# SOME RECENT FRENCH STUDIES ON RABBIT CARCASS AND MEAT QUALITY

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Since the last 2-3 years French rabbit scientists made a specific new effort to study the effects of breeding conditions on carcass quality and moreover on meat quality. The main reason of this effort is the hope of French rabbit producers to propose to the market a greatest variety of types of rabbits in order to increase the number of rabbit consumers: the wider is the supply quality, the greater should be the total bought quantity. The present paper will try to summarise these efforts. The synthesis will be divided in 2 main parts: one devoted to the effects of age and the second one to the effects of raising conditions during the fattening period.

## EFFECT OF AGE ON MEAT QUALITY

The first question, to which French scientists tried to answer, was the smallest age variation that can be detected through a sensory test. Effectively since the synthesis of Ouhayoun (1992), it's known that an age variation is the most easily attainable source of rabbit meat qualitative variation.

A first experiment was conducted with *longissimus lumborum* meat of commercial hybrid rabbits fed *ad libitum* and slaughtered at 8, 10, 12, 14, 16 or 18 weeks of age (Juin *et al*., 1998). The muscles were separated from the carcass and were individually cooked at 100°C in vacuum plastic bag introduced 30mn in a humid heat oven. The sensory test was conducted as a tripartite test, i.e. determination of a single sample out of three. The control muscles were those of 10 weeks old rabbits for all comparisons, and the challenge muscles were obtained from 8, 12, 14, 16 or 18 weeks old rabbits. The single sample was correctly determined in 60 to 75% of the tests (table 1). In all cases, this proportion was significantly different from the 33% one expected from a random distribution.

**Table 1: Results of tripartite tests conducted with *longissimus lumborum* muscles of rabbits slaughtered between 8 and 18 weeks of age** (according to Juin *et al*., 1998)

| Muscles of 10 weeks old rabbits *versus* | Number of correct determinations | Percentage | Probability |
|---|---|---|---|
| 8 weeks | 24 out of 40 | 60.0% | P < 0.01 |
| 12 weeks | 28 out of 37 | 75.7% | P < 0.01 |
| 14 weeks | 26 out of 36 | 72.2% | P < 0.01 |
| 16 weeks | 28 out of 38 | 73.7% | P < 0.01 |
| 18 weeks | 30 out of 44 | 68.2% | P < 0.01 |

It must be emphasised that the proportion of correct answers does not increase with interval of age.
This well standardised methodology applied on isolated *longissimus lumborum* muscle was able to distinguish 2 groups of rabbits with only 2 weeks of age variation. Nevertheless, the meat preparation (muscle separation before cooking) and cooking methodology are not "classical" for French rabbit consumers. It's why other cooking methods were tested.

Roasting of separated *longissimus lumborum* muscles on a grill pan, like a beefsteak, gave untasty dry meat (Juin *et al*., 1998). Series of test were conducted to estimate the optimal inside temperature of meat for sensory tests. Unlike beef or mutton meat for which minimum temperature is 60°C, for rabbit meat it was established that 80°C could be considered as a minimum.
The present methodology is cooking of half back part of carcass, i.e. half loin + perirenal fat + the corresponding hindleg. The half back is cooked at 100°C in vacuum bags until inside temperature arrive at 80°C, i.e. during a time length depending on weight of the piece (30 to 40 min for 10 to 14 weeks old rabbits). For the sensory test, cuts of *longissimus lumborum* muscle separated after cooking and cuts of hindleg muscles without bone are proposed to the panel of judges.
Meat samples of 10, 12 or 14 weeks old rabbits were compared in these conditions of preparation (Jehl and Juin, 1999). As for *longissimus lumborum* muscle separated before cooking, judges were able to distinguish meat of 12 or 14 weeks old rabbits from that of 10 weeks old ones, after tasting of loin or hindleg meat in a tripartite test (table 2)

**Table 2: Results of tripartite tests conducted with loin or hindleg meat of commercial rabbits slaughtered at 10 weeks of age (2.33 kg alive), 12 weeks (2.97 kg) or 14 weeks (3.45 kg)** (according to Jehl and Juin,1999)

| Meat of 10 weeks old rabbits *versus* | Number of correct determinations | Percentage | Probability |
|---|---|---|---|
| 12 weeks loin | 43 out of 82 | 52.4% | P < 0.01 |
| 12 weeks hindleg | 44 out of 82 | 53.7% | P < 0.01 |
| 14 weeks loin | 38 out of 73 | 52.1% | P < 0.01 |
| 14 weeks hindleg | 51 out of 73 | 69.9% | P < 0.01 |

This possibility of distinction between 2 classes of age is interesting, but does not indicate which of the sensory criterion is modified. Jehl and Juin (1999) tried to determine these criteria in a notation test conducted on the same rabbits (10, 12 or 14 weeks old). The judges have to establish a note from 1 to 10 for external criteria (odour, smooth aspect, dry aspect, colour) and according to the taste in mouth (tenderness, juiciness, floury sensation, smoothness) of meat samples (table 3).

**Table 3: Results of notation tests made with loin and hindleg meat of commercial rabbits slaughtered at 10, 12 or 14 weeks of age.** (according to Jehl and Juin,1999). See table 2 for slaughter live weights. For each criterion, 98 notes from 1 (low intensity) to 10 (high intensity).

| | **Hindleg** | | | | **Loin** | | | |
|---|---|---|---|---|---|---|---|---|
| **Age in weeks** | **10** | **12** | **14** | *Proba.* | **10** | **12** | **14** | *Proba.* |
| Odour | 5.3 a | 5.7 ab | 6.2 b | *< 0.01* | 5.4 a | 5.8 ab | 6.1 b | *< 0.01* |
| Smooth Aspect | 3.6 | 3.8 | 3.9 | *ns* | 3.7 a | 3.8 a | 4.2 b | *< 0.01* |
| Dry aspect | 5.5 | 5.6 | 5.7 | *ns* | 3.8 a | 4.2 ab | 4.4 b | *= 0.01* |
| Darkness | 4.7 ab | 5.2 a | 4.3 b | *< 0.01* | 3.8 | 3.9 | 3.4 | *= 0.02* |
| Tenderness | 6.3 | 5.7 | 5.9 | *=0.06* | 5.4 | 5.0 | 5.5 | *ns* |
| Floury sensation | 3.3 | 3.7 | 4.0 | *= 0.09* | 5.4 | 5.6 | 5.6 | *ns* |
| Smoothness | 5.3 | 4.7 | 5.0 | *= 0.06* | 3.7 | 3.4 | 3.6 | *ns* |
| Juiciness | 5.1 a | 4.6 b | 4.8 ab | *= 0.01* | 3.6 | 3.3 | 3.3 | *ns* |

The most important result is that differences were observed mainly for external criteria. For some criteria such as colour (darkness), a difference is observed between 12 and 14 weeks old rabbits but not between 10 weeks old one and any of the 2 others.

The consequences of age on sensory criteria estimated in notation tests was also measured with a greater variation of age : between 11 and 18 weeks (Juin *et al.,* 1998). In this case it must be noticed that tenderness was greater for older rabbits without significant variation of juiciness.

**Table 4: Results of notation tests made with *longissimus lumborum* meat of NZW rabbits slaughtered at 11 or 18 weeks of age.** (according to Juin *et al*.,1998) (36 determinations per age)

| Age | 11 weeks | 18 weeks | Probability |
|---|---|---|---|
| Tenderness | 5.03 | 6.89 | < 0.01 |
| Fibrousness | 6.53 | 5.33 | < 0.01 |
| Juiciness | 4.25 | 4.72 | ns |
| Floury sensation | 4.94 | 6.69 | <0.01 |
| Flavour | 6.36 | 6.42 | ns |

In addition to these sensory criteria, a study was made on the effects of age at slaughter on the conditions of utilisation of fresh meat, namely on exsudation during conservation and on cooking loss of loin slices (Delmas and Lebas, 1998). This experiment was conducted in relation with 2 additive points : 1/ with the increasing proportion of rabbit meat sold in France as cuts and no more as whole carcasses, and 2 / with some side remarks made about the "too great" exsudation observed in the commercialisation bags and claimed to be related to the "always decreasing slaughter age". Two centimetres thick slices were cut in the loin 24 hours after slaughter of 10 or 19 weeks old NZW rabbits, and weighted. These slices were stored 6 days at +2°C, weighted again and then cooked in plastic bags under vacuum at 100°c for 15 min. In opposition with the "expected" result, relative exsudation during storage was smaller for 10 weeks old rabbit than for 19 weeks old ones (table 5).

**Table 5 : Effect of age on exsudation during a 6 days storage at +2°C and on cooking loss of loin slices of NZW rabbits slaughtered at 10 or 19 weeks of age** (according to Delmas and Lebas, 1998)

| Age | 10 weeks | 19 weeks | Probability |
|---|---|---|---|
| - Slaughter live weight (kg) | 2.25 | 3.26 | < 0.001 |
| - Perirenal fat (% of carcass) | 1.65 | 4.20 | < 0.001 |
| - Carcass storage loss in 24h (% carc.) | 3.97 | 3.55 | = 0.009 |
| - Average weight of loin slices (g) | 38.4 | 49.7 | < 0.001 |
| - Exsudation after 6 d. (% fresh weight) | 1.47 | 1.69 | 0.019 |
| - Cooking loss (% of stored slice weight) | 33.7 | 32.1 | 0.009 |

As known from the literature, cooking loss decreased with age increasing, but no correlation can be established between storage exsudation and cooking loss within age or with all experimental rabbits considered together.

## EFFECTS OF RAISING CONDITIONS ON MEAT QUALITY

Different studies were conducted during the last few years, but not always linked together, and not always with the same criteria. It can be mentioned experiments on effects of sex, effects of feed restriction and and effects of raising condition (type of housing).

## Effect of sexual hormones

Males, females and castrated males were fed *ad libitum* until the age of 14 weeks and then slaughtered (Delmas *et al*., 1999). The castrated males were operated at 15 days of age. Shearing force of *longissimus lumborum* (LL) was determined with standard shearing apparatus and a Warner-Bratzler shear. Measures in relation with colour were taken on fresh cut surfaces of LL. The live weight was not influenced by the sex of rabbits (table6).

**Table 6: Effect of sex and castration on carcass and meat characteristics of 14 weeks old rabbits** (according to Delmas *et al*., 1999).

| | Females | Castrated males | Entire males | Probability |
|---|---|---|---|---|
| - Carcass weight (g) | 2117 | 2100 | 2076 | ns |
| - Perirenal fat (% carcass) | 3.77 | 3.79 | 3.39 | ns |
| - Hindleg cooking loss (%) | 23.4 | 23.01 | 23.5 | ns |
| - Triglycerides (% fresh LL meat) | 0.90 | 0.91 | 0.80 | ns |
| - Shearing force (Newtons) of LL | 39.3 | 37.4 | 45.3 | < 0.001 |
| - Luminosity (pale < dark) | 61.7 | 61.3 | 59.3 | = 0.007 |
| - Red colour (index -60 to +60) | 0.07 | 0.45 | 1.69 | < 0 001 |
| - Yellow colour (index -60 to +60) | 6.75 | 6.55 | 6.27 | = 0.060 |

LL = *longissimus lumborum* muscle

Sex or castration insignificantly modified carcass, cooking loss and *longissimus lumborum* chemical characteristics, even for traits relative to fatness. *Longissimus lumborum* muscle of castrated males or of females was less red and less pale than that of entire males. Moreover, LL muscle tenderness (low mechanical shearing force necessary to cut the muscle) was greater for females and castrated males than for entire males. It was conclude that if balance of sexual hormones has no external effect on carcass or meat appearance, it can significantly influence the internal structure of muscle, of *longissimus lumborum* muscle in the present case.

## Effect of feed restriction

**The aim of a first study** was to determine the effects of feed restriction during the final part of fattening on some carcass and muscle characteristics (Gondret *et al.,* 1999). From 11 weeks onwards NZW male rabbits were fed *ad libitum* (AL group) or received 70% of the voluntary feed intake (R group). At the same slaughter weight (2.9 kg) restricted rabbit were 3 weeks older than the AL ones. (18 *vs* 15 weeks). As expected, restriction induced of reduction of fatness indexes such as perirenal fat proportion (table 7). In both of the 2 tested muscles *longissimus lumborum* (LL) and *biceps femoris* (BF), feed restriction increased water content and decreased intra-muscular fat content. Muscular fibre size was not modified. Proportion of oxidative fibres was unaffected in the BF muscle whereas it was reduced (12 *vs* 17%) in LL muscle in R rabbits compared to AL rabbits. A decrease of intra-muscular fat is generally correlated with a lower muscle juiciness and/or tenderness. In the same manner a lower oxidative metabolism is correlated with lower water holding capacity of meat (Gondret and Bonneau, 1998). For these 2 reasons late feed restriction cannot be considered as a suitable technique for high quality rabbits production, despite the age increase for the same slaughter weight.

**Table 7: Effects of feeding level (*ad libitum* or 70% restriction) between 11 weeks of age and a common slaughter weight (2.9 kg), on carcass and muscle characteristics of NZW male rabbits** (according to Gondret en al., 1999)

| | Ad libitum | Restricted 70% | Probability |
|---|---|---|---|
| - Slaughter live weight (g) | 2905 | 2933 | ns |
| - Hot carcass weight (g) | 1910 | 1729 | < 0.001 |
| - Perirenal fat (g) | 43.8 | 11.7 | < 0.001 |
| *longissimus lumborum* | | | |
| - Water content (%) | 74.7 | 75.5 | < 0.01 |
| - Protein content (%) | 23.0 | 22.6 | ns |
| - Lipids content (%) | 1.2 | 0.9 | < 0.001 |
| - Average surface of fibres (µm²) (a) | 2698 | 2694 | ns |
| - Proportion of SDH+ fibres (b) | 16.9 | 11.8 | < 0.001 |
| *biceps femoris* | | | |
| - Water content (%) | 75.2 | 76.4 | < 0.01 |
| - Protein content (%) | 22.1 | 21.5 | ns |
| - Lipids content (%) | 1.6 | 1.1 | < 0.001 |
| - Average surface of fibres (µm²) (a) | 2526 | 2452 | ns |
| - Proportion of SDH+ fibres (b) | 21.0 | 20.0 | ns |

(a) average surface of transversal sections ; (b) proportion of fibres positively coloured after treatment of 10µm thigh muscle slices for observation of succinate deshydrogenase (SDH) activity.

**The aim of the second study** was to determine the effect of an initial feed restriction applied during the first 2 or 3 weeks after weaning, and followed by *ad libitum* feeding until the rabbits arrived at 2.4 kg of weight (Perrier, 1998). As in the previous experiment restriction level was 70% of *ad libitum* feeding. The expected result was a valorisation of the compensatory growth that is observed during the *ad libitum* feeding period placed after a restriction period. Nevertheless, in this experiment the compensatory growth was not sufficient and the fattening period was increased by 3 or 4 days for rabbits restricted during 2 or 3 weeks respectively (table 8).

**Table 8: Effects of the duration of the initial feed restriction period on carcass characteristics** (according to Perrier, 1998)

| | ad libitum feeding | restriction at 70% | | Probability |
|---|---|---|---|---|
| | | 2 weeks | 3 weeks | |
| - Slaughter weight (g) | 2380 | 2388 | 2376 | ns |
| - Age at slaughter (days) | 63 | 66 | 67 | - |
| - Commercial slaughter rate (%) | 57.2 a | 56.3 b | 56.2 b | < 0.001 |
| - Renal +Scapular fat (% carc.) | 3.02 a | 2.64 b | 2.56 b | < 0.001 |
| - Hindpart (% carcass) | 37.5 a | 37.6 a | 38.3 b | < 0.05 |
| - Meat to bone ratio (hindleg) | 6.30 | 6.34 | 6.19 | ns |

The initial feed restriction induced a lower slaughter rate and a modification of carcass composition: lower proportion of fat but higher proportion of hindpart (one of the first retail cuts). Before any conclusion, sensory determination of meat must be done.

**Effect of caging conditions**

In this experiment rabbits of both sexes were kept in classical wire mesh cages (7 rabbits per cage, 16/m²) or in larger pens with an outdoor part (64 rabbits per pen, 8/m²). Raising in pens reduced growth rate (Van der Horst *et al*., 1999). Live weight at 86 days was reduced by 14% (table 9)

**Table 9 : Effect of caging conditions of "*Normand*" rabbits on live weight at 86 days and carcass characteristics** (according to Van der Horst *et al.,* 1999).

| | Cages | Pens | Probability |
|---|---|---|---|
| - Rabbits per group | 7 | 64 | - |
| - Weight at 86 days (g) | 2657 | 2269 | < 0.01 |
| - Carcass weight (g) | 1617 | 1428 | < 0.01 |
| - Commercial slaughter rate (%) | 59.3 | 57.2 | < 0.01 |
| - Kidney fat (% carcass) | 2.8 | 1.8 | < 0.01 |

In addition, slaughter rate and adiposity were reduced. In a complementary experiment (unpublished), meat quality of NZW x Normand rabbits raised until 92 days in pen was compared to that of commercial hybrid rabbits slaughtered at 71 days for a similar live weight. Older rabbits raised in large pens have tenderer meat with a higher juiciness, both for loin meat and for hindleg meat (table 10).

**Table 10: Effects of the type of production on meat quality - additive sources of variation were type of caging, breed and age at slaughter**. Test of notation (notes from 1 to 10 for light to intense)

| | Pens of 64<br>+ 92 days<br>+ NZW x Normand | Cages of 7<br>+ 71 days<br>+ Comm. Hybrids | Probability |
|---|---|---|---|
| Carcass weight (g) | 1493 | 1364 | - |
| *Loin meat* | | | |
| - tenderness | 5.85 | 4.50 | < 0.01 |
| - juiciness | 3.26 | 2.15 | < 0.05 |
| - fibrousness | 3.35 | 4.50 | < 0.01 |
| - flavour | 5.08 | 5.04 | ns |
| - odour | 4.81 | 5.08 | ns |
| *Hindlegs meat* | | | |
| - tenderness | 6.81 | 4.50 | <0.001 |
| - juiciness | 5.81 | 5.08 | < 0.05 |
| - fibrousness | 3.31 | 4.15 | = 0.06 |
| - flavour | 5.00 | 5.04 | ns |
| - odour | 5.23 | 5.35 | ns |

It can be conclude that if the producers mixed different sources of variation of meat quality, it is possible to increase the number of qualitative types of rabbits proposed to the consumers, and the to expect an extension of rabbit meat market.

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