Effects of feed withdrawal prior to slaughter and nutrition on stomach weight, and carcass and meat quality in pigs

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ABSTRACT

Withdrawing feed from pigs for a period of time before harvest (fasting) can be a valuable approach to reduce deaths during transport, and improve pork quality and safety. However, factors such as time of last feed, feeding regime, and feed type may limit the efficiency of this procedure, and produce variation in the response to fasting for aspects such as carcass yield, stomach weight and contents, and microbial contamination of the carcass at slaughter. Furthermore, the presence of liquid contents in the gut due to the hunger-related higher drinking rate suggest that more research is needed to resolve the potential conflict between animal welfare and food safety objectives of this pre-slaughter procedure.

Keywords: Feed withdrawal Carcass yield Stomach content Meat quality Pigs

1. Introduction

Feed withdrawal is one of the practices for on-farm preparation of pigs before harvest which in some countries is regulated by codes of practice or by legislation (AAFC, 1993; Official Bulletin of the European Community, 1995). The potential advantages of feed withdrawal include the higher well-being of animals during transport (Bradshaw et al., 1996; Guàrdia et al., 1996), reduced carcass contamination due to lower risk of gut contents spillage during carcass evisceration (Berends et al., 1996; Saucier et al., 2007), and improved pork quality (Guàrdia et al., 2004, 2005).

Despite these potential advantages, however, feed withdrawal is sometimes not used or misapplied by producers, resulting in complaints and penalties from the slaughter sector. For instance, a survey conducted at swine farms in Quebec reported that only 15% of pigs had no access to the feeder until the time of transport (Viau and Champagne, 1998). Some
reasons for not withholding feed prior to transport were: 1) lack of a shipping room to which pigs sorted by live weight (split-marketing) could be transferred from their home pen in order to withdraw feed and allow them to rest until the arrival of the truck and 2) concern about body weight losses reducing the economic value of the carcass.

The aim of this article is to review the effects of feed-withdrawal time and on-farm feeding strategy on the effectiveness of preslaughter fasting in terms of carcass yield losses, stomach weights and contents, and pork quality to identify the best strategies to optimize the impact of pre-harvest fasting of pigs.

2. Liveweight changes and carcass yield

In the first 24 h of fasting, the pig can lose up to 5% of its live weight, at an approximate rate of 0.2% per hour, or 0.25 kg/h, resulting in a live weight loss of approximately 5 kg after 24 h of fasting (Peloso, 2001). However, during this time liveweight losses are more related to the excretion of urine and feces rather than to body tissues and consequently carcass weight is not affected (Beattie et al., 2002). Losses in carcass weight of approximately 100 g/h are reported after 24 h fasting (Chevillon, 2000) which would be equivalent to a total decrease of 1% of carcass yield after a fasting period of 24 h (Faucitano et al., 2006); however, other studies have shown that fasting times as long as 60 h did not affect carcass weight losses (Ellis, 1998; Turgeon, 2003). This discrepancy in the results can be explained by the different levels of stress imposed on pigs between studies. For example, Warriss (1982) emphasized that transport to slaughter may contribute more to the liveweight weight loss rate than fasting alone. Chevillon et al., (2006b) reported carcass weight losses of 360 g/h after 24 h of fasting, resulting in a total reduction in carcass yield of 0.33 percentage units for a pig weighing 110 kg at slaughter (Fig. 1). This is a relatively small reduction in carcass yield given that it would be associated with the removal of one meal per day (morning or evening), or 1.3 kg of feed. Kephart and Mills (2005) reported that 24 h of feed withdrawal resulted in savings of 2 kg of feed/pig. Furthermore, feeding pigs until the time of transport may be little efficient because feed consumed by pigs takes 4 h to 8 h to be absorbed in the small intestine after ingestion and most nutrients enter the blood 9 h after intake; thus, feed provided to pigs in the last 10 h will not be converted to carcass gain and forms a waste that the processing plant needs to deal with (Warriss, 1985).

In a study where the effects of fasting time (4, 14 or 24 h), meal frequency (2 vs 5 meals per day) and feed type (mash vs pellet) were investigated, it was shown that carcass weight decreased with increasing duration of feed withdrawal, but this weight reduction was greater in pigs given mash compared to pelleted feed (Faucitano et al., 2006). As a result, carcass yield was also greater in pigs fed a pelleted diet compared to those fed mash (81.2 vs 79.3%), but it also increased in pigs fed 5 times/day compared to 2 times/day (80.7 vs 79.8%), independent of pre-slaughter fasting time. The variation in carcass yield between the feed type treatments may be explained by the differences in the weight of the stomachs removed in the dressing procedure as showed later in this paper.

3. Gastro-intestinal (GI) tract characteristics

According to Schoonderwoerd (1997), feed withdrawal accounts for 71% of the variation in the carcass contamination rate. The greater the content of the GI tract at slaughter, the higher the risk of lacerations during evisceration. Miller et al., (1997) reported a 1% decrease (from 1.6 to 0.5%) in GI tract lacerations during the evisceration process for pigs fasted for 4 h compared to unfasted animals. In fact, it has been shown that approximately 50% of live weight loss in pigs fasted for 24 h is due to GI tract emptying, as a consequence of a reduction of around 80% in GI content and offal weight (Mayes et al., 1988; Peloso, 2001). Based on the correlation between carcass yield and the ratio between the empty stomach and body weight ($r = -0.48; P < 0.001$), Faucitano et al., (2006) reported that approximately 25% of the variation in carcass dressing yield between treatments was explained by the weight of the stomachs being removed in the dressing procedure. Turgeon (2003) and Kephart and Mills (2005) reported a difference of between 0.90 kg and 2 kg in stomach weight at slaughter between fed pigs and pigs fasted for 16 h to 24 h, whereas, Eikelenboom et al., (1991) reported twofold greater stomach weight in pigs fasted 6 h than 24 h (11.5 vs 6.7 kg). A pre-slaughter fasting period of 22 h to 26 h was recommended by Chevillon et al., (2006b) to meet the industry requirements for

![Fig. 1. Carcass yield variation according to feed withdrawal time (Chevillon et al., 2006b).](image-url)
a total weight of the stomach and its content of <1.4 kg and <0.5 kg, respectively (Chevillon, 1994). It has been shown that a feed withdrawal period of up to 48 h reduces the amount of waste to be disposed of at the abattoir (Miller et al., 1997). Indeed, a 1–2 kg increase in the GI tract weight at the time of slaughter would result in approximately 10,000 kg of waste per day to be disposed for an abattoir slaughtering 8000 pigs per day (Murray, 2000).

Lower weights of full stomach and its contents have been reported in pigs fed ad libitum compared to those subjected to restricted feeding (Magras et al., 2000; Saucier et al., 2007). This difference can be explained by the intake of smaller feed portions at each meal in pigs with ad libitum access to feed, which favours food digestion and consequently accelerates stomach emptying (Laplace et al., 1981).

According to Guise et al., (1995), smaller feed particle size and pelleting may also influence the gastric emptying rate in fasted pigs. In support of this hypothesis, Saucier et al., (2007) recently reported an interaction between feed type (pellets vs mash) and fasting time (4, 14, or 24 h) for full stomach, stomach weight, and stomach solid weights. All weights decreased with increasing fasting time in pigs fed mash; however, in pigs fed pellets, full stomach and water content weights were less in pigs fasted 14 than 4 h, but greater after 24 h of fasting. In this study, the presence of water in the stomach was partially explained by the positive correlation between the weight of water in the stomach and the total water used (including water wasted while drinking) in the lairage pen \((r = 0.40; P < 0.01)\). A possible explanation is that pigs fed pellets are hungrier during lairage because pellets are easier to digest (Fekete et al., 1983) as showed by the lower full stomach and content weights in pelleted-fed pigs at slaughter (Saucier et al., 2007). Indeed, Miller et al., (1997) and Brown et al., (1999) observed that long-term (24 h) feed deprived pigs tend to increase water intake. Rabaste et al., (2007) reported that in pigs subjected to 22 h of fasting prior to harvest, 23.5% of them had stomachs that were still full and mostly contained liquid (79.4%) coming from water drunk in lairage. The presence of liquid contents, even in small quantities, in the stomach at slaughter can be worrying because, in the event of stomach laceration during the dressing procedure, liquids would spread more readily over the carcass and jeopardize meat safety than solid contents. This finding would suggest that, besides stomach and content weights, the stomach content type must be also considered when auditing for potential sources of carcass contamination at the abattoir.

Magras et al., (2000) assessed the effects of type of feeding system on the efficiency rate (ER = 100 – percent of pigs with full stomach weight greater than 1.4 kg) of fasting in pigs subjected to 16, 22 or 28 h of fasting. It was noted that an ER close to 100% is indicative of efficient fasting based on the stomach weight at slaughter, and, regardless of the feed type (solid or liquid), 16 h of fasting time seemed sufficient to obtain an acceptable ER in ad libitum fed pigs (95.5%). However, for restricted-fed pigs, the application of 16 h fasting time only resulted in a ER of 75% and thus, in this particular case, it was suggested to extend this time to at least 22 h to achieve a higher and more acceptable ER (88.9%). Even higher ER values (95.7%) were obtained with 28 h of fasting time in restricted-fed pigs but at the detriment of carcass yield. Furthermore, within feed-restricted pigs, those fed two meals/day had a lower ER (ER = 75%) compared to those fed either three (ER = 91.5%) or four meals/day (ER = 95.8%).

Feed composition can also have an effect on the ER, as shown by Magras et al., (2000) in pigs fed corn- or wheat-based diets in 3 to 4 meals/day and fasted for 22 h prior to slaughter. Because of its higher fibre and carbohydrate content, wheat-based diets appear to slow down gastric emptying, resulting in a lower ER value (87.9%) compared to corn-based diets (95.4%). Thus, a fasting time longer than 22 h is recommended for pigs fed wheat-based diets in order to improve the efficiency of preslaughter fasting and to obtain empty stomachs at slaughter.

4. Meat quality

Preslaughter fasting is seen as a tool for raising muscle ultimate pH and reducing the incidence of pale, soft and exudative (PSE) pork (Warriss, 1982). According to Guàrdia et al., (2004), the risk of PSE occurrence increases at a fasting duration below 18 h. On the other hand, long fasting periods (>22 h) increase the prevalence of DFD (dark, firm, dry) pork due to muscle glycogen exhaustion (Eikelenboom et al., 1991; Gispert et al., 2000; Guàrdia et al., 2005). Turgeon (2003) and Faucitano et al. (2006), respectively, reported an increase in pHu of 0.03 and 0.07 units in the longissimus muscle of pigs fasted for 24 h compared to those fasted for 4 and 14 h, respectively. Similarly, 24 h of fasting pre-harvest, compared to either 18 h or 30 h, increased the percentage of hams with pH levels between 5.6 and 6.2 (71, 56 and 57%, respectively), which is the target pHu for cooked ham processors (Chevillon et al., 2006a). Furthermore, 24 h pre-harvest fasting would result in 1.6% increase in cooking yield compared to 18 h, which confirms the correlation \((r = 0.7 \text{ to } 0.8)\) between pHu and technological yield of cooked hams (Monin, 1988). Conversely, a number of other studies (Beattie et al., 2002; Murray et al., 2001; Morrow et al., 2002; Kephart and Mills, 2005) reported little to no impact of feed withdrawal time on pork quality. The discrepancy among reported results may be explained by the differences in the level of stress or activity imposed on pigs prior to slaughter and by the muscle being used for the meat quality assessment in each study. It has been observed that when fasting is not confounded by other preslaughter practices (e.g., mixing, long transportation, etc.), muscle glycogen does not become depleted to an extent that pork quality is influenced (Leheska et al., 2002; Bertol et al., 2005; Faucitano et al., 2006). However, muscle glycogen reduction can be enough to influence pHu in those muscles supporting the animal’s posture and weight and/or having a lower glycolytic potential (Warriss, 1982; Fernandez and Tornberg, 1991; Hambrecht et al., 2005).

5. Carcass contamination

Although reducing the likelihood of carcass microbial contamination due to lower risk of GI tract lacerations during evisceration, increasing feed withdrawal time may produce a more favourable environment in the GI tract for the growth of certain pathogens such as the cecal Enterobacteriaceae (e.g., Salmonella and E. coli) through changes in fermentation patterns (Nattress and Murray, 2000; Martin-Peláez et al., 2008a, b). For example, Nattress and Murray (2000) observed
an increase in stomach cell counts, and caecum pH values with a fasting time of 20 h compared to 5 h resulting in an increased concentration of coliforms and E. coli biotype 1. More recently, Martin-Pélaez et al., (2008a,b) reported an increase in Enterobacteriaceae numbers with longer feed withdrawal times (2 vs 12 h) and lairage times (0, 5 and 10 h) and a trend (P= 0.09) towards an increase of Salmonella in feces in pigs being fasted 30 h compared to 15 h. In contrast, Isaacson et al., (1999) reported a decrease in the proportion of pigs positive for the presence of Salmonella in the ileocaecal contents at slaughter when a 24 h feed withdrawal was applied, but the effect was only observed in combination with a 4 h transport time.

The presence of manure on the truck or lairage pen floor is also a likely source of fecal bacteria (e.g. E. coli, Salmonella) contamination and shedding rate of animals is known to be increased with both feed withdrawal time and stress (Isaacson et al., 1999; Reid et al., 2002). Stressors appear to increase the rate of gastric emptying (Enck et al., 1989) and the E. coli population in the caecum (Franklin et al., 2002). The manure present on the floor or walls of the pen is an important potential source of oral contamination for pigs (Hurd et al., 2005). For example, mouth bacterial contamination is reported at North American swine slaughter plants (Gill, 2000). Contamination of the mouth of the pig is of concern as it can be a source of cross-contamination with coliforms and E. coli on the dressing line (Gill and Jones, 1997; Saucier et al., 2007).

In the aforementioned study, Saucier et al. (2007) showed that feeding pellets 5 times per day combined with a 24 h feed withdrawal minimized E. coli and Total Aerobic Mesophilic (TAM) contamination on the thoracic area of the carcass.

6. Impact of feeding behaviour on response to fasting

At the farms where the split-marketing (which generally involves removal of the heaviest 10 to 50% of pigs from a pen on one or a number of occasions during the marketing process) is applied, the use of shipping rooms or pens to which the pigs to be marketed are transferred before loading is recommended for a better control of fasting time and to avoid loss of weight gain for the pigs remaining in the pen (Viala and Champagne, 1998). However, the use of this system is limited given the cost to build these rooms and the environmental restrictions related to the expansion of agricultural buildings (Viala and Champagne, 1998).

Alternative management strategies based on the pig’s natural feed intake pattern could be applied to allow producers to keep the selected pigs in the finish pen without closing the feeders. The diurnal feeding behaviour of finishing pigs is likely to have a significant effect on responses to fasting in a number of the aspects discussed in this review, such as carcass yield, GI tract contents, and muscle glycogen levels. In a model based on pig daily feed intake and feed passage rate through the GI tract, Lewis and McGlone (2008) predicted that shipping pigs early in the morning (between 0400 and 0800 am), combined with transportation of 4 h or more, would increase the incidence of empty stomachs at slaughter because pigs consume relatively little feed during the night time. Indeed, pigs consume the majority of the daily feed intake in a 12 hour period between approximately 0600 h and 1800 h. For example, Hyun et al., (1997) and Hyun and Ellis (2001, 2002) showed that both growing and finishing pigs consumed approximately 70 to 75% of the daily feed during the daytime (0600 to 1800 h). This obviously has major implications for the timing of the start of fasting as well as its duration. Clearly, pigs that start the fasting process at 0600 h compared to 1800 h are likely to have much different amounts of feed in the stomach and GI tract.

The aforementioned drop in feed intake at night is even greater in uncrowded situations (0.25 vs 0.56 m²/pig; Hyun et al., 1998). However, high environmental temperature is likely to change this diurnal feed intake pattern resulting in pigs consuming a greater proportion of the daily feed intake during the cooler night time (Hyun et al., 1998). Night feed consumption can also be influenced by the social status of the individual pigs within the group, as subordinate pigs tend to transfer part of their feed intake at night while their dominant pen-mates are sleeping (Nielsen and Lawrence, 1993).

7. Concluding remarks

Based on current data, a period of 24 h between the last meal and slaughter appears to be an acceptable compromise to obtain optimal carcass yield and pork quality and safety. However, under certain conditions, such as a restricted feeding plan and mash feeding, a 24 h fasting may not be sufficient to obtain empty stomachs at slaughter and may increase the risk of carcass contamination. Furthermore, the welfare of fasted pigs still needs to be elucidated as pigs arriving at slaughter with empty stomachs are likely to feel hungry, as suggested by the increased drinking rate. Furthermore, Lewis and McGlone (2008) have suggested an association between the incidence of fatigued or downer pigs and fasting time based on the reduced blood glucose levels in fasted pigs caused by feed restriction. However, further research is needed to validate this hypothesis. These events put animal welfare in conflict with food safety objectives. Additional research on feeding behaviour is warranted to study its interaction with fasting in order to assess the impact of the time of the start of fasting on pigs’ responses. The outcomes of this research may also assist swine producers fast the pigs ready for slaughter without removing and restricting an entire group of pigs in a large pen prior to transportation to slaughter.

References


