Arch. Tierz., Dummerstorf 43 (2000) 5, 487-497

Research Institute of Animal Production, Nitra, Slovak Republic[1]; Research Institute for the Biology of Farm Animal, Dummerstorf, Germany[2]; Chemical College, Slovak Technical University Bratislava, Slovak Republic[3]

RUDOLF LAHUCKY[1], PETER KRSKA[1], ULRICH KÜCHENMEISTER[2], KARIN NÜRNBERG[2], TIBOR LIPTAJ[3], GERHARD NÜRNBERG[2], IVAN BAHELKA[1], PETER DEMO[1], GERDA KUHN[2] and KLAUS ENDER[2]

# Effect of Vitamin E on changes in Phosphorus Compounds assessed by $^{31}$P NMR Spectroscopy and ATPase from postmortem Muscle samples and Meat quality of Pigs

*Dedicated to Professor Dr. Dr. h. c. Gerhard von Lengerken on the occasion of his 65$^{th}$ birthday*

## Summary

The effect of addition of vitamin E (α-tocopherol) to pig diets on muscle metabolism of phosphorus compounds, ATPase activity and meat quality was studied. Experimental pigs were fed with a diet supplemented with vitamin E (200 mg α-tocopherol/kg diet) for 60 days before slaughtered (110 kg live weight). *Longissimus* muscle (LD) vitamin E level was more than twice higher ($P<0.01$) in pigs supplemented with vitamin E. Changes of muscle phosphorus compounds like sugar phosphate (SP), inorganic phosphate (Pi), phosphocreatine (PCr), and adenosinetriphosphate (ATP) assessed by $^{31}$P NMR spectroscopy (15 min post mortem) differed between control pigs and vitamin E administered pigs. Significantly lower ($P<0.05$) values of SP and significantly higher values of PCr were found in pigs administered with vitamin E. Efficiency of muscle energetic metabolism measured as index PCr/Pi was higher in pigs supplemented with vitamin E. ATPase activity of *longissimus* muscle (LD) was not influenced by vitamin E in diet. Drip loss of LD measured 24 h post mortem and conductivity of *semimembranosus* (SM) and LD measured 3 h post mortem ($P<0.05$) improved by administration with vitamin E. Differences between pH of LD and SM muscles measured 45 min post mortem were not significantly influenced.

Dietary vitamin E administered for 60 days to finishing pigs may have beneficial effects on muscle energetic metabolism, electrical conductivity, and drip loss.

Key Words: pig, α-Tocopherol, Muscle Phosphorus Compounds, ATPase, meat quality

## Zusammenfassung

Titel der Arbeit: **Einfluß von Vitamin E auf die phosphorhaltigen Verbindungen ($^{31}$P-NMR Spektroskopie) und auf ATPase Aktivitäten im post mortem Muskel sowie auf die Fleischqualität beim Schwein**

Der Einfluß einer erhöhten Zugabe von Vitamin E (α-Tocopherol) zum Futter von Schweinen auf den Muskelstoffwechsel von Phosphorkomponenten, ATPase Aktivitäten sowie auf die Fleischqualität wurde untersucht. Die Versuchschweine wurden 60 Tage lang vor dem Schlachten mit Vitamin E angereichertem Futter (200 mg α- Tocopherol/kg Futter) gefüttert. Die Vitamin E Konzentration im *Musculus longissimus* (LD) der Versuchstiere war mehr als zweifach höher ($P<0,01$) als bei den Kontrolltieren. Durch $^{31}$P NMR Spektroskopie ermittelte (15 min post mortem) Phosphorkomponenten wie Zuckerphosphat (SP), anorganisches Phosphat (Pi) Creatinphosphat (PCr) und Adenosintriphosphat (ATP) unterschieden sich zwischen der Versuchs- und Kontrollgruppe. Signifikant geringere Werte ($P<0,05$) für SP und signifikant höhere Werte für PCr wurden in der Vitamingruppe gefunden. Die Effizienz des Muskelenergiemetabolismus, gemessen als Index PCr/Pi , war höher in der Versuchgruppe. Die ATPase Aktivität im *Musculus longissimus* war durch die Vitamin E Supplementierung nicht beeinflußt. Der Dripverlust des LD, gemessen 24 h post mortem, wie auch die Leitfähigkeit des *Musculus semimembranosus* (SM) und des LD, gemessen 3 Stunden post mortem, wurden durch die Vitamin E Zufuhr verbessert. Der pH-Wert 45 min post mortem sowohl im LD als auch im SM wurde nicht beeinflußt.

Eine 60tägige Fütterung von Vitamin E angereichertem Futter vor der Schlachtung scheint einen positiven Einfluß auf den Energiestoffwechsel des Muskels sowie auf die Leitfähigkeit und den Dripverlust auszuüben.

Schlüsselwörter: Schwein, α-Tocopherol, Muskel-Phosphorkomponente, ATPase Aktivität, Fleischqualität

## Introduction

The beneficial effect of dietary supplementation of vitamin E on some aspects of meat quality has been reported by various investigators. The stability of lipid and colour in beef (ARNOLD et al., 1993), pork (MONAHAN et al., 1992), and a reduction of drip loss from pork chops following frozen storage (ASGHAR et al., 1991) could be achieved by dietary supplementation of vitamin E. Oxidative processes may contribute to the loss of membrane integrity. This oxidation leads to a decrease in fluidity and disruption of normal membrane structure and function, and may affect the ability of the membrane to act as a semi-permeable barrier (STANLEY, 1991). Positive effects vitamin E on the oxidative stability and quality of pig meat (drip loss) were reported by BUCKLEY et al. (1995) and on the amount of fluid in muscles by LAURIDSEN et al. (1999). Some investigators did not find significant differences between drip loss of vitamin E supplemented and control porcine muscles (JENSEN et al., 1997; DUFEY, 1998; HONIKEL et al., 1998), whereas the effect of vitamin E supplementation observed by CHEAH et al. (1995b) depended on the muscle investigated. Also, the effect of vitamin E supplementation on drip loss of bovine muscles seems to depend on the muscle studied (DEN HERTOG-MEISCHKE et al., 1997). As was shown (MITSUMOTO et al., 1998) appropriate feeding, dose of vitamin E, and concentrations in muscles should be achieved to be effective in reducing drip losses from fresh beef steaks.

There were proposed more potentially modifying factors influencing muscle metabolism, malignant hyperthermia (MH) and meat quality in pigs as was discussed by FLETCHER et al., (1993). Abnormality in the antioxidant defence system could be one of the factors (DUTHIE et al., 1991). It was shown that the capacity of muscle energetic metabolism could also be an important factor influencing and modulating the MH syndrome and meat quality (LAHUCKY et al., 1993; KOHN et al., 1998). Heterozygotes can form a metabolically distinct phenotype between homozygotes negative and homozygotes MH susceptible pigs as was shown using phosphorus nuclear magnetic resonance ($^{31}$P NMR) spectroscopy (MOESGARD et al., 1994; LAHUCKY et al., 1998). Phosphorus NMR spectroscopy has previously been applied in studies on skeletal muscle energetic metabolism using frozen or fresh bioptates (SHEN et al., 1992; LAHUCKY et al., 1993).

The objective of this study was to determine the effects of dietary vitamin E supplementation on changes in phosphorus compounds assessed by NMR spectroscopy and also overall ATPases as major energy consumers from postmortem muscle samples. Meat quality values of pigs were evaluated as well.

## Material and Methods

### Animals and sample preparations

In total 18 pigs were used in this experiment. They originated from lines of Large White and crossbred Large White x Pietrain pigs. The RYR-1 genotype (FUJII et al., 1991) of this animals was determined by a DNA based test described previously (LAHUCKY et al., 1998). Two groups (experimental, control) with 5 normal and 4 heterozygotes on MH syndrome in each group were taken in this experiment. The pigs

Arch. Tierz. 43 (2000) 5

(3 barrows and 6 gilts in each group) were penned in double boxes at institute facilities to minimise the influence of stress. At the beginning of vitamin E administration (70 ± 2 kg live weight) water holding capacity (WHC) and pH from bioptate (*longissimus* muscle) were estimated (CHEAH et al., 1993) from heterozygote pigs. Values of WHC and pH did not differ significantly ($P<0.05$) between heterozygotes of control and experimental group. Experimental animals were supplemented daily with 200 mg vitamin E (Slovakofarma, Hlohovec) per kg of standard diet for 60 days before slaughter. The animals were electrically stunned and slaughtered at 110 kg in the slaughter house of the institute in Nitra (transportation about 200 m).

Immediately after the exsanguination (10 min) a sample from the *longissimus* muscle was removed (referred to as 0 h sample). At 24 h post mortem the next sample was taken after chilling. All these samples were frozen in liquid nitrogen, stored at -70° C, homogenised and treated as described by KÜCHENMEISTER et al. (1999).

From the right side of *longissimus* muscle (last rib) 15 minutes after slaughter a sample of approx. 1 g using was taken out by a biopsy instrument (Biotech, Nitra), immediately frozen and stored in liquid nitrogen until analysed.

The pH value of the carcass (*longissimus* - between 13th and 14th rib, *semimembranosus* muscle- middle) was determined at 45 min post mortem using combined pH electrode (Ingold). Electrical conductivity was measured with a Tecpro Quality instrument (Germany) at 3 h and 24 h post mortem. Drip loss analysis was made according to HONIKEL (1998) 24 h post mortem. The experiments were in accordance with the institutional guidelines for animal care (Research Institute of Animal Production, Nitra, 1998).

### α-Tocopherol determination

A samples of *longissimus* muscle (frozen in liquid nitrogen and stored for five months at -70° C) were analysed in duplicate for α-tocopherol content.

### Vitamin E

The concentration of vitamin E of blood and muscle were measured by HPLC (BERLIN et al., 1994). A mixture of 1.5 ml muscle homogenate or 3 ml plasma, 2 ml absolute ethanol and 0.5 ml 10 % ascorbic acid was heated to 70° C for 5 minutes. After adding 1 ml 10 n KOH, the mixture was incubated at 70° C for 30 minutes. After cooling, 5 ml n-hexane was added for extraction. The solvent was removed by evaporation under nitrogen, and the vitamin E was immediately resolved in absolute ethanol and assayed by HPLC. HPLC analysis was performed with the mobile phase methanol with a flow rate of 1 ml/min and a Lichrospher RP 18 column with precolumn (Muder & Wocherle Chromatographietechnik Berlin, 12.5 x 0.4 cm, 5 mm). Detection was performed by fluorescence at 292 nm excitation/336 nm emission. Peaks were quantified upon calibration with authentic samples of α-tocopherol (Sigma, Deisenhofen).

### ATPase activity measurements

The total ATPase activity of the muscle homogenates was measured spectrophotometrically with a coupled enzyme assay at 30°C by a modified method

described previously (SIMONIDES et al, 1990), but without the inclusion of any inhibitors. The reaction mixture consisted of 20 mM HEPES (pH 7.5), 100 mM KCl, 2 mM ATP, 5 mM $MgCl_2$, 1 mM EGTA, 1 mM $CaCl_2$, 0.2 mM NADH, 16 IU lactate dehydrogenase, 10 IU pyruvate dehydrogenase, 10 mM phosphoenolpyruvate and 2 M $Ca^{2+}$ ionophore A23187. The free $Ca^{2+}$ concentration was calculated to be about 10 M. After a preincubation for 10 min to equilibrate the temperature, 10 l homogenate were added and the decrease of the absorbance followed for about 5 min.

**Phosphorus nuclear magnetic resonance spectroscopy**

The biopsy sample (approx. 1 g) was introduced into a 10 mm diameter tube (maintained at 39°C) filled with deuterated water ($D_2O$) for NMR measurements. The $^{31}$P NMR spectrum was recorded at 121 MHz on a VXR 300 (Varian) spectrometer. The total $^{31}$P spectrum was recorded with a sweep width of 3932.4 Hz and 45 pulses of 35.0 s The recycle time was 0.8 s. Each spectrum was a result of 512 transients. An exponential line broadening of 20 Hz was used as internal reference at -2.47 ppm. The time of accumulation per spectrum was 7.6 min. Out of a number of spectra for calculation only the first and second were used.

The levels of the individual phosphorus compounds were expressed in percentage of the total content of phosphorus compounds as described previously (LAHUCKY et al., 1993).

**Statistical analyses**

We used a three-way cross classification model with three factors:

- feeding group (two levels: with vitamin E and without)
- status (two levels : homozygotes negative and heterozygotes)
- sex (two levels: barrows and gilts)

and interaction effects feeding group x status and feeding group x sex.

For the influence of the sampling time a repeated measurement model was used.

The analysis was done by means of statistical software package SAS©, procedure GLM.

## Results

Figure 1 shows series of $^{31}$P NMR spectra obtained from *longissimus* muscle of control (a) and of vitamin E (b) administered pigs. The spectra of pig muscle contained six peaks corresponding mainly to resonances of sugar phosphate (SP), inorganic phosphate ($P_j$), phosphocreatine (PCr), and the three phosphate groups of adenosinetriphosphate (ATP), respectively. The signals of PCr and ATP decreased in the time course, whereas $P_j$ and SP increased to a lesser extent.

The rate of changes in concentration of phosphorylated compounds varied between pigs. In the vitamin E supplemented and in the control pigs there was still a high ATP level at the beginning of the NMR measurements (1. spectrum) and remained high or decreased till the end of measurements (3. spectrum). By contrast, the PCr level was lower from the beginning and was almost exhausted at the end of measurements,

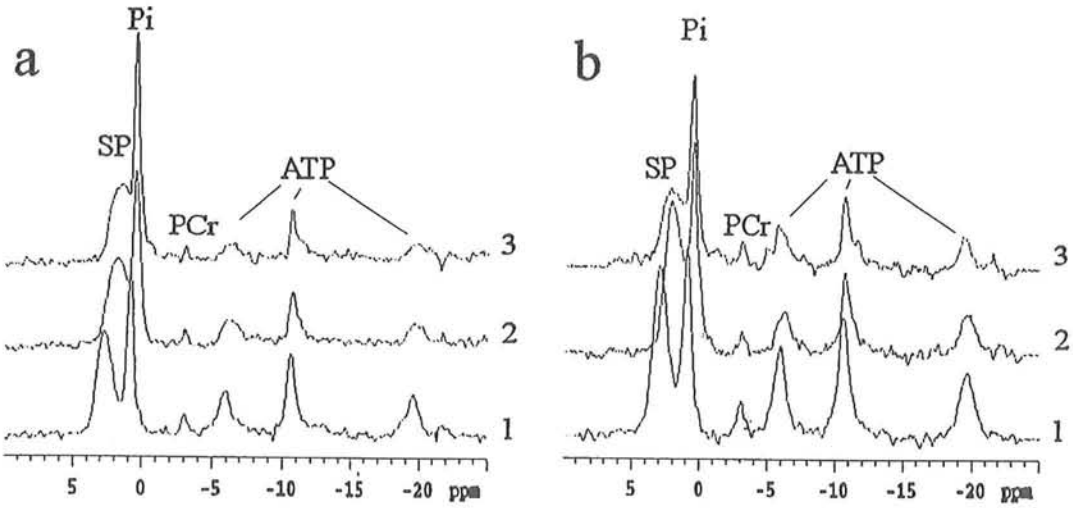


Fig. 1: Time course of $Fe^{2+}$/ascorbate induced lipid peroxidation of *longissimus dorsi* muscle post mortem of control and supplemented (vitamin E, organic selenium and vitamin E + organic selenium) pigs. All differences between supplemented with vitamin E groups and groups not supplemented with vitamin E are significant ($P < 0.01$) (Die Serien von $^{31}P$ NMR Spektren von Muskelbiopsien vom *Musculus longissimus* (gewonnen 15 min post mortem) zeigen Konzentrationen von Zuckerphosphaten (SP), anorganischem Phosphat (Pi), Creatinphosphat (PCr) und Adenosintriphosphat (ATP): (a) von Kontrollschweinen (MH-heterozygot); (b) von Schweinen, gefüttert mit Vitamin E angereichertem Futter (MH-heterozygot). 1-3 weist auf die chronologische Folge der Spektren hin mit 12 min für das 1. Spektrum und mit jeweils 8 min Intervallen für die folgenden Spektren)

Table 1

Groups of supplementation with vitamin E and organic selenium in diet and concentration of vitamin E (α-tocopherol) in *longissimus dorsi* muscle (Least square means (LSM) und Standardfehler (SE) von Phosphorkomponenten (% von Gesamt) im *Musculus longissimus* (15 min post mortem) von Schweinen unter dem Einfluß von Vitamin E Supplementierung (200 mg/kg Futter))

| | Spectrum | Control (n=9) | | Vitamin E (n=9) | | Significance | |
|---|---|---|---|---|---|---|---|
| | | LSM | SE | LSM | SE | group x status | group x sex |
| SP | 1 | $30.35^{a}$ | 2.049 | $23.15^{b}$ | 2.174 | - | - |
| | 2 | $36.46^{a}$ | 2.166 | $29.88^{b}$ | 2.209 | - | - |
| $P_i$ | 1 | 31.75 | 2.049 | 32.89 | 2.089 | - | - |
| | 2 | $30.56^{a}$ | 1.065 | $34.27^{b}$ | 1.086 | * | - |
| PCr | 1 | $2.39^{a}$ | 0.634 | $4.41^{b}$ | 0.646 | - | - |
| | 2 | $1.77^{a}$ | 0.199 | $2.92^{c}$ | 0.203 | - | - |
| ATP | 1 | 9.72 | 1.014 | 11.25 | 1.034 | - | - |
| | 2 | 7.89 | 0.887 | 8.36 | 0.905 | - | - |

Least squares means with different superscripts differ $^{a,b}$ ($P<0.05$); $^{a,c}$ ($P<0.01$)
SP-sugar phosphate; Pi-inorganic phosphate; PCr-phosphocreatine; ATP-adenosinetriphosphate
1. spectrum - 12 min obtaining of spectra; 2. spectrum - 8 min after 1. spectrum
Interactions group x status; group x sex; * significance $P<0.05$

mainly in samples taken from control pigs (Fig. 1a). That's why we have calculated only the results from 1. and 2. spectrum. The level of SP and $P_j$ were higher at beginning of measurements and SP was increased in a higher extent in control pigs till the end of measurements (3. spectrum).

As follows from the results introduced in Table 1 significant differences ($P<0.05$) of SP were received at the 1. and 2. Spectrum. Differences in $P_j$ of 2. spectrum and also differences of PCr values at 1. spectrum ($P<0.05$) and second spectrum($P<0.01$) were significant between control and vitamin E supplemented group. Values of ATP were also lower in *longissimus* samples of control pigs but differences were not significant ($P>0.05$).

Figure 2 illustrates the change of the ATPase activity of *longissimus* muscle determined just after slaughter (0 h) and 24 h post mortem from control and vitamin E supplemented pigs. The ATPase activity did not differ between experimental groups immediately after slaughter and 24 h post mortem as well. There was no significant decrease of activity from the 0 h sample to the 24 h samples from vitamin pigs whereas this decrease was significant in samples from control pigs (Fig. 2).

The content of vitamin E (α-tocopherol) of the *longissimus* muscles was determined and the results are presented in Table 2. Dietary vitamin E level in pigs supplemented with vitamin E was more than twice higher if compare to control pigs ($P<0.01$).

Meat quality values measured as pH, electrical conductivity and drip loss of *longissimus* muscle and pH and electrical conductivity of *semimebranosus* muscle (Table 2) showed differences between control and with vitamin E administered pigs. There was a tendency ($P=0.1$) of lowering the drip loss in *longissimus* muscle of pigs with supplementation of vitamin E. Dietary vitamin E levels significantly ($P<0.05$) affected electrical conductivity of *longissimus* and *semimebranosus* muscle measured 3 h post mortem. Differences of pH measured 45 min post mortem of *longissimus* and *semimebranosus* muscles were not significant ($P>0.1$).

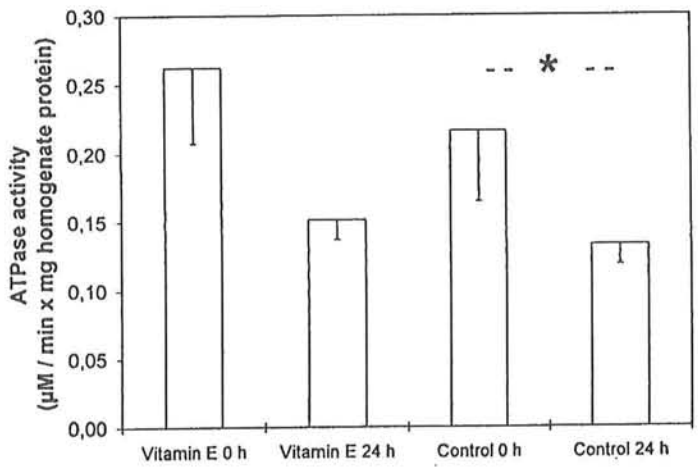


Fig. 2.: Total ATPase activity of *longissimus* muscle homogenates of control and vitamin E supplemented pigs from 0 h and 24 h post mortem samples (Gesamt-ATPase Aktivität von Muskelhomogenaten (*Musculus longissimus*) von Versuchs- und Kontrolltieren, gewonnen 0 h und 24 h post mortem)

Table 2
Colour measured as reflectances and amount of thiobarbituric acid (TBA) related compounds in muscles *longissimus dorsi* (LD) and *psoas major* (PM) of pigs during chill storage (Least square means (LSM) und Standardfehler (SE) der Konzentration von Vitamin E im *Musculus longissimus* und von Fleischqualitätsparametern im *Musculus longissimus* und *Musculus semimembranosus* unter dem Einfluß einer Fütterung mit erhöhten Vitamin E Gehalt)

| | | Control (n=9) | | Vitamin E (n=9) | | Significance | |
|---|---|---|---|---|---|---|---|
| | | LSM | SE | LSM | SE | group x status | group x sex |
| *Longissimus* | | | | | | | |
| Vitamin E (mg/kg) | | 0.48[a] | 0.079 | 1.24[c] | 0.092 | - | - |
| pH | 45 min | 6.23 | 0.095 | 6.34 | 0.096 | - | - |
| Conductivity | 3 h | 4.36[a] | 0.352 | 3.12[b] | 0.359 | * | * |
| | 24 h | 4.11 | 0.426 | 3.60 | 0.435 | - | - |
| Drip loss | 24 h | 4.77 | 0.409 | 3.79 | 0.417 | - | - |
| *Semimembranosus* | | | | | | | |
| pH | 45 min | 6.39 | 0.074 | 6.53 | 0.074 | - | - |
| Conductivity | 3 h | 8.98[a] | 1.114 | 5.26[b] | 1.136 | - | - |
| | 24 h | 9.95 | 1.154 | 7.43 | 1.177 | - | - |

Least squares means with different superscripts differ [a,b] ($P<0.05$); [a,c] ($P<0.01$)
Interactions group x status; group x sex; * significance $P<0.05$

## Discussion

The higher level ($P<0.01$) of α-tocopherol in *longissimus* muscle of vitamin E supplemented pigs (200 mg/kg diet for 60 days) is in agreement with those of other authors (BUCKLEY et al., 1995; O'SULLIVAN et al., 1997). Tissue levels of α-tocopherol were 2.5 to 3.0 times higher in pigs fed the supplemented diet (200 mg/kg diet for 125 days) than in those on the basal diet (30 mg/kg diet) (BUCKLEY et al., 1995). Similar results were reported by ASGHAR et al. (1991) for pigs receiving 10, 100, or 200 IU vitamin E per kg of feed. We have no information about the basal level of α-tocopherol in the diet. This and/or longer storage of the samples (five months, at -70° C, non vacuumed, ones thawed and frozen) could be reasons for the overall lower values of α-tocopherol in *longissimus* muscle from both supplemented and control pigs obtained in our experiment. It is known that α-tocopherol levels in porcine tissues depend on the supplementation time. When pigs were given a diet supplemented with 200 mg α-tocopheryl acetate per kilogram of feed, α-tocopherol levels increased with supplementation time up to 91 days in tissues (BUCKLEY et al., 1995). It is believed that incorporating vitamin E into subcellular membranes increases the antioxidant capacity of the system and possibly also increases their physical stability (BUCKLEY et al., 1995).

Different changes in breakdown of PCr and ATP were measured comparing control and vitamin E supplemented pigs (Fig. 1, Tab. 1). In every case PCr and ATP decreased in the time course, whereas SP increased. Changes of $P_i$ were different, the

level of this compound reaching a plateau at 1. spectrum (muscle sample taken 15 min post mortem and 12 min NMR spectrum). That could be consistent with results introduced earlier (LAHUCKY et al., 1993). After 20-30 min incubation usually a plateau of $P_j$ level was reached. Breakdown of PCr was higher in the control group with significant differences in both spactra: 1. spectrum ($P<0.05$) and 2. spectrum ($P<0.01$). The level of SP was significant lower ($P<0.05$) in samples from vitamin E group (mainly in 1. spectrum).

The ratio of free inorganic phosphate to phosphocreatine ($P_j$/PCr) was proposed as an indicator of the energy state of muscle tissue in various conditions and the inverse ratio (PCr/$P_j$) was also used (LAHUCKY et al., 1993). Rate of breakdown of PCr seems to be higher in pigs supplemented with vitamin E as follows from the level of PCr in control vs. vitamin E group (Tab. 1) and/or higher ratio PCr/Pi (1. spectrum - 0.075 vs. 0.013) in the vitamin E group. Higher variability was found in ATP and differences between groups were not significant ($P>0.05$). This was also supported by the results of the ATPase activity measured from *longissimus* muscle just (0 h) and 24 h after slaughter (Fig. 2). ATPase activity from pigs supplemented with vitamin E were higher at beginning (0 h) and 24 h post mortem but differences between groups were not significant ($P>0.05$). However, the decrease of ATPase activity from control pigs from 0 h to 24 h post mortem was significant, but not so in vitamin E supplemented samples (Fig. 2).

As possible mechanism for the beneficial effect of vitamin E supplementation on drip loss has been suggested that α-tocopherol could preserve integrity of the muscle cell membrane by preventing oxidation of membrane phospholipids during refrigerated storage (ASGHAR et al., 1991). This could be consistent with higher efficiency of energetic compounds in muscle (lower breakdown of PCr, higher level of index PCr/Pi) and lowering of conductivity (3 h post mortem) in animals administered with vitamin E.

The effect of vitamin E supplementation on drip loss seems to depend on the muscle studied (DEN HERTOG-MEISCHKE et al., 1997). Their results suggested that vitamin E supplementation may have both positive and negative effects on drip loss of meat, depending on muscle studied. Results received (Tab. 2) on pH, conductivity, and drip loss supported positive effects of vitamin E. Differences in conductivity of *longissimus* and *semimebranosus* muscles measured 3h post mortem between control and the vitamin E administered group were significant ($P<0.05$). There was a tendency in improving drip loss of *longissimus* muscle ($P=0.1$). Differences in pH of LD and SM muscles measured 45 min post mortem were not significant ($P>0.1$) between groups. Using a higher level of vitamin E supplementation (500 mg/kg diet) administered for 46 days could reduce drip loss in unfrozen *longissimus thoracis* in heterozygotes and in normal on malignant hyperthermia pigs as was shown by CHEAH et al. (1995). Authors indicated that part of vitamin E effectiveness in improving the WHC of *longissimus thoracis* and in preventing changes in meat quality is due to inhibition of phospholipase $A_2$ activity connected with hydrolysis of phospholipids and stability of mitochondrial membranes. This could be also supported by our results of higher efficiency muscle energetic metabolism of pigs administered higher level of α-tocopherol. However, there are contradictionary results about posi-

tive effects of vitamin E supplementation on drip loss (BUCKLEY et al., 1995), or the amount of fluid in muscles (LAURIDSEN et al., 1999) and some investigators were not able to find significant differences between drip loss of supplemented and control porcine muscle (JENSEN et al., 1997; HONIKEL et al., 1998). MONAHAN et al. (1994) have shown that membrane lipid oxidation and drip loss of pork are not directly related. In agreement with HONIKEL et al. (1998) membrane changes (oxidative changes) post mortem have not to be in relation to some quality values (e.g. drip loss, conductivity) when muscle is stored for a longer time. The influence of vitamin E supplementation on conductivity and drip loss of muscles was not always consistent in our experiment. It is believed that conductivity and drip loss could be affected not only by dietary vitamin E supplementation but also by other factors such as moisture and fat content of the muscle (MUTSIMOTO et al., 1998) but animal model (occurrence of mutation on RYR1 gene and muscle metabolic state) should also be controlled in pig experiments (CHEAH et al., 1994, 1995, 1998; LAHUCKY et al., 1997, 1998). From our results on muscle energetic metabolism using $^{31}P$ NMR spectroscopy follows that vitamin E may have other biochemical effects not yet investigated. It seems also the effect of vitamin E supplementation on conductivity and drip loss needs further investigation.

## Conclusion

Dietary vitamin E (200 mg/kg diet) administered for 60 days to finishing pigs may have beneficial effects on muscle energetic metabolism, electrical conductivity and drip loss values but results could depend on the muscle studied and conditions of the experiment (animal model). In pigs occurrence of mutation in ryanodine receptor and muscle metabolic state should be controlled.

## Acknowledgements

The DNA test was made by Genetic Department of RIAP, Nitra. This study was partly supported by the DAAD (Bonn, Germany) Foundation. Slovakofarma (Hlohovec, Slovakia) provided vitamin E free of charge.

## References

ARNOLD, R.N.; ARP, S.C.; SCHELLER, K.K.; WILLIAMS, S.N.; SHAEFER, D.M.:
Tissue equilibration and subcellular distribution and subcellular distribution of vitamin E relative to myoglobin and lipid oxidation in displayed beef. Meat Science **71** (1993), 105-118

ASGHAR, A.; GRAY, J.I.; BOOREN, A.M.; GOMMA, E.A.; ABOZIED, M.M.; MILLER, E.R.:
Effect of suppranutritional dietary vitamin E levels on subcellular deposition of α-tocopherol in the muscle and on pork quality. Journal of the Science of Food and Agriculture **57** (1991), 31-41

BERLIN, E.; MCCLURE, D.; BANKS, M.A.; PETERS, R.C.:
Heart and liver fatty acid composition and vitamin E content in miniature swine fed diets containing corn and menhaden oils. Comparison Biochemical and Physiological 109A, **1** (1994), 53-61

BUCKLEY, D.J.; MORRISSEY, P.A.; GRAY, J.I.:
Influence of dietary vitamin E on the oxidative stability and quality of pig meat. Journal of Animal Science **73** (1995), 3122-3130

DEN HERTOG-MEISCHKE, M.J.A.; SMULDERS, F.J.M.; HOUBEN, J.H.; EIKELENBOOM, G.:
The effect of dietary vitamin E supplementation on drip loss of bovine longissimus lumborum, psoas major and semitendinosus muscles. Meat Science **45** (1997), 153-160

DUFEY, P-A.:
Schweinefleisch: Einfluss einer zusätzlichen Vitamin-E-Zulage. Agrarforschung **5** (1998), 417-424

DUTHIE, G.G.; MCPHAIL, D.B.; MORRICE, P.C.; ARTHUR, J.R.:
Dietary vitamin E decreases ESR signal intensity in hepatic microsomal preparations from malignant hyperthermia susceptible pigs. Free Radical Research Communications **14** (1991), 133-137

FLETCHER, J.E.; CALVO, P.A.; ROSENBERG, H.:
Phenotypes associated with malignant hyperthermia susceptibility in swine genotyped as homozygous for the ryanodine receptor mutation. British Journal of Anaesthesia **71** (1993), 410-417

FUJII, J.; OTSU, K.; ZORZATO, F.; DE LEON, S.; KHANA, V.K.; WEILER, J.; O'BRIEN, P.J.; MAC LENNAN, D.H.:
Identification of a mutation in the porcine ryanodine receptor that is associated with malignant hyperthermia. Science, Washington **253** (1991), 448-451

HONIKEL, K.O.:
Reference Methods for the Assessment of Physical Characteristics of Meat. Meat Science **49** (1998), 447-457

HONIKEL, K.O.; ROSENBAUER, H.; FISCHER, K.; MÜLLER, W.D.; PRZYTULLA, J.:
Einfluß von Vitamin E und Rapsöl auf Quatitätsmerkmale von Schweinefleisch und daraus hergestellten Produkten **78** (1998), 1205-1207

CHEAH, K.S.; CHEAH, A.M.; LAHUCKY, R.; MOJTO, J.; KOVAC, L.:
Prediction of meat quality in live pigs using stress-susceptible and stress-resistant animals. Meat Science **34** (1993), 179-189

CHEAH, K.S.; CHEAH, A.M.; KRAUSGRILL, D.I.:
Variation in Meat Quality in Live halothane Heterozygotes Identified by Biopsy Samples of M. longissimus dorsi. Meat Science **38** (1995), 293-300

CHEAH, K.S.; CHEAH, A.M.; KRAUSGRILL, D.I.:
Effect of dietary supplementation of vitamin E on pig meat quality. Meat Science, **39** (1995), 255-264

CHEAH, K.S.; CHEAH, A.M.; JUST, A.:
Identification and Characterisation of Pigs Prone to Producing "RSE" (Redish-Pink, Soft and Exudative) Meat in Normal Pigs. Meat Science **48** (1998), 249-255

JENSEN, C.; GUIDERA, J.; SKOVGAARD, I.M.; STAUN, H.; SKIBSTED, L.H.; JENSEN, S.K.; MOLLER, A.J.; BUCKLEY, J.; BERTELSEN, G.:
Effects of dietary α-tocopheryl acetate supplementation on α-tocopherol deposition in porcine m. psoas major and m. longissimus dorsi and on drip loss, color stability of pork meat. Meat Science **45** (1997), 491-500

KOHN, G.; BAULAIN, U.; HENNING, M.; LAHUCKY, R.; LEIBFRITZ, D.; KALLWEIT, E.:
In vivo und post mortem Untersuchungen des Muskelstoffwechsels von Schweinen mit unterschiedlichem MHS-Genotyp mit Hilfe der $^{31}P$-NMR-Spektroskopie. Arch. Tierz., Dummerstorf **41** (1998), 299-310

KÜCHENMEISTER, U.; KUHN, G.; WEGNER, J.; NÜRNBERG, G.; ENDER, K.:
Post mortem changes in $Ca^{2+}$ transporting proteins of sarcoplasmic reticulum in dependence on malignant hyperthermia status in pigs. Molecular and Cellular Biochemistry **195** (1999), 37-46

LAHUCKY, R.; MOJTO, J.; POLTARSKY, J.; MIRI, A.; RENOU, J.P.; TALMANT, A.; MONIN, G.:
The Effect of Handling Pre-Slaughter And Carcass Processing Rate Post-Slaughter On Pork Quality. Meat Science **33** (1993), 373-384

LAHUCKY, R.; CHRISTIAN, L.L.; STADLER, K.J.; KOVAC, L.; BAUEROVA, M.:
Meat Quality Assessed Ante- and Post Mortem by Different Ryanodine Receptor gene Status of Pigs. Meat Science **47** (1997), 277-285

LAHUCKY, R.; DEMO, P.; VASICEK, D.; PRONAYOVA, N.; DUBRAVICKY, J.:
Ante-mortem muscle metabolism assessed by 31P NMR specroscopy and meat quality in heterozygotes and MH normal pigs. In The 44th Proccedings of International Congress of meat Science and Technology, A-16, pp. (1998) 292-293, Barcelona

LAURIDSEN, CH.; NIELSEN, J.H.; HENCKEL, P.; SORENSEN, M.T.:
Antioxidative and Oxidative Status in muscles of Pigs Fed Rapeseed Oil, Vitamin E, and Copper. Journal of Animal Science **77** (1999), 105-115

Arch. Tierz. 43 (2000) 5

MITSUMOTO, M.; OZAWA, S.; MITSUHASIHI, T.; KONO, S.; KOIDE, K.; ARNOLD, R.N.; SCHAEFER, D.M.; CASSENS, R.G.:
Effect of dietary vitamin E supplementation for 30-36 weeks, 4 weeks and 1 week before slaughter on drip loss from fresh beef muscle during display. In The 44th Proccedings of International Congress of meat Science and Technology, B-7, pp. (1998) 492-493, Barcelona.

MOESGAARD, B.; QUISTORFF, B.;GROSFIELD-CHRISTENSEN, V.;JORGENSEN, I.T.; JORGENSEN,P.F.:
Differences of Post-Mortem ATP Turnover in Skeletal muscle of Normal and Heterozygote malignant-Hypertermia Pigs: Comparison of $^{31}$P-NMR and Analytical Biochemical Measurements. Meat Science **39** (1994), 43-47

MONAHAN, F.J.; BACKLEY, D.J.; MORRISSEY, P.A.; LYNCH, P.B.; GRAY, J.I.:
Influence of dietary fat and a-tocopherol supplementation on lipid oxidation in pork. Meat Science **31** (1992), 229-241

MONAHAN, F.J.; ASGHAR, A.; GRAY, J.I.; BACKLEY, D.J.:
Effect of oxidized dietary lipid and vitamin E on the colour stability of pork chops. Meat Science **37** (1994), 205-215

O' SULLIVAN, M.G.; KERRY, J.P.; BUCKLEY, D.J.; LYNCH, P.B.; MORRISSEY, P.A.:
The distribution of Dietary Vitamin E in the Muscles of the Porcine Carcass. Meat Science **45** (1997), 297-305

SHEN, H.; LAHUCKY, R.; KOVAC, L.; OÏBRIEN, J.P.:
Comparison of HAL gene status with $^{31}$P NMR-determined muscle metabolites and with Ca sequestration activity of anoxia-challenged muscle from pigs homozygous and heterozygous for porcine stress syndrome. Pig. News and Inform., **13** (1992), 105N-109N

STANLEY, D.W.:
Biological membrane deterioration and associated quality losses in food tissues. Critical Review of Food Nutrition **30** (1991), 487-495

SIMONIDES, W.S.; VAN HARDEVELD C.:
An assay for sarcoplasmic reticulum $Ca^{2+}$ -ATPase activity in muscle homogenates. Analytical Biochemistry **191** (1990), 321-331

Received: 1999-10-25

Accepted: 2000-07-04

Authors' addresses
Dr. RUDOLF LAHUCKY, PETER KRSKA, Dr. PETER DEMO, IVAN BAHELKA
Research Institute of Animal Production
94992 Nitra
Slovak Republic

Dr. ULRICH KÜCHENMEISTER, Dr. KARIN NÜRNBERG,
Dr. GERHARD NÜRNBERG, Dr. GERDA KUHN, Prof. Dr. habil. KLAUS ENDER
Research Institute for the Biology of Farm Animals
D-18196 Dummerstorf
Germany

Dr. TIBOR LIPTAJ
Slovak Technical University, Chemical College
81237 Bratislava
Slovak Republic

Arch. Tierz., Dummerstorf 43 (2000) 5, 498

## Buchbesprechung

# Ziegen

HELMUT KÜHNEMANN

96 Seiten, 54 Farbfotos, 19 Zeichnungen, zahlreiche Tabellen, Verlag Eugen Ulmer, Stuttgart, 2000,
ISBN 3-8001-7472-3, 24,80 DM

Ziegen gehören nicht nur zu den ältesten Haustieren, sondern sie besitzen heute noch in vielen Ländern, vor allem in Asien und Afrika, eine große Bedeutung für die Ernährung und die Verbesserung von Einkommensverhältnissen der ländlichen Bevölkerung. In Deutschland ist die Anzahl dieser Nutztiere zurückgegangen. Trotzdem vergrößert sich der Kreis von Personen, die diese Tiere aus Freude am Tier oder am ländlichen Leben halten und die darüber hinaus deren Produkte für den Eigenbedarf gerne verarbeiten. Grundlage einer erfolgreichen Ziegenhaltung und -zucht ist ein ausreichendes Basiswissen und die nötige Sachkenntnis. Das vorliegende Buch soll dazu einen Beitrag leisten.

In der Reihe „Ratgeber Nutztiere" herausgebracht, richtet sich dieses Buch sowohl an den Tierhalter mit langjähriger praktischer Erfahrung als auch an Neueinsteiger, die sich für eine Ziegenhaltung entschlossen haben. Es vermittelt eine Fülle von auf ein notwendiges Textmaß begrenzten wissenswerten Aussagen.

Nach einer Einführung, in der allgemeine Voraussetzungen, Eigenschaften und Bedürfnisse der Tiere besprochen werden, gibt es eine Übersicht wichtiger Rassen. Ob die in Bild und Text vorgestellten Rassenporträts, verteilt auf fünf verschiedene Buchstandorte, eine glückliche Lösung darstellen, sei dahingestellt. Dies mindert aber nicht den Aussagewert. Den Hauptteil des Buches bilden die speziellen, sehr praxisrelevanten Informationen, deren Kenntnis eine erfolgreiche Ziegenhaltung sichern soll. Unterbringung, Fütterung bis zu praktischen Futterbeispielen, Nachwuchs, gesund oder krank seien als Hauptüberschriften angeführt. Ein abschließender Teil widmet sich den Produkten, von der Milchgewinnung und –verarbeitung, über Fleisch bis Wolle und Fell. Erwähnt sei das abschließend angeführte Verzeichnis wichtiger Anschriften, das dem potentiellen Ziegenhalter die Kontaktaufnahme zu Verbänden und tangierenden Unternehmen im deutschsprachigen Raum erleichtert.

So wie es die Ratgeberreihe des Ulmer-Verlages verspricht, erfüllt dieser preiswert angebotene Titel die Erwartungen mit einer Fülle von Informationen. Dieses Buch gehört daher ebenso in die Hand des erfahrenen Ziegenhalters wie auch in die des an dieser Tierart interessierten Laien, der sich nicht nur einen Überblick über die Nutzung dieser liebenswerten Tierart verschaffen will. Dank der vom Verlag gewohnt guten Ausstattung des Buches ist es vor allem durch die guten Farbfotos auch einem Leserkreis zu empfehlen, der selbst keine Ziegen hält, aber Freude am Betrachten schöner Tierfotos hat und Informationen über das Leben und die Haltung von Ziegen erwartet.

ERNST RITTER, Dummerstorf