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Review

SEXUAL MATURITY AS RISK FOR DEVELOPMENT OF DEVIANT BEHAVIOURS IN PIG PRODUCTION SYSTEMS WITH ENTIRE MALES

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Abstract

Male piglets are castrated primarily to avoid the unpleasant boar taint in meat, and additionally for the predisposition of castrates to accumulate fat and for their lower risk of developing unwanted behaviours. There are two main strategies available for withdrawing from surgical castration: one is immunocastration and the other is to raise entire male pigs or boars. Additionally, raising intact boars is more profitable because of the production of carcasses with lean meat and better feed conversion. Boars (compared to castrates) exhibit more aggressive, sexual, damaging social behaviour and reduced feeding behaviour with a lower prevalence of sickness behaviour as a result of good health and low susceptibility to chronic inflammation. In this review, the behaviours specific for boars as a result of sexual maturity are reviewed, with an overview of differences in the behaviour of surgically castrated barrows, immunocastrates and boars reared in group-housed systems. The raising of boars allows for good welfare of these animals in early life, but later, on reaching sexual maturity, the welfare of boars can be

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diminished because of their propensity to aggression and more mounting behaviour than castrates. Innovations in the breeding and management of boars are needed to improve their performance and to reduce welfare implications of these animals raised in social groups, and in particular to minimize deviant behaviours towards pen mates.

Key words: boar, castration, damaging behaviour, pubertal behaviour

HIGHLIGHTS

Farmers have traditionally castrated their male piglets surgically to avoid the boar taint of pork and to reduce male-specific behaviour, and this procedure is still common in most countries. However, in some countries (such as Germany, Spain and the UK), production of entire males is well-established. Castration of male piglets as a husbandry practice has usually been performed during the first days or up to 7 days of age without any pain relief. Therefore, this type of castration induces pain followed by specific physiological and behavioural reactions, including stress and discomfort before and following the procedure. Alternatives without surgical castration in pig production are raising entire males or immunocastration. Nowadays, consumers favour more lean meat, and this, together with some advantages from rearing intact boars, contributes to the avoidance of castration as a common husbandry practice in pig production. On the other hand, managing boars (entire males) differs from managing castrates and gilts. Experiences with keeping boars differ between pig farmers. Some pig farmers observe high levels of deviant behaviour of the boars on their farms, while other farmers do not observe this behaviour.

This review has the intention to provide an overview of the welfare consequences of surgical castration and give an overview of the most prevalent behaviours specific for boars reared in the entire male pig production system.

WELFARE IMPLICATIONS OF SURGICAL CASTRATION AND ITS ALTERNATIVES IN PIGS

Animal welfare is becoming an increasingly important topic for consumers in the context of food source, traceability, and food quality. Intensive pig production is characterized by high animal productivity with an economic dimension due to low inputs of labour, feed and confine space per animal. As a result of this trend, the herds become bigger with a high stocking density in pens, followed by specific management practices within a farm. Compared to extensive production, intensive pig production offers many advantages related to animal health, animal welfare, food safety, hygiene and biosecurity. Extensive rearing systems pigs to express their natural behaviour, but the implementation of specific disease control and biosecurity measures, and poor management efficiency give priority to intensive rearing systems. Considering the welfare of pigs, contradictions and dilemmas exist in these different rearing systems (Hristov et al., 2019).

One of the most challenging welfare problems in pig production is surgical castration of male piglets without the use of anaesthesia and analgesia. Castration of piglets in the European Union (EU) is regulated by the Council Directive 2008/120/EC of 18 December 2008, relating to the minimum standards for the protection of pigs. Surgical castration of male pigs is a practice that will probably be completely abandoned in Europe in the future because of a growing concern for animal welfare. In 2010, the European Declaration on alternatives to surgical castration of pigs committed stakeholders to end this practice by 2018 and develop sustainable pork production based on alternatives to surgical castration. Despite all efforts made to reach this aim and introduce available alternatives, 75% of male piglets in EU are still surgically castrated (Weiler and Bonneau, 2019; De Briyne et al., 2016). Rearing entire males will, though, unavoidably be integrated in the pig sector.

Surgical castration of male pigs

The common handling procedures for piglets at the beginning of their extra-uterine life in commercial pig breeding farms lead them to experience a stressful situation. These procedures include iron administration, teeth clipping, tail docking, and castration. As a part of management, these procedures are performed to prevent potential health and welfare problems and boost meat quality. As a rule, these husbandry practices can cause pain and physiological changes that can have long-term negative consequences on piglet welfare and behaviour (Hay et al. 2003). The possible ways to avoid these negative consequences are to provide obligatory pain relief before these procedures or to ban these painful procedures.

Castration without the use of anaesthesia and analgesia is a painful and stressful procedure and is recognized as a reason for deteriorating animal welfare (Marchant-Forde et al., 2009). In consideration of these welfare issues, consumers show different beliefs and attitudes towards animal welfare, castration and meat from castrated pigs (Tomasevic et al., 2020a; Tomasevic et al., 2020b). The authors identified three clusters of consumers: one with consumers indifferent towards animal welfare; one with consumers concerned about animal welfare, but who believe it is difficult to achieve; and one with consumers concerned about animal welfare, and who believe it is possible to achieve.

Castration is a husbandry procedure that is performed to diminish the occurrence of boar taint in the meat of sexually mature male pigs and to reduce deviant behaviour toward other pigs and farmers. The occurrence of boar taint is due to the accumulation of metabolic compounds, mainly skatole and androstenone, in the meat of boars, which cause a disagreeable odour and flavour that is intensified after thermic preparation of pork meat (Bonneau et al., 2000). Nowadays, farmers practice two methods of castrating male piglets: surgical castration and more recently, immunocastration.

Conventionally, surgical castration of male piglets is performed during the first days or up to 7 days of life without any anaesthesia or analgesia. Castration after the 7th

day of life of the piglet can only be performed by a veterinarian and with the use of anaesthesia and analgesia. Castration without anaesthesia induces physiological and behavioural reactions indicative of pain, exposing the piglets to stress and discomfort before the procedure with a tendency to persist for several days. The pain caused can be reduced with the use of pain relief (Castrum, 2017). Some farmers complete castration by the first three days after birth, together with tail docking, iron injection and tooth resection, while other farmers perform castration later than the first week of life, mainly for practical reasons, as piglets are easier to handle, and the testes are of greater size and fully descended, which avoids risk from inguinal hernia (Prunier et al. 2020). Potential complications associated with surgical castration include failure to remove both testicles, haemorrhage, moderate swelling or oedema, infection and deprived wound healing (Prunier et al. 2005). These reactions are severe in the first hours following surgical castration, but decrease rapidly thereafter.

The consequences of castration on welfare result from the surgical process itself and from the deficiency of testicular hormones. Castration of piglets resulted in raised concentrations of cortisol, ACTH (Adrenocorticotropic hormone), and lactate in plasma, raised mean arterial blood pressure, heart rate and respiration rates, and a larger EEG (Electroencephalogram) response within the first few hours after the castration was performed (Sutherland et al. 2012; Haga and Ranhein 2005; Prunier et al. 2005). During the castration, piglets manifest defensive behaviour and loud vocalisations as a result of stress that they experience (Leidig et al. 2009; Puppe et al. 2005; Marx et al. 2003). Behavioural changes observed after castration included reduced nursing, prostration, stiffness and trembling, which could make castrated piglets more susceptible to hypoglycaemia, reduced walking, lower overall activity and weight loss (Llamas Moya et al., 2008; Carroll et al., 2006; Taylor et al., 2001). Furthermore, castrated pigs are inclined to become socially isolated rather than have contact with other piglets or the sow (Sutherland et al., 2012; Sutherland et al., 2010; Hay et al., 2003), which makes them more vulnerable to hypothermia (Trajcev and Nakov, 2009). These physiological and behavioural changes suggest that piglets experience acute pain in response to castration, and probably there are long-term welfare implications of castration. Still, there is no clear evidence for an increased mortality rate as a consequence of surgical castration.

Alternatives to surgical castration of male pigs

Immunocastration is a provisional form of castration. Immunocastration can cause complications that are similar to those of any other injection of pigs in a production system. The mechanism of immunocastration is administration of a protein compound that induces antibody production against gonadotropin-releasing hormone (GnRH). The immunization requires two doses, the first one at the age of 8 to 11 weeks before slaughter and the second one 4 weeks before slaughter. Immunocastration results in decreased production of gonadal steroids (testosterone and androstenone) with increased metabolism of skatole and, consequently, reduction in boar taint (Quiniou et

al., 2012). Potential complications include handling stress, injection-site lesions, needle breaking, and risk of self-injection to the stockperson. Handling and injections in pigs caused acute stress, which is followed by changes in behaviour and moderate increases in cortisol level that return to normal within 24 h of injection administration or handling of piglets (Hemsworth et al., 1996; Robert et al., 1989; Hemsworth et al., 1986). However, because GnRH vaccines are directed against hormones produced by the secretory tissues, they probably induce cellular damage (Vargas et al., 2005).

The behaviour of immunocastrated male pigs is similar to that of surgically castrated pigs (Puls et al., 2017). In comparison to entire males, they show fewer aggressive and mounting behaviours and increased feeding behaviour. It is necessary to double immunize because until the second dose of the GnRH vaccine, the pigs behave like boars. The welfare aspects of immunocastration are greatly variable and depend on the rearing system, including the potential for stress as a result of additional handling for vaccine administration (Zamaratskaiaa and Rasmussen, 2015). The main acquisition from immunocastration is the lower risk of the development of undesirable behaviours that are specific for entire males.

Another alternative, sperm sexing to produce only female offspring, would have great potential for a sustainable and welfare-friendly long-term practice instead of pig castration. However, this alternative is not acceptable for implementation in the near future because it is strongly dependent on improvement of new insemination techniques for sows, along with the development of more efficient methods for sexing sperm.

On the other hand, the rearing of entire male pigs is less common than rearing castrates because of entire male pigs' association with boar-taint (Bonneau et al., 1992). However, attitudes of consumers to animal welfare are increasing the pressure on pig producers to stop castration. Raising entire males improves their welfare in early life, as they are not endangered by the pain and stress of castration. However, their subsequent welfare can be reduced because of increased aggressiveness and mounting behaviour as they reach sexual maturity, leading to a higher prevalence of injuries as a result of sexual activity with increased mountings.

BEHAVIOURS SPECIFIC TO ENTIRE MALES

Commercial pig breeding systems are challenging for pigs' social behaviours and lead to a range of abnormal, or normal but unwanted behaviours. Supported by literature sources, there is clear evidence that surgical procedures such as castration, when performed without pain relief, are the cause of stress (Prunier et al., 2006). However, worries exist that raising intact boars in an intensive pig raising system could in itself be a significant welfare problem.

Domestic pigs have congenital extensive social and hierarchical traits, inherited from their ancestors. Immediately after birth, a more or less stable social dominance order

is established among litter-mates. The strongest piglets ensure their access to the front teats with more milk, and once this dominance order has been established, it is kept until the end of the suckling period. Later, the established social hierarchy in a group of pigs influences their access to resources such as food, water, and preferable lying areas.

Under the influence of genetic, social, and environmental factors, sexual maturity (puberty) in domestic pigs occurs between seven and nine months, with some considerable variations. Aggression and sexual mounting as social behaviours are strongly dependent on sexual maturation and are predominantly noticeable in entire males compared to females and barrows (Fredriksen et al., 2004).

Aggressive behaviours

The lack of environmental enrichment such as manipulable materials is common in confining rearing systems, which are associated with high competition for resources such as food and water. This competition between pen-mates contributes to the animals carrying out normal behaviours at a high frequency and to the extent that they become problematic, resulting in increased social and body contact with other pigs. Aggressive behaviours in pigs can be observed in any stage of their life, beginning in the suckling period when the dominant status of each piglet according to teat order is established. In general, aggression can be observed as a result of mixing unfamiliar pigs, when the animals intensively fight to establish social dominance and as a result of longer competition for feed or other resources (Fraser, 1984). According to Andersen et al. (2000), aggressive social behaviour is more common in group-housed pigs, when pigs are frequently mixed or they are equable in weight, and then it is more difficult for pigs to maintain a social hierarchy; the aggressive behaviour is rarely observed in small, established social groups. Frequently, aggressive behaviours increase in entire male pigs after they reach puberty (Cronin et al., 2003), with such behaviours escalating when animals are mixed or moved (Fredriksen et al., 2004). Ford (1990) indicated that this increased aggression is stimulated by male steroid hormones, but also, this increase in deviant behaviours on its merits goes with an increase in plasma testosterone, forming a positive feedback axis between hormone levels and aggressive and sexual behaviour (Fredriksen et al., 2008). The concentrations of serum testosterone and oestrogen are raised in male piglets during the first three weeks after birth, leading to increased prepubertal mounting activity and higher numbers of social interactions compared to gilts or castrated boars (Berry, 1984). The manifestations of these behaviours reach peaks at around two months of age, and then in prepubertal pigs they decline to a low frequency (Ford, 1990). The masculinisation of sexual behaviours in boars is strongly dependent on the increased secretion of testicular steroid hormones that begins from three months of age continuing through six months of age (Ford, 1990), which correlates with escalating aggressive and sexual behaviours in entire males (Cronin, 2003).

Sexual behaviours

Sexual mounting is normal pig behaviour (Hemsworth and Tilbrook, 2007), but it tends to be problematic in commercial housing systems with high stocking density where close social interactions exist between animals. The welfare consequences of sexual behaviour are risks of leg problems and skin lesions (Rydhmer et al., 2006), although there is inconsistency among studies as some did not identify leg problems as an issue (Fredriksen, 2008). The results of research conducted by Vanheukelom et al. (2012) show a higher prevalence of aggressive and mounting behaviour in boars compared to gilts, without lameness or leg injuries, but high skin lesion scores are more frequent in boars. In any case, lameness or leg injuries, caused by frequent mounting behaviour, could be a problem in the production of entire males.

Boars show more active behaviour compared to their female pen-mates, as boars are less inactive, walk more, and tend to display more explorative behaviour. Intact boars, when compared to females and castrates, have been shown to spend more time occupied in social, aggressive and sexual behaviours and less time resting and feeding (Fabrega et al., 2010; Rydhmer et al., 2010). Fredriksen et al. (2004) observed decreases in sexual mounting among females and castrates a few weeks before slaughter. Some studies showed that sexual behaviour is more frequent when pigs are housed in single-sex pens (Salmon and Edward, 2006), but other studies did not find any sexual behaviour differences in pigs that were housed in single-sex or mixed sexed pens (Andersson, 2005). Male pigs showed mounting behaviour such that they were as likely to mount other male pigs as to mount female pigs (Rydhmer et al., 2006). Mounting behaviour in mixed-sex pens of entire males and sexually mature females increases the possibility of pregnancy in female pigs planned for slaughter (Andersson, 1999).

In the context of aggressive and sexual behaviours, boars are inclined to perform more non-violent social interactions and spend less time resting than castrates, which increase the level of general disturbance in a pen (Rydhmer et al., 2010; Rydhmer et al., 2006). With regard to male-specific behaviours (e.g. fighting, mounting, penis biting), Cronin (2003) observed that with age, pigs had lower activity level, showed less aggressive behaviour, walked less, and slept more. Einarsson (2006) reported entire males engage in socio-sexual behaviour for longer times than do immunocastrates after their second vaccination at 21 weeks of age and surgically castrated male pigs. Factors that cause stress or give a negative stimulus are associated with raised levels of sexual and aggressive behaviour and more skin lesions. This means that restriction in eating places, restricted feeding, a low level of amino acids in the diet, insufficient water supply from the drinking system, illness of the pigs, a suboptimal climate, and fear of humans are associated with a raised level of sexual and aggressive behaviour and more skin lesions (von Borell et al., 2020).

Damaging behaviours

Damaging behaviours can cause severe injuries and lead to significant impairment of animal welfare. Most of the damaging behaviours have a multi-factorial origin, and environment, nutrition and genetics influence their occurrence (Bracke et al., 2018; Taylor et al., 2012). The most prominent form of damaging behaviour in pigs is tail biting, and this can be more frequent when tails are short-docked (Valros et al., 2016; Goossens et al., 2008). The tail is not the only part of the animal that can attract another pig's interest; ears, vulva, penis, and other body parts can also be damaged through intentional or non-intentional biting (van Staaveren et al., 2018; Rizvi et al., 1998). These damaging oral bite behaviours are mostly associated with young growing and finishing pigs and can be aggressive in nature (Rizvi et al., 2000). The occurrence of damaging behaviours has a multidimensional origin, but the initial factor is a barren environment that restricts the pigs' normal foraging behaviour (D'Eath et al., 2014). Then, the animals devote foraging activity towards elements in the environment that are most readily manipulated, and this includes the body parts of pen-mates (van Putten, 1969). In the beginning, these behaviours are not aggressive in origin, but later become aggressive when the bitters start to use them as a "weapon" to displace others from the feeding area (Prunier et al., 2019). In general, tail lesions more often affect males, either entire or castrated, than females (Schroder-Petersen and Simonsen, 2001). Holinger et al. (2015) found more tail lesions in boars than in barrows or females, but only at the beginning of the fattening period, while later there were no differences in tail lesion numbers and their prevalence decreased.

Sickness behaviours

It is well established that boars have better health than barrows and are less susceptible to chronic inflammation. It has been reported that surgically castrated barrows suffer from suppressed immunity (Weary and Fraser, 1999), and they have higher incidences of chronic inflammation, like pericarditis, pleuritis, pneumonia, inflammation of the tail, or the feet and other diseases than do gilts (de Kruijf and Welling, 1988). Therefore, the risk of sickness behaviour developing in boars is less common. In addition, the risk of manifest damaging behaviour (tail biting, ear biting, vulva biting and penis biting) increases with inflammation. The physiological changes induced by immune activation following infection are in focus to explain the mechanisms behind mental health challenges, such as depression, as a predisposing factor for deviant behaviours. Immune activation could be a major factor influencing social interactions in pigs, with outbreaks of damaging behaviour such as tail biting, ear biting, and vulva and penis biting (Nordgreen et al., 2020). Sickness could influence the likelihood of damaging behaviour in different ways. Pigs weakened because of disease are perceived as less competitive by their pen-mates, and have difficulty escaping from intimidation.

However, an increased likelihood of victimization in sick pigs does not explain what contributes to a pig beginning bite. The central cause in the development of damaging

behaviour is provided by the hypothesis that cytokines produced by several types of immune-competent cells could be the central mediator. Cytokines have various roles in orchestrating the physiological changes specific for inflammation, but they also induce changes in the behaviour that allow the animal to save energy to recover. This has led to the hypothesis that immune activation could be the culprit behind many cases of psychological disease and has given a new dimension to mood deterioration. Nordgreen et al. (2020) realized that pro-inflammatory cytokines like TNF-a and IFN-g increase the expression of *IDO1* gene (producing indoleamine-pyrrole 2,3-deoxygenase), which in turn increases the production of kynurenine from tryptophan, and this reduces serotonin levels. This seems to be important in the development of psychological symptoms following immune activation. Therefore, we can surmise that a change in mood and social behaviour could be induced by competition caused by illness. This conclusion is supported by the findings that uncastrated boars tended to perform more tail- and ear-biting shortly before they were diagnosed with respiratory disease compared to healthy controls (Munsterhjelm et al., 2019; Dantzer et al., 2008).

Feeding behaviours

Entire male pigs display efficient feed conversion and better weight gain with leaner growth than castrated males (Skrlep et al., 2020). Boars have a higher growth during the final fattening phase but gilts show better carcass traits. Barrows can be fattened after reaching puberty without risk of developing boar taint, but they have poorer feed conversion and more fat deposits than boars. In addition, barrows exhibit fewer sexual and aggressive behaviours (Hansson et al., 2011). Regarding production results, immunocastrated males have a higher growth rate (Batorek et al., 2012) and lower feed conversion (Fábrega et al., 2010) than surgically castrated males. In particular, the endocrine system has a major role in the expression of production characteristics and growth rate in boars. Castration reduces the maximum limit for protein deposition by 30% (Campbell and Taverner, 1988).

Pigs are omnivores with great capability to adapt to a wide range of feeds and environmental conditions (Brunberg et al., 2016). Pigs manifest a variety of feeding behaviours depending on their genetic make-up and the management system, such as ad libitum feeding in feeders or restricted group feeding (Rohrer et al., 2013). The capability of adapting their feeding behaviour and of coping with environmental factors can be an indicator of robustness and disease tolerance in pigs (Nakov et al., 2019; Cross et al., 2018).

For research purposes, feeding behaviour can be used as an indicator for damaging behavioural traits occurring around the feeding table that are difficult to record, such as the risk of victimisation due to tail biting (Wallenbeck and Keeling, 2013). Rohrer et al. (2013) found that pigs with a reactive coping style tended to eat fewer but longer meals per day. Breuer et al. (2005) found a positive genetic correlation between tail biting and lean tissue growth rate and a negative genetic correlation between tail biting

and backfat thickness. Brunberg et al. (2013) reported a genetic association between tail biting and fatness.

Group-housed intact boars have more efficient growth before sexual maturation than do castrates. However, the growth rate of boars through puberty is greatly influenced by confounding factors such as stocking density, social interactions, and group size. Feeding from a long manger, ad libitum feeding, feeding wet by-products, feeding diets with high amino acid levels, good hygiene of the feeding and drinking place, and sufficient water supply from the drinking system are associated with fewer sexual and aggressive behaviours and fewer skin lesions than when these procedures are not used. The feeding system and non-optimal number of animals per eating place are related to undesirable behaviour in boars. When the number of eating places or feed quantity does not satisfy boars' needs, then competition can occur around the feeding table, possibly resulting in undesirable, aggressive behaviours and skin damage. Sexually mature boars are less interested in feeding than are immature boars, and therefore, they have reduced growth rates and spend more time manifesting social behaviour including aggressive and mounting behaviours (Rydhmer et al., 2006; Cronin, 2003). In addition, when social activity of boars increased, they drove away subordinate pigs from the feeders, thereby inducing reduced feed intake and reduced growth in their victims (Schmidt, 2011).

SOCIAL BEHAVIOURS IN GROUP-HOUSED BOARS

As a rule, mixing of pigs leads to fighting. Competition in the group to occupy a rank order leads to aggression. Aggressive behaviour is also seen in stable groups of familiar pigs. Several studies have investigated the influence of pen groups on the behaviour of entire males. According to Salmon and Edwards (2006), entire males are more motivated to perform sexual behaviour in single-sex pens than in mixed-sex pens. Boyle and Bjorklund (2007) found a higher prevalence of agonistic interactions leading to higher aggression and mounting behaviour in male and mixed-sex groups than in female groups. Therefore, Rhydmer et al. (2006) have uncertainties that rearing pigs in mixed-sex groups could reduce aggression in males, concluding that males probably mount other pigs regardless of sex and weight. These authors confirmed that a positive correlation exists between aggression in pigs and growth rate, and sexual behaviour could disturb not only the pig being mounted but all pigs in a pen. In addition, there was more mounting behaviour and lameness or injured legs or feet amongst males in both mixed-sex groups and single-sex groups than amongst females. As a result of mounting, penis injuries are also quite common (Weiler et al., 2016; Rydhmer et al., 2006). Reiter et al. (2017) concluded that immunocastration reduces the frequency and severity of penis injuries compared with boars of the same age and weight.

During the finishing phase, aggression and skin lesions decreased until the moment when the heaviest, meaning the dominant, pigs were removed for slaughter, and then

aggression increased in the remaining pigs (Vanheukelom et al., 2012). A similar result was also found by Fredriksen and Hexeberg (2009) when the heaviest pigs were removed for slaughter. There were fewer 'fighting lesions' around the head and shoulders at the abattoir in castrated and immunocastrated males or females as compared to entire males (Fábrega et al., 2010; Velarde et al., 2007; Einarsson, 2006). Mixing of unfamiliar pigs at the abattoir causes more skin lesions in entire males than in females (Andersson, 2005).

Parois et al. (2017) hypothesised that dominant boars have greater concentrations of fat androstenone but do not show an association between their dominance status and plasma testosterone or oestradiol. This dichotomy could be related to the role of androstenone in controlling social behaviour, whereas it is not involved in the control of the reproductive function of males.

The behaviour of completely immunocastrated male pigs is similar to that of surgically castrated ones. Immunocastrated males tend to have exacerbated deviant behaviours, including aggressive and sexual behaviours, compared to surgically castrated males and females, and this is reduced after full immunization (Santos et al., 2016; Puls et al., 2017). During the finishing phase, boars showed significantly higher activity than castrated or immunocastrated males and gilts, and displayed more aggression and mounting behaviour Velarde et al. (2007). Zamaratskaia et al. (2008) noticed that immunocastrated pigs tend to manifest a reduced amount of social, manipulating, and aggressive behaviour than entire male pigs. Boars that were housed next to a female pen showed more explorative and drinking behaviour than their male counterparts next to a boar pen. They also tended to show less biting behaviour (Vanheukelom et al., 2012). The presence of a boar can stimulate the onset of puberty in gilts and vice versa. Gilts housed next to a boar pen tended to be more active. Boars mixed with gilts during rearing can have elevated concentrations of androstenone in the fat tissue (Patterson and Lightfoot, 1984) which can lead to an increase in the intensity of boar taint (Walker, 1978). Other studies report no such effect (Andersson et al., 2005) or even lower androstenone levels in boars reared with females (Patterson, 1982).

During the transport of fatteners for slaughter, the pigs selected for high lean tissue growth were more disposed to aggression than pigs selected for low lean tissue growth rate (Rocha et al., 2013).

Chemical changes in the carcasses of animals exposed to stress can be a cause of poor meat quality in terms of pale, soft, exudative (PSE) meat or dark, firm, dry (DFD) meat. In general, fighting can lead to deterioration of meat quality, measured by an increase in the incidence of DFD meat (Wariss, 2000). Compared to pigs with intact skin, pigs with skin damage due to fighting have higher levels of blood cortisol at slaughter, which affect the meat quality (Faucitano, 2001). D'Eath et al. (2009) concluded that at the slaughterhouse, mixing pigs with an above-average propensity for aggression could be an important determinant of increased stress and inferior meat quality. The

higher prevalence of aggression in boars could induce stress in the pigs, and stress can cause deterioration in meat quality (Vanheukelom et al., 2012).

Adapting management and housing conditions might help to reduce undesired behaviours and improve growth and performance in boars (Vanheukelom et al., 2012). Enriching the environment (Oliver, 2008) and installing point-source objects in the pen, like chewable rods (Averós, 2010), can improve welfare in all classes of pigs by reducing skin lesions and levels of chronic stress.

CONCLUSIONS

It is well established that castration of male piglets without the use of anaesthesia and analgesia causes pain and is, therefore, a welfare issue in pig breeding farms. Immunocastration effectively reduces behaviours such as agonistic and sexual aggression to the same levels observed in females and surgically castrated males. Rearing of entire male pigs is challenging in terms of economics and welfare. Entire males have better welfare than castrates in early life, because they are not subjected to the pain and discomfort of castration. However, the welfare of fattening/slaughter pigs can be impaired because boars are more aggressive and perform more mounting behaviour than castrates. When entire males are reared in intensive commercial systems, the potential for higher and leaner growth is neglected due to the high stocking density, with little enrichment and high competition for resources, increased aggressive, sexual, damaging, and social behaviours, and reduced feeding behaviour. The main advantage of rearing boars is a lower prevalence of sickness behaviour as the result of good health, and less susceptibility to chronic inflammation. The risk of deviant behaviour is low when the farm conditions regarding feeding and drinking water, housing and climate, health and overall management are optimal for boars.

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Authors' contributions

Conceptualization, D.N. and M.T; Data Curation, B.S.; M.C.; Z.Z.; Writing - Original Draft Preparation, D.N.; Writing - Review and Editing, M.T.; S.H.; B.S.; M.C.; Z.Z. and J.B. All authors have read and agreed to the published version of the manuscript.

Competing interests

The authors declare that they have no competing interests.

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POLNA ZRELOST KAO IZVOR RIZIKA U POJAVI IZMENJENOG PONAŠANJA U PROIZVODNIM SISTEMIMA SVINJA SA NEKASTRIRANIM NERASTOVIMA

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Kratak sadržaj

Muška prasad se kastriraju prvenstveno kako bi se izbegao neprijatan nerastovski miris u mesu, zbog veće tendencije kastrata da deponuju masnoću u trupu, kao i zbog manjeg rizika od razvoja neželjenog ponašanja. Postoje dve glavne strategije za nepraktikovanje hirurške kastracije: jedna je imunokastracija, a druga je uzgoj nekastriranih mužjaka svinja ili nerastova. Uz to, uzgoj nekastriranih mužjaka svinja je isplativiji zbog trupova bez masnoće i bolje konverzije hrane. Nerastovi ispoljavaju pojačano agresivno, polno, štetočinsko i socijalno ponašanje, kao i slabije iskazano ishrambeno ponašanje uz ređu

pojavu bolesnog ponašanja kao rezultat dobrog zdravlja i slabije podložnosti hroničnim upalama. U ovom preglednom radu su razmotreni oblici ponašanja specifični za nerastove koji su rezultat polne zrelosti, sa pregledom razlika u ponašanju hirurških kastrata, imunokastriranih i nerastova uzgajanih u grupno držanim sistemima. Uzgoj nerastova poboljšava dobrobit ovih životinja u ranom životu, ali dobrobit polno sazrelih nerastaova može biti narušena jer su agresivniji i manifestuju više polno skakanje nego kastrati. Inovacije u uzgoju i upravljanju nerastovima su potrebne u cilju poboljšanja njihovih performansi i smanjenja uticaja na dobrobit grla koja se uzgajaju u grupama, posebno da bi se umanjilo devijantno ponašanje prema grlima oko njih.

Ključne reči: nerast, kastracija, štetočinsko ponašanje, polno ponašanje