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The effects of selenium addition in feed and freezing to technological characteristics of broiler meat

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Scientific paper

Summary

The paper researches the effects of selenium addition to the diet and freezing process to technological characteristics of broiler meat. The research was conducted on hybrid broilers (n=300) of Cobb 500 genotype which were separated into three groups considering the form and content of added selenium in their diet. Selenium addition in the feed had no significant effect to electrical conductivity and color of chicken meat (P>0.05). Deep freezing had a significant influence to electrical conductivity (P<0.001) and brightness, that is, to L value (P<0.05) whereas the only insignificant differences were found for color parameters a* and b* (P>0.05).*

Keywords: *selenium, technological characteristics, broiler meat*

Introduction

In the last five decades poultry production has experienced great changes, primarily in terms of a significant increase in meat consumption, which has even doubled/tripled in some areas in the world. Those changes resulted in certain pressure put on selectioners, farmers and nutritionists to improve the nutritional effectiveness and increase the share of the pectoral muscle (*m. pectoralis profondus*). Such production manner is very stressful for poultry, which results in the more frequent appearance of pale, soft and exudative meat (PSE).

It's known that the appearance of PSE meat is mostly the result of accelerated post-mortem glycolysis which leads to protein denaturation (Offer and Knight, 1988; Pietrzak et al., 1997; van Laack et al., 2000; Barbut et al., 2008; Schilling et al., 2008). Such meat is characterized by a rapid drop in pH value, lighter color of meat, weaker water binding capacity and an unacceptably great drip loss (Warriss and Brown, 1987; Woelfel et al., 2002). Meat color is a very important quality parameter and is often used as an indicator of PSE meat (Chizzolini et al., 1993; Kauffman et al., 1993; Barbut, 1998.). Pale meat has a higher L* value which represents lightness and ranges from 0 (black) to 100 (white). In terms of color, PSE meat also has a lower a* value (redness), because due to a higher content of extracellular water there is a decrease in myoglobin concentration. pH value is an important indicator of chicken meat quality. The dynamics of glycolysis and changes of pH value in muscles have a dual effect on meat quality. If pH value drops fast, the meat is pale, soft and exudative, whereas a slow and incomplete drop of pH value 24 hours after the slaughter of an animal is characteristic for dry, firm and dark meat (DFD). The appearance of DFD meat in broilers and generally in poultry meat is very rare. Water binding capacity is also an important characteristic of meat quality (Huff-Lonergan, 2005). Pale, soft and exudative meat has a fast decrease in pH value and a low pH24 which causes weaker water binding capacity in meat and an unacceptably great drip loss. Electrical conductivity is considered to be an indirect measure of water loss or muscle softness which appears as a consequence of cracks in membrane structures that enables water to pass between the intracellular and extracellular space (Pliquett et al., 1990). Completely undamaged muscle tissue has low values for electrical conductivity (EC) which increases along with the increase of free water within muscles, that is, if water loss appears, there is also an increase in the value of electrical conductivity (Byrne et al., 2000). Page et al. (2001) list that electrical conductivity is a measure of a "structural condition" of meat, where higher values indicate to a higher electrical conductivity, more significant muscle damage and a higher share of extracellular fluid.

Methods, rate and techniques of cooling and deep freezing can have a significant effect to quality of chicken meat. Rapid cooling in poultry is considered to create forming of very small reflective ice crystals on the surface of the meat, which can give a product a brighter appearance.

There are numerous data in professional literature on the effect of selenium (Se) as an addition of the feed to its content in food (foodstuffs of animal origin) (Mahan et al., 1999; Mahan and kim, 2002; McIntosh and Royle, 2002), that is, to the production of "functional food". Foodstuffs defined as the food which has a positive impact on health, physical and mental condition of an individual, are implied under this name. Changes in characteristics of meat in terms of changes in technological or sensorial

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characteristics of meat due to the addition of Se into the feed have not been determined (Bou et al., 2005; Ryu et al., 2005). It is considered that the primary role of Se in the animal system is creating of glutathione peroxidase, the enzyme which protects muscle cells from oxidative damages caused by hydrogen peroxide and other hydroperoxides. Chan and Decker (1994) list that an increase of Se in tissues does not always cause an increased activity of glutathione peroxidase, which suggests that the addition of Se can, but it doesn't have to, have an effect to oxidative stability of skeletal muscles. Unfortunately, too little data are accessible on the effect of Se to lipid peroxidation and color stability of chicken meat.

The goal of this paper was to determine the effect of the addition of Se to the diet and the effect of freezing to individual technological characteristics of broiler meat.

Material and methods

The research was conducted on hybrid broilers of Cobb 500 breed. Chickens (n=300) were separated into three groups considering the form and content of added selenium in their diet. The control group (C) consists of 100 broilers fed on the feed which contained 0.3 ppm Na-selenite. The first test group (G2) consisted of 100 broilers fed on the feed which contained 0.3 ppm Sel-Plex, and the other test group (G3) consisted of 100 broilers fed on 0.5 ppm Sel-Plex. During fattening (up to day 42) broilers received food and water *ad libitum*, and the day prior to slaughter they were deprived of food. After the slaughter, carcasses were cooled up to +2°C in a tunnel system during the period of 1.5-2 h, then they were stored in a cooling chamber to 0.5°C, and one part in a freezing chamber to -20°C.

Meat color was determined according to the CIE standard (Commission Internationale de l'Eclairage, 1986), by the device Minolta Chroma Meter (Minolta Co., Ltd., Japan) with 50 mm diametrical area of measuring by the range of colors L*, a* and b*. The range of colors was determined by a standard illumination D65. Prior to any measurement the device is calibrated by a calibration plate No. 21433027. Electrical conductivity was determined by a LF-Control system device (Würthinger, Pettenbach, Austria) in milliSiemens/cm (mS/cm). The monitored parameters were measured at the cross section of the samples *m. pectoralis superficialisa* 24 hours *post mortem* and 96 days *post mortem*, after the stabilization of meat color (20-minute of bloom time of the surface of *m. pectoralis superficialis*). The final color values were determined as mean of the measured three values.

Monitoring results of quality parameters were processed by a statistical program SAS (SAS Institute, 1999) using a GLM procedure. In the expression analysis of the effect of Se and freezing to meat quality, ANOVA multivariate linear model was used.

Table 1. Qualitative indicators EC and color parameters (L*, a* and b*) of broiler meat on total researched sample

Parameters	$\bar{x}$	sd	$s_{\bar{x}}$	min.	max.	Cv
EC	10,57	6,85	0,75	2,80	19,90	64,84
L*	57,08	2,56	0,28	52,24	62,61	4,49
a*	14,61	1,47	0,16	11,07	18,95	10,05
b*	14,06	1,75	0,19	9,55	17,79	12,48

Results and discussion

The values of qualitative indicators of broiler meat (EC and color) are shown in Table 1.

Average values of electrical conductivity (EC) and color indicators (L*, a* and b*) on total researched sample were mostly within limits of standard quality. Meat color is a very important criterion whilst determining meat quality and it is used as a criterion for categorizing meat to quality classes in terms of PSE, desirable and DFD meat. QIAO et al. (2001) sort out chicken breast according to color to "brighter than regular" (L* > 53), "regular" (48 < L* < 53) and "darker than regular" (L* < 46). In professional literature there can also be found a more lenient criterion according to which L* ≥ 58.9 characterizes meat brighter than desirable, whereas desirable meat is the one whose color was determined with the L* value lower than 58.9, that is, higher than 50.9 (BIANCHI, 2005). According to the listed criterion, our samples can be considered to be the meat of desirable quality (Table 1.).

It is evident from the Table 2. that the addition of Se in the feed had no significant effect to electrical conductivity and color of broiler meat (P > 0.05). Our results are in accordance with the researches by Ryu et al. (2005), Skrivanova et al. (2007) and O'Grady et al. (2001) who also determined that Se had no significant effect on color parameters. Klein (2004), Combs (1981) and Flohe (1997) list that Se has a very important role in the creation of Se-gluthatione-peroxidase and that the listed enzyme prevents the cell damage caused by free radicals. Page et al. (2001) list that electrical conductivity is a measure of a "structural condition" of meat. In that sense higher values of EC indicate to a more significant muscle damage and a higher share of extracellular fluid. Our results show that EC has decreased insignificantly in comparison to the control group C (P > 0.05). Some authors list that the addition of Se increases oxidative stability in beef, pork and chicken meat (Gatellier et al., 2004; Scholz et al., 1981; Daun et al., 2001; Daun and Akesson, 2004). Our results

Table 2. Significance of differences of EC and broiler meat color considering the content of selenium and cooling

Parameters	Concentration SE	Cooling		$s\bar{x}$	Average[2]	$s\bar{x}$
		Cooled	Deep frozen			
EC	C	3,85[a]	17,46[b]		10,66	
	G2	3,81[a]	17,35[b]	0,26	10,58	1,31
	G3	3,81[a]	17,12[b]		10,46	
	Average[1]	3,82[a]	17,31[b]	0,15		
L*	C	56,19	57,78		56,88	
	G2	56,71	58,04	0,68	57,37	0,49
	G3	56,61	57,34		56,98	
	Average[1]	56,50[a]	57,65[b]	0,39		
a*	C	14,77	14,62		14,70	
	G2	14,78	14,49	0,40	14,64	0,28
	G3	14,51	14,47		14,49	
	Average[1]	14,69	14,52	0,23		
b*	C	13,85	14,16		14,00	
	G2	13,67	14,18	0,48	13,92	0,33
	G3	14,15	14,38		14,27	
	Average[1]	13,89	14,24	0,27		

[a,b] Values in the same row and the same column of the table marked by different letters differ significantly
Average[1] –average value of three groups treated with selenium considering different cooling
Average[2] - average value of two groups of cooling considering different selenium treatmentt

show that the content of Se had an insignificant effect on color parameters (L*, a* and b*) in comparison to the control group C ($P > 0.05$). Still, it should be emphasized that our research was conducted on a slow-twitch muscle of *m. pectoralis superficialis* which falls into a group of white (glycolytic) muscles and whose metabolism is mostly based on glycolysis, as opposed to fast-twitch which falls into a group of red (oxidative) muscles and whose metabolism is mostly based on myoglobin oxidation. Therefore, that is one of the reasons why we haven't determined a significant role of the addition of Se in stabilization of broiler meat. Skrivanova et al. (2007) list that the addition of Se led to insignificant increase in L*, a* and b* values, as well as an insignificant decrease of a* values in comparison to the control group. WANG et al. (2009) list that the level of selenium in feed did not have the effect on L* value of meat color ($P > 0.05$). The same is listed by Kralik et al. (2012). Some researches list that synergic activity of Se and vitamin E (D-α-tocopherol) had a more favorable effect on color parameters (L*, a* an b*), that is, that it had a favorable effect on quality of pork, beef and poultry meat (Miezeliene et al., 2011; Mahan et al., 1999; Nielsen and Rasumssen, 1979; Higgins et al., 1998; Combs and Regenstein, 1980; Edens, 1997). Still, our results suggest that the addition of Se had an insignificantly beneficial effect on discoloration of broiler meat.

The effect of deep freezing on EC and meat color parameters (L*, a* and b*) are also presented in Table 2. Deep freezing had a significant effect on electrical conductivity ($P < 0.001$) and brightness of meat, that is, on the L* value ($P < 0.05$), whereas only insignificant differences were determined for color parameters a* and b* ($P > 0.05$). Our results show that the values of electrical conductivity were significantly higher with meat of deep frozen broilers in comparison to meat of cooled broilers ($P < 0.001$). Pliquett et al. (1990) say that electrical conductivity is an indirect measure of water loss. Patiasi et al. (2008), Redmond et al. (2005) and Fagon et al. (2003) list that deep freezing increased the loss of water significantly. Considering the color parameters (L*, a* and b*), a significantly higher L* value ($P < 0.05$) and an insignificantly higher b* value, then an insignificantly lower a* value were determined at deep frozen broilers in comparison to cooled broilers ($P > 0.05$; Table 2.). Patias et al. (2008) say that they didn't determine significant differences between the deeply frozen and the cooled broilers considering the color parameters (L*, a* and b*) and that the L* value insignificantly increased, whereas a* and b* values insignificantly decreased. Fagan et al. (2003) also list that they didn't determine differences between the deeply frozen and the cooled broilers considering the color parameters (L*, a* and b*), but that the b* value insignificantly increased. We think that our results are caused by the appearance of large ice crystals in broiler meat during deep freezing that consequently leads to structural damages of muscle cells and to denaturation of muscle proteins and finally causes an increased release of bound water on the surface of the meat (significantly higher EC; Table 2.) causing a higher reflection of light (a significantly higher L* value; Table 2.) and decreasing myoglobin content (insignificantly higher a* value; Table 2.). We believe that a significant fall in parameter a* (redness) did not occur due to the reason that our researches were conducted on a white (glycolytic) muscle which contains lower contents of myoglobin pigment. The listed assumptions also confirm some previous researches which list that methods, speed

and techniques of freezing itself can have a significant influence on structural damage of muscle cells, discoloration of meat and water loss (Seman et al., 1988; Gill, 1990; Guldager et al., 1998; Boknaes et al., 2000; O'Leary et al., 2000; Martinsdottir and Magnuson, 2001).

Conclusion

Based on the research of the addition of selenium in the feed and freezing procedure to technological characteristics of broiler meat, it can be concluded that the addition of Se in the feed had no significant effect to electrical conductivity and color of broiler meat ($P > 0.05$). The procedure of deep freezing had a significant effect on electrical conductivity ($P < 0.001$) and meat color, i.e., on L* value ($P < 0.05$), whereas only insignificant differences were determined for color parameters a* and b* ($P > 0.05$).

We believe that further research should be directed to the effect of synergic activity of Se and antioxidative vitamins (vitamin E and vitamin C) on stability of muscle color, all in the purpose of extending the meat quality in the sense of extending the shelf life of the meat during deep freezing and storage.

Aknowlegment

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Einflus von Selen-Zusätzen in der Nahrung und des Einfrierens auf technologische Eigenschaften des Fleisches bei Broilern

Zusammenfassung

In der Arbeit wurde der Enifluss von Selen-Zusätzen in der Nahrung und des Einfrierens auf technologische Eigenschaften des Fleisches bei Broilern untersucht. Die Untersuchung erfolgte auf Hühnern (n=300) Hybriden der schweren Rasse Cobb 500, die mit Bezug auf die Form und die Menge der Selen-Zusätze in der Nahrung gruppiert wurden. Die Selen-Zusätze hatten keinen bedeutenden Einfluss auf elektrische Leitfähigkeit und Farbe des Hühnerfleisches (P>0,05). Tiefes Einfrieren hatte einen bedeutenden Einfluss auf elektrische Leitfähigkeit (P<0,001) und Helligkeit des Fleisches, dh. auf den L Wert (P<0,05) während unbedeutende Unterschiede für Farbenparameter a* und b* (P>0,05) festegestellt worden sind.*

Schlüsselwörter: *Selen, technologische Eigenschaften, Broiler*

Influencia de añadidura de selenio en la comida y de congelación sobre las características tecnológicas de la carne de los broiler

Resumen

En este trabajo fue estudiada la influencia de añadidura de selenio en la comida y del procedimiento de congelación sobre las características tecnológicas de la carne de los broiler. La investigación fue realizada en los polluelos (n=300) híbridos de la raza pesada Cobb 500, divididos en tres grupos en vista de forma y cantidad de selenio añadido en la comida. La añadidura de selenio en la comida no tuvo significante influencia sobre la conductividad eléctrica ni el color de la carne de pollos (P > 0,05). La congelación tuvo una influencia significante sobre la conductividad eléctrica (P < 0,001) y la claridad de la carne, es decir, sobre la variable L (P < 0,05), mientras las diferencias desdeñables fueron identificadas para los parámetros del color a* y b* (P > 0,05).*

Palabras claves: *selenio, características tecnológicas, los broiler*

l'influenza degli aggiunti di selenio negli alimenti e la surgelazione sulle caratteristiche tecnologiche della carne dei broiler

Riassunto

In questo lavoro è stata studiata l'influenza degli aggiunti di selenio nel mangime e il procedimento di surgelazione sulle caratteristiche tecnologiche della carne dei broiler. La ricerca è stata fatta su pulcini (n=300) ibridi della razza pesante Cobb 500, che sono stati suddivisi in base alla forma e alla quantità di Se aggiunto nel mangime in tre gruppi. L'aggiunta di Se nel mangime non ha avuto un'influenza significativa sulla conducibilità e sul colore della carne di pollo (P>0,05). Il profondo surgelamento ha avuto un'influenza significativa sulla conducibilità elettrica (P<0,001) e sulla chiarezza della carne, cioè sui valore L (P<0,05), mentre ci sono solo trascurabili differenze osservate per i parametri di colore a* e b* (P>0,05).*

Parole chiave: *selenio, caratteristiche tecnologiche, broiler*

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