominal fat content of 6.28 and 6.50% in the two systems without free range as opposed to the low 3.01% obtained in the free range system. They also produced a higher breast and thigh proportion under free range rearing. The said differences were attributed to differences in locomotor activity, which has an important effect on abdominal fat content. Similar data were reported by Fanatico et al. (2005) while comparing conventional floor system without free range and floor system with free range. The effect of fattening length on meat quality has been studied by numerous authors. The protein content of breast, thigh and drumstick increases with their age, the increase being accompanied by a fat content reduction in breast and drumstick- by 2.5% on day 42 and 2.1 % on day 52 in breast, and by 9.3% on day 42 and 8.9% on day 52 in thighs (Suchy et al., 2002). Suto et al. (1998) report the following data: crude protein content in male broilers during weeks 2, 6 and 12 of age was about 17.2, 19.6 and 20.5%, respectively. The percentage remains constant until week 20. In females, the observed differences in crude protein content were as follows: 16.4 % during week 2; 20.1% during week 6, with the value decreasing thereafter to 19.1% in week 12 and 18.5% in week 20. Fat content increased in both males and females.

The differences observed were due to different metabolism in male and female broilers. Castellini et al. (2002) and Haro (2005) observed an increase in fat content between days 56 and 81. Females have a higher fat content than males (Sanz et al., 1999b; Haro 2005), the differences being associated by Tumova and Teimouri (2010) with metabolic differences, higher competitiveness among males, different fat accumulation capacity, different nutritional requirements and higher hormonal effect in females. Genotype is another factor significantly affecting body protein and fat percentage in broilers. Berri et al. (2001) determined statistically significant differences in protein content between commercial and some experimental broiler hybrids. Sogunle et al. (2010) compared two commercial hybrids, Arbor Acres and Marshal MY, and reported about 1% higher protein content and lower total fat content in breast and thigh muscles in Arbor Acres than in Marshal MY. Meluzzi et al. (2009) found the highest breast protein content in the slow-growing hybrid, followed by medium- and fast-growing ones, and a 30% higher fat content of breast muscle in the fast-growing hybrid (Cobb 700) as compared to medium-growing (Naked Neck Kabir) and slow-growing (Brown Classic Lohman) hybrids. The fat content of thighs showed even greater differences: 4.34% fat in the fast-growing hybrid, 3.07 % in the medium-growing one, and as low as 2.29% in the slow-growing hybrid. As for fat composition, a significantly higher content of unsaturated, polyunsaturated, total omega-3 and omega-6 fatty acids was determined in the slow-growing hybrid than in The fast-growing one, whereas the percentage of

monounsaturated fatty acids was higher in the fast-growing hybrid. The medium-growing hybrid showed intermediary values as compared to the other two hybrids. Farran et al. (2000) reported a higher content of abdominal fat and total crude fat in Arbor Acres than in Ross and Hybro G. Ristić (2005) obtained a 0.4% lower abdominal fat content in Cobb 500 as compared to Ross. Lorengsan et al. (2003) and Rizzi and Chiericato (2010) confirmed the strong effect of genotype on meat protein content, as well as the importance of selection for substantial improvement of the trait.

## CONCLUSION

Proteins and lipids of muscle tissue are important meat quality parameters. They contribute substantially to the nutritional characteristics of meat. Given the increasing importance of quality in any production and hence, broiler production, a number of studies have been conducted on the effect of different (genetic and non-genetic) factors on the nutritive value of broiler meat quality. To this end, most authors have attached particular importance to nutrition. Research results reveal that increased dietary levels of proteins result in an increased protein content of broiler meat. Studies on the effect of dietary fat generally suggested a higher effect on adipose tissue composition than on the meat fat content. Some authors emphasise the importance of essential amino acids (lysine and methionine) in broiler feed; others report the importance of inorganic feed supplements. An important effect of broiler genotype and sex has been confirmed by many studies. Substantial differences in the fat and protein content of muscle tissue were observed between fast- and slow-growing hybrids, as well as between some strains and hybrids commonly used for broiler meat production. Proteins and lipids of muscle tissue have been frequently evaluated in terms of the effect of broiler rearing system. Given the differences observed between the test production systems in fattening length, stocking density, access to free range, effect of different climatic factors, etc., the results reported in these studies are often quite variable. Some authors have reported no significant effect of rearing system on the fat and protein content of broiler meat; others have obtained statistically significant differences. Overall speaking, this review suggests that the results of previous studies have confirmed the importance of proteins and lipids in terms of meat quality, as well as the substantial effect of a large number of factors on the traits. Moreover, more thorough and detailed future research would facilitate further clarification of the issue herewith presented.

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