Feed-induced muscle-glycogen changes in slaughter pigs and their influence on meat quality

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Background

Despite elimination of the halothane gene from the Danish breeding stock of slaughter pigs, excessive drip loss and light colour are still problems in the production of pig meat. Todays problems with excessive drip loss and light colour are believed to be a consequence of relatively low ultimate pH in the meat. Low ultimate pH depends on the initial glycogen level in the muscle at the time of slaughter and the level of stress induced on the animals during transportation and pre-slaughter procedures.

The composition of the feed with respect to carbohydrates, fat and protein can affect the glycogen level in the muscles as recently shown in model studies on rats (Lapachet et al., 1996). Consequently, a strategic regulation of the feed composition should also be possible in pigs in order to regulate the muscle glycogen level at the time of slaughter, and hereby control the ultimate pH in the meat, as supported by data on rabbit muscles (Gierus & Rocha, 1997). A strategic feeding regime, retaining the standard diet known to give superior performance trait, and a change in diet in the immediate time before slaughter, which regulates the muscle glycogen concentration at the time of slaughter down, might be an economic feasible and relatively easy way to increase ultimate pH and hereby improve colour in the Danish pig.

Objectives

The aim of the present study was to investigate the possibility of reducing the muscle glycogen level in porcine *M. longissimus dorsi* through strategic feeding programmes and examine the subsequent impact on meat quality.

Materials and Methods

Animals and treatment. Female slaughter pigs (n = 29) of crossbreed between Danish Landrace and Yorksire free of the halothane gene were used. All pigs were reared at the experimental farm at Foulum. At a live weight of approx. 70 kg the pigs were placed in single pens and given a standard diet until a weight of approx. 80 kg. From this point of time (called day 1) to day 7 a diet habituation period was initiated where 10% test diet was given. The composition of the test and control diet is presented in Table 1. From day 8, 100% test diet was given. On day 1, 8, 10, 12 and 22 biopsies were taken from the *M. longissimus dorsi* using an automatic biopsy pistol from Biotech, Slovakia. The animals were slaughtered at day 22 at a live weight of 100 kg, after the final biopsi was taken.

Slaughter. The pigs were transported from the stable to the experimental plant (< 200 m), where the animals were kept for lairage for at least one hour before stunning (80% CO_2 for 3 minutes). Subsequently the pigs were exsanguinated, scalded at 62°C for 3 minutes, cleaned and eviscerated within 30 minutes. After 45 minutes the carcasses were placed at 4°C in a chilling room.

pH measurements. In the *M. longissimus dorsi* (at the last rib) duplicate pH measurements were performed with a pH-meter (Metrohm Model 704, Switzerland) equipped with an insertion glass electrode (Hamilton Tiptrode P/N: 238'080, Switzerland) 24 hours *post mortem*.

Meat colour. Surface colour was measured on pork chops (taken at the last rip at 24 hours *post mortem*) after blooming for 1 hour at 14°C using Minolta tristimulus colorimeter. Five replicate measures were performed on each chop. A white tile (L = 92.30, a = 0.3160 and b = 0.3323) was used as standard.

Muscle glycogen. Muscle glycogen in the biopsies was determined spectrophotometrically (Alcyon 300ISE) using the principles from Passonneau and Lowry (1993).

Statistical methods. The data were analysed by the method of least squares means using the GLM procedure from SAS, version 6.12. The statistical model included the fixed effect of diet.

Results and Discussion

Table 2 shows the registered glycogen concentrations and total change in muscle glycogen concentration during the 22 days trial period as a result of the different diets. A decrease in muscle glycogen concentration was found for all test diets compared to the control. As shown in Figure 1, the decrease in muscle glycogen concentration at the 22nd day was closely correlated to the amount of digestible starch in the diets. The relatively big changes in muscle glycogen concentration as a result of diets Nos. 2 and 6, despite their content of starch, can be explained by the starch source, as both diets have a high content of raw potato starch (16.5 and 27.9 %, respectively). Raw potato starch is known to be poorly digested in pigs (Wünsche et al., 1987). The observed muscle glycogen difference between diets Nos. 1 and 5 containing equal amount of starch can be explained by the relatively high protein content in diet No. 1, as protein can maintain the muscle glycogen level in the muscle through the gluconeogenic pathway.

Table 3 shows the meat quality parameters ultimate pH and colour, measured as L*-, a*- and b*-values, 24 hours after slaughter for pigs given the different diets. Data show no connection between muscle glycogen concentration at the time of slaughter and ultimate pH. However, meat from pigs fed on control diet was found to have the lowest pH, which corresponds to the highest muscle glycogen concentration at the time of slaughter. Moreover, all test diets resulted in lower L*-values in the meat compared to meat from pigs fed on the control diet.

Despite the relatively few animals in this study the results seem rather convincing and further studies are in progress.

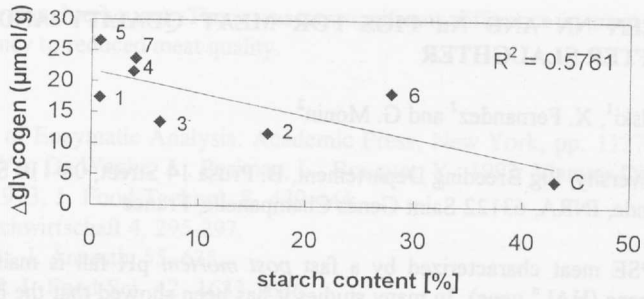

Figure 1 Least squares means of change in muscle glycogen as a function of the starch content in the diets. $\Delta glycogen = glycogen_{day1} - glycogen_{day22}$. Numbers indicate the different diets outlined in Table 1 and C equals the control diet.

Conclusion

Using the outlined strategic feeding procedure, it was possible to reduce muscle glycogen concentrations at the time of slaughter. This reduction was found to correspond to decreasing digestible starch content in the diets. Moreover, this reduction resulted in darker meat superior to the control, and a tendency towards higher pH.

References

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Table 1 Composition of control and test diets with respect to energy, starch, protein and fat content. The diets fulfil all the requirements with respect to nutritional value.

Diets	Control	1	2	3	4	5	6	7
Energy [MJ/kg]	18.7	21.6	20.5	19.2	21.5	20.8	21.4	22.1
Starch [%]	43.0	0.8	16.5	6.4	3.9	0.8	27.9	4.1
Protein [%]	19.7	31.0	22.6	24.4	25.0	23.0	22.6	21.5
Fat [%]	2.5	15.5	12.8	4.8	15.2	13.6	14.1	18.5

Table 2 Least squares means and standard error of the muscle glycogen level [μmol/g] through the trial period (22 days), where 10% test diet was given during the first 7 days and 100% test diet was administered the rest of the period. The change in muscle glycogen level (Δ) is calculated as the least square means of $((\text{muscle glycogen level})_{day1} - (\text{muscle glycogen level})_{day22})$. $^{+}$ indicate a statistical significant difference ($p < 0.10$) between the relevant test diet and the control diet.

Diets	Control (n = 4)	1 (n = 3)	2 (n = 3)	3 (n = 4)	4 (n = 4)	5 (n = 3)	6 (n = 4)	7 (n = 4)	SE
Day 1	92.9	89.8	92.3	98.4	90.0	104.1	93.8	86.8	6.2
Day 8	98.7	87.7	89.3	91.9	82.9	93.0	87.7	83.2	5.6
Day 10	95.4	77.4	83.1	84.3	79.9	90.5	84.8	78.6	4.5
Day 12	97.2	78.7	89.4	81.3	77.1	88.3	79.8	73.4	5.3
Day 22	91.0	72.4	80.6	85.0	68.4	77.5	75.6	63.1	4.5
Δ	4.1	17.4	11.7	13.5	21.6	26.6^{+}	18.2	23.7^{+}	7.5

Table 3 Least squares means and standard error of pH and colour measured in *Longissimus dorsi* 24 hours *post mortem*. $^{+}$ and * indicate a statistical significant difference ($p < 0.10$ and $p < 0.05$, respectively) between the relevant test diet and the control diet.

Diets	Control	1	2	3	4	5	6	7	SE
pH	5.51	5.59	5.66^{+}	5.65^{+}	5.63	5.51	5.60	5.52	0.06
L*	54.55	52.30^{*}	50.79	52.83	52.16	51.53^{+}	52.17	50.70^{*}	1.15
a*	6.58	6.08	5.96	5.45	6.14	6.71	5.88	4.85^{+}	0.64
b*	5.77	5.21	4.94	5.13	5.37	5.66	4.83	3.86^{*}	0.49