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EFFECTS OF A MAGNESIUM FUMARATE SUPPLEMENTATION ON CATECHOLAMINES, CORTISOL AND BLOOD METABOLITES IN SWINE

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INTRODUCTION

Magnesium is an important co-factor in many enzymatic reactions of the energy and protein metabolism (Niemack, 1985; Romani, 1990). It is also involved in muscle contractures and signal transmission in nerves. As an antagonist of calcium (Nguyen-Duong, 1989), magnesium is supposed to counteract catecholamine effects in stress situations (Classen, 1986; Kaemmerer *et al.*, 1984; Kietzmann *et al.*, 1985). Stress susceptibility in swine is accompanied by an abnormal intracellular calcium release in skeletal muscle, including hypercatabolism, a high release of stress hormones and a subsequent elevation of the body temperature. Those abnormal metabolic reactions are also a main reason for the development of poor meat quality. Thus, it was the aim of this study to investigate the effects of a different magnesium fumarate supplementation on catecholamines, cortisol and blood metabolites in pigs from different genotypes.

MATERIAL AND METHODS

Eighteen German Landrace pigs and 18 Pietrain pigs were obtained from different breeding schemes. Half of each group was tested to be halothane positive and half was halothane negative according to the barnyard challenge test. Twenty-four animals were castrated males and 12 were females. Three feeding groups were formed: one control group, one magnesium supplementation group with 10g and another magnesium supplementation group with 20g magnesium fumarate per kg standard fattening diet. Starting at a body mass of approximately 30kg, animals were fed without restrictions *ad libitum* until reaching a slaughter weight of 100kg. Blood samples were obtained by venipuncture when animals reached an average body mass of 35, 59 and 87kg. After immediate centrifugation plasma samples were stored at -30°C until further analysis. Concentrations of epinephrine and norepinephrine were measured by high pressure liquid chromatography, concentrations of cortisol and insulin by radioimmunoassay and concentrations of lactate, glucose and cholesterol by standard enzymatic procedures. Data were analyzed by ANOVA using the SAS software package for personal computers. The following statistical model was applied:

$$y = \mu + \text{breed(B)} + \text{halothane genotype(G)} + \text{sex(S)} + \text{feeding group(F)} + \text{date(D)} + \text{animal(BxGxSxF)} + \text{BxG} + \text{BxS} + \text{BxF} + \text{BxD} + \text{GxS} + \text{GxF} + \text{GxD} + \text{SxF} + \text{SxD} + \text{FxD} + b_{\text{body weight}} + e.$$

RESULTS AND DISCUSSION

In general, supplementation with magnesium fumarate reduced the plasma concentrations of norepinephrine and

cortisol. The plasma concentration of norepinephrine in the 10g supplementation group and the plasma concentration of cortisol in both supplementation groups were significantly reduced compared to the control group (Table 1). Furthermore, the plasma norepinephrine concentration was negatively correlated with meat quality criteria (r=-0.274). The most distinct effects on blood metabolites were also found in the 10g supplementation group, where the plasma concentrations of glucose, lactate and cholesterol were significantly lower compared to the control and to the 20g supplementation group (Table 1). Significant differences were also found between breeds and halothane genotypes. Animals of the Pietrain breed showed lower concentrations of epinephrine, insulin and cholesterol compared to the German Landrace animals. Halothane positive animals showed lower concentrations of cholesterol and higher concentrations of norepinephrine compared to their halothane negative counterparts (Table 2). Significant interactions were found for the combination of "feeding group" and "halothane genotype", for the plasma concentrations of glucose and lactate. Supplementation by magnesium fumarate brought about the most distinctive reduction effects on glucose and lactate concentrations in the halothane negative animals (Table 3).

CONCLUSION

We conclude, that a supplementation of the diet by magnesium fumarate counteracts catecholamine and cortisol effects. In addition, this reduction of preslaughter stress reactions may be a main reason for the beneficial effects of a magnesium fumarate supplementation on post mortem meat quality (Otten *et al.*, 1992).

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Table 1. Effects of different magnesium fumarate supplementations on plasma concentrations of epinephrine, norepinephrine, cortisol, insulin, glucose, lactate and cholesterol in swine (least square mean values ± standard error).

	magnesium fumarate supplementation			
	0 g	10 g	20 g	
	a	b	c	
	n = 12	n = 11	n = 11	Signif.
epinephrine (nmol/l)	5.1 ± 1.5	6.3 ± 1.5	7.7 ± 1.5	n.s.
norepinephrine (nmol/l)	19.1 ± 1.8	13.0 ± 1.8	15.5 ± 1.9	a:b *
cortisol (g/l)	31.3 ± 2.7	21.7 ± 2.6	21.0 ± 2.7	a:b * a:c **
insulin (U/l)	19.5 ± 1.8	18.2 ± 1.7	21.4 ± 1.8	n.s.
glucose (mmol/l)	6.4 ± 0.1	6.0 ± 0.1	6.3 ± 0.1	a:b ** b:c *
lactate (nmol/l)	9.3 ± 0.6	7.3 ± 0.6	9.0 ± 0.6	a:b *
cholesterol (mg/dl)	93.6 ± 2.4	83.9 ± 2.3	92.6 ± 2.5	a:b ** b:c *

* = significant difference ($P<0.05$); ** = ($P<0.01$).
n.s. = no significant difference between all possible group comparisons.

Table 2. Effects of different breeds and halothane genotypes on plasma concentrations of epinephrine, norepinephrine, cortisol, insulin, glucose, lactate and cholesterol (least square mean values ± standard error).

	breed		
	Germ. Landr.	Pietrain	
	n = 17	n = 18	Signif.
epinephrine (nmol/l)	8.9 ± 1.3	3.8 ± 1.4	*
norepinephrine (nmol/l)	15.0 ± 1.6	16.7 ± 1.7	n.s.
cortisol (g/l)	23.0 ± 2.3	20.4 ± 1.1	n.s.
insulin (U/l)	24.1 ± 1.6	15.3 ± 1.7	***
glucose (mmol/l)	6.1 ± 0.1	6.3 ± 0.1	n.s.
lactate (nmol/l)	8.1 ± 0.5	8.9 ± 0.6	n.s.
cholesterol (mg/dl)	102.5 ± 2.1	77.5 ± 2.3	***

Table 2 (cont). Effects of different breeds and halothane genotypes on plasma concentrations of epinephrine, norepinephrine, cortisol, insulin, glucose, lactate and cholesterol (least square mean values ± standard error).

	halothane genotype		
	H^-	h^+	
	n = 18	n = 17	Signif.
epinephrine (nmol/l)	7.5. ± 1.2	5.3 ± 1.4	n.s.
norepinephrine (nmol/l)	13.4 ± 1.5	18.4 ± 1.6	*
cortisol (g/l)	25.4 ± 2.1	23.8 ± 2.4	n.s.
insulin (U/l)	20.6 ± 1.4	18.8 ± 1.6	n.s.
glucose (mmol/l)	6.1 ± 0.1	6.3 ± 0.1	n.s.
lactate (nmol/l)	7.9 ± 0.5	9.1 ± 0.6	n.s.
cholesterol (mg/dl)	97.2 ± 1.9	82.9 ± 2.2	***

* = significant difference ($P<0.05$); ** = ($P<0.01$); *** = ($P<0.001$).
H^- = halothane negative; h^+ = halothane positive.* = significant difference.

Table 3. Significant interaction between feeding group and halothane genotype concerning the plasma concentrations of glucose and lactate (least square mean values ± standard error).

halothane genotype x feeding group		glucose (mmol/l)		lactate (nmol/l)	
H^-x0g mg.fum.	a	6.38 ± 0.13	a:c *	10.49 ± 0.84	a:b ***
H^-x10g mg.fum.	b	6.02 ± 0.15	a:e *	6.16 ± 0.97	a:c **
H^-x20g mg.fum.	c	5.96 ± 0.14	b:f *	7.15 ± 0.87	a:d *
h^+x0g mg.fum.	d	6.33 ± 0.14	c:f **	8.01 ± 0.88	b:f ***
h^+x10g mg.fum	e	5.87 ± 0.15	d:e *	8.41 ± 0.96	c:f **
h^+x20g mg.fum.	f	6.54 ± 0.15	e:f **	10.83 ± 0.92	d:f *

* = significant difference ($P<0.05$); ** = ($P<0.01$); *** = ($P<0.001$).
H^- = halothane negative; h^+ = halothane positive.
mg.fum. = magnesium fumarate supplementation.