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The relationship between selected physiological post-mortem measures and an overall pig welfare assessment from farm to slaughter

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ABSTRACT

On the day of slaughter, stressors associated with the handling, transport and lairage of pigs may have a significant impact on animal welfare. A welfare assessment based on the Welfare Quality® (WQ®) principles involving 480 pigs from 12 different commercial herds and including behavioural, clinical and physiological measures was carried out from farm to slaughter with the aim of investigating the relationship between selected post-mortem physiological measures and an aggregated animal welfare index (AWI). Blood temperature was quantified at exsanguination, and a blood sample collected at exsanguination was analysed for plasma concentration of glucose, lactate, albumin, total protein and creatine kinase activity. pH was measured 45 min after sticking in the *m. longissimus dorsi* (LD).

All welfare measures were categorised on a three-point scale (mild level: 0, moderate level: 1, severe level: 2) and aggregated into an AWI using a weighted (based on expert opinion of 38 experts) linear sum of prevalence on animal level. An overall AWI ($AWI_{Overall}$) and an AWI per stage (AWI_{Stage}) were calculated. For $AWI_{Unloading}$, significant relationships with the plasma concentration of glucose (positive), creatine kinase activity (positive) and total protein (negative) content of the blood were found. Furthermore, significant positive relationships between AWI_{Race} and the plasma concentration of lactate and albumin were found. Based on the current data, we suggest one method to identify AWIs above vs. below a certain threshold using the post-mortem measures with AWI_{Race} and lactate as an example.

In conclusion, physiological post-mortem measures may, after the development of technological solutions for implementation at abattoirs, be used in daily operations as on-site tools for systematic monitoring of welfare of finishing pigs in order to document the level of welfare.

1. Introduction

On the day of slaughter, stressors associated with handling, transport and lairage may have a significant impact on animal welfare and meat quality (Edwards et al., 2010a; Hambrecht et al., 2004; Støier et al., 2001). To maintain a high level of animal welfare monitoring is necessary, in order for the abattoir staff to locate and correct the cause of inexpediencies for the subsequent batch of pigs. Welfare assessment of finishing pigs at an abattoir can be carried out using the Welfare Quality® Protocol (Welfare Quality®, 2009). However, this approach is time-consuming (Dalmau et al., 2009) and is therefore not suitable for systematic monitoring of animal welfare under commercial conditions.

Recently, we used a protocol inspired by the Welfare Quality® (WQ®) and supplemented with post-mortem physiological measures to demonstrate a relationship between the handling of the pigs, their behaviour in the race to the stunning chamber and the exsanguination blood content of lactate and glucose (Brandt et al., 2013) as measures of fatigue. These results were supported by earlier findings of increased plasma lactate concentration in pigs that, compared with control pigs, experienced jamming, backing up or rearing immediately prior to slaughter (Edwards et al., 2010b). One typical measure of pig welfare at slaughter is skin damage, which has been shown to correlate with the plasma content of creatine kinase (Barton Gade, 2008; Brandt et al., 2013), the latter known to increase in humans as a result of tissue damage or muscular effort (Brancaccio et al., 2007). Hence, creatine kinase measured in the exsanguination blood may be used as an indicator of those aspects of welfare that are related to tissue and muscle damage in pigs on the day of slaughter.

Other physiological measures may also be relevant as indicators of welfare in pigs on the day of slaughter, e.g. total plasma protein

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and albumin (Averos et al., 2007; Knowles and Warriss, 2000), which are linked to dehydration and the plasma concentration of cortisol (Dokmanovic et al., 2014) which is linked to stress. Results from earlier studies suggest that physiological measures obtained relatively easily from exsanguination blood can be used to gain knowledge about animal welfare on the day of slaughter (Correa et al. 2010; Edwards et al., 2010b; Hambrecht et al., 2004). These studies demonstrated the potential of selected post-mortem measures as valid animal welfare measures. Post-mortem blood measures are non-invasive and more likely to become automated than measures obtained on live pigs due to the ease with which the samples can be collected. Physiological measures can be used as indicators of welfare when the relationship between the physiological measure and the underlying motivation is adequately validated, as emphasised by Rushen (2003). Hence, if correlations between the level of welfare on the day of slaughter measured by an animal welfare index (AWI) and physiological post-mortem measures exist, the latter may be potential candidates for systematic monitoring of animal welfare on the day of slaughter, irrespective of their biological relevance.

The aim of the present study was to investigate the relationship between selected post-mortem physiological measures and an aggregated animal welfare index (AWI). In addition the relationship between meat quality and AWI were indicated by measuring the muscle pH post-mortem. The AWI was calculated using the methodology developed by Brandt et al. (submitted), where the direct animal-based welfare measures were aggregated for each of six stages during the day of slaughter, AWI_{Stage}: pick-up pen, loading, transport, unloading, lairage and race, and across these stages, $AWI_{Overall}$. We hypothesised that an AWI_{Stage} and $AWI_{Overall}$ would be related to the post-mortem physiological measures and, more specifically, that a relationship between skin damage score and creatine kinase activity would exist. In addition, we hypothesised that the physiological post-mortem measures could be used to detect levels of welfare above vs. below a selected threshold measured by the $AWI_{Stage}/AWI_{Overall}$.

2. Materials and methods

2.1. Animals

This study involved 480 pigs from 12 different commercial herds (40 focal pigs per herd) transported to slaughter as one load from each farm. A private Danish transport company selected pig producers who had registered at least 90 pigs to the relevant abattoir on the selected experimental days. A subsample of the focal pigs (a total of $n=45$ pigs) from five of the commercial herds was included in the study by Brandt et al. (submitted) in order to develop the animal welfare index. Selected data from 57 other pigs have been presented by Schild et al. (2015) in a study on umbilical outpouchings. The day before slaughter, each of these 57 pigs was nose slinged for 5 min (± 1 min) for clinical examination.

In the present study, the total number of pigs delivered for slaughter from each herd was decided by the farmer and therefore differed between herds (Table 1). The pigs were transported by different commercial triple-decker Finkl lorries. The specific crosses of pig breeds used were not recorded on the farms; however, the majority of Danish slaughter pigs are crossbred Duroc (sire) and Landrace–Yorkshire (sow). The pigs were slaughtered at 100–110 kg body weight, corresponding to approximately six months of age, and the gender distribution was: 224 females, 140 castrates, 60 entire males and 56 unknown.

2.2. Study outline and design

This study was designed as an observational study (Kjaer Ersboll et al., 2004) and conducted at two standard Danish commercial abattoirs (slaughter rate: 820 pigs/h using CO_2 group stunning and a slaughter line speed of 410 carcasses/h) chosen as being representative of abattoirs in Denmark.

The experiment was conducted on 12 experimental days (pigs from one herd per experimental day), selected for reasons of convenience, in November 2012 and January, April/May and June 2013. Half of the pigs were slaughtered during the winter and the other half during the spring. The two abattoirs were used equally during the two seasons. The 24-h average outdoor temperature during the experimental periods was 5 °C and 15 °C for abattoir A and −3 °C and 7 °C for abattoir B. A large private Danish transport company selected pig producers having at least 90 pigs ready for slaughter at one of the two abattoirs.

Data recording was carried out at six stages during the day of slaughter: (1) in the on-farm pick-up facilities, (2) at loading, (3) during transport, (4) at unloading, (5) during lairage and (6) in the race to the stunning chamber. In addition, skin damage was assessed the day before slaughter in the home pen, and the duration of breaks during transport was recorded (Table 1).

2.3. Procedures

Data collection was intentionally performed under commercial conditions, which is why no instructions regarding handling of the pigs were given to farmers or staff. On each farm, the 40 focal pigs were marked for individual recognition the day before slaughter and tattooed on both hindquarters for slaughter line identification. The pigs were moved from the home pens to conventional pick-up facilities by the farmer, either the day before slaughter (four herds) or in the morning of the day of slaughter (seven herds), and the pigs were therefore haphazardly mixed at this point. The duration of transport varied from 20 to 75 min (Table 1). At the abattoir, the

Table 1
Duration of time spent in pick-up facility, loading, transport, breaks during transport, unloading and holding time in lairage for the delivery of pigs from each of 12 herds included in this observational study of pig welfare on the day of slaughter. The specified durations are rounded to the nearest five minutes.

Herd	1	2	3	4	5	6	7	8	9	10	11	12
Total no. of pigs delivered per herd	140	130	150	210	90	115	210	146	90	215	146	215
No. of focal pigs	40	40	40	40	40	40	40	40	40	40	40	40
Pick-up facility, h	>8	<2	<2	0	<2	>8	<2	<2	<2	>8	m[a]	>8
Loading, min	20	15	55	45	20	25	35	30	15	35	25	40
Transport, total, min	20	m	m	m	30	20	30	50	60	75	60	55
Break, total, min	–	10	15	–	–	45	–	–	50	–	20	–
Unloading, min	30	20	m	20	10	25	20	20	10	15	15	15
Lairage, min	120	80	m	m	90	100	90	45	90	95	90	95
Race[b], min	15	10	m	m	10	15	20	15	15	10	10	10

[a] m=missing value.
[b] Duration of time spent in the last three compartments prior to stunning.