Evaporative weight loss of pig carcass between slaughter and 24 hours post mortem in relation to rapid chill conditions and meat quality.

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INTRODUCTION.

The evaporative weight loss of carcasses is an important economic factor that can be modified by changing traditional chilling systems. Weight loss is caused by the tranfer of humidity from carcass surface to the surrounding air. This phenomenon depends on the air temperature and velocity, and the relative humidity conditions. Conventional chilling systems above freezing point (0 to 4°C) for a period of 24 h with relative low air velocity (0,5 m/s) produced more then 2% weight loss from the hot weight. KEMPSTER, CUTHBERTSON and SMITH (1981) estimated the national weight loss in Britain from a total of 20,600 carcasses over a 12 month period measured at 48 slaughtering plants. Weight loss at 24 hours post mortem was 2.27% of the hot weight.

Carcass evaporative weight loss can be reduced by one per cent of carcass weight by applying very low air temperatures to obtain a rapod fall in carcass surface temperatures just above the freezing point in the shortest time (MEAT RESEARCH INSTITUTE, - 1981). This type of treatment is know as "rapid chill". Furthermore an increase on the shelf live can be obtained because the majority of the bacterial load on a carcass is found on its surface and a rapid reduction of the temperature retards bacterial growth.

Care should be taken in rapid chilling to avoid cold-shortening wich occurs when meat temperature decreases from 15 to 0°C at a time when post mortem glycolysis is insufficiently advanced. Cold-shortening due of rapid chilling in beef and lamb is well documented (LOCKER and HAGYARD, 1963; BENDALL, 1972) and it can be avoided by using electrical stimulation to accelerate the rate of pH fall in muscle. The cold shortening of pig muscle has been obtained under laboratory conditions (BENDALL, 1975). But is less of a problem than in cattle and sheep because of the rapid rate of the post mortem glycolysis and protection of muscle by subcutaneous fat in skin layer. JAMES, GIGIEL and HUDSON (1983) found that loins obtained from carcasses subjected to a "ultra rapid chill" -30°C and 1 m/s for 4 hours, were tougher than controls. However, thid difference is probably too small to be detected it (WOOD, DRANSFIELD and RHODES, 1979). GIGIEL and JAMES 1984, reduced the difference in toughness between ultra rapid chill and conventional chill carcasses by applying electrical stimulated carcasses was reached 50 min post mortem and produced muscle on the border line between pale, soft and exudative (PSE) and normal.

Recently, HONIKEL (1984) found that a significant decrease of temperature in the early hours post mortem influencies the drip loss of PSE-muscle substantially. It is well know that PSE muscle drips more because of the lower water holding capacity (SMITH and LESSER, 1982). Fluid loss in PSE m. longissimus compared with normal is at least double measured 4 h, 3, 4 and 6 days after slaughter (HONIKEL, 1985). Even though the PSE pig meat problem is not solved with rapid chilling, meat quality should be improved.

However, there is little evidence on the relationship between pig meat quality and carcass evaporative weight loss. The present work was conducted to study the effect of rapid chilling conditions and pig meat quality on carcass evaporative weight loss.

MATERIAL AND METHODS.

Five hundred and twenty seven commercial pig carcasses of unknow breed and sex, and weighing 75.6±10.31 Kg were studied in this experiment. All carcasses were subjected to a rapid chilling process and measurement on hot and cold carcass were taken 45 min and 21 to 26 hours post slaughter respectively.

Rapid chilling conditions

All carcasses were subjected to a rapid chill process for 75 min after approximately one hour post slaughter in a conveyerised tunnel. The tunnel temperature varied day to day and during the slaughtering task. The evaluated carcasses were introduced into the tunnel in groups of 20 to 25 and the air temperature was measured at the begining and the end of the 75 min cycle. Differences between these two temperatures was up to 3°C and tunnel temperature (TT) was obtained by calculating the average of these two measurements. The TT ranged during this experiment from -19.0 to -6,5°C. The relative humidity (RH) of the tunnel was measured when each group of the evaluated carcasses was introduced ranging from 75 to 95%. The air velocity was measured every day and it was constant being approximately 2.5 m/s.

Subsequently, the carcasses were held in a chilled room and the air temperature (RT) was registred when carcasses were removed for taking the cold carcass measurements.

Measurements on hot carcasses.

Carcass weight (W45): Carcass weight including the head, hind and fore feet, kindneys and perinephric and retroperitoneal fat.

M. semimembranosus pH (pH 45): The average of three measurements taken in the m. semimembranosus with a portable pH meter provided with a glass probe.

Ham internal temperature (HT 45): Internal temperature of the muscular mass of the leg taken with portable thermometer with a probe (°C).

Fat Thickness (F): The larger depth in subcutaneous fat and skin of two measurements taken at the midline, one at the level at the last rib and the other at the level of the sacrum (mm).

Conformation score (c): A visual assessment of the overall conformation of the carcass where 1= very good conformation to 4= very poor conformation.

Measurements on cold carcasses.

Carcass weight (W 24): Carcass weight taken without removing any part described in W 45.

M. semimembranosus pH (pH 24): pH of the m. semimembranous taken with the same instrument and procedure as pH 45.

Ham internal temperature (HT 24): Internal temperature of the leg muscular mass taken with the same instrument as HT 45.

Time between hot weight (W 45) and cold weight (W 24) was recorded and ranged from 21 to 26 hours (TI) and carcass evaporative weight loss (WL) was calculated from the hot weight: $WL = (W\,45 - W\,24 / W\,45) \times 100$.

Statistical analysis

Outliers were calculated by adjusting the variables to the Normal curve N(0.1). Values with bias greater than ± 3 s.d. from their mean value were eliminated. From 535 carcasses first measured 8 were rejected and 527 cases were used in the statistical analysis described below. A multiple regression analysis was carried out

with pH m. longissimus and internal ham temperature both measured 45 min and 24 hours post mortem, carcass weight, fat thickness, conformation and time between weighings as predictors of the evaporative carcass weight loss (WL). Durbin-Watson coefficient was calculated to avoid auto-correlations between the independent variables included in the equation. An analysis of variance was carried out to determine the effect of discrete variables on carcass weight loss. Those that had significant effect were analized using the covariance analysis together with those that had significant effect on weight loss in the regression analysis described before. A multiple classification table was used to evaluate the discrete variables each one grouped into categories.

RESULTS AND DISCUSSION.

Means, standard desviations and ranges for measurements recorded on carcasses are given in Table 1. In general, the sample shows great variation in all variables measured. Carcass evaporative weight loss was 1.45% of the hot weight. This value is equal to that obtained by MEAT RESEARCH INSTITUTE (1981). Although they used 4 h at -10°C and then 10 h at 4°C with air velocities of 2 and 0.5 m/s respectively. Tunnel conveyerized temperatures in our condition ranged from -6.5 to -19.0°C with a mean of - 13°C. Also, the time that carcasses were subjected to rapid chill condition was shorter (75 min). Although we did not measured tunnel air velocity for every group of carcasses evaluated we registered daily values of approximately 2.5 m/s. JAMES, GIGIEL and HUDSON (1983) obtained a greater reduction in evaporative weight loss (1.10%) using a ultrarapid chill system wich involved the application of -30°C for 4 h.

Table 2 shows correlation coefficients between all variables recorded on carcasses. Evaporative weight loss was nwgatively correlated wuth final internal ham temperature (HT 24). This association could indicate that carcass internal temperatures are equalized. A negative correlation was also observed between weight loss and time between hot and cold weighings. KEMPSTER et al. (1981) found this relationship was positive but time between weighings in their study was larger and no rapid chill involved. This result indicates that is not posible to stablish and adjustment for carcass weight loss when rapid chill is applied after slaughter. M. semimembranosus pH (pH 45) was positive correlated with carcass weight loss (r=0.117). However, care should be taken when examiniting the significance levels for large tables because some individual correlation coefficients will be statistically significant only by change. These two pig meat quality parameters, pH and muscle temperature measured 45 min post mortem were negatively correlated (r=-0.366). This relationship was expected because high muscle temperature and low muscle pH in early post mortem is the combination needed to develop PSE (pH 45 5.8) and 17% were dry, firm and dark (DFD) with muscle pH measured at 24 h post mortem higher than 6.0 .

Coefficients of determination and values of regressions to predict carcass evaporative weight loss from measurements taken at 45 min and 24 h, and time between weighings are given in Table 3. Carcass weight loss was only dependent on carcass weight (W 45), internal ham temperature at 24 h (HT 24) and time between weighings (TI). Only 21% of the variation of carcass weight loss was accounted with the equation including seven independent variables. M. semimembranosus pH and internal ham temperature both taken 45 min after slaughter had no significant effect on carcass evaporative weight loss. This results indicate that the differences on the amount of drip loss between normal and PSE pig muscles, the lower pH 45 the higher amount of drip (WARRIS, 1982), does not occur when evaporative weight loss from whole carcass is studied using a rapid chill system.

Table 4 presents an analysis of covariance with carcass evaporative weight loss as dependent variable, with measurements taken on carcass at 45 min and 24 h covariables, and tunnel temperature (TT), tunnel relative humidity (HT), and chill room temperature (RT) as main effets. Carcass weight loss was significatly affected by the three main effects. Table 5 shows a multiple classification analysis where each of the main effects were grouped into categories. Carcass evaporative weight loss mean values for each category expressed as the desviation of the overall mean (ETA) and adjusted by covariates (BETA) indicated that the greatest reduction in carcass weight loss occurred when tunnel temperatures were below -13°C.

This study has shown that carcass evaporative weight loss can be reduced successfully in practical conditions using rapid chilling in the early post mortem. Tunnel temperature and time that carcasses are subjected to rapid chill was showed to be less demanding compared with previous smale-scale trials. Significant effects of meat quality characteristics on carcass evaporative weight loss were not observed. This phenomen could be because of the protection of fat and skin in pig carcasses, or may be due to the reduction in the kinetic of biochemical post mortem muscle reactions by applying low temperatures during the early post mortem period. This aspect would be interesting to study with more detail measurements of muscle drip loss as well as evaporative loss of carcasses weight.

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TABLE 1

Means, standard desviations and minimun and maximun values of measurements taken on hot and cold carcasses.

Measurements	Mean	s.d.	Minimun	Maximun
Carcass weight loss (%)	1.45	0.36	0.25	2.93
M. longissimus pH45	6.07	0.31	5.40	6.70
Ham internal temperature 45 min (ºC)	40.65	0.63	38.70	42.60
Carcass weight 45 min (kg)	75.62	10.31	43.40	107.00
Backfat thickness (mm)	22.49	4.55	8.00	35.00
Visual conformation	2.39	0.97	1.00	4.00
M. longissimus pH24	5.84	0.20	5.40	6.90
Ham internal temperature (ºC)	3.15	2.29	0.00	8.90
Carcass weight 24 h (kg)	74.52	10.15	42.80	105.40
Time between weighings (kg)	22.93	1.27	21.20	25.90

TABLE 2

Correlation coefficients between measurements

Measurements	WL	HT45	pH45	HT24	pH24	TI	F
Carcass weight loss (%)	--						
Ham internal temperature 45 min (ºC)	0.12	--					
M. longissimus pH45	-0.06	-0.37	--				
Ham internal temperature (ºC)	-0.36	0.20	0.06	--			
M. longissimus pH24	-0.07	-0.09	0.40	-0.08	--		
Time between weghings (kg)	-0.33	-0.12	-0.06	0.34	-0.07	--	
Backfat thickness (mm)	-0.10	-0.00	0.04	0.12	0.09	-0.09	--
Carcass weight 45 min (kg)	0.02	0.18	-0.08	0.14	0.01	0.11	0.37

TABLE 3

Statistics parameters obtained from multiple regresion analysis for the prediction of carcass evaporative weight loss from different combinations of measurements.

Predictors	R^2	F value
Carcass weight	0.07	11.46
Carcass weight + pH45	0.37	0.02
Carcass weight + pH45 + pH24	0.59	4.75
Carcass weight + pH45 + pH24 + Ham temp.45	1.66	0.04
Carcass weight + pH45 + pH24 + Ham temp.45 + Ham temp.24	14.17	40.54
Carcass weight + pH45 + pH24 + Ham temp.45 + Ham temp.24 + Time between weighings	19.62	41.78
Carcass weight + pH45 + pH24 + Ham temp.45 + Ham temp.24 + Time between weighings + fat thickness.	21.22	10.54

TABLE 4

Analysis of variance with carcass evaporative weight loss as dependent variable, carcass measurements as covariables and conveyerised tunnel temperature (TT), conveyerised tunnel relative humidity (HT) and chill room temperature (RT) as main effects.

	F value	Signification
Covariables	26.9	***
Backfat Thickness(mm)	3.8	NS
Time between weighings(h)	45.3	***
Ham temperature 24 (ºC)	12.3	**
Ham temperature 45 (ºC)	0.0	NS
M.longissimus pH24	3.8	NS
Main effects:	25.7	***
Tunnel temperature (ºC)	39.9	***
Chill room relative humidity (%)	16.5	***
Chill room temperature (ºC)	3.4	**

TABLE 5

Multiple classification anlysis grouping the main effects into categories expressing carcass evaporative weight loss mean value for each category as the desviation from its overall mean without adjusting (ETA) and adjusted to the covariables (BETA).

	Categories	ETA	BETA
A	1(-10.5)		
	2(-10.5 to -13.0)	0.18	0.16
	3(-13.0)	-0.27	-0.24
B	1(83 to 75)	-0.19	-0.09
	2(83)	0.15	0.07
C	1(-4.5 to -1.0)	0.10	0.07
	2(-1.0 to 0.0)	0.20	-0.05
	3(0.0 to 3.5)	-0.10	-0.03

A (Tunnel temperature (ºC)
B (Tunnel relative humidity (%)
C (Chill room temperature (ºC)