Effect of storage time, muscle type, and animal genotype on drip loss in raw pork

Efecto del tiempo de almacenamiento, el tipo de músculo y el genotipo del animal sobre las pérdidas por goteo en carne cruda de cerdo

Iván D. Ocampo[1], Fanhor Bermúdez M.[2], Hector Díaz[3]

[1]Universidad Nacional de Colombia sede Palmira. Author for correspondence: ivanocampoi@gmail.co,

[2]Universidad Nacional de Colombia sede Palmira. fbermudezm@palmira.unal.edu.co, [3]Universidad Nacional de Agricultura. Honduras, C.A. hectordiazhn@yahoo.com

Rec. 11.08.09

Abstract

A factorial design arranged in Subdivided Plots evaluated the effect of storage time (24, 48 and 72 hours at 6° C), the muscle type (*Longissimus dorsi, Triceps brachii, Biceps femoris*) and the genotype of the animal (3 pure breed: Yorkshire, Landrace, Duroc; 2 genotypes: F1 from a hybrid between Yorkshire and Landrace (YL), and one cross between the F1 and Duroc (F1D)) on the drip loss in raw pork. The samples were taken at 24 hours post mortem and were stored for 72 hours. The greatest percentage of drip loss was presented for pork obtained from the *Biceps femori* muscle taken from F1 animals. The greatest percentage of drip loss occurred the first 24 storage hours. The results shoed highly significant statistical differences ($p<0.01$) for the individual effects: genotype, muscle type and storage time on the percentage of the drip loss.

Key words: Pork, drip loss, meat, storage, muscle, genotype.

Resumen

En un diseño factorial con arreglo en parcelas subdivididas se analizó el efecto del tiempo de almacenamiento (24, 48 y 72 h a 6 °C), el tipo de músculo (*Longissimus dorsi, Tríceps brachii, Bíceps femoris*) y el genotipo de animal (tres razas puras: Yorkshire, Landrace, Duroc; dos genotipos: F1 por el cruce Yorkshire x Landrace (YL), cruce de la F1 x Duroc (F1D) sobre las pérdidas por goteo en carne cruda de cerdo. Las muestras se tomaron a las 24 h postmortem y

[1] Zoot. Universidad Nacional de Colombia sede Palmira.
[2] Ing. Agroindustrial. M.Sc. Universidad Nacional de Colombia. A.A 237. Palmira, Valle.
[3] Ing. Agr. M.Sc. Universidad Nacional de Agricultura. Honduras, C.A.

se almacenaron durante 72 h. El mayor porcentaje de pérdida se presentó para la carne obtenida a partir del músculo *Bíceps femoris* proveniente de los animales pertenecientes al genotipo F1. El porcentaje de pérdida por goteo más alto se presentó durante las primeras 24 h. Los resultados indicaron diferencias estadísticas altamente significativas ($P < 0.01$) para los efectos individuales genotipo, tipo de músculo y tiempo de almacenamiento sobre el porcentaje de pérdida por goteo.

Palabras clave: Cerdo, carne fresca, pérdida por almacenamiento, músculos, genotipos**.**

Introduction

Water represents between 70% and 80 % of the weight of –raw meat, and so influences the sensorial quality and organoleptic attributes – juiciness, tenderness, texture, smell and color – and the technological quality (Arango & Restrepo, 2003), traits that meat processing, such as capacity for water retention (CWR), the pH and the condictivity (Eguinoa et al., 2006).

The free water bound to muscle by superficial forces has the greatest importance during cooling and storage of the meat, as it is at this point that losses through drip loss or exudation occur (Genot, 2003). These losses represent the meat exudates (extra-cellular water) without the application of external forces, and are due to the change in volume of the micro fibrils caused by rigor mortis (contraction). The fluid accumulates in the bundles of fibers, and on cutting the muscle, drains through gravity through the cut surface for a duration varying from a few hours to several days (Cannon et al., 1996*;* Morón & Zamorano, 2003*;* Castro et al., 2004). Thus quantification of drip loss is one of the methods used to determine CWR in raw meat (Kauffman et al., 1986; Cannon et al., 1996).

Morón and Zamorano (2003) established that drip loss in the swine channel was almost none, but once butchered, these losses increase to between 2% and 6% (Genot, 2003). Drip loss of water, as well as the organoleptic traits of the meat, depend directly on the slaughter conditions, particularly the stress-triggering conditions to which it is exposed before slaughter, and which have a direct influence on the reserves of intramuscular glycogen and the anaerobic production of lactic acid. These have a significant effect on the pH of the muscle, and thus on the production of meat of types DFD, normal or PSE (Lawrie, 1977; Sañudo, 1992)

Drip loss is an economic problem first for the raw meat producers due to the loss of weight caused in the butchering, with accumulation of fluid around the meat at the point of sale, reducing acceptance and causing rejection by consumers (Roseiro et al., 1994); and second, for the processor as the exudation contributes to the loss of some nutrients, such as

proteins through the liquid membrane, which may reduce yield during the production of meat products (Eguinoa et al., 2006). For these reasons, the evaluation of drip loss is vitally important to calculate the negative economic effects in the meat industry.

Given the former, it is considered important to evaluate the effect of time of storage, muscle type and the race / genotype of the animal on drip loss in raw meat, establishing the capacity for water retention (CWR).

Materials and methods

This study was carried out in the meat processing plant if the National Agricultural University, Catacamas, Olancho (Honduras) between 14º 26' and 14º 53' N and 86º 19' and 86º 46' W, at 350 m.a.s.l., with 24.6 °C temperature, 1400 mm precipitation, and relative humidity of 74%, annual mean.

In the study, five genetic groups were evaluated: three pure races (Yorkshire, Landrace and Duroc) and two genotypes: an F1 obtained from a cross Yorkshire x Landrace (YL), and an F1 x Duroc (F1D) (terminal cross through the paternal line). The muscles evaluated were: *Longissimus dorsi*, *Tríceps brachii* and *Bíceps Femoris*, as these are the most relevant in terms of quantity and quality of meat. Measures were taken by genetic group for four weeks.

The individuals were selected randomly, and muscle samples were taken 24 hours after slaughter, noce the cadavers were located in the storage room.
Meat samples were taken using a modified method of Honikel and Hamm (1994) taking portions of 1.5 cm width x 1.5 cm high x 1.5 cm long. Initial weight was determined with a digital electronic balance (OHAUS® ExplorerPro®, precisión 410 g ± 1 mg), and then suspended from a thread inside closed plastic jars to avoid contact with the walls. The jars were maintained in the cold room, between 6 ºC and 8 °C while the assay was carried out. The sample weight was determined at 24, 48 and 72 hours of storage.

Accumulated drip loss was registered as percentage (%), both for the total storage time (percentage of loss after 72 h of storage), and for the percentage of drip loss for each storage period (24, 48 and 72 h), taking into account initial (P_i) and final (P_f) sample weights.

To determine the effect of the variables of storage time, muscle type, and genotype of the animal on the percentage of drip loss, an analysis of variance (ANOVA) was used with a GLM. When minimum significant differences were detected ($P < 0.05$) a Tukey test was performed.

The data war analyzed using the statistical packet SPSS version 10, in a factorial design with a subdivided plot arrangement, with the aim to determine the simple and the compound (interactions) effects of the variable response as a percentage of drip loss. To determine the effect of each of the factors the following linear model was used:

$$Y_{ijkl} = \mu + R_i + H_j + (RH)_{ij} + V_k + (HV)_{jk} + (RHV)_{ijk} + M_l + (HM)_{jl} + (VM)_{kl} + HVM_{jkl} + RHVM_{ijkl}$$

where,

Y = Response variable or percentage (%) drip loss.

R_i = Repetition.

H_j = Genotype factor.

V_k = Muscle type factor.

M_l = Time factor.

The behavior of the percentage loss of meat as a function of storage time was obtained using graphs adjusted to a linear regression of the form $Y = b + mX$. Comparisons of the drip loss as a function of each of the individual time periods was done using a bar chart.

Results and discussion

FRom the analysis of de variance for the percentage drip loss of raw prok meat, significant differences ($P < 0.01$) were seen in the simple effects of genotype, muscle type and storage time. However, no differences were seen ($P > 0.05$) for the interactions between these effects (Box 1). The determination coefficient (R^2) for the variable percent drip loss was 0.322. This value was low, and may be explained because the drip loss from raw meat is not only due to the effects of storage time, muscle type, and and animal genotype, but also is influenced by other effects such as temperature, relative humidity, and air velocity for the storage room, amongst others.

1. Mean percent drip loss with storage time, muscle type and animal genotype.

ment	Loss (%)	Treatment	Loss (%)	Treatment	Loss (%)
sh*TB*24 h	2.94	Landra*TB*24 h	3.02	Duroc*TB*24 h	3.04
sh*TB*48 h	2.74	Landra*TB*48 h	2.65	Duroc*TB*48 h	1.70
sh*TB*72 h	2.63	Landra*TB*72 h	3.02	Duroc*TB*72 h	2.36
sh*LD*24 h	2.76	Landra*LD*24 h	3.87	Duroc*LD*24 h	3.09
sh*LD*48 h	2.26	Landra*LD*48 h	3.42	Duroc*LD*48 h	2.49
sh*LD*72 h	2.49	Landra*LD*72 h	2.91	Duroc*LD*72 h	2.93
sh*BF*24 h	3.51	Landra*BF*24 h	3.81	Duroc*BF*24 h	4.54
sh*BF*48 h	2.47	Landra*BF*48 h	3.63	Duroc*BF*48 h	3.30
sh*BF*72 h	2.08	Landra*BF*72 h	2.71	Duroc*BF*72 h	2.61
B*24 h	3.47	F1D*TB*24 h	3.27		
B*48 h	2.97	F1D*TB*48 h	2.12		
B*72 h	2.59	F1D*TB*72 h	2.58		
D*24 h	3.92	F1D*LD*24 h	3.18		
D*48 h	2.99	F1D*LD*48 h	2.74		
D*72 h	3.61	F1D*LD*72 h	2.92		
F*24 h	4.76	F1D*BF*24 h	4.31		
F*48 h	4.04	F1D*BF*48 h	2.20		
F*72 h	3.51	F1D*BF*72 h	3.65		

Tríceps brachii; LD: *Longissimus dorsi*; BF: *Bíceps Femoris*.

ysis of variance	
ce of variation	**Drip loss (%)**
type	**
le	**
	**
type*Muscle	ns
type* Time	ns
le* Time	ns
type*Muscle* Time	ns
	0.322
	2.22

P < 0.01. ns = no sig.(P >0. 05). R^2: determination coefficient. CV = Coefficient of variation.

Significant differences (P < 0.01) were seen in percent drip loss between animal genotypes. The raw meat with the highest loss came from animals with the genotype YL, while meat from the pure Yorkshire race had the lowest loss. A similar behavior was seen in the meat from animals of the genotypes Landrace, Duroc and F1D (Figure 1). Edwards et al. (2003) and Martel et al. (1988) found similar results to those of the present study, while Stoller et al. (2003) found lower values and Gerbens et al. (1999) higher ones. It is necessary to take into account that other factors from those studied here may affect meat quality, including the presence of the recessive gene, halotano (Sutton et al., 1997; Maddock et al., 2002).

The results showed differences (P < 0.01) for the percent drip loss related to muscle type, with the greatest loses of water in the meat from the muscle *Bíceps femoris*, while the muscle *Tríceps brachii* had the least loss (Figure 2). Van Laack and Smulders (1992), Karlsson et al.

(1993), D'Souza et al. (1998) and Lonergan et al. (2001) found similar percent drip loss, although, in contrast to the present results, the greatest drip loss occurred in the meat obtained from the muscle *Longissimus dorsi*.

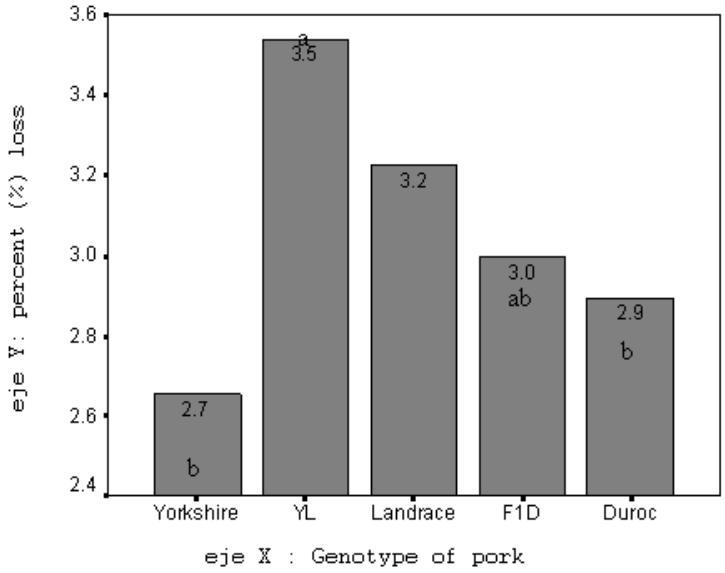

Figure 1. Mean values of percent drip loss in raw pork meat according to the animal genotype.

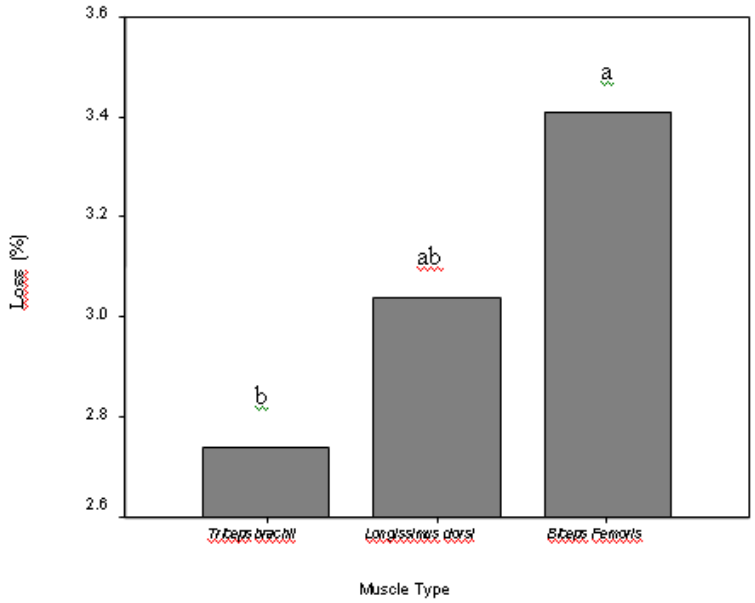

Figure 2. Mean values of percent dril loss in raw pork meat according to muscle type.

Values with different letters are statistically different ($P < 0.01$).

Maddock et al. (2002) studied meat quality from different muscles, including those evaluated here, and noted that *Bíceps Femoris* presented the greatest loss over 24 h of storage. In the present study a similar behavior was seen, but the mean values for percent drip loss were greater, due to the longer storage time.

Meat drip loss increased with storage time (Figure 3). Karlsson et al. (1993), Lesiak et al. (1996), Lonergan et al. (2001), and Morón and Zamorano (2003) found similar results, attributing this effect to the controllable variables inside the storage room, such as relative humidity, air velocity, and temperature, amongst others, variables that were not taken into account as fixed factors for the development of this study.

Significant differences ($P < 0.01$) were found in drip loss between each of the evaluated periods (Figure 4), with the highest loss during the first 24 h of meat storage. These results can be explained by the interruption of blood circulation after slaughter, which deprives the muscle of oxygen (Arango & Restrepo, 2003).

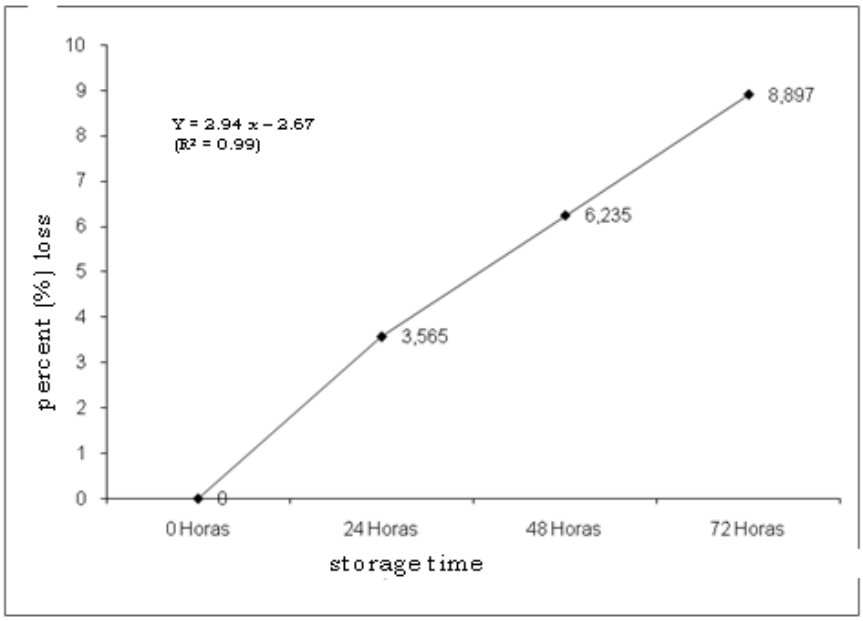

Figure 3. Mean values for percent drip loss in raw pork meta alter 72 h storage.

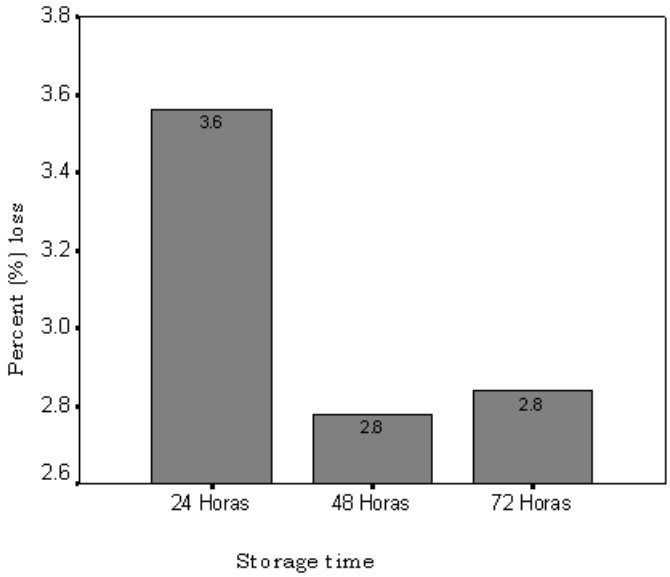

Figure 4. Percent drip loss of raw pork meat for the durations evaluated. Values with different letters are statistically different (P < 0.01).

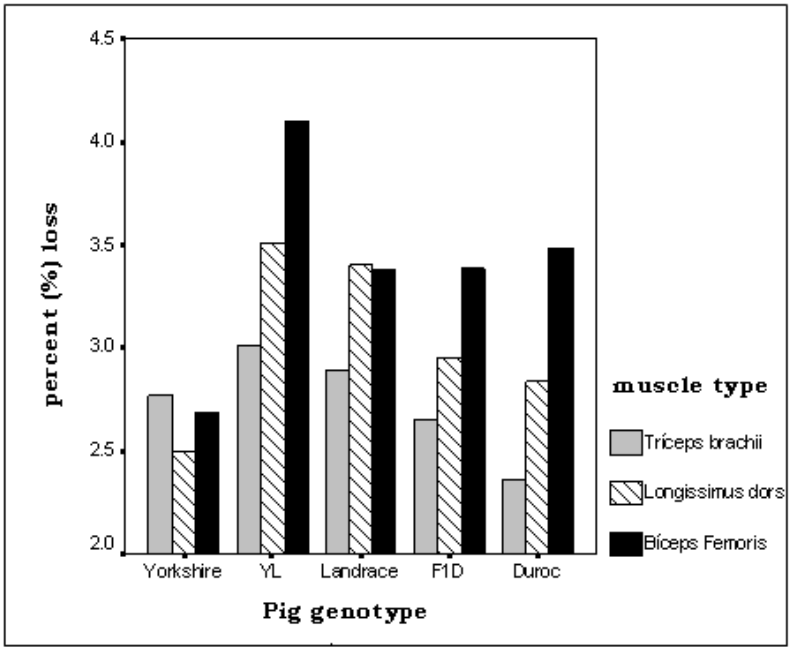

Figure 5. Percent drip loss in raw pork meat according to muscle type and genotype of the animal..

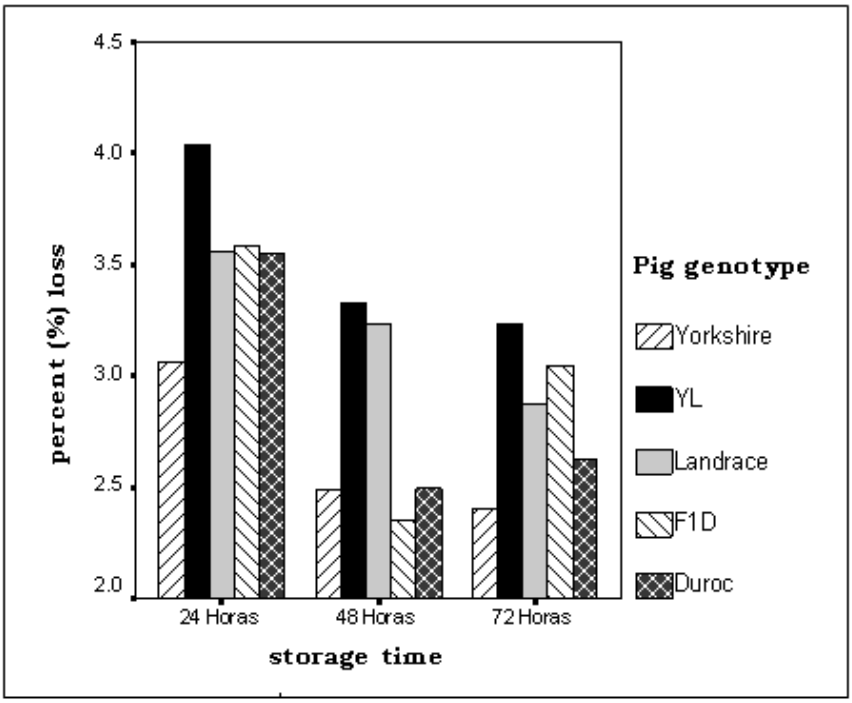

Figure 6. Percent drip loss of raw pork meat according to storage time and animal genotypes.

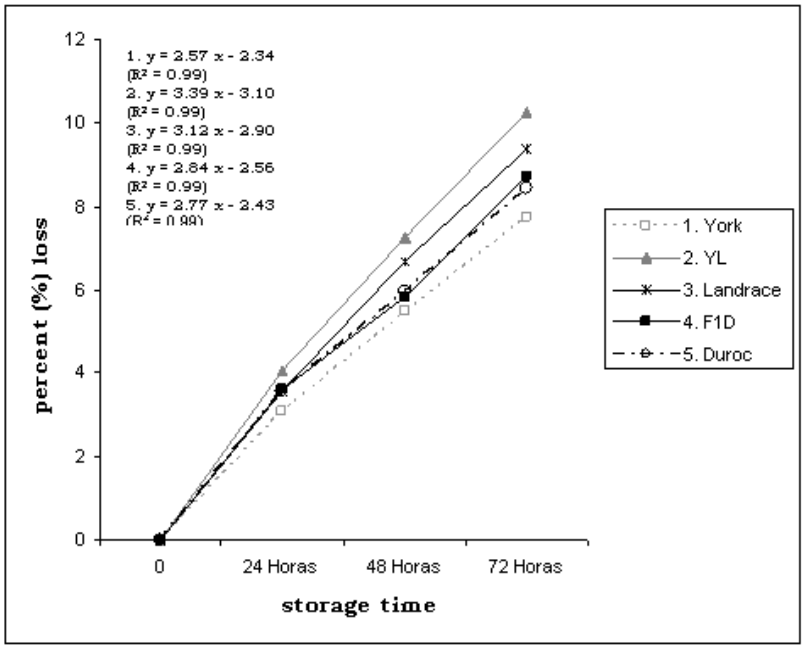

Figura 7. Percent drip loss in raw pork meat alter 72 h of storage, according to animal genotype.

During the first 24 h post mortem and before the oxygen and ATP deficit, anaerobic glycolysis begins from the glycogen reserves in the muscle, producing lactic acid (Monin, 1998). This causes a reduction in pH in the muscle, and an irreversible bonding of the muscular proteins (actin and myosin), which causes rigor mortis. In this stage the sensorial characters of the meat degrade: hardness increases, CWR decreases, and the amount of fluid expelled increases (Beriain & Lizaso, 1997).

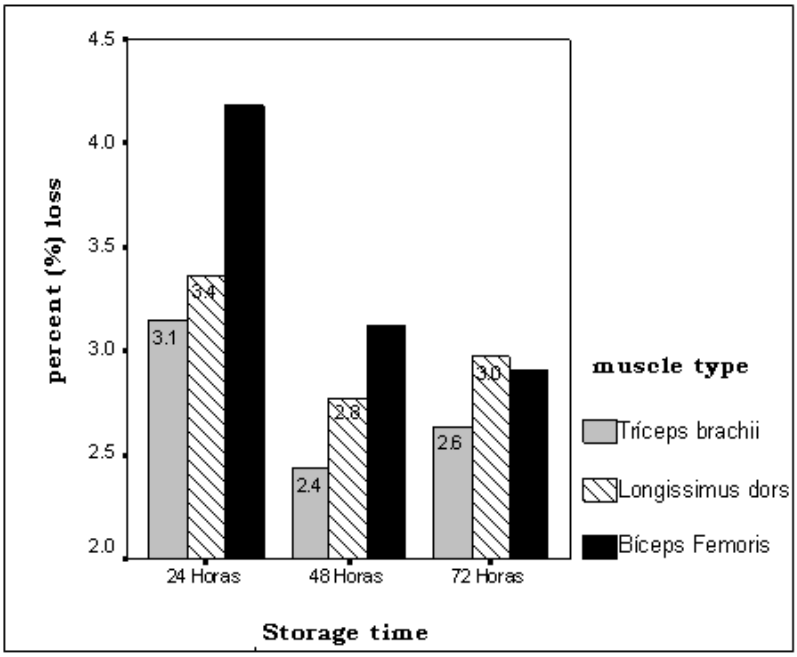

Figura 8. Percent drip loss in raw pork meat by storage time and muscle type

The reduction in CWR occurs as a result of the reduction in pH to values close to the isoelectric point of the proteins, which causes a reduction in the free ionic groups for binding water (loss of CWR) (Renerre et al., 1998) and protein denaturation. Thus, exudation or libaration of water through drips occurs, as the denatured proteins are not able to maintain ligated water (Arango & Retrepo, 2003).

The analysis of variance for percent drip loss showed no significant differences ($P > 0.05$) for the interaction genotype x muscle (Figure 5), however, the highest values wer epresented by raw meat coming from the muscle *Tríceps brachii* in the pure Yorkshire race, *Longissimus dorsi* in the pure Landrace race, and *Bíceps femoris* for the genotypes YL, F1D and the race Duroc.

Although no differences (P > 0.05) were seen for the interaction genotype x storage time (Figure 6), it was observed that the meat from evaluated animals had the greatest drip loss during the first 24 h following the initiation of storage.

The greatest accumulated drip loss over 72 h was seen in the meat from the genotype YL (Figure 7). The curves of the regression equations in figure 7 allow the prediction of the percent drip loss over whichever storage time for the meat of each genotype evaluated in this study .

The interaction muscle x time did no affect (P > 0.05) the percent drip loss (Figure 8). Despite this finding, the greatest percentage losses were seen during the first 24 h of storage of the meat from the muscle *Bíceps femoris*.

After 72 h of storage the greatest percent accumulated drip loss was seen in the muscle *Bíceps femoris* (Figure 9).

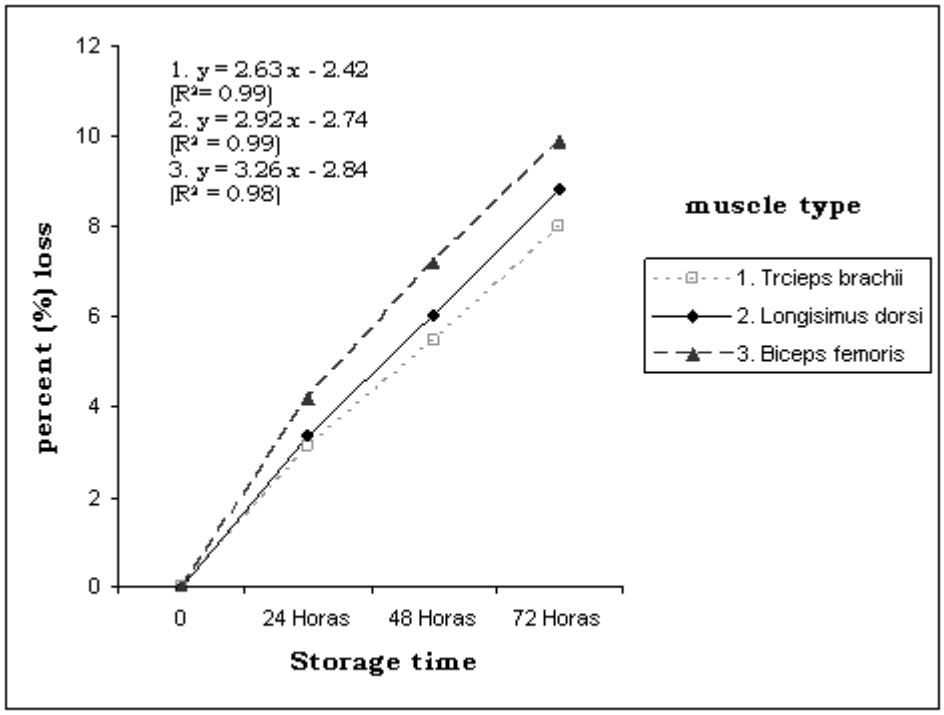

Figura 9. Percent drip loss of raw pork meat by muscle type after 72 h of storage

No differences (P > 0.05) were seen for the interaction genotype x muscle x storage time, however, the results indicated that the greatest percent drip loss occurred in the first 24 h of storage from muscles *Bíceps femoris* in animals of the pure races Yorkshire and Duroc, and the

two genotypes YL and F1D, and in samples of the muscle *Longissimus dorsi* from animals of the race Landrace.

Conclusions

The results of this study allow the following conclusions to be made:

- Storage time (24 – 72 h), muscle type, and animal genotype affected the losses and retention of water in raw pork meat.
- Drip loss increased with storage time, and for this reason raw meat should not be stored for more than 24 h.
- The prok meat presented the greatest loss of water through drip loss in the first 24 h of storage after slaughter.
- Raw meat taken from the muscle *Tríceps brachii* in animals from Landrace, Duroc, the cross Yorkshire x Landrace (YL), and the F1D presented less drip loss, and in consequence, greater capacity for water retention over 72 h of storage.
- Raw meat from animals of the cross YL had the least capacity for water retention, and consequently the greatest percent drip loss at the end of 72 h of storage.
- The low value of the determination coeficent ($R^2 = 0.322$) obtained suggests that the percent drip loss could be influenced by factors other than those of this study, including: temperature, relative humidity and air velocity in the storage room, as well as genetic factors such as the presence of the gene holotano, and factors triggering stress prior to slaughter, such as transport, movement and stunning.
-

Acknowledgements

To the Agricultural Sciences Faculty of the National University of Colombia Palmira Campus, for financing travel to Honduras for practical professional development. To the Academic Vice- and the Animal Production Department of the National Agricultural University of Honduras, for enabling this work to be carried out. To the agricultural engineer M.Sc. Esmeling Obed Padilla, Associate Professor at the National Agricultural University of Honduras.

References

Arango, M. C. y Restrepo, M. D. 2003. Estructura, composición química y calidad industrial de la carne. Universidad Nacional de Colombia sede Medellín. 163 p.

Beriain, M. J. y Lizaso, G. 1997. Calidad de la carne de vacuno. En*:* Buxadé, C. (ed.). Vacuno de carne: aspectos claves. Madrid: Mundi–Prensa. P. 493 - 510.

Cannon, J. E.; Morgan, J. B.; Schmidt, G. R.; Tatum, J. D., Sofos, J. N.; Smith, G. C.; Delmore, R. J., y William, S. N. 1996. Growth and fresh meat quality characteristics of pigs supplemented with vitamin E. J. Anim. Sci. 74:98 – 105.

Castro de Cabo, M. J.; Sánchez, G. C.; García, C. M.; Garzón, C. A.; y González, M. I. La capacidad de retención de agua de la carne de reses de lidia. http://www.simposiotorozafra.org/simposio.phtml?menu=5&codigo=126. 2004. 15–09–2007.

D'Souza, D. N.; Warner, R. D.; Leury, B. J.; y Dunshea, F. R. 1998. The effect of dietary magnesium aspartate supplementation on pork quality. J. Anim. Sci. 76:104–109.

Edwards, D B.; Bates, R. O.; y Osburn, W. N. 2003. Evaluation of duroc- vs. pietrain-sired pigs for carcass and meat quality measures. J. Anim. Sci. 81:1895 – 1899.

Guinoa, P.; Labairu, J.; y Granada, A. 2006. Calidad de la canal porcina: efecto de la genética paterna. ITG Ganadero. Navarra Agraria. Octubre – noviembre: 57 – 64.

Genot; C. 2003. Congelación y calidad de la carne. 2ed. Zaragoza. Acribia. p. 15 - 20.

Gerbens, F.; Van Erp, A. J.; Harders F. L.; Yerburg, F. J.; Meuwissen, T. H.; Veerkamp, J. H. y Te Pas, M. F. 1999. Effect of genetic variants of the heart fatty acid-binding protein gene on intramuscular fat and performance traits in pigs. J. Anim. Sci. 77:846 – 852.

Honikel, K.O. y Hamm, R. 1994. Measurement of water-holding capacity and juiciness. En: Quality atributes and their measurement in meat, poultry and fish products. Adv. Meat Res. Series. 9:125 – 161.

Karlsson, A.; Enfalt A. C.; Essh-Gustavssont, B.; Lundstrom, K.; Rydhmer, L. y Stern, S. 1993. Muscle histochemical and biochemical properties in relation to meat quality during selection for increased lean tissue growth rate in pigs. J. Anim. Sci. 71:930 – 938.

Kauffman, R. G.; Wacholz, D.; Henderson, D.; y Lochner, J. V. 1986. Shrinkage of PSE, normal and DFD hams during transit and processing. J. Anim. Sci. 46: 1236 - 1240.

Lawrie, R. A. 1977. Ciencia de la carne. 1ed. Zaragoza: Ed. Acribia. 171 p.

Lesiak, M. T.; Olson, D. G.; Lesiak, C. A.; y Ahn, D. U. 1996 Effects of postmortem temperature and time on the water-holding capacity of hot-boned turkey breast and thigh muscle. Meat Sci. 40:51 – 60.

Lonergan, S. M.; Hugg-Lonergan, E.; Rowe, L. J.; Kuhlers, D. L.; y Jungst, S. B. 2001. Selection for Lean growth efficiency in duroc pigs influences pork quality. J. Anim. Sci. 79: 2075 – 2085.

Maddock, R. J.; Bidner, B. S.; Carr, S. N.; McKeith, F. K., Berg, E. P. y Savell, J. W. 2002. Creatine monohydrate supplementation and the quality of fresh porkin normal and halothane carrier pigs. J. Anim. Sci. 80:997 – 1004.

Martel, J.; Minvielle, F.; y Poste, M. 1988. Effects of Crossbreeding and sex on Carcass composition, cooking properties and sensory characteristics of pork. J. Anim. Sci. 66:41-46.

Monin, G. 1998. Recent methods for predicting quality of whole meat. Prod. Anim. 4: 151 – 160.

Morón Fuenmayor, O. E.; y Zamorano, G. L. 2003. Pérdida por goteo en carne cruda de diferentes tipos de animales. Rev. Cient. Maracaibo 4:36 – 39.

Renerre, M.; Touraille, C.; Bordes, P.; Labas, R.; Bayle, M. C.; y Fournier, R. 1998. Influence on straw feeding and growth-implant on veal meat quality. Meat Sci. 26:233 - 244.

Roseiro, L.C.; Santos, C.; y Melo, R. S. 1994. Muscle pH 6.0, color (L, a, b) and water-holding capacity and the influence of postmortem meat temperature. Meat Sci. 38:353-359.

Sañudo, C. 1992. La calidad organoléptica de la carne con especial referencia a la especie ovina: factores que determinan, métodos de medida y causas de variación. Curso Internacional de Produccion Ovina. SIA, Zaragoza. 117 p.

Stoller, G. M.; Zerby, H. N.; Moeller, S. J.; Baas, T. J.; Johnson, C.; y Watkins, L. E. 2003. The effect of feeding ractopamine (paylean) on muscle quality and sensory characteristics in three diverse genetic lines of swine. J. Anim. Sci. 81:1508 – 1516

Sutton, D. S.; Ellis, M.; Lan, Y.; McKeith, F. K. y Wilson, E. R. 1997. Influence of slaughter weight and stress gene genotype on the water holding capacity and protein gel characteristics of three porcine muscles. Meat Sci. 46:173 - 180.

Van Laack, J. M. y Smulders, J. M. 1992. On the assessment of water holding capacity of hot vs. cold boned pork. Meat Sci. 32: 139-147.