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VARIATION IN WATER LOSS OF PSE PORK MUSCULATURE OVER TIME

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BACKGROUND: When water-holding capacity (WHC) of pork muscle is measured at 24 hr postmortem (PM), it is low for pale, soft and exudative (PSE) pork. However, when pork cuts were obtained from retail stores (usually 96 hr PM), we observed that WHC varied considerably for PSE and often the results resembled that of RFN pork (reddish pink, firm, non-exudative). Kim et al. (1993) indicated that WHC of PSE pork changes PM; during storage WHC tends to be normal, and suggested that exudation is a time-dependent process. However, it is not known what mechanism is responsible for this change in WHC. Van Laack and Smulders (1992) suggested that the change in drip loss is because the fluids contained in muscle can only be lost once. PSE meat looses drip early PM. Thus, at a later time PM there is a limited amount of fluid that may be lost as drip. In RFN pork, the source for potential drip loss remains and thus after 96 hr PM, RFN pork may loose similar or larger amounts of fluid than PSE pork. Alternatively, it may be that PM storage results in an actual increase of WHC (Hamm, 1972). These observations would suggest the hypothesis that WHC as expressed by % shrink of musculature at extended PM times may have improved, but another explanation is that excess fluids may have "leaked out". In the present study, the leaking out hypothesis was tested.

OBJECTIVE: The objective of this study was to investigate the variation in water loss of PSE pork musculature over time.

METHODS: Trial 1; Six commercial PSE pork loins were selected from a pork packing company at 24 hr PM. The *longissimus thoracis et lumborum* (LTL) was examined using 3 cm thick sections at 24 and 96 hr PM. Each section was tested for WHC by % drip loss (PDL) (Honikel, 1987), water-binding capacity (WBC) (Kauffman et al., 1994), total water content (TWC) (AOAC, 1990) and SDS-electrophoresis (Fritz et al., 1989). Lightness (L*), pHu and PDL values were used to select PSE pork as described by Joo (1994). To evaluate the differences between measures at 24 and 96 hr PM, data were analyzed by ANOVA using the General Linear Model (GLM) of SAS (1990). Trial 2; At 24 hr PM six commercial PSE pork loins were selected using pHu and the subjective appraisals of color and wetness (NPPC, 1991). For each loin the LTL (seventh thoracic vertebra to third lumbar vertebra) was used. The first and most cranial 3 cm thick section of LTL was dissected at 24 hr PM and tested for WHC, WBC, TWC and SDS-electrophoresis as described in trial 1. Also, after measuring PDL, the TWC was measured for this PDL sample. This procedure was repeated on sequentially caudal and adjacent sections at subsequent PM times of 42, 54, 66 and 90 hr. The potential effects of anatomical location on WHC were ignored. This was necessary because of the need for five different samples from the same muscle, and because it was impossible to obtain the paired muscle from the carcass. Similar statistical analysis as used in trial 1 was employed to assess the significance of differences.

RESULTS AND DISCUSSION:

Trial 1; Figure 1 includes the significant differences ($P < .05$) observed in WHC and WBC at two different PM times. No significant difference in TWC was detected. The WHC values as expressed by PDL at 24 hr were higher than 96 hr samples and the WBC values at 24 hr were lower than those at 96 hr. An example photograph of an SDS gel of the total, sarcoplasmic and myofibrillar protein fractions at 24 hr and 96 hr is shown in Figure 2. The gel patterns of these protein fractions were similar except the intensity of the sarcoplasmic protein factions at 96 hr was decidedly lower than at 24 hr.

Trial 2; Figure 3 graphically depicts the WHC improvement (decline in PDL) and WBC increase (% water uptake) over time. Although these two measures at 90 hr were significantly ($p < .05$) different from those at 24 hr, there was no significant ($p > .05$) difference until 66 hr PM. It was observed that these two measurements changed considerably after 66 hr PM. Figure 4 includes the changes in total water content in samples before and after drip loss over time. TWC was not changed over time but (as expected) it was always significantly lower after drip loss when compared to before drip loss. Examples of SDS-PAGE gels of the sarcoplasmic and myofibrillar proteins are shown in Figures 5 and 6. It was distinctly shown that the intensity of the sarcoplasmic protein fractions [especially phosphorylase (PH), creatine kinase (CK), triose phosphate isomerase (TPI) and myokinase (MK)] were reduced over time. There was little evidence that myofibrillar proteins were effected.

We observed that WHC and WBC of PSE pork increases over time PM, but these changes were not linear. The significant changes occurred after 66 hr PM. This was not in agreement with the results of Kim et al. (1993). They reported that the majority of the fluid was lost in the first 24 to 48 hours PM. Our results showed that the PDL was lower (an absolute 8.3%) and WBC was higher (an absolute 10.3%) after 66 hr PM. According to Offer and Cousins (1992), drip is thought to originate from the lateral shrinkage of muscle fibers PM and appears to accumulate in extracellular spaces. It is possible that the similarity of low WHC (high PDL) from 24 to 66 hr times PM may have been a consequence of continuous release of fluid from the myofilament lattice. At 90 hr PM, the WHC improved (4.4% decrease in PDL) and the WBC improved (18.6% increase in water uptake). These results suggest that even though some muscle proteins have been denaturated, the content of water which can be released from muscle as drip is limited. During the rigor period, firmly bound water remains constant but free or loosely bound water moves out of the myofibrils (Offer et al., 1989). According to Hamm (1986), most of the changes in the WHC of pork are not related to changes in the primary hydration shell.

There is little doubt that proteins are primarily responsible for the binding of water in muscle. Over the entire 90 hr PM time interval, gradual reduction of sarcoplasmic protein intensity in SDS gels was observed. Savage et al. (1990) observed that PSE drip contained less protein because of denaturation of specific proteins. Also, Joo (1994) observed that PSE muscles exhibited lower protein solubility compared to the other pork quality classes, and the sarcoplasmic proteins of PSE samples were precipitated onto myofibrils (as was observed earlier by Warner, 1994) and the precipitated proteins were PH, CK, TPI and MK. Monin and Laborde

(1985) suggested that the sarcoplasmic proteins play an important role in determining pork WHC and that precipitation of sarcoplasmic proteins may explain the increased drip in PSE. SDS-PAGE gels of the sarcoplasmic proteins distinctly indicated a reduction of some sarcoplasmic proteins, but we failed to detect any changes in myofibrillar protein fractions. The observations made in this study suggest that WHC of PSE pork changes over time PM and these changes are associated with sarcoplasmic protein changes. However, further research is necessary to explain the "leaking out" theory. The WHC of the musculature may have improved, possibly either through renaturation of the proteins or through expansion in the myofibrils with time PM (Hamm, 1972). Unknown factors such as changes in cations and anions or changes in protein structure due to protein renaturation may be involved in the apparent improvement of WHC.

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Legends to Figures: Fig.1. Changes in water loss over time postmortem (Trial 1). Different letters refer to significant difference ($p<.05$). (N=6)/ Fig.2. An example of an SDS-polyacrylamide gel patterns of total (T), sarcoplasmic (S) and myofibril (M) proteins at 24 and 96 hr PM./ Fig.3. Changes in water-holding and water-binding capacity over time postmortem. (N=6)/ Fig.4. Changes in total water content of muscle before and after drip loss measures. (N=6)/ Fig.5. An example of SDS-polyacrylamide gel patterns of sarcoplasmic proteins (Posphorylase=PH; Creatine kinase=CK; Triose phosphate isomerase=TPI; Myokinase=MK) over time postmortem./ Fig.6. An example of SDS-polyacrylamide gel patterns of myofibrillar proteins (Myosin=My; α-actinin=AA; Actin=A) over time postmortem.

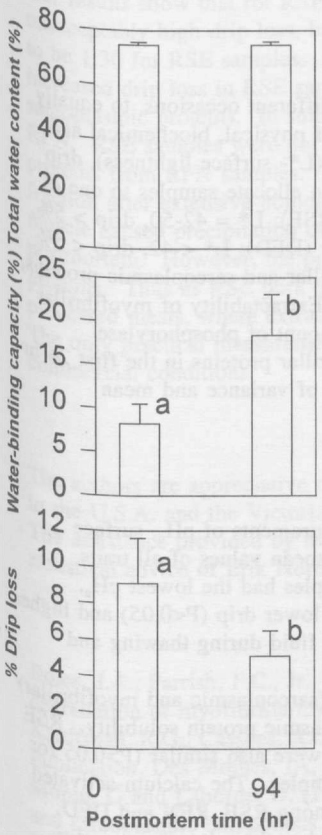

Figure 1.

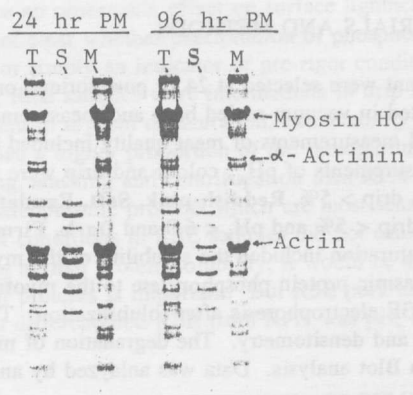

Figure 2.

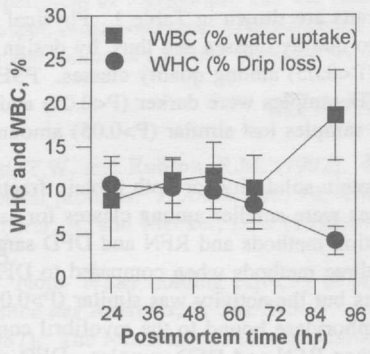

Figure 3.

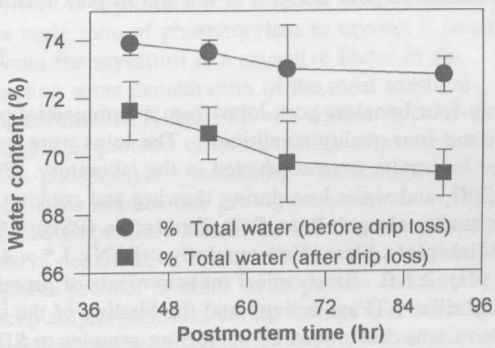

Figure 4.

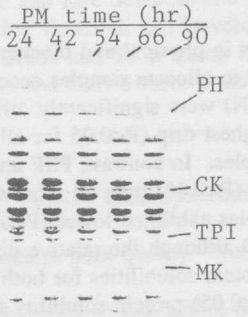

Figure 5.

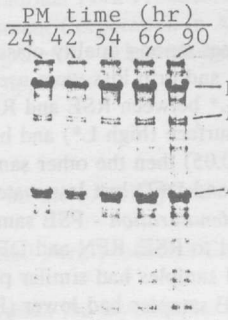

Figure 6.