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THE SIGNIFICANCE OF A MUSCLE GLYCOGEN REDUCING DIET ON PORCINE MEAT AND FAT COLOR

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Introduction

Meat and fat color are important factors for the appearance of meat. Meat color depends beside the concentration of the muscle pigment on the structure of the meat and the redox-state of the main muscle pigment, myoglobin. Both the structure and the present myoglobin species in fresh meat are dependent on the history of *post mortem* pH and temperature, which directly affect the degree of protein denaturaton including metmyoglobin reductase activity (metMbRA) and the oxygen consumption capacity of the meat, and hereby the degree of oxygenation of deoxymyoglobin (Mb) to the cherry-red oxymyoglobin (MbO_2) and the depth of the MbO_2 layer in meat and i.e. degree of blooming. Moreover, the history of *post mortem* pH and temperature during the conversion of muscle to meat continuously affects the activity of metMbRA and oxygen consumption capacity of the meat during aging why the blooming potential of meat during aging has been reported to change, being optimal 3-4 days post slaughter (Ledward, 1992).

Recently, it was reported that a muscle glycogen reducing diet could change the history of *post mortem* pH and temperature in pork resulting in a superior technological quality of the meat, i.e. improved water-holding capacity (Rosenvold et al., 2001). The diet found to have the most optimal effect on the history of *post mortem* pH and temperature was reported to contain a high amount of rapeseed and grass meal. However, other studies have reported that a high content of grass meal in the diet can have inferior influence on fat color, especially, in ruminants (Daly et al., 1999; Priolo et al., 2002). Consequently, the influence of a muscle glycogen reducing diet with a high content of rapeseed and grass meal on fat and meat color has to be elucidated before such a strategy can be recommended as a quality control tool in the production of pork of high quality.

Objectives

The objective of the present study was to elucidate the significance of a muscle glycogen reducing diet containing a high ratio of rapeseed and grass meal on fat color, and the blooming potential of the pork during 1, 2, 4, 8 and 15 days of aging compared to a standard diet.

Methodology

40 pigs (Danish Landrace x Danish Yorkshire sows and Duroc Boars) originating from 20 litters with one female and one castrate in each litter were included in the study. 20 pigs were given a standard grower-finishing diet (control diet) which consisted mainly of barley (55%), soybean meal (20%), wheat (20%), and sugar beet molasses (1%), and 20 pigs were given a diet with a low content of digestible starch (experimental diet) which consisted of high levels of grass meal (24%), rape seed cake (36%), dried sugar beet pulp (25%), soybean meal (7%), animal and vegetable fat (6%) resulting in a 2 (diet) x 2 (sex) experimental design. The experimental diet was offered to the experimental group at a live weight of approximately 65 kg with an initially 1-week habituation period gradually changing from the standard grower-finishing diet into the experimental diet, as described by Rosenvold et al. (2001). All pigs were slaughtered at approximately 90 kg live weight with an initial fasting period of 48 hours for experimental pigs where the animals had free access to water.

On the day of slaughter, the pigs were transported from rearing house to slaughterhouse (200m). The pigs were stunned by 85% CO_2 for three min, exsanguinated, scalded at 62 °C for three min, cleaned and eviscerated within 30 min. pH ($pH_{45\ min}$) and temperature ($T_{45\ min}$) were measured 45 min *post-mortem* in M. *longissimus dorsi* (LD) at the last rib and M. *semimembranosus* (SM). After measurement the carcasses were placed in a chill room at 4 °C.

The day after slaughter the pH ($pH_{24\ h}$) and temperature ($T_{24\ h}$) were measured together with the color of back fat and stripped bacon fat. Moreover, LD (12 cm of the loin 19-31 cm from the last rib) and SM were removed from the carcass. 2 cm thick samples from the loins and SM's were cut and bloomed for 1 h at 4 °C prior to color measurement (1 day *post mortem*). The remaining loins and SM's were vacuum-packed and stored at 4 °C for 2, 4, 8 and 15 days *post mortem* where an identical procedure was applied prior to color measurements. Five color measurements across the individual sample surfaces were carried out and mean values were used for statistical analysis. Color was measured using a Minolta Chroma Meter CR-300 (Osaka, Japan) calibrated against a white tile (L*=93.30, a*=0.32 and b*=0.33).

The Mixed procedure in SAS was applied when calculating least squares means (LSM) and standard errors (SE). The statistical model for fat color parameters included diet, sex and fat as fixed effects, litter, slaughter date and animal nested within sex, diet and slaughter date as random effects. The model analyzing LD and SM color included fixed effects of diet, sex and aging, random effects of litter and slaughter date. Two-way interactions were included when significant. The model for temperature and pH included fixed effects of diet and sex and as random effects litter and slaughter date.

Results & Discussion

Figure 1 shows temperature and pH measured 45 min and 24 h *post mortem* in LD and SM and confirms the previous result of using a muscle glycogen reducing diet on the history of *post mortem* pH and temperature (Rosenvold et al., 2001). Moreover, the muscle glycogen reducing diet resulted in a slightly higher ultimate pH.

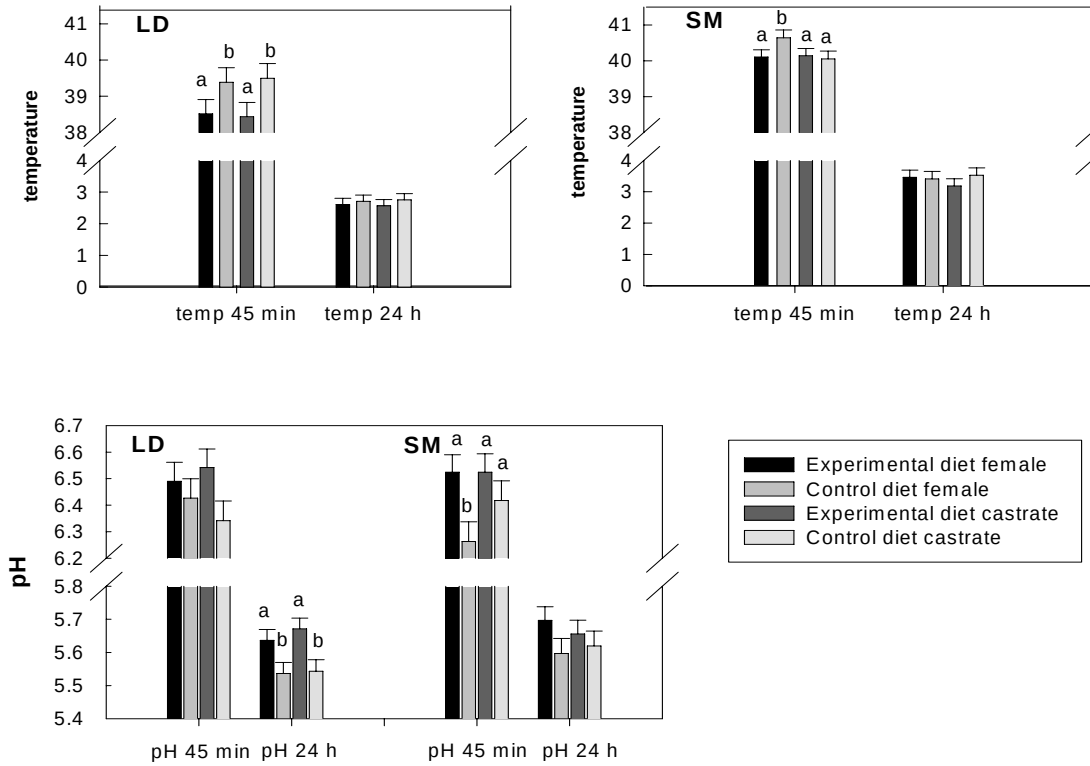

Figure 1. Temperature and pH measured 45 min and 24 h *post mortem* in LD and SM from pigs fed with strategic finishing feeding (experimental diet) and pigs fed with control feeding, least squares means (LSM) and standard errors (SE) are shown. LSM with different letters (a-b) indicate significant differences between groups, P<0.05.

Figure 2 shows that the experimental diet only had minor effect on fat color, and if any, the experimental diet tended to a higher L*-value while the gender effect was more pronounced, however, without practical importance.

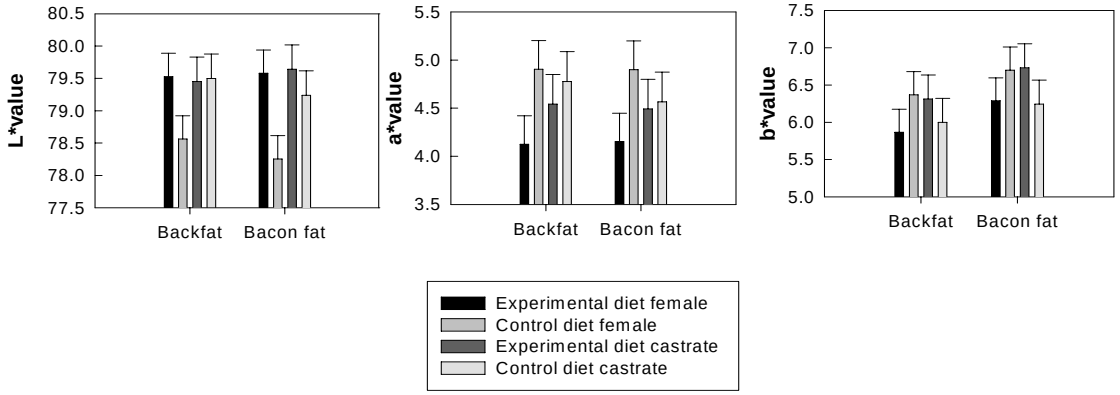

Figure 2. L*-, a*- and b*-values measured in back fat and bacon fat from pigs fed with strategic finishing feeding (experimental diet) and pigs fed with control feeding, least squares means (LSM) and standard errors (SE) are shown.

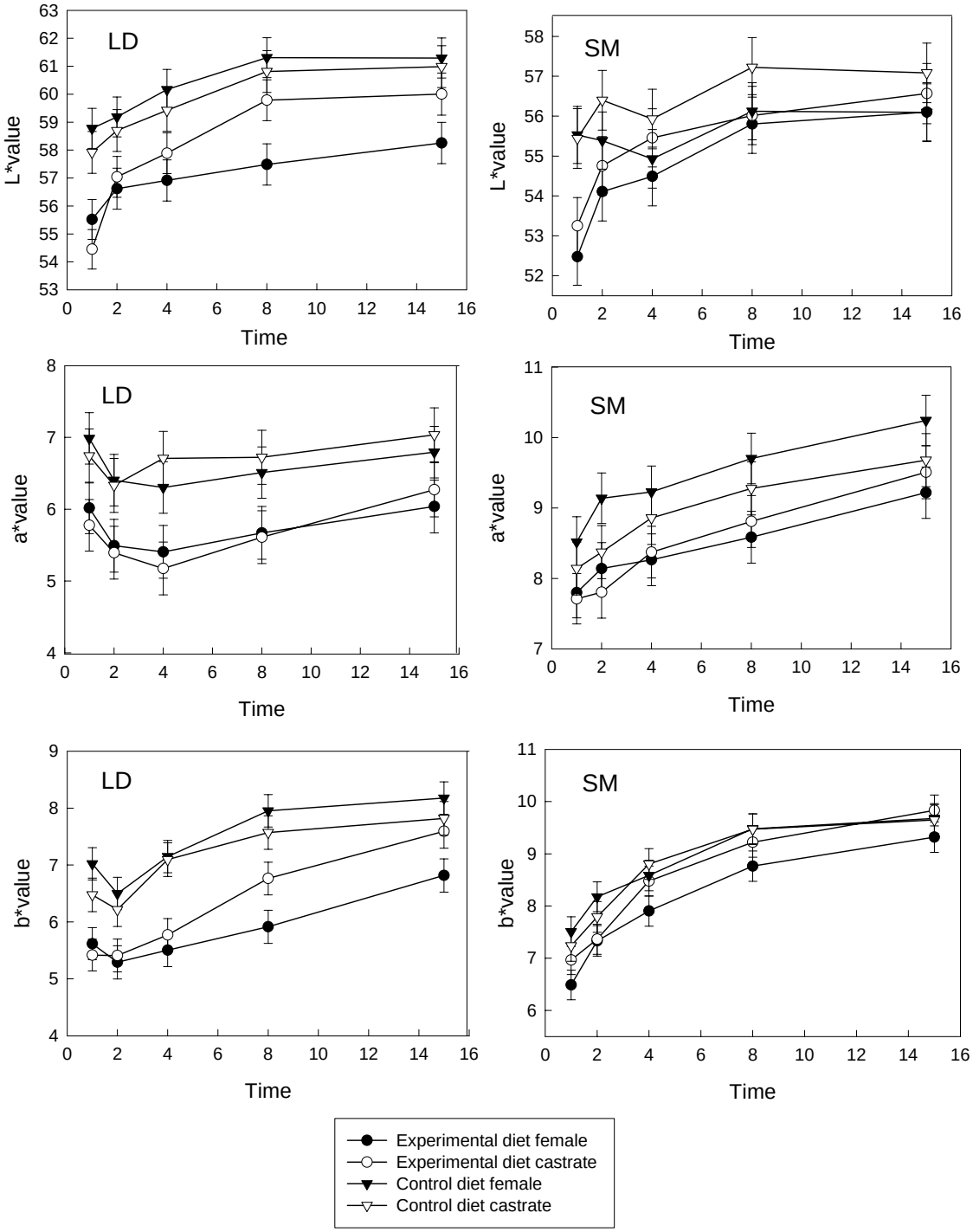

Figure 3. L*-, a*- and b*-values measured in M. *longissimus dorsi* (LD) and M. *semimembranosus* from pigs fed with strategic finishing feeding (experimental diet) and pigs fed with control feeding after vacuum-packed storage for 1, 2, 4, 8 and 15 days *post mortem*, least squares means (LSM) and standard errors (SE) are shown.

Figure 3 shows the color (L*-, a*- and b*-value) of bloomed cuts of LD and SM as a function of aging time. Due to difference in muscle fiber distribution between the two muscles, with SM being more oxidative than LD, an expected significant difference

(p_{muscle}<0.0001) in L*-, a*- and b*-value between the two muscles was found independent of aging time. Independent of muscle, the color of bloomed pork pigs fed with control diet had higher L*-, a*- and b*-value compared to pork from the experimental diet with the effect being most pronounced in LD (see also Table 1). This diet effect was independent of aging in vacuum of the pork for up to 8 days, however, after 15 days of aging in vacuum the differences in L*-, a*- and b*-value in bloomed pork was found to begin to get closer to each other independent of the diet given to the living pigs. Considering that the experimental diet resulted in higher $pH_{45\ min}$ and $pH_{24\ h}$ in the muscles, lower $T_{45\ min}$ in LD, and that the effect was found to be most pronounced in LD (Table 1) compared to the standard diet, the effect of the experimental diet on pork color can be explained by a higher enzyme activity including metMbRA and higher oxygen consuming activity within the meat together with reduced protein denaturation which together are known to result in the found color characteristics (Lindahl et al., 2005; van der Wal et al., 1988).

Table 1. The significance (P-value) of diet (D), aging time (A) and sex (S) on the color parameters of bloomed cuts from LD and SM

Muscle	Color	D	A	S	D x A	D x S	A x S
LD	L*-value	**0.0022**	**<.0001**	0.5566	0.4619	**0.0079**	0.2102
	a*-value	**0.0369**	**0.0013**	0.3066	0.8322	0.5702	0.5515
	b*-value	**0.0016**	**<.0001**	0.3679	0.1595	**<.0001**	0.1952
SM	L*-value	0.085	**<.0001**	**0.0034**	**0.0072**	0.5773	0.9148
	a*-value	0.0976	**<.0001**	0.2040	0.9228	**0.0005**	0.5515
	b*-value	0.0828	**<.0001**	**0.0356**	0.1665	**0.0005**	0.2512

Moreover, Table 1 and Figure 3 show the influence of aging time and gender on the color characteristics of bloomed cuts from LD and SM. In SM the degree of blooming, which is proportional to a simultaneous increase in L*-, a*- and b*-value, was found to be most pronounced preceding 8 days of aging in vacuum, while additional aging in vacuum for seven days did not seem to have any drastic effect on the degree of blooming, even though the degree of redness (a*-value) still was found to increase. In contrast, the degree of blooming in LD after a preceding period of aging in vacuum was found to be more complex, as an initial decrease in a*- and b*-value was found to take place within the first two to four days of aging, after which the degree of blooming again became more pronounced being optimal after eight days of aging in vacuum. An additional seven days of aging in vacuum did not seem to improve the degree of blooming in cuts from LD. This difference between the two muscles with respect to blooming potential as a function of a proceeding aging period in vacuum may be explained by differences in heat stability of the enzyme systems known to influence the color of meat (Ledward, 1992). LD is a more superficial muscle compared to SM, and consequently the degree of enzyme activation in SM must be expected to be more pronounced, as the temperature in this muscle will be higher during its conversion of muscle to meat compared to LD, as also seen in Figure 1. The present findings could be explained by the fact that metMb reducing enzymes are more sensitive to the combination of high temperature and the progressing pH decrease *post mortem* in muscles than the inherent oxygen consuming enzymes. A complete inactivation of the metMb reducing enzyme system would render

the picture found in SM where a gradual inactivation of oxygen consuming enzymes during aging in vacuum would result in an increasing depth of the surface MbO_2 layer upon exposure to oxygen and hereby in the progressing blooming potential. In contrast, in LD where both enzyme systems are active on the proposed hypothesis, the activity of these systems will interact. This somehow influences the depth of the surface MbO_2 layer upon exposure to oxygen and might cause the development in blooming potential seen in LD. However, further studies have to be carried out to understand this initial decrease in blooming potential of pork chops from LD exposed to aging in vacuum.

Only minor gender effects on the color characteristics were observed, with the L*- and b*-value being lower in bloomed SM from female pigs (Table 1). However, an interaction between diet and gender was found on the color characteristics indicating that female pigs responded more pronounced to the experimental diet which however, cannot directly be confirmed by observed influence of diet on the history of *post mortem* pH and temperature and the expected effect of these on pork color.

Conclusions

The results of the present study showed that a muscle glycogen reducing diet containing a high ratio of rapeseed and grass meal only had negligible influence on the color of bacon fat and back fat compared to a standard diet. In contrast, the used muscle glycogen reducing diet containing a high ratio of rapeseed and grass meal significantly reduced the blooming potential of the meat and hereby the color of fresh cut pork from LD and SM. Moreover, this difference in fresh meat color was independent of aging in vacuum for up to 15 days. Consequently, further studies need to be carried out, especially the influence on color stability of a muscle glycogen reducing diet, before final recommendations for use of such a potential quality control tool should be given.

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