Modified atmosphere packaging of meat

Summary

Modified atmosphere packaging has been expanded and improved with the arrival of new technologies and increasing demands of buyers. Modified atmosphere packaging is a mixture of different kinds of gases (Oxygen O2, Carbon Dioxide CO2 and Nitrogen N2) in different ratios.

Total viable count of aerobic mesophyllic bacteria in fresh beef and pork meat packed in a modified atmosphere and unpacked meat as control samples through the period of six days and stored at 4ºC, was determined in this paper. Total count of bacteria was lower in meat packed in a modified atmosphere and was from 7 x 102 /g on the first day of beef meat storage, to 2.5 x 106/g on the sixth day of storage. In control samples of beef, the total count was 8.8 x 104/g even on the first day of storage; it was 4.2 x 106/g on the fourth day, to be 1.6 x 107/g at the end of storage. The total count in pork samples packed in a modified atmosphere was from 1.8 x 103/g to the most of 4.2 x 106 /g on the sixth day of storage. Unpacked pork contained 3.4 x 106/g even on the fourth day of refrigerator storage, i.e. 8.8 x 107/g on the last day.

Key words: fresh meat, modified atmosphere packaging, total count of bacteria

Fleischverpackung in modifizierter Atmosphäre

Zusamenfassung

Das Packen in einer modifizierten Atmosphäre wird mit neuen Technologien und immer größeren Forderungen der Käufer breiter und entwickelter. Das Packen in einer modifizierten Atmosphäre ist eine Mischung verschiedener Gase (Sauerstoff O2, Kohlendioxyd CO2 und Stickstoff N2) in verschiedenen Größenverhältnissen. In dieser Arbeit ist die gesamte Zahl der aeroben mesophylen Bakterien in frischem Rind- und Schweinefleisch verpackt in einer modifizierten Atmosphäre, sowie nicht verpacktem Fleisch als Kontrollmuster, während sechs Tage aufbewahrt auf Temperatur von 4oC, bestimmt. Die gesamte Bakterienzahl war im Fleisch, verpackt in einer modifizierten Atmosphäre, niedriger und bewegte sich von 7 x 102/g am ersten Tag der Rindfleischaufbewahrung bis 2,5 x 106/g am sechsten Tag der Aufbewahrung. In den Rindfleisch-Kontrollmustern betrug die Gesamtzahl schon am ersten Tag der Aufbewahrung 8,8 x 10 4 und schon am vierten Tag war sie 4,2 x 106, während sie am Ende der Aufbewahrung 1,6 x 107 /g betrug. In den Schweinefleischmustern verpackt in einer modifizierten Atmosphäre bewegte sich die Gesamtzahl von 1,8 x 103/g bis höchstens 4,2 x 106/g am sechsten Tag der Aufbewahrung. Das nicht verpacke Schweinefleisch enthielt schon am vierten Tag der Aufbewahrung im Kühlschrank 3,4 x 106/g, bzw. am letzten Tag 8,8 x 10´/g.

***Schlüsselwörter:** frisches Fleisch, Packen in einer modifizierten Atmosphäre, Bakteriengesamtzahl*

Confezionamento nell'atmosfera modificata

Sommario

Il confezionamento nell'atmosfera modificata si diffonde e progredisce con evoluzione di nuove tecnologie e con le richieste sempe più grandi. Il confezionamento nell'atmosfera modificata è un misto di tipi diversi di gas (ossigeno O2, carbone diossigeno CO2 ed azoto N2) nelle pecentuali diverse. In questo lavoro è stato determinato il numero totale dei batteri aerobi mesofili in carne fresca di vitello e di maiale, confezionata nell'atmosfera modificata, e la carne non confezionata, come i campioni di controllo, deposti durante sei giorni a temperatura di 4ºC. Il numero totale di batteri era inferiore nella carne confezionata nell'atmosfera modificata, e il primo giorno di deposito della carne di vitello aveva 7 x 102 /g di batteri, rispetto al sesto giorno in cui ne aveva 2,5 x 106/g. Nei campioni di controllo subito il primo giorno il numero totale era 8,8 x 104/g, e il quarto giorno 4,2 x 106, e alla fine di deposito era 1,6 x 107/g. Nei campioni di maiale confezionato nell'atmosfera modificata il numero totale si muoveva da 1,8 x 103/g fino al massimo di 4,2 x 106 /g il sesto giorno di deposito. La carne di maiale non confezionata conteneva 3,4 x 106/g il quarto giorno di deposito nel frigorifero, e l'ultimo giorno 8,8 x 107/g.

Parole chiave: *carne fresca, confezionamento nell'atmosfera modificata, numero totale di batteri*

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Influence of crude pretein level in forage mixtures on pig meat and carcass quality of black slavonian pigs

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Scientific paper

Summary

The research was conducted on pig carcasses and meat from two groups (A and B) of Black Slavonian pigs (Croatian autochthonous, endangered breed), fed with higher (group A) and lower (group B) level of crude proteins in forage mixtures, during two fattening cycles (14%/12% and 12%/10%). In each group there were 16 pigs (8 gilts and 8 castrated male pigs).

Increase in the crude protein level in forage mixtures had a very significant impact (p<0.01) on reduction of fat tissue share (34.55% : 39.09%) and on increase in muscle tissue share (47.10% : 46.11%) in pig carcasses, although not to a statistically significant (p>0.05) extent. Pig carcasses from group A, compared to those in group B, had a significantly (p<0.01) higher share meat of ham (15.62% : 14.62%). Meat (MLD) of pigs from both of the groups was of very good quality, considering the analyzed indicators (pH1, pH2, water holding capacity, colour). Pig meat from group A, compared to meat from pigs in group B, had a statistically significant (p<0.05), higher level of crude proteins (21.47% : 20.93%), a very significantly (p<0.01) higher water content (70.62% : 65.70%), and lower level of crude fat (6.89% : 12.34%), while no significant differences (p>0.05) were determined between the analyzed groups of pigs in terms of ash content (1.02% : 1.02%).

***Key words:** crude protein level, carcass quality, meat quality, Black Slavonian Pig.*

Introduction

Quality of pig meat and carcasses depends on interaction between genetic and paragenetic factors. Among paragenetic factors, food quality and quantity is, in addition to the final body weight of pigs, one of the most important factors influencing the slaughterhouse quality of pigs. Crude protein level in forage mixtures during fattening influences not only the quality of pig carcasses, but also the quality of muscle tissue, that is, meat *(Nieto et al. 2003; Millet et al. 2006; Barea et al. 2008)*. In the available literature there are no data on the influence of crude protein level in forage mixtures on phenotype expression of meatiness of Black Slavonian pig, an autochthonous Croatian breed of lard and meat type. Black Slavonian pigs have been fed empirically so far, without exact research conducted on their real nutritional needs.

Materijal and methodsm

Research was conducted on pig carcasses and meat of 16 Black Slavonian pigs fattened up to 130 kg body weight with higher crude protein level in forage mixtures (Group A), and on pig carcasses and meat of 16 Black Slavonian pigs fattened up to the same body weight, but with lower crude protein level in forage mixtures (Group B). Sex ratio (barrows and gilts) was the same in each group. Pigs in Group A were fed forage mixture with 14.00 % crude protein and 13.37 MJ ME/kg in the period from 30 to 60 kg body weight, and with forage mixture with 11.88% crude protein and 13.34 MJ ME/kg in the period from 60 to 130 kg body weight, as well as with fresh green alfalfa, which were both fed ad libitum. Pigs in Group B were fed forage mixture with 12.13 % crude protein and 13.34 MJ ME/kg in the period from 30 to 60 kg body weight, and with forage mixture with 10.09% crude protein and 13.00 MJ ME/kg in the period from 60 to 130 kg body weight. Pigs from both analyzed groups were kept in the semi-outdoor system with the same housing and feeding conditions, during the summer-autumn season.Dissection of right sides

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Table 1 Pig carcass conformation in relation to crude protein level in forage mixtures

Indicators	Statistical value	Crude protein level	
		A (higher)	B (lower)
Body mass, kg	$\bar{x}$	130,37^{NS}	130,40
	s	6,84	6,70
Cold carcass mass, kg	$\bar{x}$	51,08^{NS}	51,22
	s	3,87	4,39
Less valuable parts, %	$\bar{x}$	8,86**	7,37
	s	0,73	0,75
Jowl, %	$\bar{x}$	2,00**	2,53
	s	0,39	0,32
Fat, %	$\bar{x}$	2,78**	4,81
	s	0,54	1,36
Neck,%	$\bar{x}$	13,34**	6,69
	s	2,04	1,14
Back part, %	$\bar{x}$	14,73^{NS}	14,96
	s	1,18	1,18
Shoulder, %	$\bar{x}$	11,07**	14,36
	s	0,81	2,91
Ham, %	$\bar{x}$	26,55**	24,62
	s	1,42	1,08
Abdominal-rib part, %	$\bar{x}$	20,64**	24,69
	s	1,08	1,05

**p<0,01 NS - Non significant

Table 2 Share of meat in pig carcasses in relation to crude protein level in forage mixtures

Indicators	Statistical value	Crude protein level	
		A (higher)	B (lower)
Body weight of cold pig carcasses, kg	$\bar{x}$	51,08^{NS}	51,22
	s	3,87	4,39
Share of meat in carcasses, %	$\bar{x}$	47,16^{NS}	46,11
	s	2,25	3,54
Share of neck meat, %	$\bar{x}$	8,02**	4,68
	s	1,13	0,75
Share of loin meat, %	$\bar{x}$	6,34**	7,21
	s	0,93	0,82
Share of shoulder meat, %	$\bar{x}$	6,25**	8,62
	s	0,58	1,60
Share of ham meat, %	$\bar{x}$	15,62*	14,62
	s	1,38	1,10
Share of meat in belly-rib part, %	$\bar{x}$	10,93^{NS}	10,98
	s	0,64	1,74

*p<0,05 **p<0,01 NS-Non significant

of cooled pig carcasses (+4ºC) was conducted according to the modified method of *Weniger et al. (1963)*. According to this modification, the total quantity of muscle tissue does not include muscle tissue of head, which was not dissected.

pH value of meat was determined 45 minutes post mortem, and pH_2 value 24 hours post mortem, by means of a contact pH meter Mettler Toledo. Meat quality was determined on the sample from M. longissimus dorsi, taken between the 13th and the 14th rib. Water holding capacity of meat was determined according to *Grau and Hamm (1952)*, and colour ("L", "a" and "b" values) was determined using a Minolta CR-410 Chromameter. The research results were processed according to LSD test system softwork statistica (Stat Soft. Inc., 2008).

Resulsts and disicussion

Data in the Table 1. show that there are significant differences in conformation of Black Slavonian pig carcasses in relation to crude protein level in forage mixtures.

Pig carcasses from Group A (higher crude protein level in forage mixtures) had a significantly (p<0.01) smaller relative share of fat parts – jowl and lard as well as abdominal-rib part and shoulder – and a very significantly (p<0.01) higher share of ham and neck, in relation to pig carcasses from Group B (lower crude protein level in forage mixtures). No significant differences were detected between the analyzed groups in terms of back part (p>0.05).

Pig carcasses from Group A had a somewhat higher share of muscle tissue in relation to those from Group B, but the difference was not statistically significant (p>0.05), while there was an absolute and relative very significantly (p<0.01) higher share of bones determined. Pig carcasses from Group B had an absolute and relative very significantly (p<0.01) higher share of fat tissue (Tables 2 and 4).

Investigating the effects of four levels of crude proteins in feed of Iberian pigs, *Barea et al. (2008)* have determined a small, but significant influence of protein level on pig carcass composition. Increased fat depositing was observed on pigs fed lower protein level feed. Feeding rations with three protein levels (high, medium, low) to pigs in organic production, *Millet et al. (2007)* determined the lower meat percentage in pig carcasses when these were fed rations with lower protein level, while the influence on meat quality was limited.

In addition to the share of muscle tissue, distribution of muscle tissue in carcasses is also very important, because

Table 3 Composition of the main basic parts of pig carcasses in relation to crude protein level in forage mixtures

Joint of carcass	Tissue	Statistical value	Crude protein level			
			A (higher)		B (lower)	
			kg	%	kg	%
Leg	Muscle	$\bar{x}$	7,95^{NS}	58,81^{NS}	7,49	59,49
		s	0,62	3,42	0,86	3,16
	Fat	$\bar{x}$	4,17**	30,76^{NS}	3,94	31,29
		s	0,58	3,09	0,38	3,32
	Bone	$\bar{x}$	1,42**	10,43**	1,16	9,21
		s	0,22	1,06	0,17	1,04
Loin	Muscle	$\bar{x}$	3,23**	42,98**	3,71	48,21
		s	0,41	4,32	0,66	3,50
	Fat	$\bar{x}$	3,27^{NS}	43,46^{NS}	3,11	40,59
		s	0,58	6,02	0,42	3,14
	Bone	$\bar{x}$	1,02*	13,56*	0,86	11,20
		s	0,25	3,11	0,20	2,01
Shoulder	Muscle	$\bar{x}$	3,19**	56,41**	4,43	60,44
		s	0,38	2,73	0,96	2,81
	Fat	$\bar{x}$	1,62**	28,60^{NS}	2,22	28,81
		s	0,28	3,03	0,76	6,69
	Bone	$\bar{x}$	0,84**	14,09*	0,73	10,74
		s	0,04	2,01	0,09	4,30

*p<0,05 **p<0,01 NS - Non significant

Table 4. Shares of tissue in pig carcasses in relation to crude protein level in forage mixtures

Tissue	Statistical value	Crude protein level			
		A (higher)		B (lower)	
		kg	%	kg	%
Muscle	$\bar{x}$	24,06^{NS}	47,10^{NS}	23,64	46,11
	s	1,56	2,25	3,04	3,54
Fat	$\bar{x}$	17,65**	34,55**	20,01	39,09
	s	2,33	2,62	2,35	3,47
Bone	$\bar{x}$	4,85**	9,49**	3,90	7,43
	s	0,54	0,94	0,60	0,71

**p<0,01 NS - Non significant

not all parts have the same utilization and commercial value. Relative share of meat in individual basic joints of pig carcasses in relation to crude protein level in forage mixtures is shown in the Table 2.

A significantly (p<0.05) higher share of ham meat and a very significantly (p<0.01) higher share of neck meat were determined in carcasses of pigs fed with forage mixture with higher crude protein level. In carcasses of pigs that were fed forage mixture with lower crude protein level, a very significantly (p<0.01) higher share of loin and shoulder meat was determined. No significant (p>0.05) differences between the analyzed groups were detected in terms of share of meat in belly-rib part of pig carcasses.

Composition of the main basic joints of pig carcasses in relation to crude protein level in forage mixtures is shown in the Table 3.

In terms of absolute and relative share of muscle tissue in ham, no significant (p>0.05) differences were detected between the pigs from Group A and Group B, although the pigs from Group A had a significantly higher share of ham meat in carcasses. Loin and shoulder had a very significantly (p<0.05) higher absolute and relative share of muscle tissue in carcasses of the pigs from Group B, which were fed with lower crude protein level in forage mixtures.

In research conducted by *Nieto et al. (2003)*, reduction of crude protein level in pig rations led to increased fat in shoulder and ham and to reduction of proportional share of shoulder in carcasses. However, *Barea et al. (2008)*, did not determine influence of protein level in pig rations on the contents of intramuscular and subcutaneous fat tissue in ham and shoulder.

Pig meat quality in relation to crude protein level in forage mixtures is shown in the Table 5.

Pig meat from Group A (higher crude protein level) had a significantly (p<0.05) lower pH_2 value and a very significantly (p<0.01) lower water holding capacity in relation to the meat of pigs from Group B (lower crude protein level). Meat from both analyzed groups had a standard initial pH_1 and final pH_2 value. Values of the final pH below 5.5 indicate the occurrence of PSE meat *(Forrest, 1998)*. Values of the final pH above 6.0 are a certain sign of dark, firm and dry (DFD) meat *(Hofmann, 1994)*.

Meat colour parameters (L*, a*, and b* values) also indicate the standard meat quality. L* value indicates meat lightness, a* value indicates meat redness, and b* value indicates meat yellowness. Since occurrence of the PSE syndrome is the largest meat defect, the most important data when evaluating meat colour is the level of its lightness (L*). Desired values of meat lightness range from 43-50 *(Joo et al., 1999)*. L* values above 50 indicate pale, soft and exudative (PSE) meat, and L* values below 43 indicate dark, firm and dry (DFD) meat.

Water holding capacity of meat, expressed as the area of filter paper wetness around the compressed meat sample, was also standard in both analyzed

Table 5 Pig meat quality in relation to the crude protein level in forage mixtures

Indicators	Stat. size	Crude protein level	
		A (higher)	A (higher)
pH_1	$\bar{x}$	6,23[NS]	6,47
	s	0,27	0,21
pH_2	$\bar{x}$	5,61*	5,75
	s	0,20	0,19
Water holding capacity, cm^2	$\bar{x}$	4,65**	3,06
	s	1,64	1,33
Colour (L* value)	$\bar{x}$	51,15**	48,27
	s	2,41	4,35
Colour (a* value)	$\bar{x}$	18,43*	19,28
	s	1,22	0,95
Colour (b* value)	$\bar{x}$	6,04[NS]	5,47
	s	0,99	1,23
Consistency, cm^2	$\bar{x}$	2,58[NS]	2,15
	s	0,76	0,42
Crude proteins, %	$\bar{x}$	21,47*	20,93
	s	0,72	0,84
Crude fat, %	$\bar{x}$	6,89**	12,34
	s	2,81	3,48
Ash, %	$\bar{x}$	1,02[NS]	1,02
	s	0,04	0,05
Water, %	$\bar{x}$	70,62**	65,70
	s	1,21	2,75

*p<0,05 **p<0,01 NS-nije značajno / non significant

groups and better than the one earlier determined for pig breeds of meat type and their crossbreds *(Senčić et al., 2002.; Senčić et al., 2003; and Senčić et al., 2005).*

Muscle tissue consistency, expressed as the area of filter paper wetness below compressed meat, was also standard and no significant differences were detected between the analyzed groups.

Crude protein level in forage mixtures also significantly influenced the chemical composition of meat. Meat of pigs that were fed forage mixtures with higher crude protein level (Group A) had a significantly (p<0.05) higher content of crude proteins, a very significantly (p<0.01) higher water content, and a very significantly (p<0.01) lower content of crude fat in relation to meat of pigs that were fed forage mixtures with lower crude protein level (Group B). No significant differences (p>0.05) were detected between the analyzed groups in terms of ash content.

Conclusion

Increased crude protein level in forage mixtures had a very significant (p<0.01) influence on reduction of fat tissue share (34.55% : 39.09%) and on increase in muscle tissue share (47.10% : 46.11%) in pig carcasses, although not to a statistically significant extent (p>0.05). Pig carcasses from Group A (higher crude protein level) in relation to those from Group B (lower crude protein level) had significantly (p<0.01) higher share meat of ham (15.62% : 14.62%). Meat (MLD) of pigs from both groups was of very good quality, considering the analyzed indicators (pH_1, pH_2, water holding capacity, and colour). The meat from the Group A pigs, in relation to the meat from the Group B pigs, had a significantly (p<0.05) higher crude protein content (21.47% : 20.93%), a very significantly (p<0.01) higher water content (70.62% : 65.70%), and the lower crude fat content (6.89% : 12.34%), while in terms of ash (1.02% : 1.02%) no significant differences (p>0.05) were detected between the analyzed groups of pigs.

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Variations in carcass and meat quality traits of heavy pigs

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Scientific paper

Summary

This research was performed on 45 randomly chosen carcasses originating from double-crossed gilts (Large White and Swedish Landrace). The gilts were housed in the same conditions and fed the same diet during the fattening period until the slaughter, when carcass and meat quality traits were measured. The samples for chemical analysis of the meat were also taken. The mean pH_{45} and pH_{24} value measured in LD muscle of pig carcasses were 6.23 and 5.6, respectively, implying normal meat quality. The mean value of electrical conductivity measured 45 minutes post mortem, EC_{45} was 4.38 mS/cm, indicating no deviation from normal quality of meat, while mean EC_{24} value was 9.74 mS/cm which could be considered as relatively high. At the same time, mean CIE-L value (52.43) indicated to some extent paler than normal meat of the investigated pigs. Average drip loss (8.29 %) could also be considered as higher than desirable. When the samples were divided into normal (n=37; 82.22%) and PSE (n=8; 17.78%) group on the basis of pH_{45} value, significant differences could be observed in LD muscle area indicating increased lean production in PSE group. Regarding the meat quality traits, groups significantly differed in pH_{45}, EC_{45} and cooking loss, while there were no differences in chemical composition. Both groups had undesirably high values of EC_{24}, CIE-L* and drip loss, with no significant differences between the formed groups. The F-test performed to analyze the influence of warm carcass weight on carcass traits revealed positive effect on carcass length, ham circumference and back fat area. In the present study, only pH_{24}, EC_{24} and CIE-a* values were found to be influenced by warm carcass weight; the chemical composition of the meat samples was unaffected by warm carcass weight. It was concluded that the common positive perception about the meat quality of heavy pigs between the pig producers should be taken with caution.*

Key words: *heavy pigs, carcass traits, meat quality traits*

Introduction

Breeding of heavy weight pigs presents an important source of raw meat in the production of dry- cured products. It is widely known that increased muscularity of modern genotypes of fattening pigs caused by intensive selection have a negative effect on meat color and water holding capacity. On the other side, heavy pigs are characterized by increased fat content in the carcasses and poor feed conversion ratio, especially in last days of fattening. However, by increasing body weight, higher carcass yield can be achieved, while cooling and meat processing costs can be reduced (Ellis and Bertol, 2001). Some investigations showed that increasing age at slaughter may result in an improvement of certain pork quality traits (Candek-Potokar et al., 1998). Meat quality of older animals rather differs from that of younger animals. Numerous authors approved that increasing age and weight of pigs at slaughter may result in a more intense color of meat (Berry et al., 1970; Martin et. al., 1980) and higher intramuscular fat content (Lawrie et al., 1963; Allen et al., 1967; Shuler et al., 1970; Malmfors et al., 1978; Candek-Potokar et al., 1998). Results of Piao et al. (2004) showed that meat that comes from heavy- weight pigs had higher juiciness and tenderness, which represents desirable characteristics in production of meat products, which could be a result of higher intramuscular fat content (Hugo et al. 1999). In the aim of achieving desirable quality, a prediction of meat quality together with economic efficiency should be performed well and on time, because the market of meat and meat products becomes more competitive. Pork processors and the pork producers could suffer economic losses if the appropriate meat quality is not achieved (Chan et al. 2002). The researches about the influence of slaughter weight on technologi-

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