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Influence of dietary creatine monohydrate and carcass cooling rate on colour characteristics of pork loin from different pure breeds

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Abstract

Increased creatine content in the muscle may delay postmortem (pm) lactate formation and postpone pH decline, hence potentially affect the colour of pork. The influence of dietary supplementation with 0 or 50 g creatine monohydrate (CMH)/d for 5 days prior to slaughter and two cooling rates of pig carcasses on the colour characteristics of pork loin from purebred Duroc and Landrace pigs was investigated. CMH increased the content of creatine phosphate in pork loin measured immediately following bleeding, delayed early pm pH decline and gave rise to less red and yellow colour, probably due to induction of a more pronounced oxidative muscle metabolism. A faster cooling rate pm induced darker and less yellow colour in loins from Duroc and Landrace pigs, while only loins from Landrace became less red. Loins from Duroc pigs were darker, less red and less yellow than loins from Landrace pigs, due to slower pH decline and a higher ultimate pH in these loins. Colour stability of pork loin during chill storage, measured as oxidation to metmyoglobin, was not affected by dietary CMH, cooling rate or pig breed. Consequently, the registered differences in colour between treatments during storage were merely due to the degree of initial blooming, and more attention to factors of importance for the degree of blooming should be in focus in future studies of factors of importance for meat colour.

Keywords: Pork; Creatine monohydrate; Cooling; Breed; Colour stability; Myoglobin species

1. Introduction

Creatine phosphate (CP) plays an important role as a muscle energy source from resting to exercise. It has been suggested that increased CP in porcine muscle may delay lactate formation and consequently postpone pH decline postmortem (pm). Dietary supplementation of creatine is shown to increase both CP and creatine levels in the muscle (Balsom, Söderlund, Sjödin, & Ekblom, 1995; Ceddia & Sweeney, 2003; Harris, Soderlund, & Hultman, 1992; Young & Young, 2002). CP is involved in oxidative ATP production in mitochondria (Bessman & Savabi, 1990; Wallimann, Wyss, Brdiczka, Nicolay, & Eppenberger, 1992), and in vitro studies have shown that creatine can increase the rate of respiration (Bessman & Fonyo, 1966; Field, Clark, Henderson, Seymor, & Radda, 1994) and shift the basal glucose metabolism towards oxidation and reduced lacate formation (Ceddia & Sweeney, 2003; Saks, Kongas, Vendelin, & Kay, 2000; Walsh et al., 2001).

Recently, feeding with creatine monohydrate (CMH) was found to improve the water-holding capacity in pork from purebred Duroc, while the opposite effect was noticed in pork from purebred Landrace (Young, Bertram, Rosenvold, Lindahl, & Oksbjerg, 2005). Feeding pigs with CMH in the period up to slaughter has also been reported to affect pork colour in several studies (Maddock et al., 2002; Stahl, Allee, & Berg, 2001), while other studies were unable to confirm this (Berg & Allee, 2001; O'Quinn et al., 2000; Stahl & Berg, 2003).

Both the rate and the extent of pH decline in pork muscles after slaughter have a profound effect upon colour

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characteristics of pork (Bendall & Swatland, 1988). Likewise, the combination of early pm pH and temperature influences the colour characteristics of pork (Lindahl, Henckel, Karlsson, & Andersen, in press). These phenomena can be ascribed to the influence of pH and temperature on the oxidation of the reduced myoglobin species, deoxymyoglobin (Mb) and oxymyoglobin (MbO_2), dominating the fresh meat surface (Andersen, Bertelsen, & Skibsted, 1988), the activity of oxygen-consuming enzymes (Ledward, 1992) and denaturation of proteins/enzymes (Lindahl et al., in press), which all affect the degree of blooming, colour stability and light scattering properties.

Moreover, the cooling regimes of carcasses have been shown to influence pork colour either through an effect of the rate of pH decline pm (Jones, Jeremiah, & Robertson, 1993; Milligan, Ramsey, Miller, & Thompson, 1998; Springer, Carr, Ramsey, & Miller, 2003) or of ultimate pH (Jones et al., 1993; Ohene-Adjei, Ellis, McKeith, & Brewer, 2002). In contrast, until now no studies have shown that cooling rate influences the colour stability of pork during retail display (Milligan et al., 1998), even though this might be expected considering the influence of enzymatic oxygen consumption on colour characteristics of meat (Ledward, 1992).

Different pig breeds produce meat with different colour. Thus, Duroc pigs are generally found to be darker and redder than pork from Landrace pigs (Cameron, Warris, Porter, & Enser, 1990; Candek-Potokar, Zlender, & Bonneau, 1998; Newcom et al., 2004). This could mainly be related to higher ultimate pH in pork from Duroc (Candek-Potokar et al., 1998; Newcom et al., 2004). As mentioned above dietary supplementation with CMH affects the water-holding capacity of pork from purebred Duroc and Landrace differently (Young et al., 2005). Considering that some of the same mechanisms also influence the colour characteristics of pork, the present study was set up to investigate the influence of dietary CMH and cooling rate on the colour characteristics of pork from purebred Duroc and Landrace, respectively, according to a $2 \times 2 \times 2$ factorial design.

2. Materials and methods

2.1. Animals and management

This study was part of a larger project described by Young et al. (2005). The experiment comprised a total of 36 female pigs, 18 purebred Danish Duroc pigs and 18 purebred Danish Landrace pigs. All pigs were from a certified breeding centre (Breeding centre Kollund, Herning, Denmark). The pigs were transported to the porcine facilities at the Danish Institute of Agricultural Sciences, Research Centre Foulum, 13 days before slaughter and penned in pairs. The pigs were stepwise introduced to the basal diet over the first seven days. Five days before slaughter the pigs were penned individually and allocated to the various treatment groups according to breed and bodyweight. The treatments consisted of the basal diet supplemented with 0 or 50 g creatine monohydrate (CMH)/d (Micronized creapure, Degussa Food Ingredients, D-85354 Freising, Germany). During the 5-day CMH supplementation period, the pigs were fed 2×1375 g basal diet or a diet supplemented with CMH, and the last meal was given 18 h before slaughter. The experiment was performed in 9 replicates including 2 treatments $\times$ 2 breeds $\times$ 2 cooling rates.

2.2. Slaughter procedure and sampling

On the day of slaughter, the animals were transported, with as little stress as possible, from the stable to the experimental slaughter plant (200 m) at the Danish Institute of Agricultural Sciences, Research Centre Foulum. Pigs were stunned by 80% CO_2 for 3 min, exsanguinated, scalded at 62 °C for 3 min, cleaned, and eviscerated within 30 min. Biopsies for analysis of phosphorous compounds were taken in *M. longissimus dorsi* at 4 cm from the last rib in the caudal direction at the time of exsanguination. The biopsies were frozen in liquid nitrogen and kept frozen at −80 °C until analysis. At 45 min pm the carcasses were placed at approximately 13 °C, and at 1 h pm one-half of the carcass (left and right randomised) was placed in a chilling room at 4 °C (slow cooling) and the other half in a freezer for 1 h at approximately −28 °C (fast cooling), and then transferred to a separate chilling room at 4 °C. At 24 h pm, 2 cm thick chops of the loin (*M. longissimus dorsi*) were cut across the fibre direction at 2 cm from the last rib in the caudal direction for colour measurements. Samples (100 mg) for analysis of pigment content were taken from the chop opposite the one for colour measurements.

2.3. Temperature and pH measurements

Temperature and pH were measured in the loin at the level of the last rib. Temperature was logged every min from 20 min until 24 h pm with temperature loggers (Stow-Away TidbiT, Bourne, MA, USA). Muscle temperatures measured at 30, 45, 60 min and then taken with 30 min intervals up to 6 h pm were included in the statistical analysis. Measurements of pH was carried out at 1, 15, 30, 45, 60, 120 and 1440 min (24 h) pm with a pH-meter (Radiometer PHM210, Copenhagen, Denmark) equipped with an insertion glass electrode (Model 704, Metrohm, Herisau, Switzerland) calibrated in buffers at pH 4.01 and 7.00 (Radiometer, Copenhagen, Denmark) at 35 °C for all measurements up to 1 h pm and up to 2 h pm for slow-cooled carcasses. In fast-cooled carcasses, pH calibration was performed at ambient temperature in the period 1–2 h pm, while pH calibration for measurements carried out 24 h pm and thereafter was performed at 4 °C. The average of two measurements was used.

2.4. Colour measurements

The 2 cm chops were allowed to bloom for 1 h at 4 °C before the colour was measured using a Minolta CM-