Note

The Interrelationship between Polyunsaturated Fatty Acids, α -Tocopherol and Glutathione Peroxidase in Chicken and Porcine Skeletal MusclesKiyoshi YAMAUCHI, Kentaro YADA,
Tomio OHASHI and Albert M. PEARSON*Department of Animal Science, Faculty of Agriculture,
Miyazaki University, 210, Funatsuka 3-chome,
Miyazaki 880, Japan*Department of Food Science and Human Nutrition,
Michigan State University, East Lansing,
Michigan 48824, U.S.A.

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It has been widely accepted that α -tocopherol is predominately located in membranous structures of the cell and functions as an *in vivo* antioxidant, which prevents the membranous polyunsaturated fatty acid (PUFA) from peroxidizing.¹⁾ On the other hand, glutathione peroxidase is believed to be located in the cytoplasm of the cell and converts hydroperoxides to hydroxy acids, thus inhibiting the chain reaction involved in lipid peroxidation.²⁾ It has been reported by Chow *et al.*³⁾ that glutathione peroxidase activity is negatively correlated with the α -tocopherol content of rat skeletal muscle. This suggests that a compensational effect may exist between α -tocopherol and glutathione peroxidase *in vivo*. Our previous work showed that the level of α -tocopherol in meat tends to be higher in red than in white muscle.^{4~6)} Similar trends have also been found in mitochondrial preparations from both chicken and porcine skeletal muscle.^{7,8)} Similarly, the glutathione peroxidase activity of bovine skeletal muscle has been reported by DeVore and Greene⁹⁾ to be higher than those reported for chicken muscle by Lin and Hultin¹⁰⁾ and by DeVore *et al.*¹¹⁾ who found chicken leg (red) muscle to have more activity than chicken breast (white) muscle. However, the relationship between α -tocopherol and glutathione peroxidase remains to be determined in meat. Thus, the aim of the present study was to investigate the relationship between PUFA, PUFA > 18:2 (PUFA with three or more double bonds), α -tocopherol and glutathione peroxidase in skeletal muscle, using the red and white muscles from both fowl and swine.

The white and red muscles used were *M. pectoralis profundus* (breast) and thigh muscle (including the leg muscle) from fowl and *M. longissimus thoracis* and *M. biceps femoris* from swine, respectively. These muscles

were obtained at a local packing plant. No attempt was made to select animals on the basis of breed or ante-mortem environmental conditions. The chicken muscles were removed from the carcasses a few hours postmortem and the porcine muscles were excised approximately 24 hr after slaughter. Lipid analyses and α -tocopherol determination were performed according to our previous procedures.⁵⁾ The glutathione peroxidase activity was estimated using the supernatant fraction ($105000 \times g$, 60 min) obtained from the muscle according to the procedure of Lin and Hultin,⁹⁾ with a reaction temperature at 25°C. The protein content of the supernatant fraction used for estimating the glutathione peroxidase activity was determined by the biuret method of Gornall *et al.*¹²⁾

The contents of α -tocopherol, PUFA and PUFA > 18:2 tended to be higher in the red muscles (chicken thigh muscle and porcine *biceps femoris* muscle) than in the white muscles (chicken *pectoralis profundus* muscle and porcine *longissimus thoracis* muscle) of both fowl and swine. These findings were consistent with our previous experience working with chicken and porcine skeletal muscles.^{5,6)} Table I presents the concentrations of α -tocopherol per gram of PUFA or PUFA > 18:2 as well as the glutathione peroxidase activity in both chicken and porcine muscle. The concentrations of α -tocopherol and the glutathione peroxidase activity for the chicken muscles did not differ significantly from each other. Similar results were found for the porcine muscles. On the other hand, the concentrations of α -tocopherol per gram of PUFA or PUFA > 18:2 in mitochondria from porcine red and white muscles differed significantly from each other although the corresponding concentrations of α -tocopherol in mitochondria from chicken red and white muscles were not significantly different from each other as reported by our previous study.⁸⁾ This discrepancy for the porcine muscle mitochondria and whole muscles might be due to the difference of the samples used, but this remains to be elucidated. The glutathione peroxidase activity of the chicken muscles seemed to be higher in comparison to that of the porcine muscles. In both chickens and pigs, the glutathione peroxidase activity of the red muscles tended to be higher than that of the white muscles. Although the concentrations of α -tocopherol in the present study were consistent with those for chicken and porcine muscles as reported in our previous studies,^{5,6)} the glutathione peroxidase activity was lower than that obtained by DeVore *et al.*¹¹⁾ for chicken muscle (1.9 to 9.7) and by DeVore and Greene⁹⁾ working with bovine muscle (5.5 to 24). DeVore *et al.*¹¹⁾ have shown that the glutathione peroxidase activity in chicken muscle is positively correlated with the dietary Se content. DeVore and Greene⁹⁾ have also observed a significant positive relationship between Se content and glutathione peroxidase activity in bovine muscle. DeVore *et al.*¹¹⁾ reported that glutathione peroxidase activity of muscle from chicken fed with a low Se basal diet (0.09 ppm Se) was lower in breast than in leg muscle, although the two muscles did not differ significantly.

TABLE I. α -TOCOPHEROL (α -Toc) CONTENT, QUANTITATIVE RELATIONSHIPS OF α -Toc TO POLYUNSATURATED FATTY ACIDS (PUFA) OR PUFA > 18:2 (PUFA WITH THREE OR MORE DOUBLE BONDS) AND GLUTATHIONE PEROXIDASE (GSH-Px) ACTIVITY IN SKELETAL MUSCLES^{a,b}

Muscle	α -Toc content per 100 g of muscle (μ g)	α -Toc concentrations per gram of PUFA or PUFA > 18:2 (μ mol)		GSH-Px Activity ^c
		α -Toc/PUFA	α -Toc/PUFA > 18:2	
Chicken muscle				
<i>M. pectoralis</i>	150 $\pm$ 32	1.69 $\pm$ 0.32 (1.77 $\pm$ 0.47)	3.01 $\pm$ 0.51 (2.95 $\pm$ 0.65)	0.94 $\pm$ 0.38
<i>profundus</i>				
Thigh muscle	254 $\pm$ 51*	1.43 $\pm$ 0.42 (2.12 $\pm$ 0.45)	3.81 $\pm$ 0.98 (3.54 $\pm$ 0.74)	0.56 $\pm$ 0.24
Porcine muscle				
<i>M. longissimus</i>	100 $\pm$ 50	0.76 $\pm$ 0.19 (1.00 $\pm$ 0.33)	3.00 $\pm$ 0.73 (3.40 $\pm$ 1.34)	0.41 $\pm$ 0.06
<i>thoracis</i>				
<i>M. biceps</i>	137 $\pm$ 57	0.95 $\pm$ 0.42 (1.35 $\pm$ 0.59)	3.32 $\pm$ 1.47 (3.73 $\pm$ 1.84)	0.33 $\pm$ 0.20
<i>femoris</i>				

^a Means and standard deviations of five samples.

^b Numbers in parentheses show μ mol of α -Toc/g PUFA or PUFA > 18:2 of polar lipids.

^c nmol NADPH oxidized/min/mg of protein.

* Significant difference between the muscles of the same animal at $p < 0.05$.

However, the glutathione peroxidase activity for leg muscle from chicken fed a Se-supplemented diet (0.31 ppm Se) was significantly higher than that of breast muscle. In the present study, however, the glutathione peroxidase activity was higher in thigh muscle (including the leg muscle) than in the *pectoralis profundus* (breast) muscle, although the two muscles did not differ significantly from each other. This discrepancy might be associated with levels of muscle Se in the present study. In addition, DeVore and Greene⁹⁾ and DeVore *et al.*¹¹⁾ have suggested that glutathione peroxidase may serve to protect refrigerated ground beef and chicken from lipid oxidation.

The results obtained in the present study show that the glutathione peroxidase activity in red muscles such as chicken thigh muscle and porcine *biceps femoris* muscle, which contain relatively high levels of α -tocopherol (μ g/100 g muscle and μ mol/g PUFA or PUFA > 18:2), tend to be lower than that in white muscles such as chicken *pectoralis profundus* and porcine *longissimus thoracis*. These results seem to be consistent with those of Chow *et al.*³⁾ for rat skeletal muscle, which suggest that a negative relationship may exist between the contents of α -tocopherol and glutathione peroxidase. Thus, the present study suggests that a compensational relationship may exist between α -tocopherol levels and glutathione peroxidase activity in both the chicken and porcine skeletal muscles. The relationships between the Se content, glutathione peroxidase activity, α -tocopherol levels and lipid oxidation in meat need to be investigated further.

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