THE INFLUENCE OF AMBIENT AIR TEMPERATURE AND RELATIVE HUMIDITY ON CIE (MINOLTA) L* AND DRIP LOSS PERCENTAGE IN PIG *LONGISSIMUS DORSI*

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Background

Pigs, like other animals, have a thermoneutral zone. Outside this zone they will have an increasing difficulty in adapting their physiology, and can ultimately die, due to increased temperature and to rough handling conditions. Pigs are particularly sensitive to high temperatures (Augustini e Fischer, 1982; Church and Wood, 1992),and Kilgour e Dalton (1984) have indicated that transport operations should be avoided when temperature exceeds 22 °C. Barton-Gade (1971), in Denmark, found meat quality in Summer to have a greater variation than in Autumn, and, in the Netherlands, Lendfers (1968) showed high environmental temperatures to de associated with a worse meat quality, when compared with lower temperatures. While, in Germany, in contrary, Scheper (1971), found PSE and DFD meat incidences to be higher in Autumn and Winter than in Spring or Summer. Also Lundström (1976), in Sweden, found low or non-significant correlations between high temperatures and meat quality in pigs, while Warriss (1991), in the United Kingdom, found that, when compared with pigs slaughtered at temperatures < 18.3°C (average 14.4 ±1.02°C), pigs slaughtered at ≥ 18.3°C (average 20.6 ± 1.10°C) – besides differences in other parameters – had significantly higher drip loss and a paler colour in the *Longissimus dorsi* (*Ld*).

Objectives

Most of the work studying the relationships between environmental factors and meat quality parameters has usually been carried out in other countries, which are known to have natural and industrial environmental conditions which are different from those prevailing in Portugal. . Due to these differences a more ample operational study of meat quality, including the characterization of Portuguese *ante mortem.* manipulation of pigs and post-slaughter phases, and their effect on animal welfare and meat quality- in general - must be carried out, if we want to establish simple and economic methods of assuring quality in these specific conditions and also making use of data existing in companies and veterinary inspection services. The result of a more extensive study will allow to establish the physiological and meat quality parameters, and others that will give us the opportunity of controlling variability in handling of animals and carcasses. Following this thinking platform, the main objective of this work was to study – with limited material resources - the relationships between: 1) a) Environmental daily temperature (minimum and average) and average daily relative humidity percentage (RH) on the day of transport at the animals' origin and the slaughterhouse area; b) the average of minimum and average temperatures and RH in both geographical areas and [(RH farm + RH slaughterhouse)/2]; c) Lairage temperature and RH immediately before slaughter; and 2) Minolta CIE L* and drip loss percentage, in a Portuguese slaughterhouse, with a slaughter rate of between about 160-200 pigs.h^{-1}.

Methods

Under *a.m.* and *p.m.* commercial conditions, all measurements where made on *Ld*, between the first and the fourth lumbar vertebrae, from June 12th to October 16th, on a group of 146 animals (female:male: sex ratio 1.03), with carcass weights between 51-105 kg,. They were submitted to: journeys between 40-120 min; a transport density between 0.41-0.56 m^2.100 kg carcass weight $^{-1}$; showered or sprayed empirically in lairage: submitted to electrical stunning (190 V, 1.5 A); after a *ca.* 24 h lairage period. The measurement of meat quality parameters was carried out as follows: 1. Minolta CIE L*, *ca.* 30 h *p.m.*: measured, after 1 h bloom, with a Minolta Chroma Meter [model CR-210b (50 mm-diameter measuring area, D65, 0° viewing angle), Minolta Camera Co., Ltd. Japan], calibrated to a white tile (Minolta CR-A44), 2 measurements were made on each of two chops, taken from the first 5 lumbar vertebrae area, submitted to pre-freezing temperatures and cut by machine, to varying thickness and weights (minimum 1.5 cm), the day after slaughter; 2. Drip loss percentage was calculated by using the 2 previous chops, from which the *Ld* was separated; these samples were weighed, placed at 2-3 °C, for 48 h, in plastic video boxes, in which 2 plastic net layers (2 mm side) were placed over a paper towel previously put in the bottom of the box; they were reweighed everey 24 hours; and as a measure of control pH and temperature were measured at *ca.* 30 h [pH meter (model pH 95, WTW, Welheim, Germany) and a glass penetration electrode (model EC-FG 63511-01B, Eutech Instruments Europe, Nijkerk, Netherlands), and penetration temperature probe for automatic temperature compensation (model TFK 150/E, WTW, Welheim, Germany)]. Environmental daily temperature (minimum and average) and average daily relative humidity percentage (RH) (at 09h00)– measured by the Instituto de Meteorologia (National Meteorology Institute). Temperature and HR in lairage are an average of 3 measurements (every 5 minutes during 15 minutes), obtained at an height of *c.a.* 1.5 m, with a thermograph (Testostor 175 Logger, marca TESTO, Lenzkirch, Germany). Statiscal methods: Scheffé test, using three temperature or RH levels.

Results and discussion

In Tables 1 and 2 are shown the cases in which temperature and RH had significant effects on the two meat quality parameters that were studied. There were no significant influences on L* and drip loss percentage that could be attributed to: 1) in the day of transport, the minimum (levels: 9.4-11.9°C; 12.5-14.1 °C; 15.6-18.4 °C) and average (levels: 16.4-19.1 °C; 20.4-23.6 °C; 24.9-26.1 °C) environmental daily temperatures and the RH (RH levels: 27-50 %; 65-77 %; 86-98 %) at the geographical area of the farm of origin; 2) in the day of transport, the average of the minimum (levels: 11.4-12.2 °C; 14.4-16.2 °C; 16.8-19.6 °C), average of average (levels: 15.5-19.2°C; 20.1-22.0°C; 25.5-27.9°C) daily temperatures and average of RH (levels: 32 a 41 %; 63 a 80 %; 85 a 98 %) measured in both farm and slaughterhouse geographical areas; 3) in the day of slaughter, average (levels: 15.7 a 20.0 °C; 21.0 a 23.5 °C; 26.3 a 29.9 °C) daily temperature and RH (levels: 25-54 %; 58-73 %; 76-97%); 4) in the day of slaughter, RH measured in lairage, immediately before slaughter. The results suggest that - considering the temperature levels recorded -, as they increased: minimum daily temperature, in the geographical area of slaughterhouse, on the day of transport, did significantly increase both L* and drip loss; while average daily temperature only – and with lower significance – increased L* value. On the day of slaughter, both minimum daily temperature and temperature in lairage immediately before slaughter only influenced drip loss, by decreasing it; with, concerning the L* value, the temperature in lairage immediately before slaughter achieving a 0.05 significance value. The reason why temperature in lairage immediately before slaughter, instead of increasing, actually lowered drip loss may attributed to empirical human control of lairage environment, in this case – as observed - by workers showering or spraying pigs, when feeling heat, and, in that way, probably lowering stress and muscular temperature. Even though our methodology was different from the one used by Warriss (1991), we may say that, on the day of transport, in the geographical area of the slaughterhouse, the temperature levels (of minimum and average temperatures), above which there were significant rises in L* and drip loss values, were similar. It seems that, since animals slaughtered after long lairage period stay a longer a period under the influence of the environmental temperatures in the geographical area of the slaughterhouse, these apparently will have significant effects on L* a drip, and could be used as predictors of the probable influence of environmental temperature on the variance of those meat quality parameters. The statistically significant differences in L* and drip loss, in practical terms, are not, probably, relevant. Maybe temperature effects could be more relevant if higher temperatures – which can be common in Portugal – and shorter lairage resting periods had been covered in this study.

Conclusions

We may conclude that: 1) Temperature may significantly affect quality parameters, but, under the conditions studied may not be of practical relevance; 2) Even though the animals had a long lairage resting period, because they are manipulated in the early morning hours [05h00 (or earlier)-07h30], the effect of minimum daily temperature – during which animals more suffered a temperature effect - seems to be more useful in explaining variation in the parameters studied; 3) Attention should be given to the accomplishment of a uniform human control of lairage environmental conditions, which are hinted to be – by observation – rather controlled by human discomfort than by pig discomfort, with the implications of this – amongst others - in pig welfare, variation in meat quality and profitability; 4) This type of study should be carried out in larger groups of animals submitted to shorter lairage periods and in warmer days - so that a larger amplitude of multifactorial real situations could be understood – the interaction between temperature and RH should be analysed.

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Table 1 – Significant effects of temperature and RH on Minolta CIE L* and on drip loss (%), on the day of transport

Minimum daily temperature in geographical area of slaughterhouse	10.5 a 15.4 °C (*n*= 64)		16.3 a 18.4 °C (*n*= 55)		19.9 a 20.8 °C (*n*= 27)		
	LSM	SD	LSM	SD	LSM	SD	P
L*	51.2^{b}	2.70	52.5^{ba}	3.00	53.0^{a}	2.95	< 0.01
Drip loss (%)	2.94^{b}	1.06	2.94^{b}	1.27	3.89^{a}	1.31	< 0.01
Average daily temperature in geographical area of slaughterhouse	16.4 a 19.1 °C (*n*= 44)		20.4 a 23.6 °C (*n*= 32)		24.9 a 26.1 °C (*n*= 31)		
	LSM	SD	LSM	SD	LSM	SD	P
L*	51.3^{b}	2.51	51.5^{ba}	3.07	52.9^{a}	2.95	< 0.05
Drip loss (%)	2.86	0.80	3.07	1.27	3.33	1.43	NS

Table 2 – Significant effects of temperature and RH on Minolta CIE L* and on drip loss (%), on the day of slaughter

Minimum daily temperature	9.9 a 14.2 °C (*n*= 52)		15.0 a 16.4 °C (*n*= 46)		17.2 a 20.5 °C (*n*= 48)		
	LSM	SD	LSM	SD	LSM	SD	P
L*	52.0	2.98	52.4	2.79	51.7	3.07	NS
Drip loss (%)	3.35^{a}	1.03	3.29^{b}	1.50	2.70^{b}	1.07	< 0.05
Temperature in lairage immediately before slaughter	16.943 a 20.473 °C (*n*= 36)		20.902 a 22.265 °C (*n*= 34)		23.164 a 25.938 °C (*n*= 46)		
	LSM	SD	LSM	SD	LSM	SD	P
L*	52.8^{a}	2.79	51.1^{b}	2.85	52.1^{ba}	2.97	NS (0.05)
Drip loss (%)	3.61^{a}	1.05	2.84^{b}	1.12	2.64^{b}	1.11	< 0.01

LSM - Least square means; SD – Standard deviation; P – Significance; NS – Non significant; Means with different superscripts are different

THE INFLUENCE OF CLIMATE ON THE RELATIONSHIP BETWEEN ULTIMATE PH AND MEAT QUALITY CHARACTERISTICS OF BEEF *M. LONGISSIMUS THORACIS*

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Background

Oman is located in the humid and semi-arid south of the Arabian Peninsula. The months of May to October are characterized by a high temperatures (hot season), while November up to April is of mild temperature (cool season). During the hot season, stressful conditions may prevail. These deplete muscle glycogen reserves before slaughter, consequently increase the ultimate pH of meat, and result in low residual levels of glucose (Bray, et al. 1989). Thus they can cause changes in protein structure and chemical composition that influence meat quality characteristics. Various stress factors have been reported as a cause for glycogen depletion: transportation of animals from the farm to the slaughterhouse, mixing animals, lairage time, and environmental temperature. In practice, any situation which provokes a substantial depletion of muscle glycogen reserves will result in meat with a high ultimate pH, if the animal is slaughtered before its energetic reserves are restored (Tarrant and Mothersill, 1987).

Objective

The aim of this study was to evaluate the influence of climatic stress (hot or cool) on the relationship between the ultimate pH and meat quality characteristics of bovine longissimus thoracis.

Methods

Fifty-two samples of the *longissimus thoracis* muscle taken between the 10th to the 13th of the right side were randomly selected from bovine carcasses slaughtered at Muscat Municipality between January 2002 and January 2003 on monthly basis. Approximately within 60 min *post mortem,* longissimus thoracis muscle samples were removed and kept in the chiller at 4-5^{0}C for 72 h. Meat quality measurements included ultimate muscle pH, Warner-Bratzler shear force, expressed juice, cooking loss and colour *L**, *a**, *b** were determined. The ultimate pH (pHu) was assessed in homogenates of 1.5-2 g muscle tissue in 10 ml of neutralized 5-mM sodium iodoacetate. Chilled muscle samples (13 mm X 13 mm cross section) for assessment of shear force by a digital Dillon Warner-Bratzler shear machine were prepared from muscle samples cooked in a water bath at 70^{0}C for 90 min (Purchas, 1990). Expressed juice was assessed using a filter paper method, as the total wetted area less the meat area (cm^2) relative to the weight of the sample (g). Approximately 60 min after exposing the fresh surface, CIE *L**, *a**, *b** light reflectance coordinates of the muscle surface were measured using a Minolta Chroma Meter CR-300 (Minolta Co., Ltd., Japan). The L* value relates to lightness; the *a** value to Red-Green hue where a positive value relates to the red intensity; and the *b** value to the Yellow-Blue where a positive value relates to yellow.

The general liner model (GLM) procedure within SAS (1985) was used to evaluate the significance of climatic stress on the relationship between ultimate pH and meat quality characteristics.

Results and Discussion

The mean pHu of 5.96 for the hot season group was significantly ($P<0.001$) higher by 7% than the cool season group (5.54) for beef longissimus thoracis (Table 1). This is a reflection of the climatic heat stress prior to slaughter. It is common to have a high incidence of high pHu beef after being held at high environmental temperature at a meat plant prior to slaughter, as was the case in this study. This indicates that the high temperature caused some depletion of the muscle glycogen ante mortem stores resulting in a decreased post mortem lactic acid production. The latter resulted in meat with an elevated pHu which negatively affect meat colour and keeping quality (Lister, et al., 1981). The responses of meat pHu to pre slaughter stress are in agreement with results of Geesink, et al. (2001). The relationship between pHu and WB shear parameters showed that the peak WB shear force values was at about 5.5 for samples from cool season group (Figure 1). This value is slightly lower than the peak reported in other studies (Purchas & Aungsupakon, 1993; Silva et al., 1999). However, there were few samples with pHu values around the peak in agreement with Purchas et al. (1999).

Meat samples darkened at a decreasing rate in terms of L*,a* and b* values as pHu increased (Figure 2), as has been shown in several other studies (MacDougall & Rhodes, 1972; Purchas, 1990, Purchas et al., 1999; Silva et al., 1999). The expressed juice and cooking loss% also decreased by high temperature. However this difference was only significant ($P<0.01$) for cooking loss%. This indicates that the early post mortem metabolism is of importance for the development of drip loss. The results reported here are for muscle samples removed from the carcass pre-rigor in a way that was likely to cause some muscle stimulation. The lack of any skeletal restraint may have enabled muscle shortening but temperature conditions were such that cold-shortening was avoided.

Conclusions

Climatic high temperature stress had a significant effect on meat quality characteristics of the beef *m longissimus thoracis*. It decreased the ultimate pH, colour *L**, *a** and *b** and cooking loss%, while there was no significant effect on expressed juice values between the hot season and cool season groups. A significant linear relationship was found between pHu and the tenderness , colour *L**, *a**, and *b**.

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Table 1. Means ± standard errors for a range of quality characteristics for *m. longissimus thoracis* influence by climatic stress (hot or cold)

Measurement	Climatic stress	
	Hot	Cold
Number of animal	22	30
Ultimate pH	5.96^{b}±0.037	5.54^{a}±0.032
Shear value (kg/cm^{2})	12.37^{a}±0.246	15.60^{b}±0.211
Expressed juice	32.85±1.243	34.36±1.065
Cooking loss %	21.94^{a}±0.690	25.95^{b}±0.591
Colour parameters *L** (lightness)	32.44^{a}±0.546	35.56^{b}±0.468
*a** (redness)	19.54^{a}±0.364	23.16^{b}±0.311
*b** (yellowness)	4.47^{a}±0.143	6.43^{b}±0.122

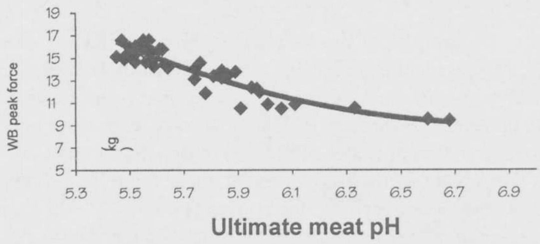

Figure 1 . Influence of climate on changes in WB peak force values with increasing pHu for samples of *M longissimus thoracis*

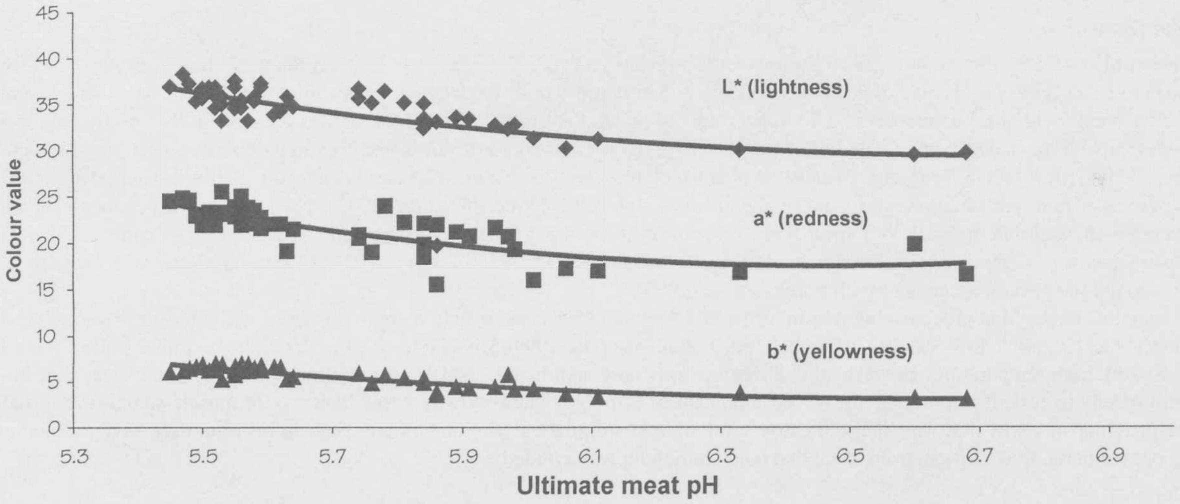

Figure 2. Effect of climate on changes in meat colour, as shown by values for *L**, *a**, and *b** with increases in pHu for samples of beef *M. longissimus thoracis*

TOWARDS UNIFYING MEAT SHEAR FORCE MEASUREMENT SYSTEMS TO DETERMINE MEAT TENDERNESS.

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Background

The subjective consumer-related evaluation of meat is reflected in the attribute termed tenderness. Its objective measurement is achieved through mechanical methods of measurement of shear force. However, the instruments used for the evaluation of shear force vary widely among research groups and institutions. Many elements of the shear force measurement system are standardised in laboratories such as thawing condition, cooking method, cooking temperature or cooking time. The direction of shearing action, the type of instrument used and the variation in shearing methods do not appear to give results that can be compared from one laboratory to another. The Warner-Bratzler shearing device is the most widely used in the USA and around the world for the evaluation of meat shear force [1]. The shear blade has a **triangular hole** and cored **cylindrical** samples (1.27 cm-diameter) from the cooked meat are assessed. One clear modifying factor is the continual change of contact area between the sample and the shear blade during the test and the fibre orientation [2,3]. The shear force results from Warner-Bratzler has been correlated with the sensory tenderness score of trained panellists (r= -0.63 – (-0.83))[4,5,6]. Wheeler et al. (1997) demonstrated that the assessment of meat tenderness by Warner-Bratzler shear force apparently varied among institutions, regardless of apparent sample treatment or cooking conditions. A modified version of the Warner-Bratzler device using a **rectangular hole** and **rectangular** samples (0.65 cm high x 1.5 cm wide) called Meat Research Laboratory device[8] has been developed in Australia that avoids fibre orientation issues and variability in the shear angle. The MIRINZ pneumatic tenderometer developed in New Zealand has the same mode of action as the Volodkevich jaws method and measures the force required to shear a standard-sized 1 cm x 1cm sample of cooked meat[9]. The shear values determined by this tenderometer were highly correlated with consumer's sensory analysis (r = 0.97)[10]. Correlations between the conventional Warner-Bratzler and MIRINZ tenderometer measurements of raw beef were not significant (r= 0.0)[11]. The present study expands those by Graafhuis et al (1991)[12] who followed the changes in meat ageing using a MIRINZ tenderometer and a Warner-Bratzler instrument in a variety of beef muscles.

Objectives

To determine the relationship between meat shear force using a MIRINZ tenderometer and a modified blade Warner-Bratzler shear device (WB device) on same meat bites.

Material and methods:

Turkey muscles (*m. pectoralis superficialis* and *m.pectoralis major*) were obtained from carcasses subjected to a range of processing conditions (electrically stimulated or non electrically stimulated, chilled at 0°C or air blast frozen) to yield meat with a wide range of shear force values that were tested after aging for 3h, 24 h or 7 days postmortem [13].

Beef porterhouse steaks (*m. longissimus lumborum*), 2.0 - 2.5 cm thick and lamb loin chops (*m. longissimus lumborum*) approximately 2.5 cm thick were randomly collected from supermarkets.

The meat samples were cooked in unsealed, weighted plastic bags partially immersed in a water bath at 80 °C until the sample centre reached an end point temperature of 75 °C as described[9]. Every sample was then cut along the muscle fibre axis using scalpel blades set apart by 1 cm to produce 8 or more samples (termed bites) 1 cm x 1cm cross section across the fibre axis. The shear force of every bite was determined sequentially using the MIRINZ tenderometer and the WB device, with a 1 cm x 1 cm hole in the blade through which the samples were inserted, mounted on an Instron Universal Machine (series 4400) at shearing rate of 100 mm min^{-1}.

Results and discussion

By taking adjacent measurements on the same bite we were able to directly compare the MIRINZ tenderometer and WB shear device in regard of their ability to assess the meat shear force. Over a wide range of meat shear values, both shear system were effective in terms of differentiating between samples (Figure 1). The correlations between tenderness readings from MIRINZ tenderometer and WB device were significant at both bite and sample levels for all meat types ($p<0.001$). Turkey samples had better correlation at both levels than lamb or beef that may be due to an inherent homogeneity or lower connective tissue levels of turkey muscle. The lower correlation at the bites level for beef and lamb samples may partially arise from a narrower range of shear values. Both instruments had very strong overall correlation for all meat samples (r= 0.92, n= 379). However, within individual samples, the correlation between shear force determined by MIRINZ tenderometer and WB modified device varied greatly from –0.20 to 0.91.

In the present study, the inherent variability of shear values for **individual** bites for both the MIRINZ tenderometer and WB device showed a relatively low correlation between the two instruments. However when all bites were considered and **means** were compared, there was a high correlation between shear values. The relationship between the two instruments was WB = MIRINZ *0.6953 + 0.7595. This relationship is remarkably close to the values obtained by Graafhuis et al (1991)[12] where WB = MIRINZ *0.63 + 0.61. In a more recent study, using the same cooking parametsrs for the MIRNZ tenderometer and a lower cooking temperature of 70°C and a wider sample of 1.5 cm for the WB device, the WB = MIRINZ *0.6251 + 1.174 (Devine, Wells and Starbuck, 2003)[14]. All of these values are close and suggest that strong relationships between the two devices exist in a variety of laboratory settings, provided a 1 cm x 1cm cross section sample is used. Any differences that do exist may be related to small, as yet non-quantified differences, in blade dimensions including the present study where the WB shear blade is 1 mm while the tip of the shearing device of MIRINZ is 1.5 mm. On the basis of the shearing force applied per unit contact area, both instruments would be expected to have the same shear force value. Hence, standardizing the thickness of the shear blade for both instruments would expect to give similar, if not identical, shear force values for same meat sample.

For WB tenderness evaluation, AMSA (1995) recommends the use of at least six good 1.27 cm circular cross section cores from a sample. However, that is relatively difficult logistically in a tenderness classification system[16] and uses an excessive amount of meat in some cases. For example, having six good cores for Warner-Bratzler measurements require using one beef striploin steak, two pork loins or three lamb loin chops as the sample[16]. Utilizing the modification of Warner-Bratzler blade as here, therefore would result in a simpler sample preparation and eliminate the problems associated with coring (coring orientation and coring angle). That is especially important when tenderness assessment is performed on meat cuts which do not have single direction for the muscle fibres (e.g. lamb leg chop). Also, the number of samples required for assessment will be reduced substantially (with the use of double-blade scalpel at least 8 bites can be obtained from 1 inch thick lamb loin chop). Given the fact that the tenderness within a steak is variable[17], using the double-blade scalpel will produce high number of bites obtained per pork and beef samples (18- 20 bites for 2.5 cm beef *m. longissimus lumborum* sample) compared to the coring method. Large numbers of samples will improve the estimation of the true tenderness value of a sample, especially since it is clear from the present study that there is a large variation in meat shear values.

Conclusion

The results indicate that the MIRINZ tenderometer and the modified Warner Bratzler device both effectively differentiate between samples over a wide range of shear values. There is clearly a large range of shear values for each bite for each given meat sample but when these values are averaged, there is a strong correlation found between the mean shear values from both shear systems suggesting that in the case of the modified flat blade Warner Bratzler device and MIRINZ tenderometer, shear values are interchangeable using a conversion factor for 1 cm x 1cm cross section samples. Provided there is the same sample preparation and cooking conditions used, data between different institutions can be realistically compared.

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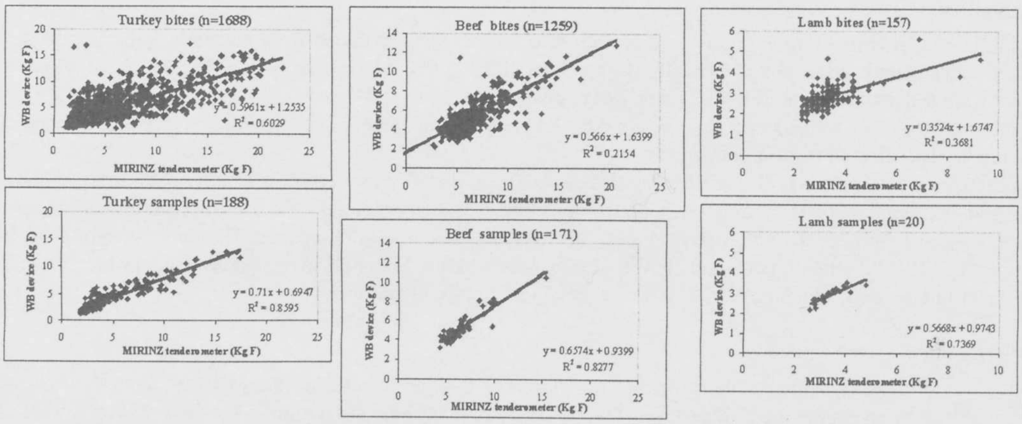

Figure 1. Relationships between meat shear force values obtained using MIRINZ tenderometer and WB shear device for turkey, beef and lamb muscles. The measurements were obtained sequentially on the same bite and the sample value represents the mean values.

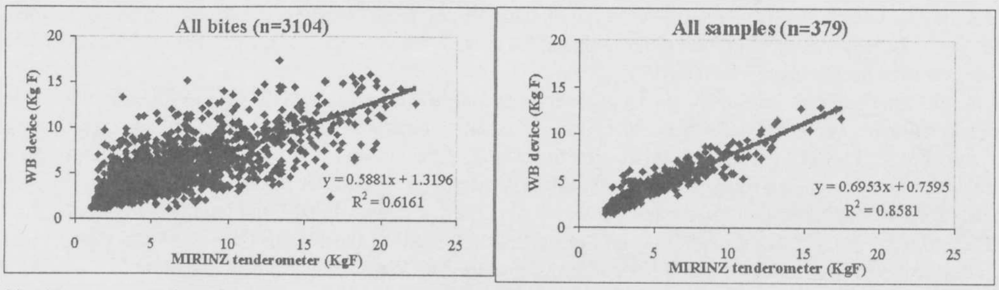

Figure 2. The relationships between meat shear force values obtained using a MIRINZ tenderometer and a modified WB shear device for all meat samples.

WATER HOLDING CAPACITY (WHC) AND SUBJECTIVE COLOR ASSESSMENT OF DIFFERENT PRE-CLASSIFIED SWINE CARCASS CUTS ACCORDING TO THE *LONGISSIMUS DORSI* PH

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Background

The search for a *in natura* pork production technological and sensory quality is one of the aims which most promote the development of domestic swine culture. Such quality characteristics interfere with the industrial processes outcome as well as the consume rates, determining market profits and agroindustrial economical capability.

Color and exudation are the main properties in drawing pork consumers' interest (BREWER *et al.*, 2001). These two elements are of great economical significance for the processing companies, particularly the water holding capacity (WHC). They are both determined by the *post-mortem* (*p.m.*) pH decrease which causes important alterations in pork proteins structure and organization (WARRIS, 1995; RUBENSAM, 2000). Thus, color and exudation would be important properties to be considered when assessing the pork technological quality in production lines.

According to Brown (1992), although the color and exudation assessment subjective methods may present problems such as individual variations among cuts, they can be successfully used to estimate the pork quality for their actual correlations to the pH_{45}, pH_u, reflectance and WHC determined by drip loss and filter paper pression (GRAU and HAMM, 1953). Such methods are fast and appliable to different production lines as long as workers receive previous training.

The continuous study of the relations among the main sensory and technological quality aspects of fresh pork meat, through different analysis methods, is important for the mantainance of monitoring programs, which are industrially possible in terms of workability, dependability and costs.

Objective

The objective of this work was to compare two methods for determining the WHC and subjective evaluation of color in different swine carcasses cuts studied under regular industrial procedures conditions. These carcasses had been previously classified as standard or, potentially, either PSE or DFD, considering the *longissimus dorsi* muscle pH.

Methods

Ninety swine carcasses obtained from animals submitted to routine pre-slaughter handling at a slaughtery industry were randomly selected, independently on origin, sex, weight and genetic constitution. After regular slaughter and inspection operations, the carcasses were classified according to the pH found in the *longissimus dorsi* muscle at 45 minutes (pH_{45}) and at 24 hours *p.m.* (pH_u), under the following criteria (MURRAY, 1995; NPPC, 2000):

- $pH_{45} < 6.0$ – pork tending to PSE (pale, soft and exudative) condition
- $pH_{45} \geq 6.0$ and $pH_u < 6.0$ – standard quality
- $pH_{45} > 6.0$ and $pH_u \geq 6.0$ – pork potentially DFD

Data were colected at the industry during 20 weeks aiming the constitution of 3 groups containing the same number of carcasses (n=30). In order to have the pH readings, a portable pH-meter plugged to a glass electrode was used. This instrument was inserted between the 13th and 14th ribs, perpendicular to the midline, in the left half carcass medial portion. At 24 hours *p.m.*, the carcasses, previously selected and split into the 3 quality groups, were deboned. The studied cuts were *longissimus dorsi*, *semimembranosus*, *biceps femoris* (inner portion) and *triceps brachii caput longum*. Such cuts were isolated and dissected. Two 2.5 cm thick slices from each cut were prepared for the subjective color assessment through the National Pork Producers Council's photographic standard (NPPC, 2000). The same samples were used to determine the WHC by the drip loss method according to Honikel (1998), and by the filter paper pressure (FPP) technic adaptaded from Grau and Hamm (1953), according toVan Oeckel *et al.* (1999a). The data were analysed in subdivided parts, being present in all parts the quality conditions (3 levels), and being present in the subparts the cuts (4 levels) under an entirely randomized 30 repetitions design. The Tukey and Dunn at 5% tests were used for the average multiple comparisons.

Results and Discussion

The pH values found have shown a small variation. Most of them has not shown any correspondence to extreme values characteristic of typically PSE ($pH_{45} < 5.8$) or DFD ($pH_u > 6.2$) pork. The initial pH avarage in the potentially PSE group was 5.87, while the final pH one in the DFD group was 6.06. The results obtained from the tests for the WHC determination and the color subjective assessment are presented on **Tables 1 and 2**. As far as the drip loss is concerned, it was possible to find a significant difference among three quality groups only in the *l. dorsi* and *semimenbranosus*. Observing the *b. femoris* data only the DFD carcasses could be differenciated. The *t. brachii* observations have not followed the previous classification. Among the cuts studied, significant differences, on the drip loss test, were observed only in the PSE and standard carcasses involving the *t. brachii*. Through the FPP technic, it was verified that in all cuts the data differed as to the 3 classification conditions, and that the *b. femoris* showed the smaller WHC value comparing to the other cuts. As to the subjective color assessment, the classification was proved once again in the loin and also in the leg cuts. In the shoulder, cut it was possible to distinguish only between the PSE and the DFD characteristics. Comparing the results among cuts, the color scores have presented a uniform variation pattern: in all the 3 groups, the *l. dorsi* and *t. brachii* received the lowest and the highest color scores, respectively, differing from the *semimembranosus* and the *b. femoris* which had intermediate scores. All the analyses have presented a great variation and standard deviation in the results. This becamc difficult the avarage comparisons among the 3 groups. Another aspect that certainly affect the overall data was the lack of PSE and DFD typical pH values. Nevertheless, the previous classification effectiveness, according to the criterium adopted, to determine the quality properties studied was satisfactory, except for a few parameters observed in the shoulder cut. The cuts composition, as to their predominant muscle fiber histochemical type has, presumably, also interfered with the data for the loin and leg cuts have shown several similar characteristics.

Conclusions

The application of a pre-classification scheme based on pH_{45} and pH_u measurements on the swine slaughter has been useful and, probably, beneficial for both economical and technological reasons. Such a model has shown to offer satisfactory results when compared to WHC and pork color. These results could be observed even in the absence of extreme PSE or DFD conditions, confirming the effectiveness and results correspondence for pH measurements obtained in the *longissimus dorsi* muscle.

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Table 1 – Average values and standard deviation for the results of drip loss test and WHC obtained by filter paper pressure method (M:T)[a], determined in 4 different muscle of pre-classified swine carcasses as standard or, potentially, either PSE or DFD, considering the *longissimus dorsi* muscle pH.

Muscle	Drip loss			Filter Paper Pressure		
	PSE	Standard	DFD	PSE	Standard	DFD
l. dorsi	5.85[b]±2.29 Aa	3.45±1.73 Ba	2.06±1.44 Ca	0.40[b]±0.09 Aa	0.49±0.11 Ba	0.55±0.10 Ca
semimembranosus	4.43±2.41 Aab	3.12±1.56 Ba	1.89±0.82 Cab	0.44±0.10 Ab	0.49±0.10 Ba	0.58±0.09 Ca
b.femoris	4.05±2.53 Ab	3.52±2.13 Aa	1.71±0.73 Bab	0.37±0.09 Aa	0.43±0.12 Bb	0.50±0.09 Cb
t. brachii	1.64±0.97 Ac	1.46±0.51 Ab	1.32±0.40 Ab	0.46±0.09 Ab	0.52±0.10 Ba	0.56±0.07 Ca

[a] M=pressured meat sample area; T=pressured meat sample area plus removed juice by pressure area.
[b] on each line, the averages followed by the same capital letters do not differ among themselves through the Tukey test ($p > 0.05$).
[b] on each column, the averages followed by the same small letters do not differ among themselves through the Tukey test ($p > 0.05$).

Table 2 – Average values and standard deviation for the results of subjective color assessment (1=extreme pale; 6=extreme dark) of 4 different muscle of pre-classified swine carcasses as standard or, potentially, either PSE or DFD, considering the *longissimus dorsi* muscle pH.

Muscle	Classification		
	PSE	Standard	DFD
l. dorsi	1.5[a]±0.6 Aa	2.1±0.6 Ba	2.7±0.5 Ca
semimembranosus	2.3±0.8 Ab	3.0±0.8 Bb	3.6±0.9 Cb
b.femoris	2.7±0.8 Ab	3.4±0.7 Bb	4.0±0.6 Cb
t. brachii	4.5±0.8 Ac	4.8±0.6 ABc	5.1±0.7 Bc

[a] on each line, the averages followed by the same caital letters do not differ among themselves through the Dunn test ($p > 0.05$).
[a] on each column, the averages followed by the same small letters do not differ among themselves through the Dunn test ($p > 0.05$).