Journal of Animal and Veterinary Advances 9 (11): 1560-1564, 2010
ISSN: 1680-5593

Water Holding Capacity and PH of Meat from the Wild Rabbit (*Oryctolagus cuniculus algirus*) Hunted Specimens

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Abstract: Wild rabbit (*Oryctolagus cuniculus*) meat is a valuable food resource in some Mediterranean countries. However, it has been scarcely studied. Aimed at characterising some properties of this meat, the Percentage of Released Water (PRW) of the *Longissimus dorsi* (LD) and pH of the LD and *Biceps femoris* (BF) muscles were measured in 53 wild rabbits (*Oryctolagus cuniculus algirus*). The rabbits were purchased in summer 2006 in several traditional markets in the province of Seville (Spain). LD muscle pH was 5.96 and BF muscle pH was 6.03 with no differences between sexes ($p>0.05$). There were negative correlations between the unskinned, eviscerated weight of the rabbits and pH of the LD and BF muscles ($r = -0.322$; $p<0.05$). PRW from LD muscle was 17.98% with no differences between sexes ($p>0.05$). The PRW and pH of LD muscle show a negative correlation ($r = -0.433$; $p<0.01$). Both muscle pH values and LD muscle PRW were higher in wild rabbits than the values described for meat breeds in the literature. This is due to the higher depletion of energy reserves and lower lactic acid production in the muscle as a consequence of the stress and flight during hunting.

Key words: Meat quality, water holding capacity, pH, wild rabbit, *Oryctolagus cuniculus algirus*, Spain

INTRODUCTION

In several countries and since Pre-historic times (Hocket and Bicho, 2000), people have been consuming meat from hunted wild rabbits (*Oryctolagus cuniculus*) (Paris and Rollan, 1989; Sandford, 1992; Hoffman *et al*., 2005). Today, hunters and their families consume a number of the rabbits that they have hunted (Gonzalez-Redondo, 2006; Gonzalez-Redondo *et al*., 2007, 2010) and commercialise the rest in local food markets. In several Mediterranean countries, consumption of wild rabbit meat is high.

However in spite of this high consumption, there are few studies characterising the quality and composition of wild rabbit meat (Cambero *et al*., 1991; Cobos *et al*., 1995; Slamecka *et al*., 1997). Conversely, the characteristics of domesticated rabbit meat are well-known (Hulot and Ouhayoun, 1999; Combes, 2004; Clinquart, 2007).

The characteristics of both types of rabbit differ in terms of their genetics (Branco *et al*., 2000), the environment in which they live (Soriguer, 1981; Lebas *et al*., 1997) and how they are slaughtered or hunted. For these reasons, the knowledge concerning domesticated rabbit meat cannot be extrapolated to wild rabbit meat because they are differentiated products. Consumers, furthermore have a different appreciation of both types of meat Hoffman *et al*., 2005; Gonzalez-Redondo, 2006; Gonzalez-Redondo *et al*., 2007, 2010). Given the importance of wild rabbit meat in several countries and given the lack of knowledge concerning its instrumental properties, this research work was undertaken with the aim of assessing hunted wild rabbit meat's Water Holding Capacity (WHC) and its pH.

MATERIALS AND METHODS

In this research were used 53 mature unskinned, eviscerated wild rabbits (49% of which were males) that had been acquired during summer 2006 in traditional markets in the Province of Seville (Spain). Using the X-chromosome markers technique (Geraldes *et al*., 2006), the rabbits were analysed in the Centro de Investigacao em Biodiversidade e Recursos Geneticos (Portugal) and subsequently identified as belonging to the *O.c. algirus* subspecies, typical of the south-western part of the Iberian Peninsula (Branco *et al*., 2000).

The rabbits were kept frozen at -20°C until handling. After a 12 h slow thawing period at 4°C and a further 4 h

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at room temperature and following the World Rabbit Science Association's recommendations (Ouhayoun and Zotte, 1996) the meat's WHC and pH were measured. pH was measured by performing a 3 mm cut in the aponeurosis of the *Longissimus dorsi* muscle (LD) at the 5th lumbar vertebra and in the *Biceps femoris* (BF) muscle using a Crison 507® portable pH meter with a thin penetration electrode and temperature probe. WHC was measured in the LD muscle using the filter paper press method of Grau and Hamm (1957) with 110 mm diameter (Filter-Lab® 1238) filters for quantitative analysis and by placing a 2,250 g weight upon 5 g of sample meat that had been minced by a 3 Claveles® mincer. WHC was measured as a Percentage of Released Water (PRW) calculated with respect to the weight of the sample. The average value of two repetitions of the pH and PRW measurements were used. The statistical analyses consisted of Student's t- tests and Pearson correlations performed with the SPSS 15.0 program (SPSS, 2006).

RESULTS AND DISCUSSION

This is the first study to describe the pH and WHC in wild rabbit meat. In general terms, the average LD muscle pH value in wild rabbit meat (Table 1) was higher than that described by most researchers for the same muscle in meat breeds and lines 5.75-5.89 according to Pla (1999), 5.83-5.90 according to Lambertini *et al.* (2004), 5.74 according to Gondret *et al.* (2005), 5.58-5.61 according to Bianospino *et al.* (2006) and 5.83-5.86 according to Maria *et al.* (2006). A minority of studies describe the LD muscle's pH in domesticated rabbits as higher than that observed by us in wild rabbits 6.05-6.20 according to Lambertini *et al.* (1996) and 6.41-6.45 according to Metzger *et al.* (2003).

The pH measurements were taken in meat that had been frozen so it is possible that had the measurements been taken in fresh meat, the pH might have been even higher since generally in meat that has been frozen pH values are lower than those of fresh meat (Hulot and Ouhayoun, 1999). The average BF muscle pH value in wild rabbit meat (Table 1) was greater than that described by Pla (1999) which was between 5.83-5.91 but similar to that found in other studies 5.87-6.06 according to Lambertini *et al.* (1996), 5.96-6.02 according to Gondret *et al.* (2005) and lower than that found by other researchers 6.20-6.60 according to Dal Bosco *et al.* (1997), 6.27-6.30 according to Metzger *et al.* (2003), all of which refer to meat breeds and lines.

Table 1: Eviscerated weight, pH of the *Longissimus dorsi* and *Biceps femoris* muscles and percentage of released water for the *Longissimus dorsi* muscle in wild rabbits (n = 53)

Variables	Mean±SEM	Minimum	Maximum	CV (%)
Eviscerated weight (g)	768±11	613.00	988.00	10.35
pH *Longissimus dorsi*	5.96[b]±0.04	5.47	6.71	5.12
pH *Biceps femoris*	6.03[a]±0.04	5.63	6.66	4.47
PRW *Longissimus dorsi*	17.98±0.48	10.94	25.27	19.63

[a,b]Mean pH values within a column and followed by a different letter are significantly different ($p<0.01$); CV: Coefficient of Variation; SEM: Standard Error of Mean; PRW: Percentage of Released Water

Contrary to what can be stated for LD muscle pH, it appears that it cannot be generalised the statement that BF muscle pH in wild rabbits differs from that in meat rabbits. There were negative correlations between the rabbits' eviscerated weight and LD muscle pH (Fig. 1) and BF muscle pH (Fig. 2) with identical significances and correlation coefficients ($r = -0.322$; $p<0.05$). The rabbits

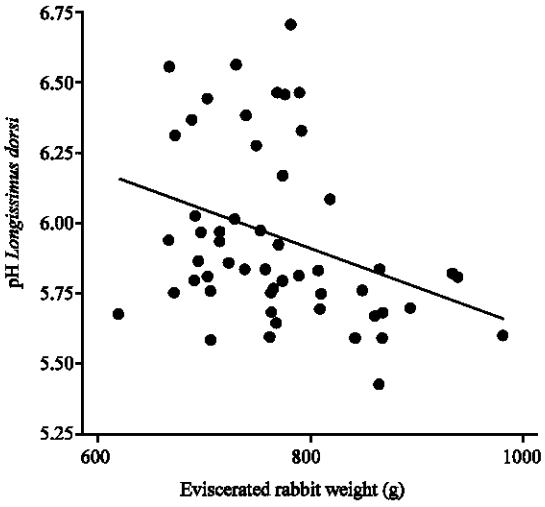

Fig. 1: Relationship between the eviscerated weight of the rabbits and pH of the *Longissimus dorsi* muscle (n = 53)

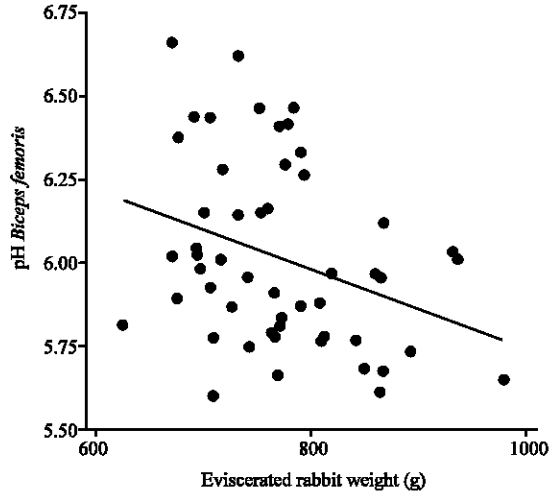

Fig. 2: Relationship between the eviscerated weight of the rabbits and pH of the *Biceps femoris* muscle (n = 53)

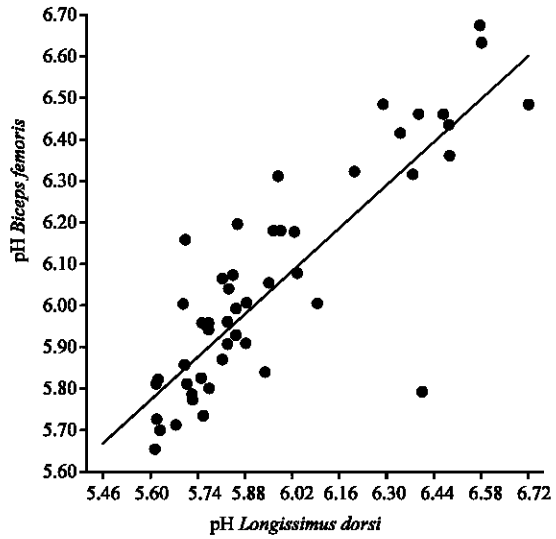

Fig. 3: Relationship between pH of the *Biceps femoris* and *Longissimus dorsi* muscles (n = 53)

used were mature as evidenced by the fact that by increasing the unskinned, eviscerated weight of the lightest animal (Table 1) by 18% corresponding to the intestinal packet and its contents (Ayyat *et al*., 1994; Bernardini *et al*., 1995), the increased weight corresponds to what would be the estimated live weight of sexually mature rabbits of the *O.c. algirus* subspecies (Soriguer, 1981).

In spite of the above, it is difficult to separate the effect of weight from that of age in the sample rabbits due to the fact that they were hunted and that their age was unknown. However, the correlations found between weight and pH followed the trends found in meat breeds in which it has been observed that pH decreases with age and for animals of the same age, pH decreases as the animal's weight increases (Hulot and Ouhayoun, 1999).

A positive correlation was found between the LD and BF muscles' pH (Fig. 3; $r = 0.861$; $p<0.01$) the pH being significantly higher in the BF muscle ($t = 3.429$; $p<0.01$). The BF muscle's higher pH coincides with what has been observed in meat breeds (Pla, 1999; Gondret *et al*., 2005) and is due to its lower glycolytic potential (Hulot and Ouhayoun, 1999).

The measurement scale for free water fraction in meat is poorly defined and dependent upon the method used to extract it (Hulot and Ouhayoun, 1999). In order for the values to be comparable were compared the PRW obtained from wild rabbits with the values that other authors using the same press method had obtained in meat rabbits. Therefore, the PRW in wild rabbit meat (Table 1) was clearly lower than that found in the majority of cases in meat rabbits (30.70-35.57; Hernandez *et al*., 2004; Ramirez *et al*., 2004; Ariño *et al*., 2006). In only one study was the PRW described in meat rabbits (13.57-13.77%; Maria *et al*., 2006) lower than the value found in wild rabbits.

It would therefore seem apparent that the wild rabbits WHC is noticeably higher than the WHC of domesticated rabbits. Furthermore, the proven fact that meat that has been frozen has in general terms, a lower WHC (Hulot and Ouhayoun, 1999) suggests that had it been measured in fresh meat, the WHC value of the wild rabbit meat might have been even higher than the one recorded in this research. On the other hand, no differences were found in the LD muscle's PRW as a function of the rabbits' weight ($r = 0.005$; $p>0.05$).

No differences between the sexes were found with regard to the LD and BF muscles pH ($t = 0.945$, $p>0.05$; $t = 0.551$, $p>0.05$, respectively). Neither were there any differences between the sexes with regard to the PRW of LD muscle ($t = 1.037$; $p>0.05$). The absence of differences between the sexes in the two parameters studied in wild rabbit meat coincided with the findings of other studies performed on meat breeds and lines with regard to pH values (Bianospino *et al*., 2006; Hernandez *et al*., 2006) and WHC values.

Only Lambertini *et al*. (1996) have found that the LD muscle pH value is higher in domestic does but they have not found significant differences between the sexes in BF muscle pH value. Therefore this study confirmed in wild rabbits the absence of sexual dimorphism found for these parameters in meat breeds (Hulot and Ouhayoun, 1999).

There was a moderate and significant negative correlation between LD muscle PRW and pH (Fig. 4; $r = -0.433$; $p<0.01$). This implies that coinciding with what has been described in the meat of domesticated rabbits (Hulot and Ouhayoun, 1999) the higher the pH, the greater also the WHC value. In fact is well-known that the rigor stages of domesticated rabbit meat have a significant effect on WHC values (Karakaya *et al*., 2006).

Rabbit meat's final pH is usually between 5.3 and 6. As it increases going further away from the miofibrilar proteins isoelectric point (pH around 5), there are more positive and negative charges that capture water (Hulot and Ouhayoun, 1999), thus explaining the lower proportion of liquid released and therefore the greater WHC found. This higher WHC and the large number of rabbits with pH values over 6 observed in this research (30.2% with an LD pH >6, 45.3% with a BF pH >6 and 26.4% with LD and BF pH values that are simultaneously >6) indicate that the rabbits were exhausted and their muscles fatigued by the hunt before

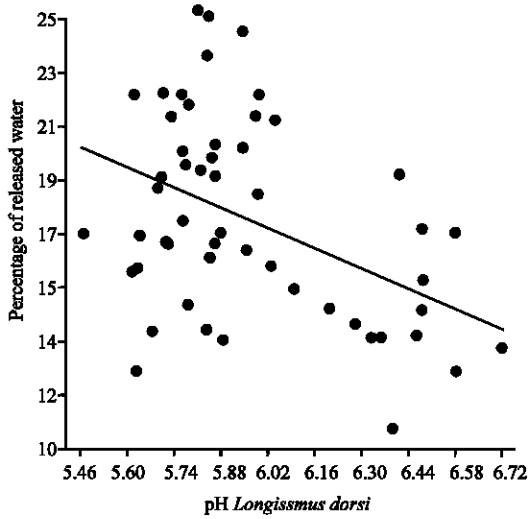

Fig. 4: Relationship between percentage of released water and pH of the Longissimus dorsi muscle (n = 53)

death and that during the chase and the stress it provoked the glycogen had been spent (Hulot and Ouhayoun, 1999) with the result that less lactic acid is formed than in domesticated breeds. Furthermore, as well as by a variability in ages, the variability of values observed in pH and in particular in WHC (Table 1) could be explained by the great differences between rabbits with regard to the chase and the stress involved in the hunt until death due to the fact that some rabbits will have suffered a long, hard chase while others will have been killed quickly.

It is possible that the higher pH and WHC values found in wild rabbit meat in comparison with the typical values found in rabbits from meat lines is due in great measure to the genetic differences between both types of rabbits. The wild rabbits in this experiment belonged to *O.c. algirus* subspecies, different to the *O.c. cuniculus* to which domestic breeds belong (Branco *et al*., 2000).

As well as the differences created by domestication, divergent selection where meat animals breeds and lines are selected according to the criteria of fast growth has had a negative effect upon pH (Hulot and Ouhayoun, 1999) and WHC and reduces them, something that Ramirez *et al.* (2004) attribute to the greater glycolytic metabolism in the selected rabbits muscles.

The notable differences in diet between wild and domesticated rabbits (Soriguer, 1981; Lebas *et al*., 1997) must also have influenced the differences in pH and WHC values of the wild rabbits in this experiment when compared with meat breeds it being known that in these latter, diet affects pH (Hulot and Ouhayoun, 1999; Pla, 1999). The greater motor activity in wild rabbits compared to that of domesticated rabbits might also give rise to the pH differences in their meat. This however, needs to be tested experimentally because it is unclear in which direction motor activity affects pH in meat breeds (Metzger *et al*., 2003).

CONCLUSION

In this study, via an ad-hoc experimental design, whether the differences in pH and WHC between wild and domesticated rabbit meat are due only to the stress suffered by wild rabbits during the chase or whether it also has a genetic basis. This would contribute to a better understanding of the instrumental properties of wild rabbit meat as a product differentiated from domesticated rabbit meat a meat that consumers familiar with game meats habitually prefer to meat from the domesticated animal (Gonzalez-Redondo, 2006; Gonzalez-Redondo *et al*., 2007, 2010).

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