

CHANGES IN QUALITY OF PARENTS STOCK HENS MEAT DURING CHILLED STORAGE

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Abstract

The aim was to study changes of chemical composition (fat content, protein content), pH and colour of poultry meat during chilled storage.

Various criteria are used for evaluation of bird and carcass quality, while the combination of several indices determines the quality of poultry meat, which has an important role in the following meat processing and quality of end product. Chilled poultry meat is offered in retail and it is used in processing plants for various meat products production. Chemical composition (fat content, protein content), pH and colour are important quality determinants. Hens' meat is cheaper compared to broiler meat, therefore its use in processing is profitable.

Parents stock hens of the cross Ross 308 were used for the study. Parents stock hens were fed compound feed. After chilling a hen fillet [*musculus pectoralis*], hen thighs [*musculus biceps*] and hen drumsticks [*musculus gastrocnemius*; *musculus fibularis longus*] were separated from carcasses. The obtained products were refrigerated at temperature $+1\pm 0.5$ °C. The analyses were performed 1 day after slaughter and on the 5th day of storage. The following parameters were analysed: pH value (3510pH Meter – JENWAY); total protein content (LVS ISO 937:1978); fat content (LVS ISO 1443:1973); colour changes (Color Tec-PCM; software ColorSoft QCW for colour data analysis).

The analysed parameters significantly differ in 'white' and 'red' poultry meat, and in various cuts of 'red' meat.

Key words: poultry, pH, meat composition, colour, texture.

Introduction

Poultry meat muscles differ by colour ('white' and 'red') and quality. 'White' meat in hens mainly is located in breast part, while the rest is considered 'red' meat. The differences in colour give the presence of protein myoglobin, which gives red colour to muscles. 'White' muscle tissue contains a little higher amount of essential amino acids, less fat, cholesterol, and phosphatides (Мысик, Белов, 1986).

Although the consumer may choose meat primarily for its aesthetic appeal, or through habit, it is important not to overlook its nutritional value. The composition of lean meat is relatively constant over a wide range of animals. Variation is most marked in the lipid content, which may be evident as different degrees of 'marbling' (Varnam and Sutherland, 1995).

Water is quantitatively the most important component of meat comprising up to 75% of weight. Water in meat is associated with muscle tissue, and proteins have a central role in the mechanism of water binding (Varnam and Sutherland, 1995).

Poultry meat is a wholesome food, which contains valuable proteins, all essential amino acids, lipids, macro- and microelements, vitamins. Cholesterol content in poultry is relatively low. The content of carbohydrates is

low as well (Мысик, Белов, 1986).

Almost all water soluble vitamins are found in poultry muscle tissue. Poultry is a good source of group B vitamins (Мысик, Белов, 1986).

Meat is justifiably considered a high protein food. Of the total nitrogen content of muscle, 95% is protein and 5% smaller peptides, amino acids, and other compounds. The quality of the protein is very high, the types and ratios of amino acids being similar to those required for maintenance and growth of human tissue. Of the essential amino acids, meat supplies substantial quantities of lysine and threonine and adequate quantities of methionine and tryptophan, although the content of these amino acids in meat is relatively low.

Meat has relatively high lipid content. This is of dietary significance in provision of energy, especially for persons engaged in heavy labour, or where overall dietary intake is limited (Varnam and Sutherland, 1995).

Post mortem lipid oxidation (rancidity) is one of the causes of deterioration of the meat product quality, affecting the flavour, colour, nutritive value, and safety (Dawson et al., 1987).

Water content compared to other compounds in poultry is higher. Water present in meat provides its digestibility and sensory properties. Water serves as

media where metabolism processes take place, which means that water participates in digestion process (Warkup et al., 1991).

Materials and Methods

Parents stock hens of the cross Ross 308 were used for the study. The average age of slaughtered parents' stock hens was 46 weeks; an average carcass weight of a bird was 2.6 kg.

The slaughter and primary treatment was performed at a meat processing plant (line Stork PMT). Laying hens were stunned, then killed with a knife, bled for 3.37 minutes and scalded in a steam bath at 60.2 ± 0.2 °C for 3.47 minutes, defeathered, eviscerated and chilled for 100 minutes at $+1 \pm 0.5$ °C. Three carcasses were randomly selected for separating a fillet [*musculus pectoralis*], thighs [*musculus biceps*], and drumsticks [*musculus gastrocnemius*; *musculus fibularis longus*] (Brūveris, 2007). The obtained products were refrigerated

at the temperature of $+1 \pm 0.5$ °C. The analyses were performed 1 day after slaughter and on the 5th day of storage.

The following parameters were analysed at the Faculty of Food Technology (Latvia University of Agriculture), and the National Diagnostic Centre of Food and Veterinary Service:

- pH value using 3510pH Meter – JENWAY;
- total protein content by the method of LVS ISO 937:1978;
- fat content by the method of LVS ISO 1443:1973;
- colour changes were evaluated using Color Tec-PCM and software ColorSoft QCW was used for colour data analysis.

The Hunter *L, a, b* system was used for food colour evaluation. The Hunter tristimulus data, *L* (value), *a* (redness or greenness), and *b* (yellowness or blueness) can be converted to a single colour function called colour difference (ΔE) by using the following equation:

$$\Delta E^* = (\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2$$

$$\Delta L^* = L^*_{sample} - L^*_{standard}$$

+ ΔL^* means sample is lighter than Standard
- ΔL^* means sample is darker than Standard

$$\Delta a^* = a^*_{sample} - a^*_{standard}$$

+ Δa^* means sample is redder than Standard
- Δa^* means sample is greener than Standard

$$\Delta b^* = b^*_{sample} - b^*_{Standard}$$

+ Δb^* means sample is yellower than Standard
- Δb^* means sample is bluer than Standard

The colour difference is a measure of the distance in colour space between two colours. It does not indicate the direction in which the colours differ (DeMan, 1999).

Analysis of pH, protein, and fat content were done in triplicate for each parameter. In colour evaluation, 10 replications were used.

Results and Discussion

Chemical composition of poultry meat depends on bird type, variety, age, fatness, and other factors (Мысик, Белов, 1986). Changes in fat content in the cuts - hen fillet [*musculus pectoralis*], hen thighs [*musculus biceps*], and hen drumsticks [*musculus gastrocnemius*; *musculus fibularis longus*] - were observed during refrigerated storage (see Fig. 1).

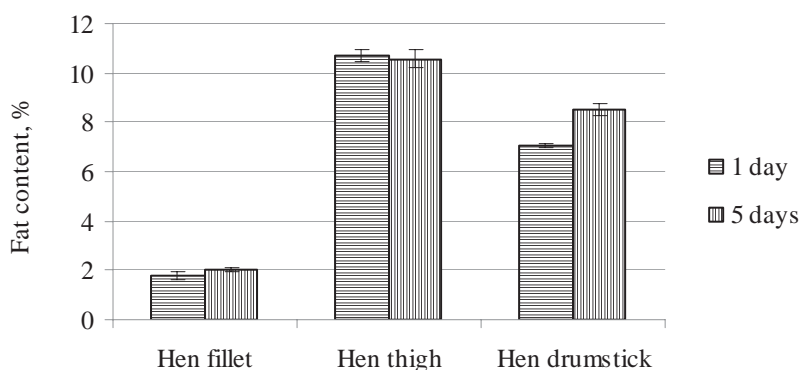


Figure 1. Changes in fat content in various poultry meat cuts during refrigerated storage.

During refrigerated storage, an increase in fat content was observed in a hen fillet which had by 14.68% higher fat content on the 5th day of storage compared to the fat content detected on the 1st day after slaughter. Fat content was by 20.22% higher in drumsticks, but it was approximately at the same level in hen thighs after 5 days of storage.

The increase in fat content in fat tissues and muscle tissues is closely related to water content reduction. Warris (2000) found that tendency of negative correlation exists between fat and water content, although strong linear correlation was not found.

The total lipid content of white meat is approximately half of dark meat, and skin contains the highest proportion of lipid (Ratnayake et al., 1989). The total fat content in light muscle with skin has been quoted as approximately 10 times higher (11.1 g 100 g⁻¹ muscle) than in muscle without skin (Decker and Cantor, 1992).

Lipids in meat are of three discrete types: subcutaneous, intermuscular, and intramuscular. The amount that accumulates in an animal depends on a number of factors including genetic predisposition, age, gender and sex status, level of nutrition, and exercise.

Chicken contains approximately 7% of fat (DeMan, 1999).

There can also be marked variation according to the location of the fat in the body. Internal body fats are significantly harder than those near the skin. This is thought to reflect the fact that the lower temperatures at the outside of the body mean the fat must have a lower melting point to permit mobilization. Conversely internal fats must have some structural rigidity and thus have a higher melting point (Varnam and Sutherland, 1995).

In poultry, fat is synthesized in the liver primarily and is transported to the adipose tissue in the form of very low density lipoproteins (VLDL). High deposition of adipose tissue is associated with high circulating levels of VLDL and high rates of hepatic lipogenesis. Significant correlations exist between body fat, hepatic activities of the lipogenic enzymes such as ATP-citrate lyase or malate dehydrogenase, and plasma VLDL concentration (Nahm, 1999).

The changes in protein content in a hen fillet [*musculus pectoralis*], hen thighs [*musculus biceps*], and hen drumsticks [*musculus gastrocnemius*; *musculus fibularis longus*] are demonstrated in Fig. 2.

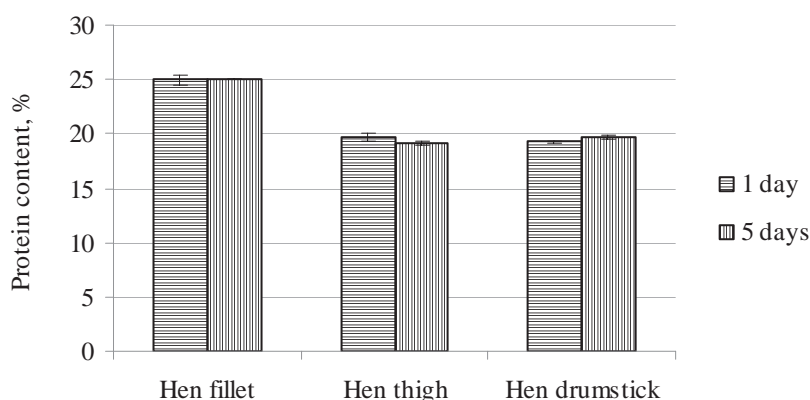


Figure 2. Changes in protein content in various poultry meat cuts during refrigerated storage.

During the storage, content of protein in chilled hen fillet was practically constant - changes of protein content in thighs and drumsticks were small, i.e., protein content in thighs decreased by 2.5%, while in drumsticks increased by 2.2%.

Muscle may be classified in a number of ways. The simplest is 'red' or 'white', colour reflecting the different myoglobin content. 'Red' muscles are characterized by high myoglobin content, a highly developed vascular system, and copious supplies of oxygen. They are consequently adapted to oxidative metabolism and are thought to be involved in sustained, repetitive activity. As a further consequence, 'red' muscles have limited glycolytic activity and a relatively high content of mitochondria. 'White' muscles have lower myoglobin content, relatively few mitochondria, and a less well developed vascular system than the 'red' ones. They have greater glycolytic

capacity and are thought to be involved in short bursts of violent activity, during which metabolism becomes anaerobic. The simple differentiation between 'red' and 'white' is of value in meat science since there is a broad correlation with post-mortem behaviour and functional properties in meat products (Varnam and Sutherland, 1995).

Research studies have shown that increasing the levels of energy as well as protein results in improved growth rates and feed conversion. Increasing the levels of energy increases the carcass fat content, while increasing protein levels decrease the carcass fat content (Nahm, 1999).

Changes in pH during chilled storage in hen fillet [*musculus pectoralis*], thighs [*musculus biceps*], and drumsticks [*musculus gastrocnemius*; *musculus fibularis longus*] are shown in Fig. 3.

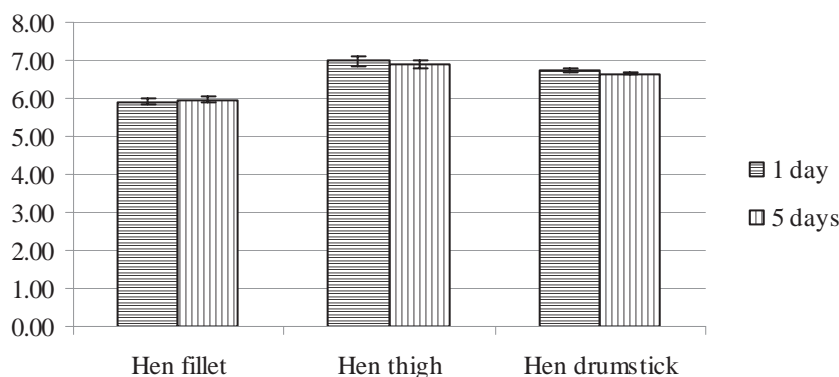


Figure 3. pH changes in various poultry meat cuts during refrigerated storage.

Experiments proved that the pH value changes during chilled storage of poultry meat are negligible due to low storage temperature (+1±0.5 °C). 'White' meat (hen fillet) pH is considerably lower than that of 'red' meat, i.e., hen thighs and hen drumsticks, which correlates with earlier findings that the lighter muscle (fillet) has lower pH values (Fletcher, 1999).

The pH values of the lighter-than normal, normal, and darker-than normal groups were 5.81, 5.96, and 6.23 respectively. (Qiao et al., 2001). Glycogen content in meat - 0.10% (DeMan, 1999).

The ultimate pH value of 'red' muscles tends to be

higher than that of 'white'. This is a consequence of the biochemical specialization of the two types of muscle, 'red' muscles having relatively low glycogen reserves and being of relatively limited glycolytic enzyme activity. Differences in the ultimate pH value of different muscles may be explained by the differing ratios of 'red' and 'white' fibres present.

The fact that poultry meat colour changes during storage is well established (Petracci and Fletcher, 2002).

The colour changes during chilled storage for hen fillet inner side and hen inner fillet are presented in Table 1.

Table 1

Colour changes in hen fillet during chilled storage

L*a*b* parameters		Hen fillet (inner side), 1 st day	Hen fillet (inner side), 5 th day	Hen inner fillet, 1 st day	Hen inner fillet, 5 th day
L* parameter	Average	48.53	46.47	43.83	43.66
	STD	±3.11	±1.41	±1.81	±1.20
a* parameter	Average	-3.52	-2.23	-2.01	-1.39
	STD	±1.51	±0.90	±1.42	±1.98
b* parameter	Average	10.63	12.91	10.68	9.84
	STD	±2.09	±2.01	±1.84	±2.96

Calculations and results for colour changes in hen fillet inner side:

$$\Delta L^*_{\text{hens fillet (inner side)}} = 46.47 - 48.53 = -2.06$$

$$\Delta a^*_{\text{hens fillet (inner side)}} = -2.23 - (-3.52) = +1.29$$

$$\Delta b^*_{\text{hens fillet (inner side)}} = 12.91 - 10.63 = +2.28$$

$$\Delta E^* = (-2.06)^2 + (1.29)^2 + (2.28)^2 = 11.09$$

The calculations show that hen fillet inner side becomes darker during its storage, Δa^* gives evidence that it becomes more red, but Δb^* in its turn proves the change towards more yellow colour compared to the colour observed at the beginning of the storage.

Calculations and results for colour changes in hen

inner fillet:

$$\Delta L^*_{\text{hens inner fillet}} = 43.66 - 43.83 = -0.17$$

$$\Delta a^*_{\text{hens inner fillet}} = -1.39 - (-2.01) = +0.62$$

$$\Delta b^*_{\text{hens inner fillet}} = 9.84 - 10.68 = -0.84$$

$$\Delta E^* = (-0.17)^2 + (0.62)^2 + (-0.84)^2 = 1.11$$

The calculations show that according to change in ΔL^* , hen inner fillet becomes darker during the storage, factor Δa^* shows tendency to become more red, but parameter Δb^* shows that increase in blueness is observed during the storage.

The hen meat colour changes in thighs and drumsticks during chilled storage are summarized in Table 2.

Table 2

Colour changes in hen thighs during chilled storage

L*a*b* parameters		Hen thigh, 1 st day	Hen thigh, 5 th day	Hen drumstick, 1 st day	Hen drumstick, 5 th day
L* parameter	Average	72.33	69.64	72.25	71.28
	STD	±1.25	±2.20	±1.78	±2.53
a* parameter	Average	-2.50	-2.75	-2.27	-3.19
	STD	±0.85	±0.77	±0.76	±0.72
b* parameter	Average	13.15	13.80	12.37	9.86
	STD	±1.49	±2.11	±1.72	±1.96

Calculations and results for colour changes in hens' thighs with skin:

$$\Delta L^*_{\text{hens thigh}} = 69.64 - 72.33 = -2.69$$

$$\Delta a^*_{\text{hens thigh}} = -2.75 - (-2.5) = -0.25$$

$$\Delta b^*_{\text{hens thigh}} = 13.8 - 13.15 = +0.65$$

$$\Delta E^* = (-2.69)^2 + (-0.25)^2 + (0.65)^2 = 7.71$$

A conclusion can be drawn that hen thigh colour after five days storage becomes darker according to parameter ΔL^* , more green – according to Δa^* , and more yellow – according to parameter Δb^* , if compared to the meat on the first day after slaughter.

Calculations and results for colour changes in hens' drumsticks with skin:

$$\Delta L^*_{\text{hens drumstick}} = 71.28 - 72.25 = -0.97$$

$$\Delta a^*_{\text{hens drumstick}} = -3.19 - (-2.27) = -0.92$$

$$\Delta b^*_{\text{hens drumstick}} = 9.86 - 12.37 = -2.51$$

$$\Delta E^* = (-0.97)^2 + (-0.92)^2 + (-2.51)^2 = 8.08$$

It means that hen drumstick colour after five days storage becomes darker according to parameter ΔL^* , more green – according to Δa^* , and more blue – according to parameter Δb^* , if compared to the meat on the first day after slaughter.

Colour is the most important factor with respect to initial selection. In red meats a bright red colour associated with a high content of oxymyoglobin is a positive determinant of quality, while metmyoglobin

content is a negative determinant.

Two specific defects – pale, soft, exudative meat (PSE) and dark, firm, dry meat (dark cutting; DFD), both of which are due to abnormal post-mortem pH values – are also recognized.

Poultry meat skin colour is thus a factor influencing perceptions of quality. Strain of bird and diet, as well as processing conditions (scalding), are often manipulated to produce a range of skin colours to suit particular markets.

The importance of colour as a quality determinant should be seen in the context of overall appearance. Perception of quality related to colour can be modified by other visual factors. The most important of these, in red meats, is the extent of marbling the adipose tissue located between muscle fibre bundles in the perimysial connective tissue. Marbling is positively associated with good eating quality and can be an important factor influencing consumer choice. At the same time, the amount of fat surrounding major muscles influences the appearance or 'finish' of the meat. Excessive fat has always been associated with poor quality, although a certain quantity is expected on some cuts (Varnam and Sutherland, 1995).

Skin and meat colour changes that occur during storage are variable and depend on processing or holding conditions (Petracci and Fletcher, 2002).

The characteristic colour of meat is a function of two factors: the meat pigments and the light-scattering properties. The basic pigment of fresh meat is myoglobin. Haemoglobin, which is very similar in chemistry, is also present in small quantities, especially if bleeding has been inefficient. Myoglobin levels vary according to breed and age, concentration increasing with age. Leg muscles

contain more myoglobin and are of darker colour. Meat from male animals also usually contains more myoglobin than that from females.

Pale, soft, exudative meat, which is of low myofibrillar volume, has a high light-scattering ability. Light is unable to penetrate a significant distance into the meat without being scattered. This means that there is relatively little absorption by myoglobin and the meat appears pale. Dark, firm, dry meat has only very limited light-scattering ability, permitting incident light to penetrate for a considerable distance. Considerable absorption by myoglobin occurs and the meat appears dark (Varnam and Sutherland, 1995).

Conclusions

Fat content in meat fat tissues is increased by decrease of water content. Fat content in 'white' meat is lower compared to 'red' meat. Analysis of 'red' meat proved higher fat content in hen thighs than in drumsticks.

Protein content in all tested cuts was relatively high, although the highest protein content was established in hen fillet. 'White' meat contained by 20% more proteins compared to 'red' meat. No significant changes in fat content were observed during five - day chilled storage.

'White' meat (hen fillet) had significantly lower pH than 'red' meat (hen thigh, hen drumstick). The pH changes during storage were negligible possibly due to low storage temperature ($+1\pm 0.5$ °C).

The most pronounced colour changes were observed in hen fillet inner side. Colour changes in 'red' meat cuts (thighs and drumsticks) were similar. The parameter ΔL^* proved that all analysed meat samples became darker during five - day chilled storage.

References

1. Brūveris Z. (2007) *Mājdzīvnieku anatomija* (Anatomy of domestic animals), Rīga, Medicīnas apgāds, Latvija, 783 p. (In Latvian).
2. Dawson P.L., Janky D.M., Dukes M.G., Thomson L.D., Woodward S.A. (1987) Effect of post-mortem boning time during simulated commercial processing on the tenderness of broiler breast meat. *Poultry Science*, 66, pp. 1331-1333.
3. Decker E.A., Cantor A.H. (1992) *Fatty acids in poultry and egg products. In: Fatty acids in foods and their health implication* (ed. Chow K. K.), Markel Dekker, New York, pp. 167 p.
4. DeMan M.J. (1999) *Principles of food chemistry*. 3rd edition, An Aspen publication, Gaithersburg, Maryland, 520 p.
5. Varnam A.H., Sutherland J.P. (1995) *Meat and Meat Products: Technology, Chemistry and Microbiology*. Springer, UK, 430 p.
6. Warris P. (2000) *Meat Science*, CAB Publishing, 310 p.
7. Fletcher D.L. (1999) Boiler breast meat colour variation, pH and texture. *Poultry Science*, 78, pp. 1323-1327.
8. Nahm K.H. (1999) Quality poultry meat production. *Korean Journal of Poultry Science* 26, pp. 65-94.

9. Petracci M., Fletcher D.L. (2002) Broiler skin and meat colour changes during storage. *Poultry Science*, 81, pp. 1589-1597.
10. Qiao M., Fletcher D.L., Smith D.P., Northcutt J.K. (2001) The effect of broiler breast meat color on pH, moisture, water-holding capacity, and emulsification capacity. *Poultry Science*, 80, pp. 676-680.
11. Ratnayake W.M.N., Ackman R.G., Hulan H.W. (1989) Effect of redfish meal enriched diets on the taste and n-3 PUFA of 42-day-old broiler chicken. *Food and Agriculture*, 49, pp. 59-74.
12. Warcup C.C. (1991) A possibility exploitation of the variation in tenderness and juiciness pig meat. *Animal production* 52, 559 p.
13. Мысик А.Т., Белова С.М. (1986) *Справочник по качеству продуктов животноводства* (Handbook of quality of animal origin products), Агропромиздат, Москва, Россия, 380 с. (In Russian).