# The Effects of Spatial Restriction and Behavioural Deprivation on Meat Quality in Grain-Fed Veal Calves

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## Introduction

The development of intensive animal production systems has often resulted in more animals being raised in a limited space, which has in turn led to concerns about the welfare of animals raised in these systems. For example, it is presumed that veal calves raised in crates are more stressed than those raised in pens as a result of spatial restriction. In some previous experiments designed to test this hypothesis, animals raised in crates were not exposed the same conditions (e.g. tethering, flooring, siding, bedding), which may have confounded the experimental results and thus the conclusions drawn from them about potentially stressful effects of spatial restriction (for discussion, see Rushen, 1994). In order to evaluate whether spatial restriction is stressful for veal calves, it would be necessary to raise all animals under identical environmental conditions, with spatial restriction as the only variable factor.

We carried out such an experiment with grain-fed veal calves raised in crates or pens under identical environmental conditions and found that the growth rate was reduced in the group raised in crates (de Passillé and Rushen, 1995). This effect on growth rate indicated that spatial restriction was stressful for the calves. Since stress plays a well-known role in the production of dark, firm and dry (DFD) meat in cattle, we hypothesised that spatial restriction would also have an effect on the quality of the meat produced from these grain-fed veal calves. Therefore, the objective of this study was to examine the effects of spatial restriction on parameters of meat quality.

## Materials and Methods

Animals and housing: Experimental procedures were approved by the local animal care committee at the Lennoxville Dairy and Swine Research and Development Centre, which is itself monitored by the Canadian Council for Animal Care. Forty-eight Holstein bull calves were raised from 1 wk of age to market weight (approximately 255 kg) according to recommended codes of practice (Agriculture Canada, 1988). They were housed in two rooms of a single barn and were fed a mixture of whole corn plus protein supplement at 0900 h and commercial milk replacer once a day at 1300 h.

Treatments: The calves were housed individually in either crates (0.5 to 0.65 m wide x 1.8 m deep) or pens (2.1 m wide x 1.8 m deep). The width of the crates was progressively expanded as the calves grew in order to provide a relatively constant degree of spatial restriction over the experimental period. Thus, the width of the crates attained a maximum of 0.65 m by 111 days of age. Apart from their size, the pens and cages were identical, with solid concrete floors covered with wood shavings as bedding, and with sides constructed of iron bars allowing limited contact between calves. The pens and the crates were interspersed throughout each room in order to ensure that all calves were exposed to identical environmental conditions.

Slaughter and determination of meat quality: When calves reached the target slaughter weight of 255 kg, they were weighed at the research centre then shipped to a commercial abattoir. The hot and cold carcass weights were determined with the hide on. The dressing percent was calculated by dividing the carcass weight (hot or cold) by the liveweight at slaughter. The luminous reflectivity (lx) of the grading site on the *pectoralis major* muscle was determined using a Minolta grading colorimeter. Carcass grade was assigned at the abattoir by a trained grader. In the Canadian grading system for veal carcasses, both colour and the muscling are taken into account. Colour grades go from 1 to 4, with 1 being assigned to the palest carcasses. In addition, carcasses with good muscling receive a score of A, those with acceptable muscling receive a score of B, and those with inadequate muscling receive a score of C. These two factors combine to make ten possible grades (A1, A2, A3, A4, B1, B2, B3, B4, C1, and C2).

Statistical analysis: Data were subjected to an analysis of variance (ANOVA) using a general linear model (SAS, 1989). The model included housing as the main factor. Since this initial ANOVA revealed that the liveweight at slaughter was significantly different between the two groups, the carcass data (hot and cold carcass weights and hot and cold dressing %) were subjected to an ANOVA which included slaughter weight as a covariable.

## Results

Results from the statistical analyses of the data are presented in Table 1. Calves raised in crates tended to take longer to reach the target slaughter weight of 255 kg compared with those raised in pens ($P<0.10$), with some animals not even reaching that weight by the end of the experiment As a result, the mean slaughter weight of calves raised in crates was significantly lighter than that of calves raised in pens ($P<0.001$). There was no effect of housing on the hot and cold carcass weights nor on the hot and cold dressing percentages when data were adjusted for slaughter weight ($P>0.05$). Carcasses from calves raised in pens were paler at the grading site compared with carcasses from calves raised in crates ($P<0.01$). Despite this significant difference in carcass colour, the overall mean carcass grades did not differ ($P>0.05$).

## Discussion

As discussed by Rushen (1994), it is often difficult to establish whether or not certain management practices used in animal production have an impact on the welfare of the species in question. Reduced productivity is often taken as an indication that the animal's welfare has been compromised. We previously reported that the average daily gain was slower for the grain-fed veal calves raised in crates compared with those raised in pens (de Passillé and Rushen, 1995), suggesting that spatial restriction was indeed stressful for these animals. As can be seen from Table 1, this slower rate of gain also prolonged time to slaughter by five days, which would be expected to increase production costs.

In addition to these effects of housing on live animal performance, we also observed effects on the colour of the carcasses produced, with carcasses from calves raised in crates being significantly darker than those from calves raised in pens. This contrasts with the results of Terosky *et al.* (1996), who found no effect of crate width (0.56 m, 0.66 m and 0.76 m) on brisket colour in special-fed veal calves. However, the maximum crate width they used was only 10 cm wider than the crates we used, so likely all their calves were spatially restricted.

Our finding of an effect of spatial restriction on carcass colour suggests that muscle glycogen reserves were lower in calves raised in crates following transport to the abattoir, although the carcass pH was not determined. If glycogen reserves were shown to be reduced in the carcasses from calves raised in crates, it would suggest that they were affected to a greater degree by transport stress, which in turn would be an additional confirmation that their welfare was compromised. It should be noted, however, that although the change in carcass colour was significant, it was not of a great enough magnitude to influence the grade assigned the carcass. This could be attributed to the fact that the carcass colour, as determined by luminous reflectivity, is an objective measure, while the carcass grade is a subjective measure.

## Conclusions

Grain-fed veal calves raised individually in crates tended to take longer to reach slaughter weight than calves raised in pens. They also produced carcasses that were darker than those of calves raised in pens. These results suggest that spatial restriction represented a stress for grain-fed veal calves.

## References


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**Table 1. Effect of housing on live and carcass weights, dressing percent, colour and grade in grain-fed veal calves.**

| | Housing[z] | | | Significance[y] |
|---|---|---|---|---|
| | Crates | Pens | SEM[x] | |
| Age at slaughter | 182 | 177 | 2.0 | 0.097 |
| Slaughter weight (kg) | 250.7 | 259.3 | 1.6 | 0.0004 |
| Hot carcass weight (kg)[w] | 160.9 | 158.4 | 1.0 | 0.12 |
| Cold carcass weight (kg)[w] | 141.1 | 138.9 | 1.0 | 0.15 |
| Hot dressing %[w] | 63.1 | 62.1 | 0.4 | 0.12 |
| Cold dressing %[w] | 55.4 | 54.5 | 0.4 | 0.16 |
| Luminous reflectivity (lx)[v] | 39.5 | 43.0 | 0.8 | 0.003 |
| Canadian carcass grade[u] | 2.9 | 2.9 | 0.3 | 1.00 |

[z]Least-squares means; Crates = 1.17 $m^2$ per animal, Pens = 3.78 $m^2$ per animal.
[y]Probability of a significant effect due to housing.
[x]Standard error of the mean, n = 24.
[w]Means adjusted using slaughter weight as a covariable.
[v]Measured on the surface of the *pectoralis major* muscle (brisket) with a Minolta colorimeter; a higher reading indicates a paler muscle colour.
[u]A combination of muscling score (A, B, C) and Minolta colour score (1, 2, 3, 4). For carcasses receiving a muscling score of A or B, a Minolta colour score > 50 = class 1, 40 to 49 = class 2, 30 to 39 = class 3, and a colour score < 29 = class 4. For carcasses receiving a muscling score of C, a Minolta colour score > 40 = 1 and 39 or less = 2. For statistical analysis, carcass grades were transformed into numbers according to the following scale: a grade of A1 = 1, A2 = 2, A3 = 3, A4 = 4, B1 = 5, B2 = 6, B3 = 7, B4 = 8, C1 = 9, and C2 = 10.