Opinion on the welfare impacts on pigs of high concentration CO_2 gas stunning and of potential alternative stunning methods

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Animal Welfare Committee
Seacole Building
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The Animal Welfare Committee is an independent expert committee of the Department for Environment, Food and Rural Affairs, the Scottish Government and the Welsh Government. Information about the Committee may be found at: https://www.gov.uk/government/groups/animal-welfare-committee-awc

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Introduction and scope

1. The Animal Welfare Committee is an independent expert committee of the Department for Environment, Food and Rural Affairs, the Scottish Government and the Welsh Government. The AWC also advises the Government in Northern Ireland on issues relating to animal welfare at the time of killing. AWC Opinions are short reports to Governments on a wide range of contemporary topics relating to animal welfare. They offer authoritative advice, which is based on scientific research, stakeholder consultation and experience. They may highlight particular concerns and indicate issues for further consideration.

2. This Opinion addresses the evidence regarding the welfare impacts on pigs of high concentration carbon dioxide (CO_2) stunning as well as the evidence of welfare impacts on pigs of potential alternative stunning methods (e.g. inert gases, manual electrical, automated electrical). The Committee was also asked to assess and compare the welfare issues arising at different points in the slaughterhouse specific to different stunning approaches, e.g. during preslaughter handling and the effects of the stunning method itself. The AWC was asked to determine if there are any significant evidence gaps.

3. As a result of this analysis, the Committee was asked to identify the best stunning methods for pigs for further commercial development and deployment by industry.

4. The AWC was also invited to offer views on the commercial viability challenges of alternative methods.

5. Objectives of this advice are:
    - To inform government policy decisions on any future reform of pig stunning methods that might be needed;
    - To inform government engagement with industry when considering best options for animal welfare;
    - To provide direction for industry in adopting stunning technology.

Evidence gathering

6. The AWC reviewed the available information on pig slaughter processes, current industry practices and standards through:
    - Scientific articles and reports on high concentration CO_2 gas stunning of pigs and on the potential alternatives (e.g. argon, nitrogen, electrical, mechanical). This included results of the EU PigStun project on the development of non-aversive alternative stunning methods for pigs.

- Written and face-to-face consultations with industry, welfare experts, vets and regulators.
- Site visits to see pig slaughter methods (high concentration CO_2 and automatic electrical stunning).
- Comparative analysis of practices/regulations in the EU and other countries.

Environmental Impact

7. This opinion specifically addresses the pre-stunning and stunning processes within the slaughterhouse. In terms of environmental impact, this is a very limited period within pig meat production and so has a minimal contribution overall. Factors involved will include the building work necessary, whether retro-fitting existing premises or the construction of new stunning facilities. Comparing the systems considered here, Electrical stunning is environmentally efficient as the availability of electricity is high compared to gases. CO_2 is easy to obtain as a by-product of various industrial processes, and nitrogen is a commonly used industrial gas. Whilst argon extraction is energy intensive, and therefore expensive, it can be produced in large quantities (EU PigStun Project).

Climate Change

8. Changing weather patterns with more extremes of both heat and cold will have welfare impacts on pigs during transport to the abattoir and during the time spent in the lairage. Therefore, the facilities and work practices in the slaughterhouse, should be evaluated in light of potential weather changes.

Definitions

9. **Pain -** Pain is an aversive sensory and emotional state resulting from nociceptor activation. Nociceptors are specialised receptors that selectively respond to aversive heat, chemical, mechanical and electrical stimuli. Note: pain is a subjective experience and cannot be felt in unconscious animals, regardless of continuing nociceptor or spinal activation.

10. (Published scientific definition: ‘an aversive sensory and emotional experience representing an awareness by the animal of damage or threat to the integrity of its tissues; it changes the animal's physiology and behaviour to reduce or avoid damage, to reduce the likelihood of recurrence and to promote recovery’)

11. **Fear and anxiety -** Fear is a negative emotional state triggered by the perception of a specific stimulus. It is understood to be a subjective state that is caused by species specific triggers and results in a suite of adaptive behavioural and physiological responses. Anxiety is sometimes used interchangeably with fear, but specifically refers to a more generalised, anticipatory and potentially prolonged response to potential threats.

12. **Stress and distress -** Stress is the response of an animal to an external or bodily challenge (the term stressor is reserved for such challenges, while stress is the response). The most common scientific definition is the 'state produced when an animal is challenged beyond its behavioural and physiological capacity to adapt to its environment'. Note that pain and fear are stressors. The acute stress response is an adaptive, short-lived emergency reaction to challenges that threaten an organism's homeostasis directly (acute physical stress) or are likely to have a reasonable probability to alter homeostasis (acute psychological stress). The term distress is not formally scientifically recognized but is usually understood to mean a state of stress sufficient to cause significant suffering.

13. **Suffering -** Suffering is a negative emotional state resulting from adverse physical, physiological and psychological circumstances. It is a broad term that can encompass a range of concurrent negative subjective states and refers to welfare compromises which range from mild to substantial, depending on the duration, type and severity of suffering.

14. **Ataxia -** Ataxia is a term that is used to describe the behavioural responses observed in the initial stages of animals succumbing to gradual stunning methods (e.g. controlled atmosphere stunning) and it is characterised by progressive loss of voluntary coordination of muscle movement. It results in visible swaying of the body and/or head and attempts to adjust body posture and regain balance.

15. **Dyspnoea (respiratory distress) -** Dyspnoea is the medical term for difficulty breathing or shortness of breath and is used generally to describe unpleasant experiences relating to respiration. These are sometimes collectively termed 'respiratory distress'. They include a sensation of not being able to breathe fast enough or deeply enough (even though it may be accompanied by hyperventilation). In humans, 'air hunger' is reported to be the most potent and unpleasant dyspnoeic experience, described as the uncomfortable urge to breathe that develops progressively during a long breath hold. It is associated with profound anxiety, frustration, fear and panic, feelings that function to warn the organism of an actual or impending threat to homeostasis and survival.

16. **Hypercapnia and acidosis -** Inhaled gases enter the blood stream via gas exchange in the lungs and inhaling high concentrations of CO_2 will cause

hypercapnia – an increased CO_2 concentration in blood. This further leads to acidosis, where the pH of blood and body tissues decreases, leading to unconsciousness and then death.

17. **Hypoxia and anoxia -** Inhaling inert gases (such as argon or nitrogen) with low residual O2 concentrations will lead to reduced O_2 concentrations in blood (hypoxia) and eventually to anoxia – an absence of O_2.

18. **Loss of posture -** Loss of posture is the inability of the animal to remain in an initial standing or sitting position and has been widely interpreted during gas stunning as a proxy for loss of consciousness as it reflects loss of postural muscle control. As such, events occurring after loss of posture are generally considered to have minimal welfare impact.

19. **Loss of consciousness -** Loss of consciousness describes a transition in which the animal moves from a state of conscious awareness (connectedness to the environment and responsiveness to stimuli, e.g. painful events) to unconsciousness which occurs when the ability to maintain an awareness of self and environment is lost (involving a complete or near-complete lack of responsiveness to environmental stimuli). These states may also be termed ‘sensibility’ and ‘insensibility’. The induction of unconsciousness and associated changes in brain state and resulting electroencephalogram (EEG) characteristics appear to be common across vertebrates, and vigilance states ranging from alert to deep unconsciousness represent a continuum. As such, the transition from consciousness to unconsciousness should not be thought of as an ‘on/off’ switch but a gradual process, especially with non-instantaneous stunning approaches.

20. **Clonic/tonic convulsions -** Convulsions consisting of neuromuscular spasms are seen in response to a range of stunning methods. Convulsions usually consist of a clonic phase, characterized by vigorous limb movement, and a tonic phase, characterized by rigidity and twitching of outstretched limbs, followed by slower leg paddling motions. Tonic and clonic convulsions sometimes alternate during Controlled Atmosphere Stunning (CAS). The time at which convulsions cease has been used as an indicator of brain death. Convulsions are never seen before loss of posture, therefore their relevance to welfare is minimal.

21. **Motionless/non-recovery state -** Motionless refers to a limp carcass with the animal being completely still including the cessation of visible breathing movements; it reflects complete and irreversible loss of muscle tone. It is considered to confirm a brainstem death and hence a non-recovery state. A non-recovery state is one in which the animal is no longer breathing, and the brain is dead, but the heart (and possibly other body systems) may still be partially functioning.

22. **Stunning** - Stunning means any intentionally induced process which causes loss of consciousness and sensibility without pain, including any process resulting in instantaneous death. Simple stunning refers to approaches that cause unconsciousness but not death. Controlled atmosphere stunning (CAS), or gas stunning, are terms used to describe stunning methods that involve placing animals in modified gas environments leading to loss of consciousness and death.

23. **Killing** - Killing means any intentionally induced process which causes the death of an animal.

24. **Harm** - Harm is a term used in ethics that refers to actions or situations where animal interests are negatively affected. Welfare harms are those which have a negative impact on the animal's affective state, i.e. its quality of life. These may be in relation to quality of life (animal welfare) or, more controversially, quantity of life.

Legal context

25. Under assimilated EU Regulation 1099/2009 on the protection of animals at the time of killing[1] (and the EU version in use in Northern Ireland) (PATOK) generally a requirement for animals to be stunned before killing and Annex I sets out the permitted methods for stunning animals. Methods currently legally permitted for the stunning of adult pigs for slaughter are penetrative captive bolt device, firearm with free projectile, head only electrical stunning, head to body electrical stunning, carbon dioxide at high concentration, carbon dioxide associated with inert gases and inert gases.

26. Gas stunning for slaughter can be a simple stun in the EU and elsewhere, which must be followed by a killing method. Stricter national rules in the Welfare of Animals at the Time of Killing (England) Regulations 2015[2] (WATOK), and similar rules established by devolved governments in Scotland and Wales, include a requirement that pigs be exposed to gas for long enough to ensure they are killed (WATOK Schedule 1, paragraph 29).

27. The post implementation review of WATOK published in 2021[3] identified improvements that could be made to protecting the welfare of animals at the time of killing. One of these improvements was a review of the usage of high concentration CO_2. A second post implementation review of the legislation is due to be published within the next year.

[1] Council Regulation (EC) No 1099/2009 of 24 September 2009 on the protection of animals at the time of killing (Text with EEA relevance)
[2] The Welfare of Animals at the Time of Killing (England) Regulations 2015
[3] ukia_20250019_en.pdf

Background

28. In 2024 the Food Standards Agency Slaughter Sector Survey[4] identified that of pigs reared in England and Wales 90% are stunned by being exposed to high concentration CO_2 using the paternoster system produced by Marel, which became known as the Backloader or Butina system. They are installed in 8 plants in England, 1 in Scotland, 3 in NI and none in Wales. This percentage of the throughput has steadily increased over recent years. The remaining 10% of pigs are stunned using manual head only or head to body electrical stunning or for a very small number, percussive stunning with a penetrative captive bolt device.

29. Historically, automated electrical stunning was a widely used commercial method for pigs in the UK. However, it has largely been replaced by group CO_2 CAS systems. CO_2 CAS systems allowed pigs to remain in groups during stunning reducing stress related for both pigs and those persons operating the system. Furthermore, CO_2 CAS enabled faster line and processing speeds and delivered improvements in meat quality. Together, these operational and product quality benefits drove the widespread adoption of CO_2 group stunning in the UK pig industry and in other pork producing countries.

30. Both the Farm Animal Welfare Council (FAWC) (2003[5]) and the European Food Safety Authority (EFSA) (2004[6], 2020[7]) have recommended that stunning live conscious pigs with direct exposure to high concentration CO_2 gas mixtures should be phased out. This is because exposure of conscious pigs to high concentrations of CO_2 is known to be both aversive to pigs and to cause them severe pain and distress before becoming unconscious.

31. Arguments are made about the balance of welfare impacts from the stunning process and from pre-slaughter handling in the different slaughter systems. The continued use of high concentration CO_2 stunning has been defended on the basis that pigs are moved in and stunned in groups, reducing handling stress in comparison to single file handling for automated electric stunning. The welfare benefit of group handling is used to argue that it is a reasonable trade-off against the pain and distress caused by exposure to high concentration CO_2.

32. In automated and manual electrical stunning systems, unconsciousness is induced near-instantaneously, but handling and restraining pigs individually to

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[4] https://www.gov.uk/government/publications/farm-animals-slaughter-sector-survey-2024

[5] FAWC report on the welfare of farmed animals at slaughter or killing - GOV.UK

[6] Opinion of the Scientific Panel on Animal Health and Welfare (AHAW) on a request from the Commission related to welfare aspects of the main systems of stunning and killing the main commercial species of animals - - 2004 - EFSA Journal - Wiley Online Library

[7] Welfare of pigs at slaughter - - 2020 - EFSA Journal - Wiley Online Library

apply the electric tongs accurately can adversely affect their welfare. However, several academic stakeholders in recent discussions with the AWC have said that a scientific comparison of the stress of separation and handling with the painful experience of high concentration CO_2 stunning is difficult. The suggested lack of viable alternative stunning methods for commercial throughputs has also helped to maintain the status quo, the continued use of high concentration CO_2 stunning.

33. Previous research[8][9] has shown that pigs do not avoid an environment containing high concentrations of inert gases, such as argon. However, there are practical constraints to the use of inert gas mixtures that have restricted commercial uptake so far. These include the need to expose pigs for longer periods of time in the inert gas in order for unconsciousness to last until death, and technical challenges in maintaining low residual oxygen concentrations.

34. DEFRA co-funded research, with the Humane Slaughter Association, into Low Atmospheric Pressure Stunning (LAPS)[10] as a possible alternative stunning method for pigs. In this work, pigs were exposed to progressive decompression in a sealed chamber to induce unconsciousness and death by hypobaric hypoxia. While effective in pigs, the results showed that LAPS operated at rates relevant to commercial slaughter did not result in improved welfare outcomes compared to high concentration CO_2. Hence, the project concluded that both LAPS and high concentration CO_2 stunning are associated with poor welfare in pigs, and data collected on high concentration CO_2 stunning further supported heightened concern about this method.

35. In 2022 the EU commissioned the PigStun[11,12] project to consider non-aversive alternatives to high concentration CO_2 for stunning pigs. The PigStun project concluded with a conference and publication of its conclusions in June 2025. Defra is also pursuing further research in this area, including into improved methods for the handling of pigs for electrical stunning.

Previous reports

36. Both the AWC's predecessor, the Farm Animal Welfare Council (FAWC), and the European Food Safety Authority (EFSA) recommended more than a decade ago that stunning live conscious pigs with direct exposure to high concentration CO_2 gas mixtures should be phased out.

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[8] Novel and humane gaseous killing methods for pigs - MH0128

[9] Containability & aversiveness of different gas mixtures used for the stunning of slaughter weight pigs - MH0135

[10] Developing an alternative method to the use of high concentration CO2 for the commercial stunning of pigs - MH0154

[11] PigStun kicks-off: The project will promote more respectful techniques for animal welfare in European slaughterhouses - News - IRTA

[12] PigStun - EURCAW-Pigs

37. FAWC said in 2003: “*We conclude that the use of high concentrations of* CO_2 *(80% and above) to stun and kill pigs is not acceptable*”; and recommended “*Government and the industry should fund research and development into the use of non-aversive gas mixtures. The use of aversive gas mixtures should be phased out within five years*.”

38. An EFSA report published in 2004 stated that CO_2 gas in concentrations exceeding 30% was aversive as it caused ‘*hyperventilation and irritation of the mucous membranes*’ as well as gasping behaviour before loss of consciousness. In contrast ‘*use of Argon, Nitrogen or mixtures of these gases.... have animal welfare advantages because hypoxia induced with these gas mixtures is not aversive to pigs*.’ As a result of these findings, it was recommended that ‘*the gas used to induce unconsciousness should be non-aversive*'.

39. A further EFSA Scientific opinion on the welfare of pigs at slaughter published in 2020 said: “*Exposure to* CO_2 *at high concentrations (defined in this opinion as higher than 80% by volume) is considered a serious welfare concern by the Panel, because it is highly aversive and causes pain, fear and respiratory distress. The exposure to inert gases and* CO_2 *with inert gases is less aversive as it causes less pain, fear and respiratory distress compared with exposure to* CO_2 *at high concentrations*”; and one of EFSA’s recommendations was that: “*Exposure to* CO_2 *at high concentration (defined in this opinion as higher than 80% by volume) should be replaced by exposure to other gas mixtures that are less aversive.*”

Changes in the industry

40. The UK pig slaughter industry has experienced sweeping transformation over the past two decades, driven by advances in technology, evolving animal welfare standards, shifting economic pressures, and the demands of a globalized food system. What was once a landscape of numerous small abattoirs and traditional husbandry practices has become a highly integrated, mechanized, and regulated sector. These changes have not only altered the way pigs are raised, processed, and marketed, but have also redefined the animal welfare and practical considerations that underpin every stage of production.

41. The industry’s approach to data collection and analysis has matured, with recent methodological updates providing more accurate and more granular insights into slaughter numbers and herd structure. This transparency supports better regulatory oversight, market forecasting, and welfare monitoring capabilities that were limited or absent in 2003.

42. Since the peak of production in 1997/98, the total number of pigs on UK agricultural holdings has fallen from 8.1 million and as of 1 June 2024 the UK pig herd stood at 4.72 million. Of these England accounts for 78% of the UK's total pig population with Northern Ireland holding a 15% share and Scotland holding 7%. Wales accounts for less than 1% of the UK pig population. In 2023, there were 10,200 commercial agricultural holdings with pigs in the UK: 4,800 had female breeding pigs, and 8,500 had fattening pigs, with numbers concentrated in larger farms.

43. Despite falling numbers within the breeding herd, the number of clean (fattening) pigs slaughtered[13] has increased demonstrating a significant increase in productivity per sow.

Year	Clean Pigs	Sows & Boars
2020	10,923,000	241,000
2021	11,264,000	256,000
2022	11,175,000	248,000
2023	10,050,000	211,000
2024	10,331,000	209,000

44. The structure of the UK pig slaughter industry has shifted from a landscape of numerous small and mid-sized abattoirs in the early 2000s to one dominated by specialised premises which are highly mechanized and use high concentration CO_2 for stun/kill. Almost 90% of pigs are processed through these premises. The number of abattoirs slaughtering pigs in England has dropped by nearly 100 since 2000. The latest figures show that 84 slaughterhouses killed pigs in 2023, and 79 operated during 2024 only 10 of which were specialist pig premises.This consolidation has enabled significant investment in automation and high-throughput systems, allowing for rapid processing and greater efficiency. However, the centralization and speed of these operations have also introduced new challenges in terms of resilience to supply chain disruptions and the maintenance of animal welfare standards at scale.

45. There has been a marked change in the age and size of pigs at slaughter. Advances in genetics and nutrition have led to pigs reaching market weight faster and with greater feed efficiency. Today the average carcass weight is around 90–91.5 kg - up by some 10 kg from 2003 - and pigs are slaughtered at a younger age compared to two decades ago. This is in part due to industry's move away from castration. Male pigs are slaughtered at an earlier age to avoid boar taint and aggressive behaviours.

[13] UK figures provided by AHDB

46. The industry has faced and continues to face acute challenges in recruiting, training and retaining skilled workers, which is crucial to achieving continual compliance with good welfare standards on farm and at slaughter.

47. The challenge from endemic and exotic diseases has intensified due to the scale and integration of modern production systems. Disease outbreaks can have far-reaching consequences across the pork supply chain.

High concentration CO_2 stunning

Controlled Atmosphere Stunning (CAS) mode of action

48. Controlled Atmosphere Systems (CAS) are designed to enable groups of 5-7 pigs to be restrained within a cage, called a gondola, and for this to be introduced quickly to a high concentration of CO_2. The construction of the system consists of a pit which contain 3-6 gondolas on a motorised loop system which lowers them into and out of the pit. CO_2 is continually pumped into the base of the pit to maintain the necessary gas concentration throughout. Being heavier than air, CO_2 remains in the pit and its concentration is continually measured at varying depths. Gondolas are constructed from a strong metal mesh which allows for the free movement of gas and are of sufficient floor area for the unconscious pigs to lie down on the floor without being stacked on each other. Pigs will walk freely into the gondola but in the interest of timing an electronic moving gate usually pushes the animals into the gondola allowing the door to be closed and the gondola to be lowered into the gas. Under GB law pigs must remain in the gas until dead. The gondola is transported around the loop and on reaching the exit point the pigs are tipped onto a conveyor where they are checked for any signs of consciousness before any further processing takes place.

49. Inhaled gases enter the blood stream via gas exchange in the lungs. In the case of gas mixtures containing CO_2, this will increase the dissolved CO_2 in the blood, changing the pH of the blood and eventually the body tissues (especially those with high oxygen demands such as the central nervous system). Breathing in mammals is controlled by motor output from the brainstem and the rate and depth of breathing is orchestrated by several reflexes designed to maintain blood gases within acceptable ranges. Arterial chemoreceptors are sensitive to changes in blood CO_2, O_2 and pH which, along with mechanoreceptors in lungs and respiratory muscles, underpin an increased ventilatory response to hypoxia (low oxygen) or hypercapnia (high CO_2).

50. Exposure to high concentrations of CO_2 causes unconsciousness and an irreversible stun via hypercapnic hypoxia leading to inhibition of neuronal

activity through acidification of cerebrospinal fluid (and hence neural tissue) and brain death. The rate of this response is relative to the concentration of CO_2 inhaled. Exposure to inert gases such as argon and nitrogen causes unconsciousness and death through anoxia (lack of oxygen), and the rate of this response is relative to the inhaled residual O_2 concentration. Because CO_2 is an anaesthetic gas, it acts more quickly than inert gases, especially at high concentrations. In the limited published studies available to date, induction times for unconsciousness with high concentration CO_2 (21-60 seconds) are generally shorter than for inert gases (Argon with less than 2% O_2, 22-77 seconds). Whilst it is desirable to induce unconsciousness quickly, this must be balanced with the experience of the animal during induction.

51. During CAS, animals experience a gradual loss of consciousness, eventually becoming unresponsive to internal and external stimuli as nervous system function is progressively impaired. Loss of posture is commonly used as a proxy for unconsciousness. After this, they continue to show reflex behaviours such as hyperventilation (gasping) and convulsions, but these are not consciously experienced and are understood to be non-relevant to welfare assessment. Finally, animals will cease breathing and become motionless.

Welfare issues with high concentration CO_2 stunning of pigs

52. Exposure of conscious pigs to high concentrations of CO_2 is associated with three major welfare concerns: pain, respiratory distress and fear. These manifest behaviourally as vocalisations, hyperventilation and escape attempts. These are observed before loss of posture and hence occur in the conscious phase of the stunning process.

53. Inhalation of high concentration CO_2 is painful because the gas dissolves in the mucous membranes of the eyes, nose, mouth and lungs to form carbonic acid. This activates nociceptors (specialised receptors that detect potentially damaging stimuli) leading to a sensation of pain. Pain severity depends on the degree of activation of nociceptors and proportion of nociceptors recruited – both of which are likely to be high at current commercial concentrations which greatly exceed the nociceptive threshold (around 40-50% CO_2). Thus, the application of high concentration CO_2 reduces time to loss of consciousness but causes pain prior to unconsciousness.

54. Inhalation of CO_2 drives a hypercapnic ventilatory response, resulting in prolonged inspiration, increased tidal volume (bigger breaths) and decreased breathing frequency - all of which are visibly expressed as hyperventilation/gasping. The thresholds for these responses are low relative to CO_2 concentrations that cause unconsciousness and death. In humans, inhalation of CO_2 is accompanied by dyspnoea (unpleasant feelings relating

to respiration, also termed respiratory distress), and in particular a sensation of ‘air hunger’.

55. In humans, intense air hunger is reported with even small increases in inhaled CO_2 (e.g. 7%). Given comparable underlying respiratory physiology, we would expect similar sensations in pigs. For example, behaviourally obvious hyperventilation was observed in pigs at 30% CO_2 and above (PigStun). Unencumbered breathing partially alleviates air hunger because it arises due to a mismatch between respiratory drive and the mechanical ventilatory response. However, in the case of hypercapnic CAS, increased ventilation does not give relief because deeper breathing exacerbates the heightened drive as more gas is inhaled, likely leading to progressively more intense air hunger despite free breathing. At high CO_2 concentrations, pigs are also exposed to hypoxia as the relative amount of O_2 available is reduced. The hypoxic ventilatory response also consists of increased ventilation and tidal volume, so during hypercapnic hypoxia, both these reflexes will be activated, with possibly greater total dyspnoea. Respiratory distress may also be exacerbated in pigs presented for slaughter with underlying respiratory impairment/disease.

56. High concentration CO_2 stunning in pigs is associated with fear and anxiety[14] due to exposure to novel stimuli, respiratory distress and experiencing a highly aversive yet inescapable environment.

Inert gases/mixtures

57. PATOK allows for the use of stunning for slaughter of pigs with methods outlined in Annex 1 of that regulation. In terms of inert gases this specifies the method as *“Direct or progressive exposure of conscious animals to an inert gas mixture such as Argon or Nitrogen leading to anoxia”*.

58. There are technical challenges to using inert gases in current CO_2 systems or with modifications. Argon is heavier than air so can be used in current systems with the appropriate modifications to sensors, whereas nitrogen is slightly lighter and may not enable an anoxic atmosphere of <2% oxygen due to loss of gas from the system. Helium is significantly lighter than air and would require novel equipment to ensure containment of the gas.

[14] Rodriquez, P., et al (2008). Assessment of unconsciousness during carbon dioxide stunning in pigs. In *Animal welfare (*Vol. 17*) 341-349.* EFSA 2020

Welfare issues with inert gases - argon

59. Immersion in inert gases (argon/nitrogen) causes minimal immediate visible reaction, since these gases cannot be sensed directly by the pig. Once hypoxia is detected by arterial chemoreceptors, respiratory reflexes (hyperventilation) will be apparent, followed by ataxia and then loss of posture, as the pig succumbs to lack of oxygen. Research suggests that pigs do not find inhalation of inert gases immediately aversive, and there is no nociceptor activation. In contrast to hypercapnia, hypoxia alone during free breathing is not a potent stimulus for air hunger in humans. Hyperventilation is still triggered, but this 'blows off' the body's CO_2, reducing the overall drive to breathe. Subjects eventually experience cognitive impairment and loss of consciousness without air hunger. Nevertheless, induction of unconsciousness remains gradual, and it should be noted that all lethal CAS mixtures are associated with some degree of welfare compromise, as indicated by vocalisations that can occur in some pigs during inert gas exposure and rare escape attempts.

60. Inducing unconsciousness and a non-recovery state using inert gases requires a longer exposure time than for high concentration CO_2, estimated to be a 40% increase in dwell time (PigStun). Dwell time has a direct relationship with the likelihood of recovery. Using recent data from PigStun project as an example, a dwell time of 250s resulted in no animals having to be re-stunned in the argon Retrofit system (residual oxygen <0.8%, mean <0.6%). Determining adequate dwell times for individual system set ups (with different residual oxygen levels) is crucial for effective stunning with inert gases.

61. In GB pigs are required to emerge dead from the gas system, while in the EU and elsewhere CAS can be a simple stun requiring a killing method to be applied as quickly as possible. Inadequate dwell time could result in an incomplete stun whereby pigs would be unconscious but still breathing. A pig able to breathe air can recover quickly which could cause a welfare issue before and during bleeding. While highly undesirable, it should be noted that applying a rapid backup stun at this point would not constitute a welfare issue, and that exsanguination would also prevent the return of consciousness. A pig not exhibiting rhythmic breathing will not recover. Individual operators will need to ensure that their stunning equipment is calibrated to ensure irrecoverable unconsciousness.

62. Commercial CCTV footage of pigs in gas stunning systems shown to AWC has been inadequate to properly assess their welfare. CCTV cameras should be positioned within gas systems so that pigs can be clearly monitored throughout the stunning process.

Welfare issues with inert gas and CO_2 mixtures

63. Exposure of pigs to combinations of inert gases mixed with CO_2 could also provide an effective stun and reduce dwell time compared to inert gas anoxia (because CO_2 acts as an anaesthetic). However, even if care were taken to ensure that the concentrations of CO_2 applied would not activate pain, they will cause respiratory distress. This is because CO_2 causes air hunger at low concentrations, well below the levels that induce unconsciousness. Therefore, there is no welfare benefit introduced by adding CO_2 to inert gases.

Inert gases other than argon

Nitrogen gas

64. The Government commissioned research starting in 2005 (MH0128 and MH0135) which explored the use of different inert gases and inert gas and CO_2 gas mixtures as potential stunning methods and concluded that '*under slaughterhouse conditions, pigs should be exposed to a mixture of 85% by volume of nitrogen and 15% by volume of carbon dioxide for at least 90 seconds*'. Research was also conducted on the 'containability and aversiveness of different gas mixtures' (MH0135) in a Butina pit and it was found that *'the containability of N_2 into the pit was very low*'. The report also concluded that '*exposures to gas mixtures with N_2 and either 15% or 30% CO_2 by volume are more aversive to pigs than 90% argon by volume in atmospheric air*'.

Helium gas

65. Helium is less aversive than CO_2 with little or no reaction before loss of posture and consciousness. It is a light, highly volatile gas and is considered safe for operatives as even in the event of a gas leak helium escapes upwards. Given that it is much lighter than air a Helium system would require significant investment in novel and complex equipment as a raised tower system rather than an adapted pit, raising questions about its feasibility in commercial settings.

66. No commercial systems are currently in use, but a novel small scale elevated system was devised as part of PigStun. It appears that time to loss of posture and stunning is greater than for high concentration CO_2, with up to 200 seconds to unconsciousness giving an exposure cycle duration of 5 minutes. There are some reports of increased blood spots with helium systems although overall meat quality was not considered significantly adversely affected.

Electrical stunning

Electrical stunning mode of action

67. Electrical stunning of pigs can be performed as either head-only or head-to-body, and both methods can be applied manually or integrated into automated systems. In automated systems, however, head-to-body stunning is generally used. Both head-only and head-to-body systems employ constant current stunning, with integrated impedance sensing circuits, which are designed to initiate current flow only when the electrodes make correct contact with the pig's head.

68. In manual group electrical stunning, operators use handheld scissor tongs to apply the stunning electrodes to individual pigs, typically working with small batches of pigs confined in a pen. This method requires operator skill to ensure correct electrode placement, adequate contact, and sufficient stun duration. Inconsistencies in application can result in variable stun quality and increase the risk of ineffective stunning, thereby compromising animal welfare.

69. Automated electrical stunning systems are designed for larger, high throughput operations. Pigs are guided into single file using funnel, stepped, or curved races, or a crowd pen, and are then restrained in a conveyor or chute. In semi-automated systems electrodes are manually positioned by an operator, whereas in fully automated systems, they are automatically placed to deliver a controlled electrical current to the correct anatomical site. Automation of electrode placement aims to provide more consistent positioning, current flow, and stun duration, thereby improving reliability and efficiency while reducing human error.

70. In both methods, an electric current is applied across the brain via electrodes positioned on either side of the head. This induces the release of excitatory neurotransmitters (e.g. aspartate, glutamate, glycine) into the extracellular space, resulting in brain dysfunction in the form of generalised, synchronised epileptiform activity. Behaviourally, this is characterised by a tonic phase of muscle rigidity followed by a clonic phase involving involuntary limb movements.

71. Electrical stunning causes a near-instantaneous loss of consciousness, which in head-only stunned pigs is transient and reversible. When correctly performed, unconsciousness should be induced within 100 milliseconds, to prevent perception of nociceptive input. Additionally, the release of the inhibitory neurotransmitter gamma-aminobutyric acid (GABA) contributes to a

period of post-stun analgesia following the clonic phase. Signs of ineffective electrical stunning include: failure to collapse immediately, presence of rhythmic breathing, absence of clonic seizure activity (although this can be an unreliable indicator), presence of cranial nerve reflexes, coordinated muscle tone, spontaneous blinking, vocalisation, and attempts to regain posture.

72. In head-to-body electrical stunning, the current is applied across both the brain and chest. This not only induces unconsciousness but also causes ventricular fibrillation, leading to irreversible cardiac arrest. As such, head-to-body stunning functions as a stun-to-kill method, whereas head-only stunning requires a secondary procedure (e.g. exsanguination) to prevent recovery of consciousness.

Welfare issues with electrical stunning

73. The requirement to reduce pigs from groups to single file in semi- and fully automated stunning systems can cause stress, with pigs often reluctant to move forward. This frequently necessitates the use of movement aids such as paddles, flags, sticks, brushes, and electric prods, which can cause additional pain and distress.

74. In group manual electrical stunning, there is a risk of inadequate stunning due to incorrect electrode placement, poor electrical contact, insufficient stun duration, and animal movement just prior to electrode application (either by the pig being stunned or from shunting caused by conspecifics). Additionally, the presence of an operator can cause stress and increased movement, further complicating the stunning process. There is no evidence that witnessing the act of stunning on conspecifics causes distress to pigs[15]. However, the final pig to be stunned may experience stress due to the absence of conspecifics.

75. Electrical stunning, when performed correctly with sufficient electrical current, can produce reliable and near-instantaneous unconsciousness. This may be reversible (head-only stunning) or irreversible (head-to-body stunning). However, there is still the potential for welfare issues associated with both forms of electrical stunning, as detailed in the following paragraphs.

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[15] Anil et al 1997 https://doi.org/10.1017/S0962728600019345 and Schaeperkoetter et al 2021 https://doi.org/10.1016/j.meatsci.2021.108538

76. Sub-threshold electrical current, due to high impedance, carbon build up on electrodes, poor contact, or equipment malfunction, can result in pigs being inadequately stunned. This can result in a shorter duration of unconsciousness, incomplete stunning, or electro-immobilisation. When electro-immobilised, pigs may be paralysed but remain conscious and capable of experiencing pain and distress. Additionally, electrodes that are damaged, dirty, or poorly insulated can cause pain or thermal burns at the contact site. If the current ramp-up is delayed due to high resistance or poor contact, this pain may be experienced prior to loss of consciousness.

77. For stunning to be effective, electrodes must be positioned to span the brain so that sufficient current passes through the cerebral hemispheres. The recommended placement is bilaterally on each side of the head, between the eye and the base of the ear. However, due to anatomical variations in pig heads (e.g. breed, sex and stage of production), this positioning may be impractical, especially in automated stunning systems. As a result, electrodes are often placed caudal to the ears or, when using scissor-type tongs, diagonally from below one ear to above the opposite eye. When electrodes are placed incorrectly (e.g. such as too far back, on the neck, or across the jaw) it can result in insufficient current flow through the brain and lead to incomplete or transient unconsciousness. Failure to maintain contact with the electrodes and head can interrupt the current flow, rendering the stun ineffective. In some automated stunning systems, inflexible electrode configurations may not accommodate variations in pig head shape or size, increasing the risk of poor contact and stun failure.

78. Fully automated electrical stunning systems are primarily designed and optimised for slaughter-weight pigs, which are relatively uniform in size and head conformation. Due to their greater body size, larger head dimensions, thicker skulls, and more developed musculature, breeding sows and boars often do not fit standard restrainers or align correctly with automated electrodes. This can result in pain and distress during the stunning process. For this reason, breeding pigs are generally not stunned using automated electrical systems.

79. To induce generalised epileptiform activity and effective unconsciousness, the electrical current must be applied for a minimum of 1 second. Shorter durations, often due to poor or inconsistent contact, can result in pigs being incompletely stunned or regaining consciousness. Electrical stunning equipment must record each stun and keep this information for a year enabling checks to be made of stun effectiveness.

80. Head-only electrical stunning induces reversible generalised epileptiform brain activity, which would lead to pigs recovering consciousness within 25-30 seconds if exsanguination is not applied promptly. To prevent recovery prior

to, during or after sticking, it is essential that the stun to stick interval is as short as possible for head-only stunned pigs.

Penetrating captive bolt device

Penetrating captive bolt device mode of action

81. Mechanical concussive stunning renders pigs unconscious by delivering sufficient kinetic energy to the skull and brain to disrupt normal brain function. This can be achieved using either penetrating or non-penetrating captive bolt devices. In England, non-penetrating captive bolt stunning is permitted as a killing method for slaughter, depopulation and euthanasia of piglets weighing less than 10kg, details of which have been previously outlined by the AWC[16]. The following sections focuses only on the use of penetrating captive bolt devices for slaughter-weight and breeding pigs.

82. A penetrating captive bolt device uses a steel bolt, propelled by a cartridge or compressed air, to transfer kinetic energy to the skull/brain and penetrate the cranium, causing direct and irreversible damage to brain structures. This results in rapid loss of consciousness through a combination of mechanisms including: direct physical trauma to critical brain regions (including the ascending reticular activating system), rapid acceleration and deceleration of the brain within the cranial vault, generation of shearing, rotational and linear forces, extensive haemorrhage, and increased intracranial pressure. Together, these disrupt neural pathways and brain activity, ensuring immediate and irreversible unconsciousness when the device is applied correctly.

83. Following effective captive bolt stunning, pigs typically exhibit vigorous involuntary clonic convulsions due to disruption of descending cortical regulation of the brain stem and spinal reflex activity. These convulsions are a normal physiological response in effectively shot pigs but can pose significant safety risks to operators, appear unsettling and result in carcass damage.

Welfare issues with penetrating captive bolt device

84. Penetrating captive bolt is not routinely used as a commercial stunning method for slaughter weight pigs in the UK. Rather, it can be employed as a back-up stunning method when there are failures or welfare issues during the slaughter process (e.g. during lairage, post CAS or electrical stunning, and on the processing line). When correctly applied, penetrating captive bolt stunning

[16] AWC Advice on methods for killing piglets on farm. 2021

can be an effective method to induce rapid unconsciousness. However, several animal welfare issues can arise if the method is incorrectly applied.

85. The primary welfare risk is incomplete concussion, which can occur if the bolt does not deliver sufficient energy to penetrate the skull fully or fails to cause adequate damage to critical brain regions such as the brainstem and the ascending reticular activating system. Factors contributing to ineffective stunning include incorrect cartridge strength, insufficient bolt length for large or mature pigs, poorly maintained equipment, or incorrect shot position. Anatomical factors, such as skull thickness, large frontal sinuses and heavy skull musculature in finishing pigs and breeding stock, can also reduce energy transfer, increasing the likelihood of an inadequate stun. An animal that is not fully stunned may experience pain and distress during subsequent handling, sticking (bleeding) or shackling. Signs of ineffective stunning include rhythmic breathing, vocalisations, cranial nerve reflexes, coordinated muscle tone and righting attempts.

86. Additional welfare concerns include the potential for operator fatigue, injury or distraction in high-throughput settings, which can compromise stunning accuracy. Moreover, poor restraint during application can result in misplacement of the shot, further increasing the risk of incomplete concussion.

Pre-stun handling

87. The same welfare considerations apply for much of the time that pigs are in a slaughterhouse: from the moment they arrive up until they enter the immediate pre-stun area. It is only at the stage where pigs enter the immediate pre-stun area, that the method of stun could dictate how pigs are managed and thus have an impact on welfare.

88. Within pre-stun handling facilities, pigs will be exposed to a range of potential physiological or psychological stressors. These may include unfamiliar surroundings with strange smells, sounds, visual distractions or inappropriate climatic conditions. How animals respond to these stressors will vary between individuals depending on their innate temperament, their overall health, previous experiences and management on farm plus how they have been impacted by the transportation and handling both prior to arrival and within the slaughterhouse.

89. Slaughterhouse staff and lorry drivers trained in low-stress handling methods combined with non-slip flooring, walkways, gates and lighting that are all designed to promote voluntary, unforced, natural and calm animal movement have been shown to reduce the stress response in animals. Furthermore,

animal-centric designs of facilities that encourage animals to move smoothly on their own volition reduces the use of physical aids such as bags, paddles, boards or electric goads. Similarly, electrically powered or hydraulic pusher gates that are quiet with sufficient safety features including manual over-rides and an automatic brake if a pig stops moving reduce the incidence of injury and stress-related behaviours.

90. Maintaining pigs within their pre-formed, familiar social groups is also important. Pigs display fewer signs of stress if they are moved as a small group and/or within sight of each other. Social isolation results in behavioural responses indicative of stress. Conversely mixing animals and penning them in large groups in the lairage can cause agonistic interactions and behaviours that are consistent with a negative experience that may last several hours.

91. In the recent EU PigStun Project, a facility with an "improved electrical stunning system" was assessed. This slaughterhouse aims to improve animal welfare in an automated electrical stunning system by running up to 4 electrical stunning lines in parallel combined with optimising pre-stun handling, design of the raceways and entrance of pigs into the stunner. It was at this last point that pigs were separated from a group into a single race (chute) and animals had free choice to enter one of two raceways. The researchers reported that lowering the throughput rate per stunner reduced pre-stunning stress. In addition, slipping and falling was not observed at the start of the raceway leading to the stunner. However, upon entering the single chute, about 50% of the animals required encouragement using a brush on their backs to keep them moving forward and operators used a low voltage electric prod on about 4% of animals to make them step into the stunner.

Meat Quality

92. Argon, helium and nitrogen have all been authorised and are regulated for food use by the Foods Standards Agency.

93. Issues with meat quality such as appearance, texture, palatability and product shelf-life have direct economic consequences for producers and retailers. Increased production wastage can result in more animals being slaughtered to meet consumer demand. Furthermore, increased wastage will also contribute to a larger environmental impact.

94. Stunning is only one of many factors influencing meat quality. Other factors include the animal's genetics, its age and sex, its previous management on farm including its health, weight, nutritional status and the quality of its feed.

95. The levels of acute stress that the animal may have experienced immediately prior to slaughter will affect meat quality. Acute stress may occur during

loading, transportation and unloading as well as whilst they are held and moved within the pre-slaughter area of the abattoir and at the time of stun itself. After slaughter, the processing, chilling and storage of the carcase will also have a significant impact on meat quality.

96. The PigStun Project assessed meat quality in four different stunning systems and compared these with each other and with five other benchmark data sources. Overall, none of the stun methods at any of the sites performed better with regards meat quality than when animals were stunned with CO_2 alone. The single commercial site that had retrofitted their dip lift system to use argon and therefore could compare meat quality with high concentration CO_2 stunning at the same location found no significant difference in meat quality between the two gas stunning methods. The meat from pigs stunned with the improved electrical system appeared to show more meat quality issues compared to meat from all other high concentration CO_2 systems tested. However, there was no local high concentration CO_2 stunning at this site to perform a direct comparison. Moreover, the large number of variables between the four different stun systems and sites meant that no statistical analysis of meat quality levels could be made across the systems but there was little indication that meat quality would not be acceptable from a commercial setting.

Costings

97. Defra have collated data from industry stakeholders regarding potential cost to both modify and then run a slaughterhouse using alternative stunning methods. In addition, the EU PigStun project researchers have also analysed economic data from their industry collaborators. The AWC working group are not party to these discussions, however considerations include:
    - the cost of alteration will be different for each site as it will depend on current layout/method of stun and the alternative method that is being adopted;
    - it is likely that there would be significant infrastructure changes to allow the adoption of alternative stun/kill systems which maintain throughput. Any sudden reduction in throughput could have welfare implications on farm.
    - when running costs are considered, argon is more expensive than CO_2 and the exposure time required for an effective stun is longer. The latter would probably impact throughput time. The EU PigStun project estimates that cost per pig for an argon-based system would be 2-3 times higher than current high concentration CO_2 systems. If a second system that can run in parallel with the first is required to be installed to maintain the overall hourly rate of production, then additional labour, electricity and maintenance costs may also be incurred.

98. Both labour and maintenance costs may also increase if an "improved electrical stunning system" is adopted as additional staff would also be required to manage the parallel stun and post-stun lines. The AWC working group have been informed that there can be challenges in recruiting suitable staff even for the number required to manage the current system. Additional staff will also require extra training, and there will be extra costs associated with this but also benefits in increased productivity from better trained staff.

Ethical analysis

99. In line with its previous work and Opinions, the ethical approach which AWC has adopted in considering this issue is a primarily utilitarian one in which the human use of animals is considered permissible to achieve important benefits, providing that animal welfare is safeguarded as far as possible and, as a minimum, in accordance with national and, where relevant, international legislation. The utilitarian approach adopted by AWC is qualified in that the justification of harms is considered in relation to both the magnitude and importance of the benefits that accrue, within the context and situation under consideration. AWC recognises that there are some harms which, due to their severity, should not be inflicted upon animals under normal circumstances. Animal welfare should be maximised as far as possible in each and every situation to ensure that animals have 'lives worth living' and ideally 'good lives'[17].

100. The provision of 'lives worth living' or 'good lives' is dependent upon the minimisation of negative welfare effects and maximisation of positive welfare effects across an animal's lifetime. This includes during the period immediately preceding and including death. The provision of a humane death is a necessary prerequisite of ethical animal use under normal circumstances.

101. In relation to the stunning of pigs before killing, this means that only minimally aversive, non-painful methods, based on current knowledge, should be used. The appropriate choice of minimally aversive, non-painful method may be dependent upon circumstance.

102. The use of an aversive or painful method to allow for greater throughput or cost-cutting is not justifiable since it does not satisfy the utilitarian harm/benefit calculation.

[17] Wathes, C. (2010), Lives worth living?. Veterinary Record, 166: 468 to 469.

Conclusions

High concentration CO2 stunning

103. Exposure to high concentrations of CO_2 in commercial systems causes pigs to suffer pain, respiratory distress and fear as demonstrated through escape behaviour, gasping and vocalisation. This impact on welfare presented by high concentration CO_2 stunning has been known for a long time, with a significant evidence base including FAWC (2003), EFSA (2004, 2020) and published scientific articles culminating in the EU PigStun project.

104. Since 2003 there have been no significant alterations to systems deploying high concentration CO_2 for the stunning of pigs and there is evidence that pigs are subject to avoidable pain, distress or suffering.

Inert gases

105. Inert gases are significantly less aversive to pigs than CO_2. However, they do not render the animals near-instantaneously unconscious thus the risk of possible welfare harm remains.

106. Of the inert gases which have been assessed in the EU PigStun project, argon is the most suitable alternative for commercial use, at this time, taking all factors into consideration.

107. Crucially, although there may be a small element of aversion due to oxygen deprivation and exposure to a novel environment, argon is significantly less aversive than CO_2 where contact between the gas and the mucous membranes results in pain. Pigs in argon demonstrate almost no escape behaviour, little vocalisation and significantly reduced hyperventilation compared to those in high concentration CO2.

108. When pigs are introduced into an argon gas system with less than 2% residual oxygen and left in the system until dead, they experience significantly less suffering than those in a high concentration CO_2 system.

109. Adequate dwell time is essential for effective stunning with inert gases; these durations are related to residual oxygen levels and are longer than those needed for high concentration CO_2. Those operating commercial stunning systems will need to calculate the time pigs must remain in the gas to achieve irrecoverable unconsciousness. This determination must be undertaken for all types of stock processed, e.g. fattening pigs, sows and boars, so that the stunning equipment can be calibrated for the individual circumstances in each slaughterhouse.

110. The results of the PigStun project modelled a dwell time of 240 sec in argon to achieve a stun/kill success rate of 99.5%. Pigs which are not killed in the process but are rendered unconscious will lose posture and the brain is significantly impaired, although they may show signs of breathing and/or reaction to stimulation of the eye. The identification and actions taken with these pigs is critical to welfare. Increasing the dwell time in argon reduces the risk of non-stun/kill.

111. Pigs stunned but not rendered irrecoverably unconscious in an argon system can regain consciousness rapidly so immediate action must be taken to induce death by an alternative process within this time. Due to the rapid recovery time, ensuring pigs do not recover consciousness from gas stunning should remain a legal requirement.

112. In the short term without necessary changes to systems to improve throughput, an increased dwell time could reduce the capacity of the processors and could impact subsequent approaches to pig production.

113. Argon can be used in a converted CO_2 stunning system because, like CO_2 it is heavier than air. For nitrogen, current pit designs may need to be adapted to prevent N_2 loss and ensure an anoxic environment of <2% oxygen, and preferably <1% oxygen or below to reduce risk of recovery at shorter dwell times.

114. Nitrogen and helium are possible alternative gases for stunning to which pigs show minimal aversion but would require increased dwell times over high concentration CO_2. Further development of these systems would be needed to enable a full welfare assessment in a commercial setting.

115. Addition of CO_2 to inert gases does not have welfare advantages as air hunger is triggered at low CO_2 concentrations. This has been confirmed in results from the PigStun project.

116. CCTV cameras should be positioned in gondolas within CAS systems so that pigs can be clearly monitored throughout the stunning process.

117. Although the EU PigStun project predicts that retrofitting an argon system into a facility that currently uses CO2 should only take 1-2 days, this has not been proven in practice and there are other considerations such as manufacturing time, sourcing of gas, training and testing and development of Standard Operating Procedures for each premises, before such a system could be brought into commercial use.

118. That said, adoption of alternative stunning systems should be undertaken as soon as possible and based on information from the PigStun

project and discussions with industry, this should be achievable within five years.

Electrical stunning

119. Electric stunning results in near instant unconsciousness without pain or suffering when the electrodes are placed in the correct position on the head-only or head-to-body.

120. Electrical stunning electrodes must span the brain to allow sufficient electrical current to flow through the cerebral hemispheres, and the current delivered must be sufficient to rapidly induce and maintain unconsciousness until brain death from exsanguination induced cerebral hypoxia.

121. To ensure correct positioning of electrodes it is necessary to restrain each individual animal and this can be a cause of anxiety, or distress. The pre-stun handling system can be designed and operated to reduce the level of these effects to those normally experienced by pigs in any animal/human interaction.

122. Automated electric stunning has a potential advantage in reduced risk of mis-stun over manual electric stunning by deploying technological positioning systems to eliminate human error. Where manual stunning is deployed, preslaughter restraint must provide for a similar level of confidence in individual restraint at time of stun.

123. Automated electrical stunning systems pose significant welfare risks for breeding boars and sows. Their larger size, thicker skulls, and different head shape compared to younger pigs mean they often do not fit standard restrainers, and the electrodes may not align correctly to deliver an effective stun. This is also applicable to fattening pigs where there is a significant range of weight or size. These animals should not be stunned in systems designed for standardized slaughter-weight pigs. Operators should determine the acceptable size/weight range of slaughter pigs for the equipment they choose to operate.

124. Prompt exsanguination is required following all forms of electrical stunning, but especially for head-only, to ensure that pigs do not start to recover consciousness during the bleeding process.

125. Head-to-body electrical stunning, which induces unconsciousness and disrupts the supply of oxygenated blood to the brain by cardiac arrest is preferable on welfare grounds compared to head-only electrical stunning.

126. Given pre-slaughter handling systems that minimise stress, electrical stunning systems that provide a near-immediate stun and therefore no welfare

challenge during induction to unconsciousness could present welfare advantages over gas stunning.

Penetrating captive bolt device

127. Penetrating captive bolt stunning, when applied correctly for the stage of production, with an appropriate power load and device type, can be an effective method for inducing immediate unconsciousness in pigs. This is not anticipated to be a high throughput method of stunning but is used as a back-up stun in individual cases.

128. Incomplete concussion due to the incorrect use of penetrating captive bolt devices, could result in the experience of pain and distress.

129. The clonic convulsions that occur post effective penetrating captive bolt stunning, may pose a risk to operator safety and conspecific welfare in group stun settings, but do not compromise the welfare of the pig being stunned.

Pre-slaughter handling

130. Pre-slaughter handling of pigs for gas systems has been improved with the introduction of automated gated systems and changes in gondola design, which reduce stress when used correctly.

131. All preslaughter handling systems should be adapted to encourage uninterrupted flow of animals through the system and reduce use of aids to encourage movement.

132. Handling pigs in single file can cause stress. Handling for automated electrical systems has been improved and could be further refined, particularly by reducing the time pigs are isolated pre-stun and by a redesign of the race to conveyor transfer point, to protect pig welfare.

133. All systems require a high degree of operator competence and are dependent on being well maintained. The training of operatives and maintenance staff is critical in the protection of animal welfare and ongoing continuous assessment is required to avoid operator complacency or a drop in standards that can result from repetitive situations.

Recommendations

High concentration CO_2 stunning

134. To prevent pigs experiencing avoidable pain, distress or suffering at slaughter associated with high concentration CO_2 its use should be prohibited as a method of stunning for pigs.

135. To prevent pigs experiencing avoidable pain, distress or suffering at slaughter associated with CO_2 in combination with inert gases its use should be prohibited as a method for the stunning of pigs.

136. Any transition period given to industry to enable the change to alternative methods of slaughter, as listed in PATOK annex 1, should be as short as possible and in any case within five years. Industry should seek to implement the changes as quickly as possible.

Inert gases

137. Operators who convert to commercial inert gas stunning systems must ensure calibration of their equipment, based on the size, age and category of pigs, to ensure that the animals remain in the gas for the duration necessary to achieve irrecoverable unconsciousness.

138. Industry should move towards reducing residual oxygen in inert gas stunning systems to 1% or below to reduce risk of recovery at shorter dwell times.

139. After exposure to an inert gas for the calculated dwell time, any pig that shows a sign of respiratory activity should receive an immediate re-stun.

Electrical stunning

140. Group stunning pens for manual electrical stunning should be adjustable in size and always adjusted to a suitable size for the number of animals contained within it in order to ensure each individual pig is properly restrained and accurately stunned to minimise fear or stress

141. Stunning systems must be designed to encourage each animal to move through the system to the point of stunning without the need for physical coercion or the use of electric goads and this is particularly important in systems requiring individual restraint.

Pre-slaughter handling

142. Slaughter lines should be approved to slaughter no more than a specified number of animals per hour. The number of animals specified per hour should be such that each animal has time to move through the system without the need for physical coercion.

143. Legislation should be amended to require pigs to be kept in a small social group, preferably with animals from their rearing group, during lairaging and slaughter or if single confinement is necessary they should be confined for the minimum amount of time and whenever possible within sight of other pigs to remove the stressor of isolation.

General

144. Training and qualification requirements should be amended to require periodic revalidation of the certificate of competence in the stunning and slaughter of pigs in a slaughterhouse, rather than it lasting for life.

145. Government and industry should encourage research into technologies, such as automated video monitoring systems, to assess animal welfare and to detect harms in animal handling, stunning and slaughter processes in the abattoir.

Appendix 1: AWC membership

Prof Madeleine Campbell—Chair*
Dr Gareth Arnott
Dr Emily Craven
Dr Jane Downes*
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Dr Julian Kupfer*
Mr Stephen Lister*
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Prof Sarah Wolfensohn
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* = member of the Working Group for this Opinion

Co-opted Working Group members

AWC is grateful to the AWC Secretariat and APHA, FSA and Defra staff who gave assistance.

References in footnotes are not an exhaustive list of the evidence considered in the preparation of this report.

Appendix 2: Those who gave evidence and assistance

Advocates for Animals
Agriculture and Horticulture Development Board (AHDB)
Animal Equality UK
Association of Independent Meat Suppliers (AIMS)
Association of Meat Inspectors
British Meat Processors Association (BMPA)
British Veterinary Association (BVA)
C&K Meats
Compassion In World Farming
Compaxo
Conservative Animal Welfare Foundation
Cranswick plc
Dunbia
Eyes on Animals
Friedrich-Loeffler-Institut
Food Standards Agency (FSA)
Humane Slaughter Association
Humane Society International/UK
Labour Animal Welfare Society
Marel
National Farmers' Union (NFU)
National Pig Association (NPA)
Pig Veterinary Society (PVS)
Pilgrim's Europe
Red Tractor Assurance
Respect for Animals
Royal Society for the Prevention of Cruelty to Animals (RSPCA)
Scotland's Rural College
Scottish Animal Welfare Commission
Scottish Society for the Prevention of Cruelty to Animals (SSPCA)
Sofina Foods
UK Centre for Animal Law
University of Newcastle
University of Winchester
Viva!