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Compensatory growth response as a strategy to enhance tenderness in entire male and female pork *M. longissimus thoracis*

Sandra Stolzenbach [a,*], Margrethe Therkildsen [b], Niels Oksbjerg [b], Rikke Lazarotti [a], Per Ertbjerg [a], René Lametsch [a], Derek V. Byrne [a]

[a] Department of Food Science – Sensory Science, Faculty of Life Sciences, University of Copenhagen, Rolighedsvej 30, DK-1958 Frederiksberg C, Denmark

[b] Department of Food Science, Faculty of Agricultural Sciences, University of Aarhus, Blichers Allé 20, P.O. Box 50, DK-8830 Tjele, Denmark

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ABSTRACT

The effects of restrictive feeding strategies aimed at promoting a compensatory growth response were investigated with respect to tenderness improvement in pork *M. longissimus thoracis.* Compensatory growth response is defined by increased weight in pigs fed *ad libitum* after a period with restricted feeding compared to pigs fed *ad libitum* the entire fattening period. Specifically, the aim was to study the sensory textural characteristics after female and entire male pigs have been exposed to restrictions in either energy, protein or both in specific growth periods. It was found that textural differences were caused by feeding strategies and not related to variation in intramuscular fat, which did not vary significantly between genders. The female pigs demonstrated compensatory growth response and the texture was significantly ($P < 0.001$) improved by low dietary level of energy from day 50 to 90 and normal dietary level of protein during the entire feeding period. For the entire male pigs, low level of protein in the late feeding period significantly ($P < 0.05$) improved the texture. Also, low level of protein and normal level of energy in the early feeding period resulted in improved tenderness. However, these texture improvements were deemed not to be an effect of compensatory growth since the entire male pigs did not compensate for the feeding restriction in the early feeding period. The tenderness enhancement for the entire male pigs compromised the production results in terms of 7–15% lower carcass weight.

1. Introduction

Feeding strategies have been actively used as a management factor in the production of meat and in relation to improvement and/or control of e.g. performance, animal welfare, nutritional value, eating quality and technological quality (Andersen, Oksbjerg, Young, & Therkildsen, 2005). One of these feeding strategies is designated compensatory growth. Compensatory growth was first defined by McMeekan (1940) who found increased weight in pigs fed *ad libitum* after a period with restricted feeding compared to pigs fed *ad libitum* the entire fattening period. Later the phenomenon of compensatory growth was confirmed by Chiba (1994, 1995), Fabian et al. (2002) and Prince, Jungst, and Kuhlers (1983). Oksbjerg, Sørensen, and Vestergaard (2002) suggested that compensation in growth was related to an increase in muscle protein synthesis which was causal in the so called 'compensatory growth response'. Subsequent to slaughter, the protein synthesis stops, but some protein degradation processes will continue. An increased proteolytic activity at the time of slaughter leads to an optimisation of the tenderness development since the up-regulated activity affect the *postmortem* protein degradation (Hansen, Therkilden, & Byrne, 2006; Kristensen, Therkildsen, Aaslyng, Oksbjerg, & Ertbjerg, 2004; Kristensen et al., 2002). As tenderness is considered by consumers to be one of the most important quality characteristics of meat (Bredahl, Gunert, & Fertin, 1998; Bredahl & Poulsen, 2002; Tornberg, 1996), it is of interest to optimise methods to enhance tenderness development. Since compensatory growth feeding studies including female pigs have shown that restricted feeding followed by *ad libitum* diet lead to increased tenderness of the meat (Kristensen et al., 2002, 2004), compensatory growth promoting strategies with a view to tenderness enhancement in pork meat could be a suitable method to produce more tender pork meat. In a literature survey by Oksbjerg and Therkildsen (2007), it was suggested that the maximal compensatory growth response was about 70–90 g/day for 50 days. Thus, full compensation was obtained when the restriction period resulted in a reduced body weight of 5 kg corresponding to a reduced daily gain of 80 g/day. However, in contrast to restrict the gain of pigs by feed allowance, it is possible to restrict gain by an imbalance between dietary protein and energy during *ad libitum* feeding. Thus, it is hypothesised that the textural properties of pork meat could be improved by

* Corresponding author. Tel.: +45 3533 3656; fax: +45 3533 3509.
E-mail address: sandrasn@life.ku.dk (S. Stolzenbach).

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exposing pigs to restrictions in either energy, protein or both in specific growth periods.

As a basis for the present study, choice of animals has been considered. It has earlier been found that gender had greater influence on objective measurements of pork quality than genotype (Channon, Kerr, & Walker, 2004). Thus, it was of interest to focus on different genders of the same genotype. Meat from entire male pigs has a lower intramuscular fat (IMF) content than meat from castrates and female pigs (Bonneau & Squires, 2004). Channon et al. (2004) found that entire male pigs were found to have a significantly ($P < 0.001$) lower IMF than female pigs. As IMF is positively correlated to tenderness (Fernandez, Monin, Talmant, Mourot, & Lebret, 1999; Kristensen et al., 2002; Teye et al., 2006; Wood et al., 2004), meat from entire male pigs may produce less tender meat. This statement is proved by Channon et al. (2004) who demonstrated that meat from entire male pigs resulted in higher Warner–Bratzler shear force value and was evaluated as tougher than meat from female pigs. In addition, castration may be banned in a few years due to ethical concerns about animal welfare (Gunn et al., 2004). This will especially affect the organic pork production systems in Denmark. Thus, entire male pigs were included to investigate if compensatory growth could be a potential method to reduce toughness in meat from entire male pigs. Female pigs were included as reference. Overall, the aim of the present study was to examine the effect of feeding strategies including restrictions in either energy, protein or both in specific growth periods to induce compensatory response in entire male and female pigs and improve the sensory tenderness of pork meat. The magnitude of sensory textural changes of the pork meat resulting from the various feeding strategies was evaluated through sensory profiling on *M. longissimus thoracis*. Further, IMF was measured since it allows determination and separation of the effects of the restrictive feeding strategies versus IMF with respect to tenderness improvement such as it can be investigated whether the textural differences are induced by the restrictive feeding strategies leading to compensatory growth or fat content in each gender muscle.

2. Materials and methods

2.1. Experimental design

The pigs were treated in accordance with the guidelines outlined by The Danish Inspectorate of Animal Experimentation. Ten litters of each four female and four entire male pigs of the breed (Landrace × Yorkshire) × (Duroc) from the abattoir production line at The Faculty of Agricultural Sciences, University of Aarhus, were included in the experiment. From day 28 to 49, the pigs were fed a weaning diet and kept in litters until they entered the experiment at day 50. The experiment consisted of a 2 × 2 × 2 factorial design for each gender including two feeding levels of protein, two feeding levels of energy in the early feeding period from day 50 to 90 and two feeding levels of protein in the late feeding period from day 91 to 112 (Fig. 1). At day 50, the pigs were within litters dispersed with one female pig and one entire male pig per treatment to elucidate if the genders respond differently on compensatory growth. Within gender, the pigs were dispersed concerning the weight – the average starting weight within the four groups of treatment was the same. The four different feeding treatments in the early feeding period consisted of; control (NN) containing normal levels of both protein and energy, protein restriction (LN) containing 80% of digestible amino acids of the control diet, energy restriction (NL) with the net energy reduced to 80% of the control diet or both protein and energy restriction (LL). From day 91 to 112, half of each group was fed *ad libitum* with a normal level of protein (N) and the other half was fed with a low level of protein (L) with a diet containing 25% less protein than required in that period. From day 112 to 150, all the groups were fed *ad libitum* with a standard diet for finishing pigs. The body weight of the pigs at day 90 was recorded. Seven animals were removed from the experiment due to illness or death.

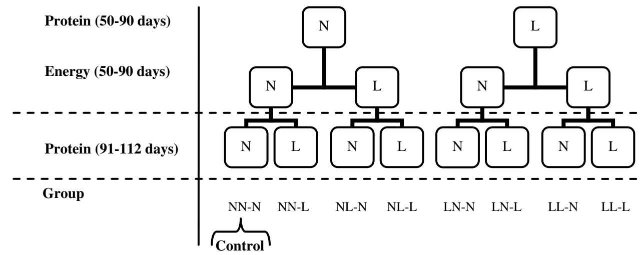

Fig. 1. Experimental design of the compensatory feeding strategies. N: normal level of feeding; L: low level of feeding (restricted feeding). Example: NL-N = normal level of protein and low level of energy from day 50 to 90. Subsequently, normal level of protein in day 91–112. This design was performed on both the female and entire male pigs. Ten litters of each four female and four entire male pigs were included in the experiment.

2.2. Slaughtering

At day 150, the pigs were slaughtered in random order within the litters at an average weight of 115 kg. The entrails were removed and the carcass was split, chilled for 1 h *postmortem* at 12 °C and stored at 4 °C until next day. The cold carcasses were weighed for comparison with the body weight at day 90 to determine if the pigs responded to the restrictive feeding strategies. Samples from *M. longissimus thoracis* (LT) from 4th to 15th rib were vacuum-packed and stored at 4 °C for two days before storing at −21 °C.

2.3. Sensory profiling

2.3.1. Sample preparation

The LT muscles were held at room temperature for 4 h before cutting. The LT muscles were unwrapped and sliced (Bizerba VE8 slicer, Bizerba, Germany) into 15 mm thick chops (producing 10 chops). The pork chops were vacuum-packed and stored at −20 °C. The vacuum-bags were coded and numbered such as each panellist received samples from the same longitudinal and transverse position within the muscles.

The samples were thawed at 5 °C for 19 h prior to cooking. Three hours before cooking the pork chops were placed in serving order on a new tray (wrapped with film) and covered with film and placed at 5 °C until cooking. The pork chops were cooked in convection oven set to 150 °C, 4 min a side. The core temperature was monitored and the final internal temperature was 65 °C. For serving, the samples were placed on preheated (50 °C) plates and covered with foil to maintain serving temperature. The time from removing the samples from the oven to serving was a maximum of 2 min.

2.3.2. Descriptive sensory vocabulary development and profiling

Prior to sensory profiling, the sensory panel was trained with reference to the texture profile method (ISO 11035, 1994; Meilgaard, Civille, & Carr, 1999) and participated in development of a sensory vocabulary to describe and discriminate the textural effects from the feeding treatments. Five texture terms (Table 1) were developed via collaboration between the panel leader and 10 panellists (Byrne, Bak, Bredie, Bertelsen, & Martens, 1999a; Byrne, Bredie, & Martens, 1999b). The training took place over four sessions of each 2 h and focussed on the span in texture variation of 25 animals. Fifteen centimeters unstructured line scales an-