Evaluation of the *PSE and DFD* abnormalities occurrence in chicken meat

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Abstract

The aim of the study was an attempt to evaluate PSE and DFD abnormalities incidence in chicken breast muscles. Chickens line Cobb were obtained from three different suppliers approximately 30, 98 and 150 km away from the factory where they were slaughtered automatically. Analyses of colour, pH, temperature and free water content in whole and minced breast muscles were performed at 15 min., 2 h and 24 h post mortem. The results of the experiment showed that chicken breast muscles, despite of the transport distance, were characterised by very light colour (L* values from 60 to 68). Lightening of the meat was connected with PSE (pale, soft and exudative) defect and it was observed in approximately 35% of analysed chickens. There were no interactions between pH values and lighter colour of meat, except those for birds, which were transported 98 km before slaughter. pH measurement showed that 15 min post mortem chicken breast muscles had pH values from 6.1 to 6.2. and it remained stable after 24 h of refrigerated storage. Due to those observations we suggest that pH values cannot be used as an exclusive PSE defect indicator. Free water content, as well as, the ability of holding water were very good and stable in time, moreover they were not connected with pH and a lighter colour. Detection of DFD faults in chicken breast, despite of high pH values, was difficult to determine. Because statistical analysis did not reveal any significant interaction between occurrences of much lighter colour of chicken breast and the rest of analytical parameters, the possibility of other than PSE causes of lighter meat still exists, that is why the study is still in progress.

Introduction

Dynamic development of poultry meat industry was achieved by intensive breeding of the specifically selected birds, which should be characterized by a good usage of the fodder, good musculature build and fast rate of growth. However, reduction in birds age before slaughter can result in a decrease of meat quality. Freeman (1987) and Barbut (1998) showed that high selectiveness of chicken lines tended to a serious problem with birds adaptation to the breeding environment, which can cause a non-specific reaction in certain animals. Factors initiated those reaction were named stressors or non-specific stimulus. One of those stressing factors is transport connected with improper handling of chickens shortly before slaughter. Even if, transport conditions are well organized, it is impossible to eliminate every unfavourable stressors, such as too low or too high temperature. There are also many technological processes e.g. stunning, which can affect meat quality. In bird's body the track of post-mortem glycolysis is then disturbed, which resulted in change of pH, colour and free water content in chicken meat. Those changes are connected with metabolic abnormalities in meat called PSE (pale, soft, exudative) and DFD (dark, firm, dry). Chicken meat, either with PSE or with DFD defectives is characterized by reduced technological and culinary values, mainly due to imbalances in water holding capacity, which can be not sufficient enough or excessive. Those types of meat has also different colour (lighter or darker) and changed texture (very soft or very tough) than meat considered normal. Stability of those types of meat is also much less than normal, so it significantly influences the quality of final products. Therefore, early detection and elimination of meat with PSE and DFD abnormalities is a crucial point in production of high quality meat products.

Aim

The aim of the study was an evaluation of PSE and DFD abnormalities incidence in chicken breast muscles in relation to the length of transport of birds from farm to the slaughter plant.

Material and methods

Studies were performed on chickens line Cobb obtained from three different suppliers approximately 30 km (I group), 98 km (II group) and 150 km (III group) away from the processing factory. Birds were slaughtered automatically within 15 min. after arrival. Carcasses were chilled quickly using combined air/water method until temperature of 4°C was achieved in the geometrical centre of breast muscles. Analyses of pH, temperature, colour and free water content were performed on both the intact *pectoralis* muscle and minced muscle samples at 15 min. post mortem, 2 h and 24 h of chilled storage at 0°C. Colour of the meat was evaluated colorimetrically using a Minolta Chroma meter and results were expressed in Hunter scale with parameters L* (lightness), a* (redness) and b* (yellowness). Free water content was done according to Grau-Hamm (1952) methods. All results were statistically analysed using Statgraphics 7.0 plus programme.

Results and discussion

pH

Ultimate pH of the muscle tissue is dependent on the dynamic of post mortem glycolysis i.e. degradation of glycogen to lactic acid. Dynamic of lactic acid formation is closely related to the chicken state before slaughter, e.g. if the birds are tired or stressed the ultimate pH of the muscle tissues is achieved much faster. Results collected in this experiment showed that there is no difference between pH measured in the lump of muscle and in minced tissue. pH values, which were taken 15 min after slaughter in chicken breast muscles removed from carcasses group II and group III (more than 100 km) were on the level 6.1 – 6.2 (Tab. 1), which is considered normal for this type of muscle. Meat obtained from the birds transported 30 km (group I) were characterized by significantly higher pH_{15} (average 6.6) ($p \leq 0.05$) and it was recognised as higher than a proper one (i.e. higher than 6.4), so it could be considered as muscles with DFD abnormalities. However, pH measurements collected in meat from this experimental group after 24 h of cold storage were on the level 6.3, which is stated as normal for chilled poultry meat. The lowest pH_{24} was measured in muscle tissue obtained from animals assigned as group II (5.8), which was connected with a normal rate of post-mortem glycolysis. pH measurements obtained in our study are in a good agreement with those reported by Molette *et. al.* (2003) for turkey *pectoralis* muscle. Moreover, our experiment showed that even though there were significant differences between ultimate pH of the muscles obtained from chicken transported 30, 100 and 150 km, they all went along with the range of pH for meat without any abnormalities. According to Goronowicz and Czaja (2002) the transport distance between living environment and processing plant had a significant effect on final pH of meat especially for chicken but our results did not confirm this statement. Apart from above, on the basis on data collected in the experiment and Olszewski (1999) we suggested that pH measurements alone is not sufficient enough for qualifying chicken breast muscles as PSE or DFD defective.

Colour

Barbut (1997) reported that pale colour is one of the main indicators of PSE in chicken meat. In our study we found that all analysed chicken breast samples were characterised by very high L* values. The highest lightness was observed in muscles removed from animals transported c.a. 30 km before slaughter (from 68.13 to 68.73) (Tab. 2), whilst the lowest for birds from group II (about 100 km away from the processing plant) (values from 55.71 to 59.22). On the basis of the results reported by McCrudy *et. al.* (1996) for turkey breast meat (samples with $L^* \geq 51$ pronounced PSE problem) and Lesiow and Kijowski (2003) ($54 > L^* < 57$ for the polish condition) the cut-off point for an L* value in this work was established on $L^* > 57$. Taking this under consideration 35% of analysed chicken breast samples should be classified as PSE meat, whilst 25% should be classified as DFD muscles, what indicated a serious problem with quality of poultry meat. Lighter colour of the muscles is usually correlated with dramatically accelerated post mortem glycolysis and low pH values. This was confirmed by Lesiow and Kijowski (2003) and McCurdy *et. al.* (1996), who found a strong negative relationship between pH and an L* value of poultry meat. Statistical calculation of the results collected in this study also revealed a significant negative correlation (-0.42) between described parameters but only at 15 min after slaughter (Tab. 4), whilst there is no significant relationship between pH and L* value after storage of meat for 24 h in chill room. It is an important finding for meat industry, that the measurements of colour of poultry muscles should be taken not more than 2 h post mortem. Close

relationship between lightness of meat and a transport distance were not found, so it is impossible to state that the longer transport the worse quality of meat. Chicken breast muscles excised from the animals transported 30 km before processing were characterised by the lowest redness of meat expressed by parameter a* (Tab. 2), whilst the highest redness was observed for meat obtained from birds from group III (values form 2.02 to 5.54). This could be caused by stressful condition and a long time of transport to the slaughterhouse, influencing an amount of remaining glycogen. However, pH values measured for those meat were consider normal (about 6.0 – 6.1), so it was not possible to state that meat from this experimental group is effected by DFD abnormalities. Yellowness measured in chicken breast muscles was on the low level for animals transported more than 100 km and it was in range from 3.18 to 8.24 (Tab. 2). However, meat from birds assigned as group I (distance 30 km) were characterised by high yellowness (b*parameter); the average value was 18.60 and it was connected with higher range of pH, especially measured 15 min after slaughter (Tab. 1). Statistical analysis of the results confirmed positive correlation between high pH and higher values of yellowness (Tab. 4), so it can be use as a background for DFD defect in meat, despite short travel distance.

WATER HOLDING CAPACITY

Water holding capacity is an ability to hold water by muscle tissue. Chicken breast muscles are characterised by relatively good water holding capacity, much better than chicken thigh muscles. Results collected in this study showed that there were not any significant differences in free water content in chicken breast muscles despite the treatment. Free water content in pectoralis muscle was on the level from 23.4% to 25.0% (Tab. 3) and it remained stable along the storage time (up to 24 h post mortem). Analysed meat samples had no watery texture and excessive drip, what is connected with PSE abnormality. Statistical analyses of the collected results did not revealed any significant correlation between water holding capacity and pH of chicken breast, what was in contrary to observation reported by Mroczek *et. al.* (1998) and Smolinska and Szmigiel (2004).

Conclusion

1. Despite the distance between the farm and slaughter plant, chicken breast muscles were characterised by very light colour (high L* values), what was connected with PSE defect in 35% of analysed material.
2. There were no interactions between pH values and lighter colour of meat, except those for birds, which were transported 98 km before slaughter. pH measurement showed that 15 min post mortem chicken breast muscles had pH values from 6.1 to 6.2. and it remained stable after 24 h of refrigerated storage. Due to those observations we suggest that pH values cannot be use as an exclusive PSE defect indicator.

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Table 1 Effect of transport distance and post mortem time on pH decline in chicken breast muscles.

	pH 15 min post mortem	pH 2 h post mortem	pH 24 h post mortem
I group	6.57[b]	5.98[a]	6.35[c]
II group	6.13[a]	6.23[b]	5.83[a]
III group	6.18[a]	6.04[a]	6.14[b]

The same letter represents insignificant differences between results (P≤0.05) (n=10)

Table 2 Effect of transport distance and post mortem time on the colour parameters L*, a*, b* in chicken breast muscles.

	pH 15 min post mortem			pH 2 h post mortem			pH 24 h post mortem		
	L*	a*	b*	L*	a*	b*	L*	a*	b*
I group	68.73[c]	1.34[a]	18.61[b]	68.13[b]	2.11[a]	18.69[c]	68.20[c]	1.99[a]	18.56[c]
II group	55.71[a]	1.78[b]	3.18[a]	59.17[a]	2.42[a]	4.25[a]	59.22[a]	2.41[a]	3.33[a]
III group	64.27[b]	2.02[b]	3.56[a]	60.09[a]	5.49[b]	7.02[b]	64.32[b]	5.54[b]	8.24[b]

The same letter represents insignificant differences between results (P≤0.05) (n=10)

Table 3 Effect of transport distance and post mortem time on free water content in chicken breast muscles.

	pH 2 h post mortem	pH 24 h post mortem
I group	23.41[a]	25.00[a]
II group	24.73[a]	24.10[a]
III group	23.83[a]	24.20[a]

The same letter represents insignificant differences between results (P≤0.05) (n=10)

Table 4 Correlation coefficient between pH and colour parameters L*, a*, b*.

	Correlation coefficient	F
L*15	-0.42	0.019*
a*15	-0.35	0.065
b*15	0.67	0.0005***
L*15	0.35	0.06
a*15	-0.28	0.014*
b*15	0.60	0.0005***

*** P≤0.001
** 0.001≤P≤0.01
* 0.01≤P≤0.05