Variations in Pig Muscle *Longissimus dorsi* glycolytic potential during transport and lairage- *In Vivo* Studies

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SUMMARY

The variations in pig muscle *Longissimus dorsi* (LD) glycolytic potential (GP, very close to glycogen content) were studied during i) a short transport of 2 h and ii) a 2 or 24 h lairage, using (Landrace x Yorkshire) x Hampshire crossbred pigs. For both trials variations in GP were assessed *in vivo* by repetitive biopsy samplings on the same animal. Meat quality traits, *i.e.* pH_1, pH_u and FOP (24 h *post mortem*) were also measured on m. LD.

Experiment 1. Four groups of 9 pigs were transported unmixed for 2 h. GP did not vary significantly during transport (-2.2%). It was concluded that a short transport during which unfamiliar animals were not mixed, did not induce any apparent stressful conditions, as shown by the stability of muscle glycogen store *in vivo* and by the lack of deviation in meat quality traits *post mortem*.

Experiment 2. Six groups of five animals underwent one of the following treatments: 2 h lairage mixed or unmixed, 24 h lairage mixed or unmixed with access to water only, 24 h lairage mixed or unmixed with access to a sugar solution. A significant glycogen depletion occurred during lairage (ranging from -12 to -16 %) except when pigs were fed liquid sugar, but the extent of this depletion was irrespective of lairage duration or mixing. Despite the depletion induced by lairage, GP values remained high and pH_u values low. This was due to the high muscle glycogen content characterizing Hampshire pigs, thus indicating that interaction between breed and handling may be important with regard to meat ultimate pH.

INTRODUCTION

The level of muscle glycogen at slaughter is an important parameter for meat quality since it determines to a large extent the ultimate pH of meat (BENDALL, 1973). Pre-slaughter stress experienced by the animals along the various handling procedures is the main factor that affect muscle glycogen store at slaughter (see review by FERNANDEZ and TORNBERG, in press). Numerous studies dealing with the effect of transport, lairage duration or mixing on muscle glycogen and/or meat ultimate pH have been published so far. However, muscle glycogen levels were always determined on *post mortem* samples so that interactions between the different handling procedures may lead to difficulties in the interpretation of results. Therefore in the present work, we studied glycogen variations during transport and lairage by means of repetitive measurements performed on the same animal, using biopsy sampling.

Variations in glycolytic potential (GP, very close to glycogen content) were studied during a short transport of 2 h (experiment 1) and during a 2 or 24 h lairage, with or without mixing unfamiliar animals (experiment 2). The effect of feeding liquid sugar during long lairage was also assessed.

MATERIAL AND METHODS

The pigs used were Swedish "Scan-H" crossbred gilts, *i.e.* (Landrace x Yorkshire) x Hampshire, slaughtered at approximately 100 kg live-weight.

Experiment 1: 36 pigs coming from 4 different rearing pens were transported unmixed for 2 h prior to slaughter. Samples of m. *Longissimus dorsi* (LD) were taken immediately before and after transport using the biopsy device and the procedure described by TALMANT *et al.* (1989). Pigs were slaughtered immediately after the second sampling, using carbon dioxide anesthesia.

Experiment 2: In 7 pens, each containing 9 pigs, 5 animals were chosen on the basis of apparent live-weight. They were transported in

7 unmixed groups of five pigs for a period of 45 min. After a careful unloading, the 7 groups were penned separately and m. LD biopsies taken. 4 groups of mixed pigs were constituted by exchanging 2 pigs , randomly chosen, between two pens. 6 groups were randomly assigned to one of the following treatment: 2 h lairage mixed or unmixed, 24 h lairage mixed or unmixed with acces to water only, 24 h lairage mixed or unmixed with access to a sugar solution (0.5 kg sucrose / 1 water).

After treatment, m. LD biopsies were taken and the pigs were immediately slaughtered. The glycolytic potential (GP), *i.e.* the potential of lactate production at time of sampling, was determined in the biopsies by means of enzymatic methods, and calculated according to the formula proposed by MONIN and SELLIER (1985):

GP= 2([glycogen]+[glucose]+[glucose-6-P])+[lactate], expressed as μmol lactate / g fresh tissue.

pH in m. LD was measured 45 min (pH_1) and 24 h (pH_u) *post mortem*, at the level of the last rib, using a portable pH-meter. Internal light scattering was measured 24 h *post mortem* using a FOP instrument. The significance of the variation in meat quality traits were tested using Student's *t* test for mean comparison (experiment 1) or two-way variance analysis (experiment 2). For both experiments, the variations in GP were tested using one- or two-way covariance analysis on GP_2 (measured after treatment) with GP_1 (measured before treatment) as covariate.

RESULTS AND DISCUSSION

Effect of transport *(experiment 1)*: Variations in GP during transport were of low magnitude and not significant (table 1). In overall, no more than a variation of -2.2 % in GP was recorded during transport. Subsequently, pH_u values were low (ranging from 5.38 to 5.43; table 2). These results agree with previous findings. WARRIS *et al.* (1983) did not report any difference in m. *Semimembranosus* glycogen content determined in *post mortem* samples, between pigs transported 6 or 1 h and non-transported pigs. The stability of muscle glycogen store *in vivo*, as well as the lack of deviation in meat quality traits *post mortem* indicate that a relatively short transport during which unfamiliar animals were kept unmixed, did not induce any apparent stressful conditions. The crossbred pigs used in this experiment may be considered free from the halothane-sensitivity gene (PETERSSON, person. communication). This is probably of relevance as well since a short transport has been shown to have little effect on meat quality of stress-resistant breed (SCHWORER *et al.*, 1981).

Effect of lairage *(experiment 2)*: pH_1, pH_u and FOP values were irrespective of lairage duration, mixing or sugar feeding (table 3). Glycolytic potential was significantly lowered during lairage (ranging from -12 to -16%, $P<0,05$, figure 1) except when pigs were fed liquid sugar, but the extent of this depletion was not affected by lairage duration or mixing (table 3). The latter result is contradictory to most previous studies on this subject. Since the early results of BENDALL *et al.* (1966) showing that extending lairage time at the abattoir from 0.5 to 1.5 h resulted in increasing m. LD pH_u, numerous studies have confirmed this effect, especially when long lairage time without food (from 16 to 24 h) were compared to shorter ones (from 1 to 2 h) (see review by FERNANDEZ and TORNBERG, in press). Despite the significant depletion in GP recorded, pH_u values remained low (5.39 - 5.46). This must be related to the high GP_2 values (from 194 to 247 μmol/g in pigs having access to water only) characterizing the Hampshire crossbred pigs used in this experiment. Hampshires and Hampshire crossbred pigs generally exhibit higher muscle glycogen content than other breeds (see review by MONIN, 1989). These results indicate that interaction between breed and handling may be important with regard to meat pH_u. These findings also point out the limit in considering variations in pH_u alone as an indicator of the amount of stress and/or muscular fatigue experienced by the animals during the pre-slaughter period.

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TABLE 1

VARIATION IN M. *LONGISSIMUS DORSI* GLYCOLYTIC POTENTIAL (GP) DURING A 2 h TRANSPORT

	group 1	group 2	group 3	group 4	overall
GP_1 (1)	275 ± 72 [a]	283 ± 42 [a]	240 ± 69 [a]	261 ± 54 [a]	272 ± 52 [a]
GP_2 (1)	258 ± 61 [a]	263 ± 46 [a]	270 ± 53 [a]	260 ± 55 [a]	262 ± 49 [a]
Variation (%) (2)	- 5.2 ± 10	- 7.1 ± 10	1.6 ± 15	- 0.2 ± 15	- 2.2 ± 9

(1), GP= 2 ([glycogen]+[glucose]+[glucose-6-P])+[lactate], expressed as μmol lactate equivalent / g.
GP_1 and GP_2 represent values of GP determined on samples taken immediately before and after transport, respectively.

(2), mean values of individual variations in GP during transport.

[a], within one column, values with same superscripts were not significantly different.

TABLE 2

VALUES OF pH AND FOP MEASURED IN M. *LONGISSIMUS DORSI* 45 min (pH_1) and 24 h (pH_u, FOP) *POST MORTEM*.

	pH_1	pH_u	FOP
group 1 (1)	6.24 ± 0.3 [a]	5.38 ± 0.13 [a]	31 ± 8.2 [a]
group 2	6.48 ± 0.2 [a]	5.43 ± 0.04 [a]	29 ± 7.7 [a]
group 3	6.43 ± 0.2 [a]	5.40 ± 0.04 [a]	26 ± 4.4 [a]
group 4	6.39 ± 0.2 [a]	5.39 ± 0.04 [a]	31 ± 7.0 [a]
overall	6.39 ± 0.2	5.40 ± 0.1	29 ± 7.0

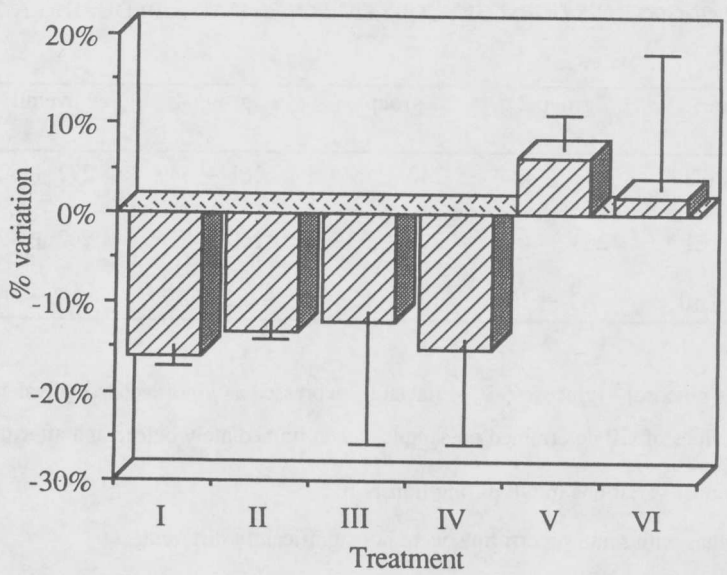
(1), 4 groups of 9 pigs, corresponding to 4 rearing pens were transported unmixed for 2 h.

[a], within one column values with same superscripts were not significantly different.

FIGURE 1

PERCENTAGE VARIATION IN GLYCOLYTIC POTENTIAL OF *LONGISSIMUS DORSI* MUSCLE DURING LAIRAGE

(m ± s.e.m.)



Treatment: I, 2 h lairage, unmixed; II, 2 h lairage, mixed; III, 24 h lairage, unmixed, access to water only; IV, 24 h lairage, mixed, access to water only; V, 24 h lairage, unmixed, access to a sugar solution; VI, 24 h lairage, mixed, access to a sugar solution.

TABLE 3

EFFECT OF LAIRAGE TIME, MIXING AND SUGAR FEEDING ON MEAT QUALITY TRAITS AND GLYCOLYTIC POTENTIAL VARIATIONS IN M. *LONGISSIMUS DORSI*.

	Lairage time								
	2 h		24 h- water		24 h- sugar		Sources of variation (1)		
	unmixed	mixed	unmixed	mixed	unmixed	mixed	lairage	mixing	sugar
pH_1	6.5 ± 0.1	6.4 ± 0.1	6.4 ± 0.3	6.3 ± 0.2	6.3 ± 0.1	6.4 ± 0.3	NS	NS	NS
pH_u	5.41 ± 0.1	5.43 ± 0.1	5.39 ± 0.1	5.39 ± 0.3	5.42 ± 0.1	5.46 ± 0.1	NS	NS	NS
FOP	43 ± 3	41 ± 4	46 ± 8	49 ± 8	42 ± 5	45 ± 10	NS	NS	NS
GP_1 (2)(3)	262 ± 53 ^{a}	276 ± 55 ^{a}	214 ± 73 ^{a}	240 ± 52 ^{a}	240 ± 63 ^{a}	216 ± 53 ^{a}	-	-	-
GP_2 (3)	225 ± 85 ^{b}	247 ± 83 ^{b}	194 ± 75 ^{b}	208 ± 65 ^{b}	250 ± 54 ^{a}	222 ± 67 ^{a}	NS	NS	P<0.01

Values are reported as mean ± s.d..

(1), interactions were not reported since they were not significant.

(2), no statistical analysis was performed for GP_1 since the latter was measured before treament was applied.

(3), GP= 2([glycogen]+[glucose]+[glucose-6-P])+[lactate], expressed as μmol lactate / g fresh tissue.

^{a,b}, for GP, values within one column with different superscripts were significantly different.