EFFECT OF SIMULATED TRANSPORT CONDITIONS ON THE WATER-HOLDING CAPACITY OF FRESH BEEF AS DETERMINED BY VARIOUS METHODS

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SUMMARY

In two experiments, each involving 8 electrically stimulated and 8 non-stimulated Dutch Friesian cattle carcasses, the effects were studied of transport vibrations on water-holding capacity of fresh beef loins, as assessed by filter paper absorption and drip loss methods. Filter paper absorption measured at 1 day post mortem was positively correlated ($R^2 = 0.5$, $n = 48$) with drip, lost during 1 or two weeks refrigerated storage in poly-ethylene bags (method 1) and poly-propylene containers (method 2). These results suggest that the filter paper method may be useful to predict drip loss of stored beef. Simulated transport resulted in a significant increase of fluid absorbed by filter paper from the surface of stored, electrically stimulated beef loins. This suggests that the negative influence of transport vibrations depends on the intrinsic water-holding capacity of the muscle. On the basis of fluid absorption and its relationship with drip loss, the latter was estimated to be 0.36% per h transport. However, as this effect was not strong enough to be reflected in drip loss results, properly handled beef is not expected to be seriously affected by transport vibrations.

Introduction

The mechanism of drip formation has not been completely revealed yet, in spite of its economic importance. Primarily, drip formation can be explained by shrinkage of myofibrils, whereby fluid migrates to the extracellular spaces and gradually to the meat surface (Offer and Knight, 1988). The contribution of post mortem pH-fall, contraction of myofibrils and chilling rate to drip loss have been studied by many authors. However, the role of further processing factors like cutting, packaging, transport and storage have been less investigated.

Transport vibrations can occur when samples are transported by truck from the abbatoir to the laboratory, and have been suggested as factor to be taken into consideration.

Various methods have been provided for both assessment of drip loss of meat (e.g. Honikel, 1987; Lundström and Malmfors, 1985) and related phenomena like fluid absorption by filter paper (Kauffman et al., 1986). It would seem desirable to identify a standard procedure, by which optimum time interval between slaughter and evaluation of drip loss in scientific studies can be determined. Clearly, the rate of drip formation during storage has significance in industry practice too, as retail cuts are kept under refrigeration for various, extended periods.

Materials and Methods

The first experiment involved 8 electrically stimulated (68 V, 14 Hz, 15 s, immediately after bleeding) and 8 non-stimulated Dutch Friesian cow carcasses. The day after slaughter the *longissimus thoracis* was excised and divided into three parts of ± 1 kg each, which were randomly assigned to three groups. Two of these were exposed to transport simulation for 2.5 and 5 h respectively, the other group served as non-transported controls. Transport was simulated by laboratory agitator equipment (Janke and Kunkel Ika Labor technik KS500, 30-40 min^{-1}) at a temperature of 1 ± 1 °C. After transport simulation, muscles were sampled for determination of intramuscular fat content and water-holding capacity.

In a second experiment the same procedure was followed, with the exception that bulls were used and the electrical stimulation parameters were different (68 V, 14 Hz, 90 s).

Muscle pH was measured at 45 min, 3 and 22 h post mortem with a portable pH meter (type CG818, Scott Geräte, Hofheim, Germany), equipped with a combined (glass/reference) electrode (type N48A, Schott Geräte, Hofheim, Germany).

The amount of intramuscular fat was evaluated by visual score using a scale from 0 (no visible fat) to 5 (strong fatty infiltration). In the second experiment intramuscular fat was also determined by fat extraction with petroleum benzine.

The assessment of water-holding capacity was performed with the following methods:

1. Drip loss determined in slices of muscle of 70-100 g, which were weighed and suspended under atmospheric pressure in plastic pouches at a temperature of 1 ± 1 °C. At 3, 7 and 14 days post mortem weight loss was assessed. This method is referred to as D_{Ho} (Honikel, 1987).
2. Drip loss determined in slices of muscle of about 200-250 g, which were weighed and placed, with the cut surface facing down, in containers supplied with a net bottom at 1 ± 1 °C. At 3, 7 and 14 days post mortem weight loss was assessed. In the following this method is referred to as D_{Lu} (Lundström and Malmfors, 1985).
3. Kauffman's filter paper method, referred to as K_{Fr}, since filter paper is placed on a **fr**esh surface (Kauffman et al., 1986)
4. Absorption of fluid by filter paper from the cut **su**rface of loins stored for 1 or 2 weeks, referred to as K_{Su}.

Significance of differences between groups was tested with Student t-test and analysis of variance.

Results and Discussion

Effect of simulated transport vibrations and anatomical location

To study the influence of transport vibrations and anatomical location on water-holding capacity, two-way analysis of variance was conducted using drip loss data at 7 days post mortem, since at this time minimum error of measurement was found. Both D_{Ho} and D_{Lu} did not reveal any effect of transport, anatomical location or interaction between the two. Similar results were obtained for K_{Fr}. However, a negative effect of transport was suggested by the significant increase of K_{Su} of samples from electrically stimulated carcasses (Table 1). These results suggests that the effect of transport vibration depends on the intrinsic water-holding capacity of the muscle, but that this effect is not strong enough to result in noticeable differences in drip loss. On the basis of the relationship between fluid absorption and drip loss obtained by linear regression [D_{Lu} (%) = 0.057 K_{Su} + 0.967] the effect of transport vibrations on drip loss was estimated to be 0.36% fluid loss/ h transport.

Comparison of methods

The various methods for assessing water-holding capacity were compared with respect to time course, sensitivity (ability of the method to detect small differences) and accuracy (ability of the method to measure the real value). Drip loss was recorded up to 14 days post mortem (Fig. 1). The amount of drip increased, whilst the rate of drip formation decreased in the course of the storage. Fluid absorption by filter paper was applied on a fresh cut surface (K_{Fr}) and on the surface of the D_{Lu}-samples (K_{Su}) at 1 and 7 days post mortem (Fig. 2). The results of K_{Su} were rather variable. This may be due to an uneven surface of the meat blocks. In general, K_{Su} is expected to increase during storage, as expelled drip is partly accumulated on the surface of the sample. K_{Fr} decreased with the time. This may indicate that a higher total drip would result in a relative lack of free water in the deeper layer of the meat. The observation of van Laack and Smulders (1991), that K_{Fr} showed minimum value after 14 days storage of vacuum pork loins, seems to confirm this hypothesis. However, Kim et al. (1993) failed to detect any changes in water content of pork loins during storage time, but they did not take into account the protein- and salt content of the drip.

Table 2 includes the correlation coefficients of the relation between drip loss and filter paper measurements. K_{Fr} at 1 day post mortem was positively correlated with drip loss after storage. This finding suggests that application of the filter paper method may be taken into consideration to predict drip loss of stored beef. K_{Fr} and K_{Su} at 7 days post mortem were positively correlated with drip loss at this time. This indicates that the use of K_{Fr} and K_{Su} may be considered when evaluating water-holding capacity of stored beef.

The relative error of duplicate measurements was calculated by using the error component of variance ($\sqrt{\sigma^2}$duplicates) related to the average drip of 8 loin sections exposed to different slaughter * transport effects (Fig. 3). The relative error of D_{Ho} seemed to be higher than that of D_{Lu}. This may be caused by differences in sample thickness and weight between the two methods, since percentage of drip becomes less dependent on initial sample weight as thickness of the slice (Taylor and Dant, 1971) or sample weight (Zarate and Zaritzky,

1985) increases. The relative error of K_{Fr} and K_{Su} seemed to be comparable to that of drip loss measurements. The error of all methods decreased with increasing storage time. For D_{Ho} and D_{Lu} minimum errors were found at 14 days post mortem, while K_{Fr} and K_{Lu} showed lowest error at 7 days post mortem.

It is well known that the rate and extent of post mortem pH-fall affects the water-holding capacity of meat (Offer and Knight, 1988). Table 3 gives the correlation coefficients of this relationship for the various methods. The correlation between the pH at 45 min post mortem and the water-holding capacity was higher when assessed by K_{Fr} than by D_{Ho} and D_{Lu}. At 3 and 22 h post mortem, correlation coefficients for K_{Fr} and D_{Ho} were similar, while the correlation coefficient obtained for D_{Lu} is still lower. Apparently D_{Lu} is less sensitive in detecting small differences in water-holding capacity than are D_{Ho} and K_{Fr}.

Influence of intramuscular fat

Muscles with a high intramuscular fat score were found to release less drip (Table 4), which is in agreement with earlier findings (Lawrie, 1991). It was expected that this effect was due to the amount of fat itself, as drip loss is always calculated on the basis of total weight, i.e. including fat. If this hypothesis is true, differences in drip loss between animals (expressed by standard deviation) will become smaller if the amount of drip is calculated on the basis of fat-free weight. However, although drip loss calculated on the basis of fat-free weight was somewhat higher than drip loss calculated on the basis of total weight, standard deviations remained the same (Table 5). This means that other mechanisms by which intramuscular fat affects the water-holding capacity must play an important role.

Conclusions

Significant increase of fluid absorbed from the surface of stored stimulated beef suggests a negative effect of transport vibrations depending on the intrinsic water-holding capacity of the muscle. Since this effect was not strong enough to be noticeable as drip loss, properly handled beef is not expected to be seriously affected by transport vibrations.

The filter-paper method of Kauffman can be used to predict drip loss of stored beef. Appli-cation of the filter paper method in the course of the latter storage may be taken into consideration when evaluating water-holding capacity. The latter method seems to be more sensitive in detection of released fluid than determination of drip loss, while the accuracy was comparable. D_{Lu} was more accurate but less sensitive than D_{Ho}, K_{Fr} and K_{Su}.

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