Question to EURCAW-Pigs: On-farm killing of piglets
31 January 2022

Question
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EURCAW-Pigs received a question from a veterinary inspector at a government of one of the Member States:

Context: Some farmers are not able or willing to kill sick or injured piglets by manual blunt force trauma and bleeding procedures. One alternative method for these could be killing piglets with CO_2. The method seems to be reliable regarding the process, and it is easier for the farmer to put a piglet into the box instead of using physical force against the animal. But can these benefits justify the respiratory distress under high levels of CO_2 for the animal? Accordingly, the question is:

- *With regard to euthanasia of piglets on farm, what are the advantages and disadvantages in terms of animal welfare of killing with high levels of CO_2 versus a manually applied blunt force trauma?*

Answers
Several EURCAW experts contributed to the response below. The EURCAW secretariat did the final editing, and may be contacted for queries: info.pigs@eurcaw.eu.

In short the answer is:

- **Blunt force trauma** in piglets by the manual delivering of a blow to the forehead with a hard object or hitting the head towards a hard surface are entirely manual processes and prone to error. It requires a level of skill that stockpersons and veterinarians may not necessarily possess, especially if they infrequently perform the procedure. This method is less reproducible between animals and there is significant risk of causing incomplete concussion, and therefore it is not recommended as an on-farm killing method (EFSA 2020).
- **Mechanically operating devices** have been developed and demonstrated as an alternative and more standardized method. These would include producing an immediate stun followed by death in piglets up to 10 kg with non-penetrative captive bolts and in piglets up to 30 kg with penetrating captive bolts. Please note that the use of the non-penetrating bolt shot has not been approved in pigs under Council Regulation (EC) No. 1099/2009. This weight specification when using the penetrating captive bolt guns modified for piglets is based on the first study conducted on these devices by Meier (2020). For the use of the penetrating captive bolt there is no legal weight restriction.
- Exposure to gasses or gas mixtures will not lead to immediate onset of unconsciousness. The induction phase is leading to a period of stress or discomfort. When placed in a prefilled container with >80% carbon dioxide it will take 22 s (in 80% CO_2) resp. 15 s (in 90% CO_2) until loss of posture (Raj and Gregory, 1996). During this time, animals are experiencing respiratory distress due to CO_2. Therefore, measures that can be implemented to decrease the length of the induction phase (e.g. prefill method) or to reduce aversiveness (e.g.

mixing carbon dioxide with inert gases) should be sustainably considered when implementing gas killing methods.

Background

Farmers are responsible to take care of sick and injured animals and in this regard, euthanasia is applied to animals that are injured or have a disease associated with severe pain or suffering and where there is no other practical possibility to alleviate this pain or suffering (EFSA 2020). Different methods are allowed (Council Regulation (EC) No. 1099/2009) and available for farmers to be applied by the farmers themselves. The available killing methods suitable for piglets can be mechanical methods and exposure to gas mixtures, both having advantages and disadvantages.

Mechanical killing methods: The principle is the induction of brain concussion resulting in unconsciousness through the impact of a penetrative captive bolt, non-penetrative captive bolt, a hard object used to deliver a percussive blow to the head or blunt force trauma. Penetrative captive bolt is followed by pithing. Percussive blow to the head must be followed by a killing method (Council Regulation (EC) No. 1099/2009) which in practice will be bleeding.

In practice for neonatal piglets **blunt force trauma** or a percussive blow to the head is performed in most cases. Important advantage of blunt force trauma is that it is a non-expensive method that can be applied in all farms at all locations. There is no need for (expensive) equipment. More important, when it is performed well it will induce immediate loss of consciousness and in cases it can be irreversible. However, blunt force trauma in piglets by the manual delivering of a blow to the forehead with a hard object or hitting the head towards a hard surface are entirely manual processes and prone to error. It requires a level of skill that most stockpersons and veterinarians would unlikely possess if they infrequently perform the procedure. If piglets are not hit on the frontal-parietal bones, the method will fail to induce unconsciousness and will cause severe pain. Lack of skilled operators, operator fatigue and poor restraint, and wrong choice of the tool to deliver the blow can lead to incorrect application of blow to the head. This method is less reproducible between animals and there is significant risk of causing incomplete concussion, and therefore it is not recommended as an on-farm killing method (EFSA 2020). Another important disadvantage is that the method needs to be followed by bleeding as a killing method. Bleeding animals often meets resistance of farmers.

As an alternative and more standardized method, **mechanically operating devices** using cartridge driven or air-pressure driven non-penetrative and penetrative captive bolts have been developed to induce brain concussion with immediate loss of consciousness. The **non-penetrative captive bolt (NPCB)**, applied in a frontal-parietal positioning, has been demonstrated as a viable method of producing an immediate stun followed by death in neonatal piglets ("Cash Small Animal Tool", average dead weight 1.20 ±0.58 kg (standard deviation), Grist et al., 2018b) and in piglets up to 10kg (e.g. "Cash Dispatch Kit" and "Zephyr EXL", Accles & Shelvoke, UK; Woods, 2012; Kluivers-Poodt et al., 2014; Grist et al., 2017; Grist et al., 2018a). According to the results of these scientific studies, the advantage of this method is that stunning and killing of the piglets could be achieved in one step without an additional subsequent killing procedure (one-step procedure). However, to date, use of the non-penetrating bolt shot has not been approved in pigs under Council Regulation (EC) No. 1099/2009.

Penetrating captive bolt (PCB) guns have also been further developed for use on piglets. According to a first study by Meier (2020), using two such modified cartridge-driven penetrating

captive bolt guns, 98.5% of the animals up to 30 kg body weight (n = 198, weight: 0.48-39 kg) were successfully euthanized in one step despite minor deviations in the targeted shooting position in 24% of the animals. The appropriate shooting position for suckling piglets was approx. 1-2 cm, for larger piglets approx. 3-3.5 cm above eye level in the median with the shooting direction as parallel as possible to the longitudinal body axis in direction to the tail. The modified captive bolt devices were equipped with a bolt that was relatively long in relation to the size of the head (for piglets up to 5 kg "Drei Puffer", now called "Ferkelblitz", bolt exit length: 5.3 cm; for heavier pigs up to 30 kg: "Blitz Kerner", bolt exit length: 8.3 cm; each used with green cartridges; turbocut Jopp GmbH, Germany). The combination of such a bolt with the correct shooting position is intended to cause the death of the animal by destroying the brain stem as a result of the entering bolt (similar to the effect of pithing) and without a subsequent killing procedure. Animals weighing up to 2.5 kg were restrained using a specially developed head restraint, while heavier animals were restrained in a commercially available load-securing net for vehicles. For the correct positioning of the captive bolt device on the head of the piglet in the net, a 90° angle between forehead and the neck was necessary. Disadvantages of the method may be the strong convulsive activity after the shot for about two minutes (in 94.1% of piglets) and the release of blood from the gunshot wound. The latter may contribute to the rejection of the method by users and bystanders (Meier, 2020). Most of the animals died directly after application of the modified penetrative captive bolt. However, according to Council Regulation (EC) No. 1099/2009, a killing procedure needs to be applied immediately after the shot.
For the effective application of these mechanically applied non-penetrating and penetrating methods, a correct positioning of the device, a good restraint of the piglet and the application of correct captive bolt parameters are crucial. These include e.g. velocity and bolt mass for NPCB resp. velocity, exit length and diameter of the bolt for PCB (Grist et al., 2018a; Grist et al., 2018b; EFSA, 2020). The latter requires appropriate equipment that is ready to use and regularly maintained. The manual restraint for the immobilization of the piglet and its head may lead to pain and fear (EFSA, 2020). Wrong placement of the device due to lack of skills of operators and staff training, operator fatigue and poor restraint of the animal as well as insufficient bolt parameters (e.g. low cartridge power, low bolt velocity) will fail to induce unconsciousness and will cause severe pain due to the impact of the bolt on the skull (Grist et al., 2018a; 2018b; EFSA, 2020). Please note that the captive bolt techniques require levels of skill that most stockpersons and veterinarians are not likely to have, as until now, these mechanically methods have mainly been used in research and not routinely on farms to euthanize piglets.

Exposure to gas mixtures: The principle of killing by gas mixtures is that animals are individually or in a group exposed to gas mixtures in containers or to a gas-filled foam. Different gas mixtures can be used to kill piglets on farm which are carbon dioxide in high concentrations, inert gasses such as nitrogen and carbon dioxide – nitrogen mixtures. The main advantage of killing by using gasses or gas mixtures are that animals are placed in a controlled gas atmosphere that induces unconsciousness followed by death. The methods are, when the exposure time and gas concentrations are right, very reliable. The lower the CO_2 concentration or higher the residual oxygen in inert gases the longer the time to induce death. Furthermore, the method is not prone to manual handling or operator skills or fatigue. Since, the method is applied in a box the methods can be less confronting for operators.
Since exposure to gasses or gas mixtures will not lead to immediate onset of unconsciousness the induction phase is leading to a period of stress or discomfort. Exposure to high levels (>40%) of

CO_2 will lead to respiratory distress and painful irritation of mucous membranes in nose and mouth (Raj and Gregory, 1996; Velarde et al., 2007; Terlouw et al., 2016). Exposure to anoxic gasses or mixtures can lead to air hunger. In all gasses the period between starting to be affected by the gas, i.e. getting drowsy, and the moment of loss of consciousness will go with difficulties to remain balance or a sitting or standing position which will lead to resistance and efforts to remain position and consciousness. This period can be seen as a stressful or a period of fear during the induction phase. The period of discomfort during exposure to gasses for killing depends on the gas concentration, in particular of CO_2. Rapid filling of the gas container after animals are placed in the container or prefilling the gas container will reduce the duration of the induction phase and thus the potential period of discomfort. When placed in a prefilled container with >80% carbon dioxide, it will take 22 s (in 80% CO_2) resp. 15 s (in 90% CO_2) until loss of posture (Raj and Gregory, 1996). For this time, as a result of the delayed onset of the anesthetizing effect of CO_2, animals consciously perceive respiratory distress (Troeger, 2008). Mixing carbon dioxide with inert gases (e.g. argon, nitrogen) may not shorten the induction phase, but it may mitigate the severity of respiratory distress (Raj and Gregory, 1996). Such mixtures with a residual oxygen content below 2% proved to be less aversive than carbon dioxide in high concentrations (Raj et al., 1997; Dalmau et al., 2010b; Llonch et al., 2012). Argon in high concentrations has not been shown to be advantageous over CO_2 in high concentrations for euthanasia of piglets (e.g. increased time to loss of posture, increased duration of open mouth breathing and ataxia, increased prevalence of righting attempts and a prolonged time to respiratory arrest; Sutherland, 2011; Sadler et al., 2014). Nitrogen has a lower relative density than air and is therefore less stable in high concentrations in an open system (Troeger et al., 2004; Dalmau et al., 2010a,b). Its application in high concentrations therefore requires, for example, foam as a carrier. For an overview on gas-killing of piglets with gases, gas mixtures as well as gas-filled foam, we refer to the recently published EURCAW Review on euthanasia of suckling piglets on farm (Wilk et al., 2021).

Relevant references

Dalmau, A., Llonch, P., Rodriguez, P., Ruíz- de la- Torre, J. L., Manteca, X., & Velarde, A., (2010a). Stunning pigs with different gas mixtures: gas stability. *Animal Welfare, 19*, 315-325.

Dalmau, A., Rodriguez, P., Llonch, P., & Velarde, A. (2010b). Stunning pigs with different gas mixtures: aversion in pigs. *Animal Welfare, 19*, 325-333.

EC (2009). Council Regulation (EC) No 1099/2009 of 24 September 2009 on the protection of animals at the time of killing. European Parliament, Council of the European Union. https://edepot.wur.nl/146812

EFSA Panel on Animal Health and Welfare (AHAW) 2020. Scientific opinion on Welfare of pigs during killing for purposes other than slaughter. *EFSA Journal 2020;18*(7):6195, 72 pp. https://edepot.wur.nl/561173

Grist, A., Murrell, J., McKinstry, J. L., Knowles, T. G. & Wotton, S. B. (2017). Humane Euthanasia of Neonates I: Validation of the effectiveness of the Zephyr EXL Non-penetrating Captive Bolt system for euthanasia of new-born and weaned piglets up to 10Kg. *Animal Welfare, 26*, 111-120.

Grist, A., Knowles, T. G. & Wotton, S. B. (2018a). Humane euthanasia of neonates II: field study of the effectiveness of the Zephyr EXL non-penetrating captive-bolt system for euthanasia of newborn piglets. *Animal Welfare, 27*(4), 319-326.

Grist, A., Lines, J. A., Knowles, T. G., Mason, C. W. & Wotton, S. B. (2018b). The Use of a Non-Penetrating Captive Bolt for the Euthanasia of Neonate Piglets. *Animals, 8*(4), 48.

Kluivers-Poodt, M., Rommers, J., Reimert, H., Troquet, L., Gerritzen, G. (2014). *Doden van dieren op het primaire bedrijf.* Lelystad, Wageningen UR (University & Research Centre) Livestock Research, Wageningen Livestock Research Rapport 378.

Llonch, P., Dalmau, A., Rodriguez, P., Manteca, X., & Velarde, A. (2012). Aversion to nitrogen and carbon dioxide mixtures for stunning pigs. *Animal Welfare, 21*(1), 33-39. https://doi.org/10.7120/096272812799129475

Meier, C. (2020). *Untersuchung der Wirksamkeit des penetrierenden Bolzenschusses als kombinierte Betäubungs- und Tötungsmethode bei Saugferkeln und Ferkeln bis 30 kg Körpergewicht und Entwicklung einer geeigneten Fixierung*. Dissertation, Veterinärmedizinische Fakultät der Universität Leipzig, Leipzig, 2020. Retrieved from: https://ul.qucosa.de/api/qucosa%3A70860/attachment/ATT-0/

Raj, A. B. M. (1999). Behaviour of pigs exposed to mixtures of gases and the time required to stun and kill them: welfare implications. *Veterinary record*, *144*(7), 165-168.

Raj, A. B. M., Johnson, S. P., Wotton, S. B., & McInstry, J. L. (1997). Welfare implications of gas stunning pigs: 3. the time toloss of somatosensory evoked potential and spontaneous electrocorticogram of pigs during exposure to gases. *The veterinary journal*, *153*(3), 329-339. https://doi.org/10.1016/S1090-0233(97)80067-6

Raj, A. B. M., & Gregory, N. G. (1996). Welfare implications of the gas stunning of pigs 2. Stress of induction of anaesthesia. *Animal Welfare*, *5*(1), 71-78.

Sadler, L. J., Karriker, L. A., Schwartz, K .J., Johnson, A. K., Widowski, T. M., Wang, C., Sutherland, M. A. & Millman, S. T. (2014). Are severely depressed suckling pigs resistant to gas euthanasia? *Animal Welfare 24*, 145–155. https://doi.org/10.7120/09627286.23.2.145

Sutherland, M. A. (2011). The use of different gases and gas combinations to humanely euthanize young suckling pigs. *Final Report to the United States National Pork Board*. Retrieved from NPPC Final Report Format (porkcheckoff.org) (accessed November 2021)

Terlouw, C., Bourguet, C., & Deiss, V. (2016). Consciousness, unconsciousness and death in the context of slaughter. Part II. Evaluation methods. *Meat science*, *118*, 147-156. https://doi.org/10.1016/j.meatsci.2016.03.010

Troeger, K. (2008). Tierschutzgerechtes Schlachten von Schweinen: Defizite und Lösungsansätze Tierärztliche Praxis (36 (suppl. 1, pp. 34 – 38), Germany: Schattauer GmbH. https://doi.org/10.1055/s-0038-1622718

Troeger, K., Machold, U., Moje, M., & Behrschmidt, M. (2004). Gasbetäubung von Schweinen: Ein Vergleich von Kohlendioxid, Argon und einer Stickstoff-Argon-Mischung bezüglich der Schlachtkörper und Fleischqualität – 2. Ergebnisse. *Fleischwirtschaft 84*(11), 117-121.

Velarde, A., Cruz, J., Gispert, M., Carrión, D., Torre, R. D. L. J., Diestre, A., & Manteca, X. (2007). Aversion to carbon dioxide stunning in pigs: effect of carbon dioxide concentration and halothane genotype. *Animal Welfare*, *16*(4), 513-522.

Wilk, I, Kernberger-Fischer, I., Gerritzen, M.A., Kongsted, H., Schrader, L. (2021): Review on euthanasia of suckling piglets on farm. EURCAW-Pigs, December 2021, version 1.0. https://edepot.wur.nl/560858 (accessed January 2022)

Woods, J. A. (2012). *Analysis of the use of the "CASH" Dispatch Kit captive bolt gun as a single stage euthanasia process for pigs* [Doctoral dissertation, Iowa State University]. Retrieved from https://dr.lib.iastate.edu/server/api/core/bitstreams/8d92f6c7-cd0d-4664-879c-c35b18dce36f/content (accessed January 2022)