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ScienceDirect
Meat Science 79 (2008) 806–816
MEAT SCIENCE
www.elsevier.com/locate/meatsci

The significance of diet, slaughter weight and aging time on pork colour and colour stability

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Received 20 June 2007; received in revised form 19 November 2007; accepted 19 November 2007

Abstract

The objective of the present study was to investigate the effect of a diet with a low content of digestible starch, slaughter weight and subsequent aging time on meat colour and colour stability. Pork colour was determined as the extent of blooming of *M. longissimus thoracis* (LT) and *M. semimembranosus* (SM) after 1, 2, 4, 8 and 15 days postmortem and as colour stability during a subsequent storage period in air for 6 days. Compared to the control diet, the experimental diet resulted in a significantly lower postmortem muscle temperature (1 °C; $p < 0.0001$). Moreover, high slaughter weight (110 kg) resulted in a higher postmortem temperature in LT ($p < 0.001$) compared to low weight (85 kg). Independent of feeding strategy and slaughter weight, the extent of blooming decreased during the first 2–4 days of aging in LT, however, the effect was more pronounced in meat from experimentally fed pigs and pigs with high slaughter weight. This effect was not seen in SM, where a gradual increase in blooming took place throughout the aging period. The colour stability was found to be superior in aged pork from experimentally fed pigs. The discoloration rate was faster in SM compared to LT. In conclusion, the present study shows that the diet composition can be used as a tool to control meat colour and colour stability in pork.

Keywords: Pork; Colour; Diet; Aging time; Colour stability

1. Introduction

Consumers relate the colour of the meat to the overall quality and especially with freshness. Meat is often prepacked prior to retail display. During extended retail display, discoloration of the meat takes place and the surface of the meat changes from bright cherry-red to greyish-brown. Even limited accumulation of the oxidized meat pigment metmyoglobin (MetMb) gives rise to the appearance of the greyish-brown colour on the surface of the meat. This has pronounced impact on consumer perception in the buying situation, as they associate this with non-fresh products (Johnson, Romans, Muller, Costello, & Jones, 1990; Kim, Han, Joo, & Lee, 1999).

The distribution and amount of myoglobin species, deoxymyoglobin (Mb), oxymyoglobin (MbO_2) and metmyoglobin (MetMb) together with internal reflectance influence the colour of the pork (Ledward, 1992). Upon exposure to oxygen, the fresh meat surface changes colour from purple to bright cherry-red. This is termed blooming, where Mb becomes oxygenated to MbO_2 (Govindarajan, 1973). The thickness of the oxymyoglobin layer depends on the oxygen partial pressure and temperature together

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0309-1740/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.meatsci.2007.11.015

with the pH, which influence the activity of oxygen-consuming enzyme systems and metmyoglobin-reducing activity, and both are of great importance for meat colour and colour stability (Mancini & Hunt, 2005). The extent/rate of blooming of the meat surface has been reported to increase during aging due to continuous inactivation of oxygen-consuming enzymes (Lindahl, Karlsson, Lundström, & Andersen, 2006; Zhu, Bidner, & Brewer, 2001). However, the subsequent discoloration rate of prior aged meat has been reported to be higher compared to non-aged meat due to loss of reducing activity over time postmortem (Ledward, 1992).

The colour of the pork is influenced by many mutual, intrinsic interactions (e.g. breed, gender, age, type of muscle) and extrinsic factors (e.g. feeding, pre-slaughter handling, slaughtering). Especially, the influence of these factors on early pH/temperature progress in muscle is known to affect fresh meat colour characteristics (Lindahl, Karlsson et al., 2006; Lindahl, Henckel, Karlsson, & Andersen, 2006). Dietary supplementation with some nutrients i.e. magnesium, vitamin D3, vitamin E, vitamin C, creatine in the finishing feeding has been reported to affect pork colour in a few studies (Gebert, Bee, Pfirter, & Wenk, 1999; Hoving-Bolink, Eikelenboom, van Diepen, Jongbloed, & Houben, 1998; Maddock et al., 2002), however, most studies have not found any influence on meat colour and stability (Berg & Allee, 2001; Cannon et al., 1996; Geesink et al., 2004; Lawrence et al., 2006). Recent studies have shown that strategic finishing feeding of pigs with diets low in digestible carbohydrates alters glycogen stores within the muscle and the subsequent progress in postmortem processes (Rosenvold, Essen-Gustavsson, & Andersen, 2003b; Rosenvold, Lærke, Jensen, Karlsson, Lundström, & Andersen, 2001). Such a strategic feeding procedure results in a darker and less intense colour of *M. longissimus thoracis* (LT) (Rosenvold et al., 2001; Tikk, Tikk, Karlsson, & Andersen, 2006). Moreover, increasing slaughter weight of the animals has been shown to affect pork colour characteristics (Beattie, Weatherup, Moss, & Walker, 1999; García-Macías et al., 1996; Latorre, Lazaro, Valencia, Medel, & Mateos, 2004). Even small differences in postmortem pH/temperature process have been reported to affect colour characteristics by influencing the activity of oxygen-consuming/metmyoglobin-reducing enzymes, denaturation of proteins/enzymes (Lindahl, Henckel et al., 2006) and the metmyoglobin-reducing activity (MetMbRA), known to be decisive for meat colour characteristics (Bekhit & Faustman, 2005; Zhu & Brewer, 1998).

The objective of the present study was to investigate the effect of a diet with a low content of digestible starch, which is reported to affect postmortem muscle metabolism, and slaughter weight on meat colour and colour stability. Pork colour was determined as the extent of blooming of chops from *M. longissimus thoracis* (LT) and *M. semimembranosus* (SM) after 1, 2, 4, 8 and 15 days of aging and colour stability during subsequent air storage for up to 6 days.

2. Materials and methods

2.1. Animals and treatments

Eighty crossbred slaughter pigs (Duroc boars and Danish Landrace × Danish Yorkshire sows) originating from 20 litters were reared at the experimental farm at the Aarhus University. In each litter there were two females and two castrates. Forty control pigs were given a standard grower-finishing feed, which mainly consisted of barley (55%), soybean meal (20%), wheat (20%), and sugar beet molasses (1%), and forty experimental pigs were given a diet with a low content of digestible starch, which consisted of high levels of grass meal (24%), rape seed cake (36%), dried sugar beet pulp (25%), soybean meal (7%), animal and vegetable fat (6%). In tables and figures the diets are referred as control feed and experimental feed, respectively. In addition, two pigs from each litter were slaughtered at high slaughter weight (live weight of 110 kg) and two pigs at low slaughter weight (live weight of 85 kg). This resulted in a 2 (feed) × 2 (sex) × 2 (slaughter weight) experimental design. The littermates were distributed equally according to sex and slaughter weight, but not as regards feed. The experimental diet was offered to the experimental group at a live weight of approximately 90 and 60 kg, respectively, with an initial 1-week adaptation period gradually changing from the standard grower-finishing diet to the experimental diet, as described by Rosenvold et al. (2001). The control pigs were given a standard grower-finishing diet during the whole experiment until slaughter. The feed withdrawal before slaughter for experimental pigs was 48 h, during which time the animals had free access to water.

2.2. Slaughtering and pH/temperature measurements

On the day of slaughter, the pigs were transported (200 m) from the stable to the slaughterhouse, where they were rested for minimum 30 min, before they were brought up individually to the stunner. The pigs were stunned by 80% CO_2 for 3 min, exsanguinated, scalded at 62 °C for 3 min, cleaned and eviscerated within 30 min. pH ($pH_{45\ min}$) and temperature ($T_{45\ min}$) were measured 45 min postmortem inside *M. longissimus thoracis* (LT) at the last rib and in the deep portion of *M. semimembranosus* (SM). Subsequently, the carcasses were placed in a chill room at 4 °C, and the day after slaughter, pH ($pH_{24\ h}$) and temperature ($T_{24\ h}$) were measured. The temperature was measured with a Testo 110 thermometer (Testo Gmbh 6 Co., Germany), and the pH was measured with a PHM201 pH Meter (Radiometer, Denmark) equipped with Methrom LL combined pH penetration electrode (Switzerland). The pH electrode was calibrated in pH 4.01 and 7.00 IUPAC buffers, equilibrated at 35 °C for the measurements on the warm carcasses at 45 min postmortem and at 4 °C for the measurements on the cold carcasses at 24 h postmortem.