J. Elem. s. 99–105 DOI: 10.5601/jelem.2013.18.1.08

INFLUENCE OF MAGNESIUM ADDED TO DIET OF PULAWSKA BREED FATTENERS ON PHYSICAL AND CHEMICAL PROPERTIES OF MEAT

Jerzy Lechowski[1], Piotr Kamyk-Kamieński[1], Anna Kasprzyk[1], Jan Zuba[2]

[1]Chair of Pig Breeding and Production Technology
[2]Department of Economy and Managements
University of Life Sciences in Lublin

Abstract

Magnesium is a macronutrient involved in numerous physiological and biochemical processes in an animal organism. This study aimed at evaluating the influence of Mg supplementation of feed for fatteners on physical, chemical and sensory properties of their meat. The experiment was conducted on 30 Pulawska breed fatteners divided into two groups: experimental and control. The former group was daily supplemented with 1 g $MgCl_2 \cdot 6H_2O$ for 30 days before slaughter. After slaughter (when fatteners had gained 105 kg ± 0.4 kg of body weight), samples of ham muscle (*musculus adductor femoris*) were taken for determinations of the meat quality.

Magnesium supplementation had a positive effect on pH_1 and pH_{24} of meat. Decreased free water percentage, re-emission and green colour share, accompanied by an increase in the red colour proportion in ham meat, occurred owing to magnesium (these differences were important statistically). Another finding was a higher level of hematin in meat from the experimental animal group. As for the general chemical composition of meat from the experimental group, dry matter and glycogen content increased. No effect of magnesium supplementation was observed in the sensory quality assessment of meat. Magnesium added to feed caused slower decomposition of muscular glycogen, thus preventing a substantial decrease in the meat pH after slaughter. The meat of fatteners from the experimental group was characterized by superior technological indices.

Key words: magnesium, meat quality, fatteners.

dr hab. Jerzy Lechowski, Chair of Pig Breeding and Production Technology, University of Life Sciences in Lublin, 20-950 Lublin, 13 Akademicka Street, Poland, phone: (81) 445-69-04. e-mail: jerzy.lechowski@onet.eu

WPŁYW DODATKU MAGNEZU ZASTOSOWANEGO W ŻYWIENIU TUCZNIKÓW RASY PUŁAWSKIEJ NA WŁAŚCIWOŚCI FIZYCZNE I CHEMICZNE MIĘSA

Abstrakt

Magnez jest makroelementem biorącym udział w wielu procesach fizjologicznych i biochemicznych w organizmie zwierząt. Celem pracy było określenie wpływu dodatku Mg w paszy podawanej tucznikom na wskaźniki fizyczne, chemiczne oraz ocenę sensoryczną mięsa. Badaniami objęto 30 szt. tuczników rasy puławskiej, które podzielono na dwie grupy: eksperymentalną i kontrolną. Grupa eksperymentalna otrzymywała przez 30 dni przed ubojem dodatek magnezu w ilości 1g $MgCl_2 \cdot 6H_2O$ dziennie. Po uboju tuczników (po osiągnięciu masy ciała 105 kg ± 0,4 kg) pobrano próbki z mięśnia szynki (*musculus adductor femoris*) do badań cech jakości mięsa.

Dodatek magnezu wpłynął pozytywnie na pH_1 i pH_{24} mięsa. Pod wpływem magnezu nastąpiło zmniejszenie procentowej zawartości wody luźnej, reemisji oraz udziału barwy zielonej, natomiast stwierdzono wyższy udział barwy czerwonej w mięsie szynki (różnice istotne statystycznie). Wykazano także większą zawartość hematyny w mięsie zwierząt z grupy doświadczalnej. W podstawowym składzie chemicznym mięsa z grupy eksperymentalnej wzrosła ilość suchej masy i zawartość glikogenu. Nie zaobserwowano wpływu dodatku Mg na ocenę sensoryczną mięsa. Dodatek magnezu do paszy spowodował spowolnienie rozkładu glikogenu mięśniowego, co zapobiegło znacznemu spadkowi pH mięsa po uboju. Stwierdzono, że mięso tuczników z grupy doświadczalnej miało korzystniejsze wskaźniki technologiczne.

Słowa kluczowe: magnez, jakość mięsa, tuczniki.

INTRODUCTION

Magnesium is a macronutrient present in bodies of mammals. It is involved in many physiological and biochemical processes in an animalorganism, and participates in about 300 enzymatic reactions by playing the role of an activator of numerous enzymes. Magnesium has a positive effect on the colour and water absorption capacity of meat. It also inhibits lipid oxidation in stored pork. Supplemented magnesium decreases post-slaughter glycolysis evoked by stress, thus preventing a considerable pH decrease (APPLE et al. 2000, D'SOUZA et al. 1999, 2000, ROSENVOLD, ANDERSEN 2003).

The aim of this study was to assess the effect of Mg in feed given to fatteners on the nutritional value and selected meat quality traits.

MATERIAL AND METHODS

The experiment comprised 30 Pulawska breed fatteners divided into two groups: experimental (E) and control (C). Animals were fed a complete mixture according to Standards of Swine Feeding (12.5 MJ of ME and 150 g protein). The experimental group was supplemented with an active form of

magnesium (Mg) (absorption 98%) at the amount of 1 g $MgCl_2 \cdot 6H_2O$ daily added to feed for 30 days before slaughter. Animals were slaughtered at the body weight of 100 kg. The evaluation of ham meat (*musculus adductor femoris*) was carried out using normalized samples taken from right halves. The following were determined: pH (45 min. and 24 h after the slaughter) applying a pH STARTER CPU device, percentage of free water according to POHJA and NIINIVAARA'S method (1957), pork colour using a leukometer, fat content in meat with the Soxhlet method (according to PN-ISO 1444:2000.), dry matter (ASM) according to the drier method (PN-ISO 1442:2000), ash with the combustion method (according to PN-ISO 936:2000), total protein with Kjeldahl method (according to PN-75/A-04018). The total content of hematin dyes was determined according to HORNSEY'S method (1956). The shear force of meat was measured using a versatile SZ type device that is analogous to a Warner-Bratzler apparatus. Meat samples were measured after thermal processing (70°C for 1 h) by recording the force necessary to break muscle fibers (kG). Meat columns measuring 5 x 1 x 1 cm (height x width x length) and with a cutting section surface area of 1 cm^2 were subject to the cutting test. Muscle fibers were arranged perpendicularly to the cutting surface. Mean value for a sample was calculated from taking 5 replicates. Meat samples for the glycogen level determination were collected directly after slaughter and stored during the transport in dry ice at about -20°C. Next, glycogen was determined on the basis of the quantity of glucose released during glycogen hydrolysis according to Bertrand method (PN-67/A--86430) by isolating the animal polysaccharide from tissues (muscles) and hydrolyzing glycogen for the final evaluation of its level (in g 100 g^{-1} of tissue). The glycogen isolation, its hydrolysis to glucose and determination of the analyzed polysaccharide content were performed as proposed by GOOD et al. (1933). The sensory assessment of ham was performed by means of the point scoring method, which evaluated the scent, tenderness, juiciness and tastiness (BARYŁKO-PIKIELNA 1975).

The content of minerals were analyzed by flame atomic absorption spectrometry – AAS-PSAA Varian AA280 FS (*Official methods*...2000).

Statistical analysis of the results included calculations of mean values (x) and standard deviation (SD). The significance of differences between the control and experimental mean values was verified applying a single-factor variance analysis of Duncan's test with the aid of Statistica 6.0 software.

RESULTS AND DISCUSSION

Physical parameters of muscle tissues from the experimental group of Pulawska breed hogs, supplemented with magnesium in a diet, differed substantially from the control group, which did not receive extra magnesi-

um (Table 1). Magnesium supplementation prevented a considerable pH decrease: pH_{24} equalled 5.83 compared to 5.72 for the control group. The element caused some decrease in the percentage of free water content and ham re-emission, as well as shares of green and blue colours. On the other hand, the share of red colour in meat significantly increased: 46.55% in the experimental versus 44.90% in the control group. A higher hematin content was also found in meat from the experimental animals. It helped to stabilize the intensity of meat's natural colour. The shear force of ham muscles attained a lower value for experimental fatteners, administered magnesium, than for the control group.

Table 1

Influence of magnesium supplementation administered to Pulawska breed fatteners on physical properties of ham

Specification	Experimental group		Control group	
	x	SD	x	SD
pH_1	6.32	0.45	6.20	0.50
pH_{24}	5.83	0.56	5.72	0.51
% of free water	17.25^A	1.45	22.86^A	1.62
% of re-emission	24.32^a	1.09	25.20^a	0.83
Share of colours (%):				
r_L red	46.55^B	0.77	44.90^B	0.88
g_L green	27.03^C	0.73	28.24^C	0.64
b_L blue	26.40	0.82	26.85	0.59
Hematin (μg g^{-1})	54.21	8.76	50.11	9.12
Shear force (N)	53.95	6.49	59.70	7.88

Mean values marked the same capitals in a row differ significantly at $p \leq 0.01$.
Mean values marked the same small letters in a row differ significantly at $p \leq 0.05$.

The content of dry matter and the level of glycogen increased in meat of swine from the experimental group (Table 2). All the above changes in meat of the experimental animals occurred owing to less intensive glycogenolysis and glycolysis processes, the fact that was confirmed by partial inhibition of glycogen decomposition in meat, and which induced a slight increase of the pH_1 and pH_{24} values in ham from the experimental swine as compared to the control group. The results of the sensory assessment of ham (Table 3) indicate its high consumption value: all the evaluated parameters scored above 4 points. No significant differences between the experimental and control group in meat's minerals composition was found (Table 4).

Among many traits which characterize meat quality, its pH value, which determines other physical features, provides some important information (Koćwin-Podsiadła et al. 2006). Stasiak and Kamyk (2001) reported some dependences between pH value and re-emission % (W) and percentage of free

Table 2

Influence of magnesium supplementation administered to Pulawska breed fatteners on chemical properties of ham

Specification	Experimental group		Control group	
	x	SD	x	SD
Dry matter (%)	22.39	0.75	21.97	0.95
Crude ash (%)	1.15	0.05	1.14	0.04
Total protein (%)	20.20	0.96	19.91	1.04
Crude fat (%)	0.69	0.04	0.65	0.03
Glycogen (g 100 g^{-1} of tissue)	0.85^{A}	0.08	0.70^{A}	0.11

Mean values marked the same capitals in a row differ significantly at $p \leq 0.01$.

Table 3

Results from sensory assessment of ham (in points)

Specification	Experimental group	Control group
Scent:		
intensity	4.3	4.3
desirability	4.4	4.3
Tenderness	4.1	4.0
Juiciness	4.0	4.0
Tastiness		
intensity	4.2	4.1
desirability	4.3	4.3

water. Strzyżewski et al. (2008) found similar tendencies. Analogous correlations were also observed for muscle tissue samples studied in the present study and involving Pulawska breed swine, both from the control and experimental group. Lower pH values in ham from the examined swine breed corresponded to higher re-emission (W) and free water coefficients (%); the achieved physical parameters were characteristic for normal quality meat: $pH_1 \geq 6.0$; $pH_{24} \geq 5.5$ (Przybylski et al. 2012). And inversely, lower re-emission (W) and free water coefficients (%) corresponded to higher pH values of the fattener's ham, which proves that glycogenolysis and glycolysis were slower. As the present results indicate, magnesium – by inhibiting glycogenolysis and glycolysis – slows down the decrease in the ham pH_1 and pH_2 , which improves the indices of re-emission (W) and free water content, and this ensures better meat quality. The achieved indices of re-emission (W) and percentage of colours provided evidence for stabilization of meat's natural colour after magnesium supplementation. D'Souza et al. (1999, 2000) reported similar results achieving higher pH values for meat after the

Table 4

Mineral composition of ham (mg kg^{-1})

Specification	Experimental group		Control group	
	x	SD	x	SD
Ca	64.18	9.13	65.17	7.41
K	3327.28	28.99	3378.19	37.25
Na	426.21	19.57	418.56	22.47
Mg	266.18	25.32	254.77	28.34
Zn	25.42	1.95	25.07	2.45
Fe	22.45	2.34	21.32	2.11
Cu	0.67	0.11	0.71	0.17

slaughter, lower percentage of free water content, and meat colour stabilization. Some of the references cited in this paper and dealing with the influence of magnesium on the fattener's meat quality do not reported positive impact of this element on pork (water holding capacity, lightness, colour); in some cases, the effect depended on the duration of magnesium supplementation and age of slaughtered animals (FREDERICK et al. 2004, 2006). Retarded decrease of the glycogen content by delaying the progress of glycogenolysis in meat owing to magnesium supplementation could support discussions on physical changes in ham reported both in this article and in the in literature. Magnesium supplementation induced some changes which slowed down glycogen decomposition, manifested as a slower pH_1 and pH_{24} decrease in meat from the experimental animals compared to the control group.

CONCLUSIONS

1. Magnesium added to a diet for 30 days before slaughter slowed down muscle glycogen decomposition and prevented a substantial pH decrease in meat after slaughter, which contributed to stabilization of the colour and improvement of meat quality.

2. Meat of the experimental fatteners was characterized by lower indices of re-emission, percentage of free water content and shear force.

3. No significant influence of magnesium supplementation on the chemical composition of ham was recorded.

REFERENCES

APPLE J.K., MAXWELL C.V., DE RODAS B., WATSON H.B., JOHNSON Z.B. 2000. J. *Effect of magnesium mica on performance and carcass quality of growing-finishing swine.* Anim. Sci., 78, 2135-2143.

BARYŁKO-PIKIELNA N. 1975. *The sensory of food analysis.* WNT, Warszawa. (in Polish)

D'SOUZA, D.N., WARNER R.D., DUNSHEA F.R., LEURY B.J. 1999. *Comparison of different dietary magnesium supplements on pork quality.* Meat Sci., 51: 221-225.

D'SOUZA D.N., WARNER R.D., LEURY B.J., DUNSHEA F.R. 2000. *The influence of dietary magnesium supplement type, and supplementation dose and duration, on pork quality and the incidence of PSE pork.* Aust. J. Agric. Res., 51: 185-189.

FREDERICK B.R. VAN HEUGTEN E., SEE M.T. 2004. *Timing of magnesium supplementation administered through drinking water to improve fresh and stored pork quality.* J. Anim. Sci., 82: 1454-1460.

FREDERICK B.R., VAN HEUGTEN E., SEE M.T. 2006. *Effects of pig age at market weight and magnesium supplementation through drinking water on pork quality.* J. Anim. Sci., 84: 1512-1519.

GOOD C.A., KRAMER K., SOMOGYI M. 1933. *The determination of glycogen.* J. Biol. Chem., 100 485-491.

HORNSEY H.C. 1956. *The colour of cooked cured pork.* I. *Estimation of the nitric oxide-haem pigments.* J. Sci. Food Agric., 7: 534-540.

KOĆWIN-PODSIADŁA M., KRZĘCIO E., PRZYBYLSKI W. 2006. *Pork quality and methods of its evaluation – a review.* Pol. J. Food Nutr. Sci., 15/56(3): 241-248.

Official methods of analysis of AOAC. (Association of Official Analytical Chemists). 2000. *17th ed.* AOAC Int., Gaithersburg, MD.

PN-67/A-86430. *Determination of reducing sugars content by means of Bertrand method.* (in Polish)

PN-75/A-04018. *Agricultural food products. Determination of nitrogen content by means of Kjeldahl method and recalculating into protein.* (in Polish)

PN-ISO 936:2000. *Meat and meat products. Determination of total ash content.* (in Polish)

PN-ISO 1442:2000. *Meat and meat products. Determination of moisture content (reference method).* (in Polish)

PN-ISO 1444:2000. *Meat and meat products. Determination of free fat content.* (in Polish)

POHJA M.S., NIINIVAARA F.P. 1957. *Die Bestimmung der Wasserbindung des Fleisches mittels der Konstantdrückmethode.* Fleischwirtschaft, 9: 193-195.

PRZYBYLSKI W., JAWORSKA D., BORUSZEWSKA K., BOREJKO M., PODSIADŁY W. 2012. *Technological and sensory quality of defective pork meat.* Żywność. Nauka. Technologia. Jakość, 1(80): 116--127. (in Polish)

ROSENVOLD K., ANDERSEN H.J. 2003. *Factors of significance for pork quality – a review.* Meat Sci., 64: 219-237.

STASIAK A., KAMYK P. 2001. *Chemical composition and quality of lean in PLW, PL and Pulawska fatteners originating from Lublin region.* An. UMCS, Sect. EE, 19(15): 115--119. (in Polish)

STRZYŻEWSKI T., BILSKA A., KRYSZTOFIAK K. 2008. *Correlation between pH value of meat and its colour.* Nauka Przyr. Technol., 2(2): 12. (in Polish)