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FACTORS AFFECTING THE DENATURATION OF MYOGLOBIN IN GROUND PORK PATTIES

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Background:
Color is an important attribute of meat quality and is affected by the chemical state and concentration of myoglobin. With intact muscle there is a predictable change in internal cooked color from red to pink to brown as endpoint temperatures increase. However, the internal cooked color of ground beef did not always correlate to endpoint temperature (Hague et al., 1994). Some patties turned brown prematurely at temperatures below those recommended by the USDA and FDA, whereas others remained pink even at safe endpoint temperatures. These abnormal cooked colors have been investigated only in ground beef. Lavelle et al. (1995) and Hunt et al. (1999) found that patties containing primarily oxy- or metmyoglobin formed a premature brown cooked color, whereas patties containing deoxymyoglobin remained persistently pink especially at higher pHs (Schoenbeck, 1998). Trout (1989) reported that pork and beef with pH>6 remained pink when cooked to 55 or 62°C, because myoglobin had not denatured. Machlik (1965) investigated the thermal stability of myoglobin in crude meat homogenates and reported that metmyoglobin denatured at the lowest temperature, oxymyoglobin at an intermediate temperature, and deoxymyoglobin at the highest temperature. These different denaturation temperatures and their interaction with pH could contribute to the occurrence of premature browning and persistent pink cooked colors. Myoglobin concentration is lower in ground pork than in ground beef; thus, the occurrence of abnormal cooked colors may not be obvious. This research investigated the effects of endpoint temperature, pork quality, cooking state (fresh or frozen), and myoglobin state on the denaturation of myoglobin.

Methods:
Inside ham muscles (semimembranosus and adductor) were selected to fill two quality levels, PSE and normal, based on pH and instrumental color measurements. Muscles were ground and then mixed with ground pork subcutaneous fat to achieve 20% and then were reground twice. One-half of the ground pork from both quality levels was immediately made into patties (114g) and frozen (-40°C) to preserve oxymyoglobin. The other half of the ground pork (both PSE and normal) was vacuum packaged and stored at 2°C for 48 hours to allow myoglobin to become fully reduced and deoxygenated. This ground pork was quickly made into patties, vacuum packaged, and stored at -20°C. One half of the patties that were PSE and normal and contained either deoxymyoglobin or oxymyoglobin were cooked from a frozen state, and the other half were cooked after thawing overnight at 2°C. Patties were cooked on an electric griddle to an internal temperature of 63, 66, 71, 77, or 82°C. Myoglobin was extracted from raw and cooked patties using the method of Warriss (1979) with slight modification. A 10-gram sample was blended with 10 volumes of a 40mM potassium phosphate buffer pH 6.8 for 60 seconds. The homogenized samples were stored at 4°C for 1 hour to facilitate myoglobin recovery. Samples then were centrifuged at 22,000 x g for 30 minutes. The supernatant was filtered through a 0.45 μm syringe filter, and the supernatant was scanned using a Hitachi Spectrophotometer U2010. Spectral data were collected from 300 to 700 nm. Peak positions were identified, and myoglobin concentration was calculated using the soret peak (418nm) for oxymyoglobin. If the peak positions indicated that myoglobin was not all oxymyoglobin, a reducing agent was added to ensure homogeneity, and the sample was rescanned. This study was replicated three times, and data were analyzed using standard statistical (SAS) procedures.

Results and Discussion:
Myoglobin denaturation for ground pork patties cooked from a frozen state to five internal endpoint temperatures is shown in figure 1. At the lower endpoint temperatures, both deoxymyoglobin and oxymyoglobin were more heat stable in normal quality patties than in PSE patties. This difference in thermal denaturation could be related to pH which was higher for normal pork (5.98) than for PSE (5.49). A higher pH can have a protective effect upon the denaturation of myoglobin (Trout, 1989). Furthermore, myoglobin from PSE muscles can be denatured more easily (Bembers and Satterlee, 1975). Myoglobin concentration also can play a role in the denaturation. The PSE patties had a myoglobin concentration of 0.70mg/g of tissue, whereas normal patties had 0.94 mg/g. At lower concentrations, myoglobin denatured to a greater extent at lower endpoint temperatures (Hawthorne, unpublished results). Myoglobin concentration and pH both may explain why myoglobin in PSE pork denatured to a greater extent at lower endpoint temperatures than that in normal quality patties.
Myoglobin denaturation is shown in figure 2 for ground pork patties cooked from a thawed state. These results differ from those for frozen patties. Myoglobin form had a greater effect on the thermal stability of myoglobin than did quality; the patties that contained deoxymyoglobin, both PSE and normal, were more heat stable than those containing oxymyoglobin. Hunt et al. (1999) also found greater denaturation of myoglobin in ground beef patties with oxymyoglobin compared with deoxymyoglobin.
Comparison of frozen and thawed patties showed little difference in the denaturation of myoglobin when the pigment was deoxymyoglobin and the quality normal. However, when the pigment was oxymyoglobin and the quality normal, the myoglobin was more heat stable in the frozen patties than in the thawed patties. This could have resulted because freezing disrupts tissues and membranes, and upon thawing, enzymes in damaged tissue are better able to contact their substrates, which can lead to an increase in enzyme activity. When normal patties containing oxymyoglobin are thawed, an increase in enzyme activity could occur. One of the enzymatic processes responsible for keeping oxymyoglobin reduced is metmyoglobin-reducing activity (MRA). Enzymes with MRA could be depleted during the thawing process because oxidation reactions are likely. Thus, less MRA is left in the patties containing oxymyoglobin when they are heated. Conversions to metmyoglobin during the cooking process would remain oxidized, thus lowering the myoglobin denaturation temperature. Myoglobin in frozen normal patties containing oxymyoglobin would not

denature as readily, because during heating, enzymes with MRA would still be available to keep oxymyoglobin reduced and limit conversions to metmyoglobin.

Only small differences occurred in the denaturation of myoglobin in normal patties containing deoxymyoglobin cooked from a frozen or thawed state. Deoxymyoglobin could not become oxygenated during thawing because patties were kept in vacuum, so no conversion to oxymyoglobin and no further conversion to metmyoglobin occurred. Enzymes with MRA were not needed, so the pigment remained deoxymyoglobin, which is the most heat-stable form.

Conclusions:

Myoglobin denaturation was affected by endpoint temperature, quality level, myoglobin state, and whether the patty was cooked from a frozen or thawed state. Patties made from normal pork that was cooked from a frozen or thawed state and contained deoxymyoglobin had the lowest myoglobin denaturation. PSE patties containing oxymyoglobin and cooked from thawed or frozen state had the highest myoglobin denaturation even at lower endpoint temperatures. PSE patties had a lower myoglobin concentration and a lower pH, which could have affected myoglobin denaturation. In the frozen patties, quality had a larger effect on denaturation than did myoglobin state. In thawed patties, myoglobin state affected denaturation more than pork quality, perhaps due to the thawing process and its effect on enzyme activity.

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Figure 1. Myoglobin denaturation in normal and PSE ground pork patties cooked from a frozen state

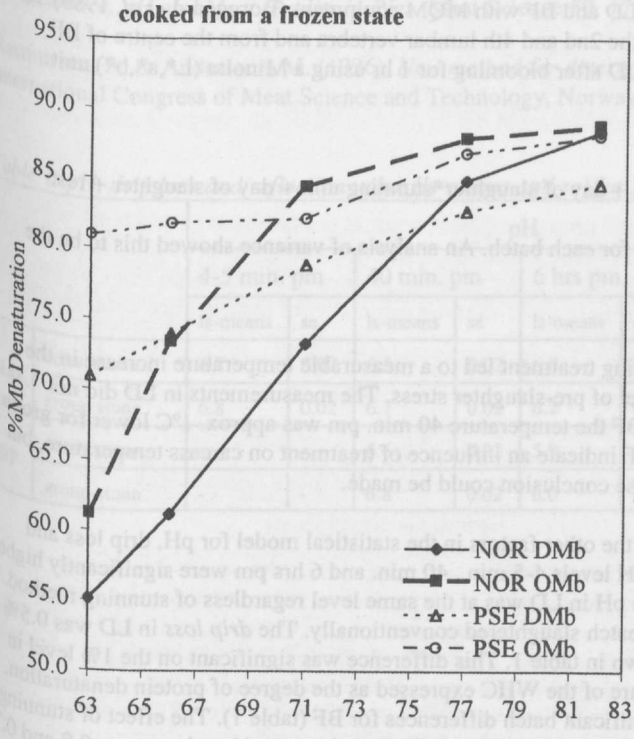

Figure 2. Myoglobin denaturation in normal and PSE ground pork patties cooked from a thawed state