

# Killing individual poultry on-farm—a survey among veterinarians and farmers

Anneleen Watteyn,<sup>\*,1</sup> Leonie Jacobs,<sup>†</sup> Bart Ampe,<sup>\*</sup> Christel P. H. Moons,<sup>‡</sup> An Garmyn,<sup>‡</sup> and Frank A. M. Tuyttens<sup>\*,‡</sup>

*\*Animal Sciences, Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Melle, Belgium; †Department of Animal & Poultry Sciences, Virginia Tech, Blacksburg, VA, USA; and ‡Faculty of Veterinary Medicine, Ghent University, Merelbeke, Belgium*

**ABSTRACT** To date, information about reasons to select and kill poultry on-farm and which method veterinarians and poultry producers preferably use is scarce. Little is also known about their knowledge of the legislation regarding on-farm killing methods and of methods alternative to the one(s) they use, as well as their perception of those alternatives. In this study, Flemish poultry veterinarians ( $n = 13$ ), broiler chicken producers ( $n = 27$ ), and turkey producers ( $n = 4$ ) were surveyed on killing methods they currently use in practice and alternative methods, on their opinion about what constitutes an appropriate method for on-farm killing of poultry, and on their reasons for killing. All poultry veterinarians and chicken producers who filled out the survey kill poultry by manual cervical dislocation (CD), whereas some turkey farmers also indicated killing by percussive blow to the head ( $n = 1$ ) or exsanguination ( $n = 1$ ). Turkey producers seem to be more inclined not to kill animals with injuries or symptoms of disease as compared to veterinarians or chicken producers, such that moribund turkeys are more

likely to remain in the flock. Veterinarians considered the following properties of a killing method important: animal friendliness, applicability inside the stable, a high success rate, and time efficiency. Producers ranked the properties similarly, but for them, ease of performance and cost-efficiency were more important than applicability inside the stable. Producers scored those killing properties rather positively for manual as well as mechanical CD. Veterinarians and chicken producers considered the captive bolt method to be easy to perform, to have a high success rate, to be feasible to perform in the stable, and to be animal-friendly. Turkey producers, however, had doubts about the latter 2 properties. Gas, injection, and electrocution were inferior methods to kill poultry according to producers. In conclusion, manual CD is the most common method for killing broiler chickens and turkeys, and knowledge of, and experience with, alternative methods is very limited, both among veterinarians and producers. Informing them about legislation and training for the use of alternative killing techniques are recommended.

**Key words:** chicken, Turkey, killing, on-farm, survey

2020 Poultry Science 99:4132–4140

<https://doi.org/10.1016/j.psj.2020.05.042>

## INTRODUCTION

In poultry farming, billions of birds are reared worldwide, resulting in a production of 117 million tons of poultry meat per year (FAO, 2017). According to European Union (EU) legislation, a broiler chicken producer must inspect the animals at least twice daily, focusing on animal health and welfare (European Union, 2007). For turkey producers, there is no such legal requirement

in the EU. In Canada, the regulations are similar but apply to both chickens and turkeys (NFACC, 2016). On the contrary, in the United States, poultry is not covered by animal welfare legislation (the Animal Welfare Act), so there is no legislation on inspection (USDA, 2019). But the Global Animal Partnership promotes the welfare of farmed animals by rating the welfare standards of various farmed animal products. They stated that a flock of chickens raised for meat or turkeys must be observed and monitored at least twice daily (GAP, 2015, 2018). During production, approximately 1% of Flemish broilers are killed by farmers, stock people, or veterinarians because of severe injuries or health problems for which an appropriate treatment is not considered feasible (Tuyttens et al., 2014). The European Council Regulation no. 1099/2009 on the protection of animals

© 2020 Published by Elsevier Inc. on behalf of Poultry Science Association Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Received February 13, 2020.

Accepted May 26, 2020.

<sup>1</sup>Corresponding author: [Anneleen.Watteyn@ilvo.vlaanderen.be](mailto:Anneleen.Watteyn@ilvo.vlaanderen.be)

at the time of killing demands that killing is done humanely and that the level of suffering is minimized (European Union, 2009).

Several killing methods are allowed, but the most common one is manual cervical dislocation (CD) (Sparrey et al., 2014). Manual CD is executed by holding the legs of the bird in one hand, while the other hand is stretching and twisting the neck (HSA, 2016). This results in dislocation of the cervical vertebrae, rupture of the spinal cord, and cerebral ischemia caused by rupture of the jugular blood vessels. This method is legally restricted to birds with a maximum BW of 3 kg and to maximum 70 birds per person per day (European Union, 2009). This limitation in numbers is to prevent inefficient killing due to operator fatigue, resulting in undue suffering by the birds. For birds weighing over 3 kg, mechanical CD can be used, based on a lever mechanism to reduce the physical strength needed from the operator. An important note is that when using a mechanical device, the Humane Slaughter Association recommends there is no crushing of the cervical vertebrae (HSA, 2016). For example, a broom stick can be used to restrain the head of the bird on the floor while holding the bird by the legs. The operator simultaneously pulls the bird upwards while pressing the feet down on the broom stick on either side of the neck, causing similar fatal lesions as manual CD (HSA, 2016). Another example of mechanical CD is the killing cone or neck crusher. It consists of a restraining cone with a clamp device underneath to dislocate the neck (HSA, 2016). Despite the name, the neckcrusher separates and does not crush the cervical vertebrae, combined with rupture of the spinal cord. Mechanical CD is allowed in the EU for killing birds up to 5 kg BW (European Union, 2009).

Percussive blow to the head (blunt force trauma), (non)-penetrative captive bolt (CB) device, and a firearm with a free projectile are killing methods which cause severe damage to the brain by either the shock or the combination of shock and penetration of a CB/projectile (HSA, 2016). For these methods, appropriate placement of the device is a key factor to cause adequate damage to the skull and brain resulting in immediate loss of consciousness. Although this method can effectively kill poultry, CB should still be followed by another method such as exsanguination or CD to ensure the death of the bird (HSA, 2016). Similar to CD, the percussive blow to the head is susceptible to operator fatigue. Consequently, EU legislation restricts its use to birds up to 5 kg BW and to a maximum of 70 animals per day per operator. The other techniques have no such limitations.

EU legislation also allows killing birds by electrocution, gassing, or injection with a lethal drug (European Union, 2009). Head-to-body electrocution normally results in death due to exposure of the whole body to the current, resulting in generalized epileptic seizure and fibrillation of the heart. The efficacy of this technique depends on the current, the voltage, the frequency, and the time of exposure (European Union, 2009). Gases that have been prescribed for killing poultry include CO<sub>2</sub>,

CO, inert gasses (argon, nitrogen), or mixtures of gasses. Important parameters are the duration of exposure and the applied concentration (European Union, 2009). In general, the exposed birds lose consciousness and die from anoxia (McKeegan et al., 2013). In the EU, a lethal injection of veterinary drugs (e.g., sodium pentobarbital) can only be applied by a veterinarian.

Although many methods are allowed, frequency of use and preferences of industry stakeholders, including veterinarians and poultry producers, are unknown. Information about the killing methods currently used on commercial poultry farms, the farmers' and veterinarians' awareness, and opinion about alternative methods as well as the extent to which legislative restrictions are adhered to is scarce. There are also no guidelines available in EU or Belgian legislation about how farmers should check whether the bird is dead. Therefore, the aims of this study were to report the reasons for killing broiler chickens and turkeys to document the killing methods used on Flemish farms, to gain insight into the opinion of veterinarians and poultry producers on what constitutes an appropriate method for on-farm killing of poultry, and what their opinion is about common and alternative killing methods.

## MATERIALS AND METHODS

The aims were fulfilled by distributing a survey among Flemish poultry veterinarians and poultry producers.

### *Poultry Veterinarians*

A list of known Flemish veterinary practices was compiled. The biggest practices (n = 6) for turkeys and broiler chickens were contacted by phone and asked to participate in this study. Veterinarians willing to participate were surveyed digitally between August and December 2017. Thirteen veterinarians filled out the survey (43% of all contacted poultry veterinarians).

### *Broiler Chicken and Turkey Producers*

In August 2017, turkey and broiler chicken producers were contacted via several methods: 1) Their veterinarian, who was informed about the study before, invited them to participate in the online survey; 2) at agricultural fairs and educational events, they were personally contacted to participate for an in-person survey; and 3) announcements with a link to the online survey were published in several professional journals. Owing to the lack of responses, paper copies of the survey were sent to 17 turkey producers (with the help of a turkey veterinarian) and 100 broiler chicken producers (whose addresses were pulled from a publicly available national database) in November 2017. The producers who received the survey represent 68 and 20% of the Belgian turkey and broiler chicken producers, respectively. In total, we received 4 completed surveys from turkey producers and 27 from broiler chicken producers, which constitutes 16 and 5.5% of the respective sectors.

## Surveys

Separate surveys for veterinarians and chicken and turkey producers were created using an online survey tool (LimeSurvey, [www.LimeSurvey.org](http://www.LimeSurvey.org)). Producers could fill out the survey anonymously. All surveys started with an explanation of the concepts of “selection” and “killing”. Selection was defined as “the identification of individual sick or weak animals with the aim to kill them, excluding the killing of birds for human consumption”. Killing was defined as “the euthanasia of sick or weak animals to avoid suffering, spread of disease, or (other) economic loss, excluding the killing of birds for human consumption”.

In the first section of the survey, demographic and work experience data were collected, including name (only for veterinarians), year of birth, gender, and number of years of experience with poultry.

In the second section, questions were asked about methods of killing. The respondents were informed about the various killing methods by pictures only; no other information about costs or how to use them was given. We listed 11 methods (CD–manual, CD–broom stick, CD–cone, neckcrusher, blow to the head, CB–without munition, CB–with munition, electrocution, gas, injection, and other) and asked which methods respondents use and how often they use each method (with answer options: always, often, rarely, never, or unknown). Another question focused on which method the respondents prefer (a single choice from a list of 10 methods). We also asked if the respondent would be willing to learn an alternative method. In addition, the respondents were asked whether they stun birds before killing and whether they consider bird weight and number of birds to be killed, as required in EU legislation for CD and CB ([European Union, 2009](#)), and whether and how they check if the bird is dead.

In the third section, poultry producers and veterinarians were asked to rank 10 killing method properties according to importance (rank 1 being the most important and rank 10 being the least important): time-efficient, cost-efficient, animal-friendly, easy to execute, low risk of fatigue, safe for the operator, high success rate, low level of maintenance, executable in the stable, and preference of the veterinarian/producer for a particular method. They were also asked to indicate to what extent the killing methods possessed each property. This was scored on a 5-point scale: completely agree, rather agree, neutral, rather disagree, and completely disagree. Veterinarians were asked about their perception of one method, CB. Poultry producers were asked about their perception for 6 methods: manual CD, mechanical CD, CB, gas, injection, and electrocution.

In the last section, respondents were asked to indicate (yes/maybe/no) for which indicator they would select birds to be killed: lameness, broken wing or leg, conrescence, injuries, gastrointestinal, respiratory or nervous system (NS) problems, runts, or other (and specify). In addition, producers were questioned about the frequency of inspection in their houses each week.

## Data Analysis

Identifying information from veterinarians was removed from the data set. Consequently, all responses from veterinarians were analyzed anonymously, in accordance with the General Data Protection Regulation. Unless stated otherwise, the responses are presented as means  $\pm$  SD, ranges, or percentages. The ranking of killing method properties according to importance is expressed as mean rank  $\pm$  SD and was analyzed using a linear model with killing method, respondent group (veterinarians, chicken producers, and turkey producers), and their interaction as categorical fixed factors. A post-hoc pairwise comparison test between respondent groups within each method was performed. A Tukey-correction was used to correct the *P* values for multiple testing. A value of *P* < 0.05 was considered significant. Owing to the small numbers or low variation of the results, other aspects of the survey were not statistically analyzed and are presented descriptively.

All analyses were performed using R version 3.6.0 (R Core Team, Vienna, Austria).

## RESULTS

### Respondent Demographics

Out of the 13 responding veterinarians, 12 were specialized in chickens, and 1 in turkeys. The veterinarians were on average 44.9 yr old (range 29–59 yr) and had 4 to 24 yr of experience as poultry veterinarians, with a mean of 15.2 yr. The poultry producers were on average about 10 yr older than the veterinarians (55.2 and 55.8 yr for chicken and turkey producers, respectively) and had at least 5 yr of experience ([Table 1](#)). About two-thirds of all respondents were male, and one-third female.

### Inspections and Killing

The chicken and turkey producers reported inspection of their poultry houses more than twice a day on average, with mean frequencies of 15.3 (range 7–30) and 19.8 (range 7–30) per week, respectively.

The main reasons to select an animal for killing were similar over the 3 respondent groups and included lameness (86.4% of respondents), broken leg (79.5% of respondents), and NS problems (79.5% of respondents). Except in the case of birds with locomotory problems (broken legs or other abnormalities to legs, NS problems, completely lame), turkey producers seemed less inclined to kill animals with injuries or symptoms of disease than veterinarians or chicken producers ([Figure 1](#)).

### Killing Methods

For all respondents, manual CD was the most common method to kill a bird, with 74.1% of chicken producers, 50% of turkey producers, and 92.3% of veterinarians always choosing this option and 25.9,

**Table 1.** Demographic characteristics of the respondents.

Characteristics	Veterinarians (n = 13)	Chicken producers (n = 27)	Turkey producers (n = 4)
Gender (male/female)	10/3	20/7	3/1
Mean (range) age in years	44.9 (29-59)	55.2 (39-75)	55.8 (51-60)
Mean (range) experience in years	15.2 (4-24)	24.5 (5-40)	19 (10-27)

25.0, and 7.7% of the respective respondents often using this method (Figure 2). In addition, 7.4% of broiler chicken producers and 25% of turkey producers stated that they often use blunt force trauma to the head as a killing method, and 11.1% of chicken producers and 7.7% of veterinarians indicated choosing this method on rare occasions. Nearly half (46.1%) of the responding veterinarians stated that they use injection rarely. One chicken farmer often uses mechanical CD with a cone, and one turkey producer always kills birds by exsanguination. Other methods are rarely or never used. The CB technique with and without munition and the neck-crusher appear to be unknown to 38.6, 31.8, and 20.5% of the respective respondents.

The preferred method for veterinarians was manual CD (100%). Chicken producers also favored manual CD (88.9%), in addition to CB (3.7%), electrocution (3.7%), and injection (3.7%). The 4 turkey producers indicated manual CD (25.0%), neckcrusher (25.0%), blunt force trauma to the head (25.0%), and exsanguination (25.0%) as preferred methods. The percentage of respondents willing to use another technique to kill poultry on farm was highest among veterinarians (69.2%), followed by turkey producers (50.0%) and chicken producers (33.3%).

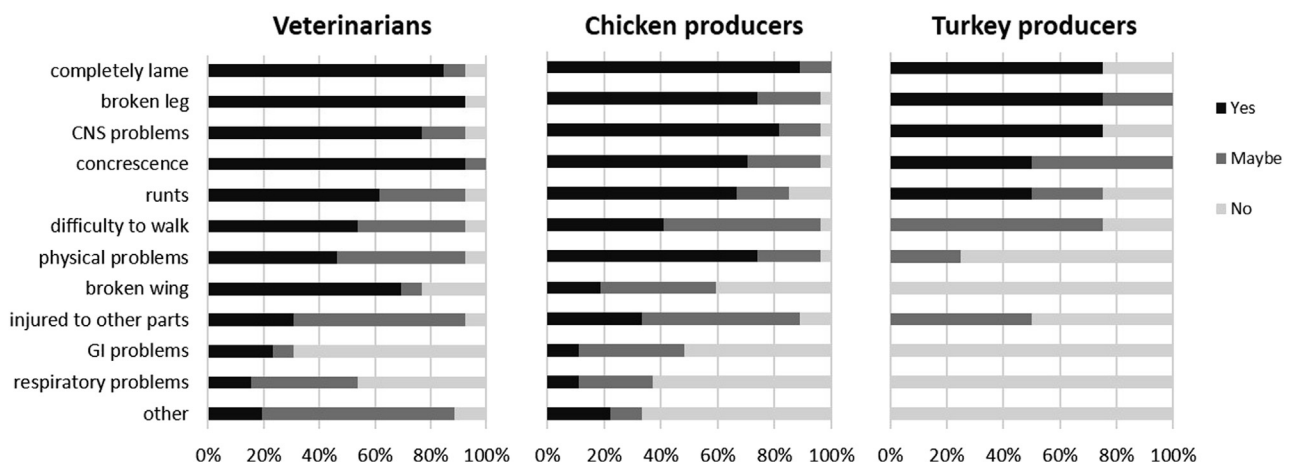
**Stunning before Killing and Legislative Restrictions**

None of the veterinarians or turkey producers, and only 2 (7.4%) chicken producers, stun birds before killing them. In addition, 7.4% of respondents adhered to the legislative maximum number of animals that may be killed per person each day (Table 2). Although half of

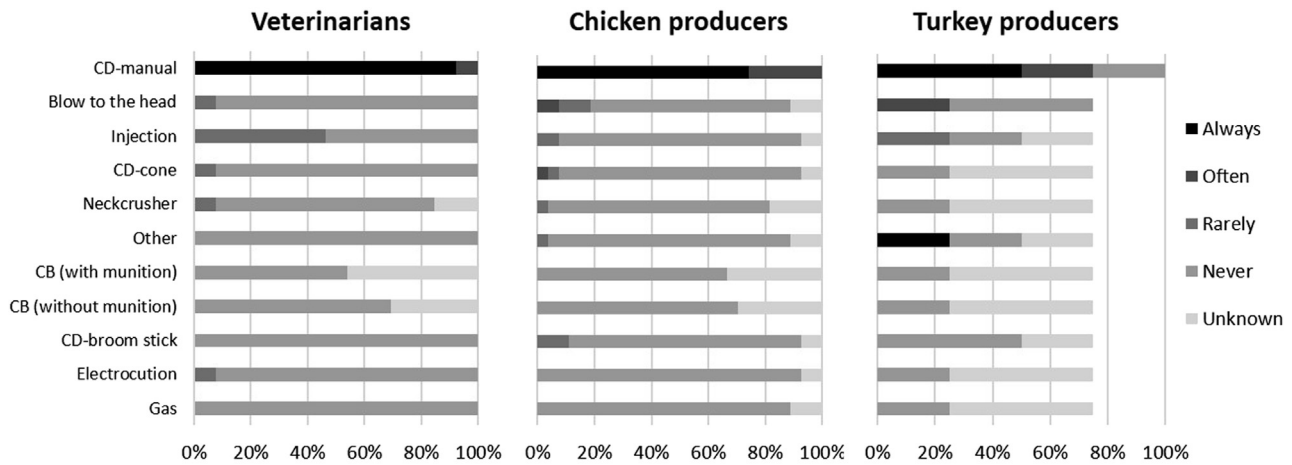
the turkey producers considered animal BW for deciding on a killing method, none of the veterinarians and one (4%) of the chicken producers self-reported to do so. One turkey producer reported using manual CD for birds up to 2.5 kg BW and blunt force trauma to the head for heavier birds. Most veterinarians (92.3%) and producers (87.1%) verify if the bird is dead, by checking indicators such as dislocation between vertebrae, onset of clonic movements, cessation of movements, respiration, or reflexes (pupil, pain, palpebral).

**Perception About Killing Methods**

“Animal-friendly” was chosen as the most important property of a killing method by veterinarians and turkey producers, whereas for chicken producers, this property was ranked in second place (Figure 3). Despite the different ranking, the mean rank scores were similar (2.62, 2.25, and 2.78 for veterinarians, turkey producers, and chicken producers, respectively). Time-efficient, easy to execute, and a high success rate were also important killing method properties for all respondents. However, veterinarians found “time-efficient” significantly less important than chicken producers (4.33 and 2.11, respectively). The opposite was observed for “executable in stable”, which veterinarians considered more important than chicken producers (3.31 and 5.44, respectively). The least important killing method properties for veterinarians, turkey producers, and chicken producers were “safe for operator” (6.09, 6.89, and 6.25, respectively), “low maintenance” (7.73, 8.00, and 7.19, respectively), “low risk of fatigue” (8.09, 7.50, and 7.33, respectively), and “preference of veterinarian/producer” (9.27, 10.0, and 9.11, respectively).



**Figure 1.** Possible indicators to select a bird for killing and prevalence of responses. Veterinarians (n = 13), chicken producers (n = 27), and turkey producers (n = 4) could respond with “yes”, “maybe”, and “no” if they would kill a bird with the indicated problem. Abbreviations: CNS, central nervous system; GI, gastrointestinal.



**Figure 2.** Self-reported frequency of various methods for killing birds being used by veterinarians (n = 13), chicken producers (n = 27), and turkey producers (n = 4). One turkey producer has only assessed one method. Abbreviations: CB, captive bolt; CD, cervical dislocation.

The perception of the use of CB among veterinarians is positive with regard to being “animal-friendly”; 38.5% responded with “completely agree” or “rather agree”, whereas 15.4% completely or rather disagreed. A higher percentage of the veterinarians agreed with the way CB is applicable in the stable (30.8%) as well as the low risk of fatigue (30.8%) than disagreed (23.1 and 7.7%, respectively). However, they were more negative about time- and cost-efficiency, maintenance, safety, and ease of execution; 30.8, 30.8, 30.8, 38.5, and 46.2% of them completely or rather disagreed, respectively (Figure 4). A high percentage of the veterinarians indicated they had no knowledge about the different killing method properties of CB (range 15.4–38.5%).

The chicken producers highly agree for all killing method properties of manual CD. Mechanical CD was assessed rather positively, whereas CB, gas, and especially electrocution and injection were assessed rather negatively (Figure 5). Manual CD was thought to be the most animal-friendly technique (77.8% responded “completely agree” or “rather agree”), followed by mechanical CD (29.6%), CB and gas (both 7.8%), injection (7.4%), and electrocution (5.2%). About a quarter of the chicken producers agreed with a high success rate of the techniques mechanical CD (29.6%), CB (22.2%), and injection (25.9%). On the contrary, more than 40% completely or rather disagreed with cost- and time-efficiency, as well as executability in the stable for gas, injection, and electrocution.

Both manual and mechanical CD scored well among the turkey producers for low maintenance (75 and 50%,

respectively), being safe for the operator (50 and 50%, respectively), cost-efficiency (75 and 50%, respectively), and being executable in the stable (75 and 75%, respectively) (Figure 6). Also, 50% of them agreed that injection can be done in the stable and has a high success rate. Two out of 4 turkey producers completely or rather agreed with the animal-friendly property of manual CD and injection, whereas it was one out of 4 for the other techniques. In contrast, one turkey producer rather disagreed about electrocution being animal-friendly.

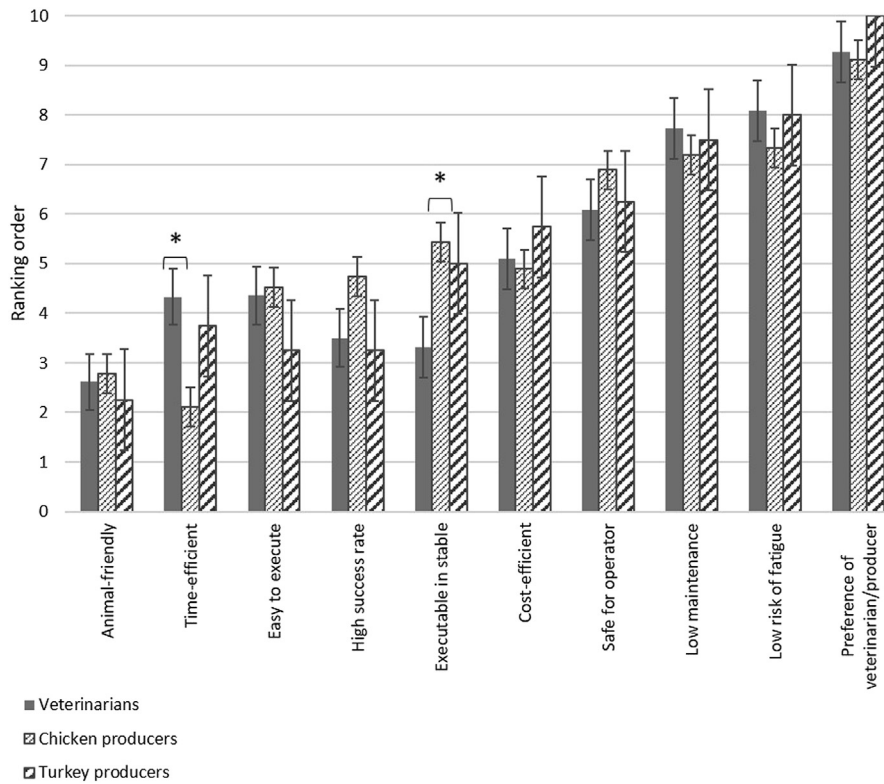
A high percentage of the chicken and turkey producers indicated having no knowledge to rate the properties of alternative techniques: mechanical CD (47.0 and 52.5%), CB (43.3 and 52.5%), gas (46.3 and 65.0%), injection (34.1 and 55.0%), and electrocution (38.2 and 82.5%). Also 29.2% of the veterinarians responded that they have no knowledge about the killing method properties of CB.

## DISCUSSION

As EU legislation (European Union, 2009) imposes restrictions on methods for killing selected poultry on-farm, it is important to investigate which methods are commonly used by veterinarians and producers, whether they take these legislative restrictions on the use of CD depending on the birds’ BW and numbers killed per person per day into account, and what their knowledge and opinions are about alternative methods. This is the first study to document the practices and

**Table 2.** Percentage of respondents (veterinarians, chicken producers, and turkey producers) who reported to stun before killing, to check kill success (brain death) after killing, and to consider regulatory limitations based on EC 1099/2009 (body weight and number of birds).

Legislative restrictions	Veterinarians (n = 13)	Chicken producers (n = 27)	Turkey producers (n = 4)
Stunning and kill success			
Stunning before killing	0%	7.4%	0%
Checking if the birds are dead	92.3%	88.9%	75.0%
Regulatory limitations			
Body weight	0%	3.7%	50.0%
Number of birds to kill per person a day	0%	7.4%	0%



**Figure 3.** Mean ranking score of 10 killing method properties (mean ± SE) as assessed by veterinarians (n = 13), chicken producers (n = 27), and turkey producers (n = 4). Lower scores indicate higher importance. Significant differences ( $P < 0.05$ ) between groups of respondents are marked with \*.

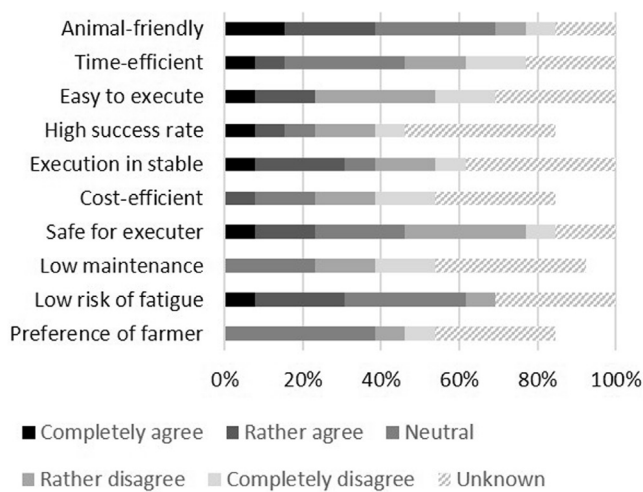
opinions of veterinarians and farmers about methods for killing individual poultry.

In contrast with the response rate of poultry veterinarians (43%), it was a challenge to encourage the poultry producers to participate in this study. It seems they were wary and reluctant to share information about this sensitive topic. However, by sending the surveys personally and providing the opportunity to fill them

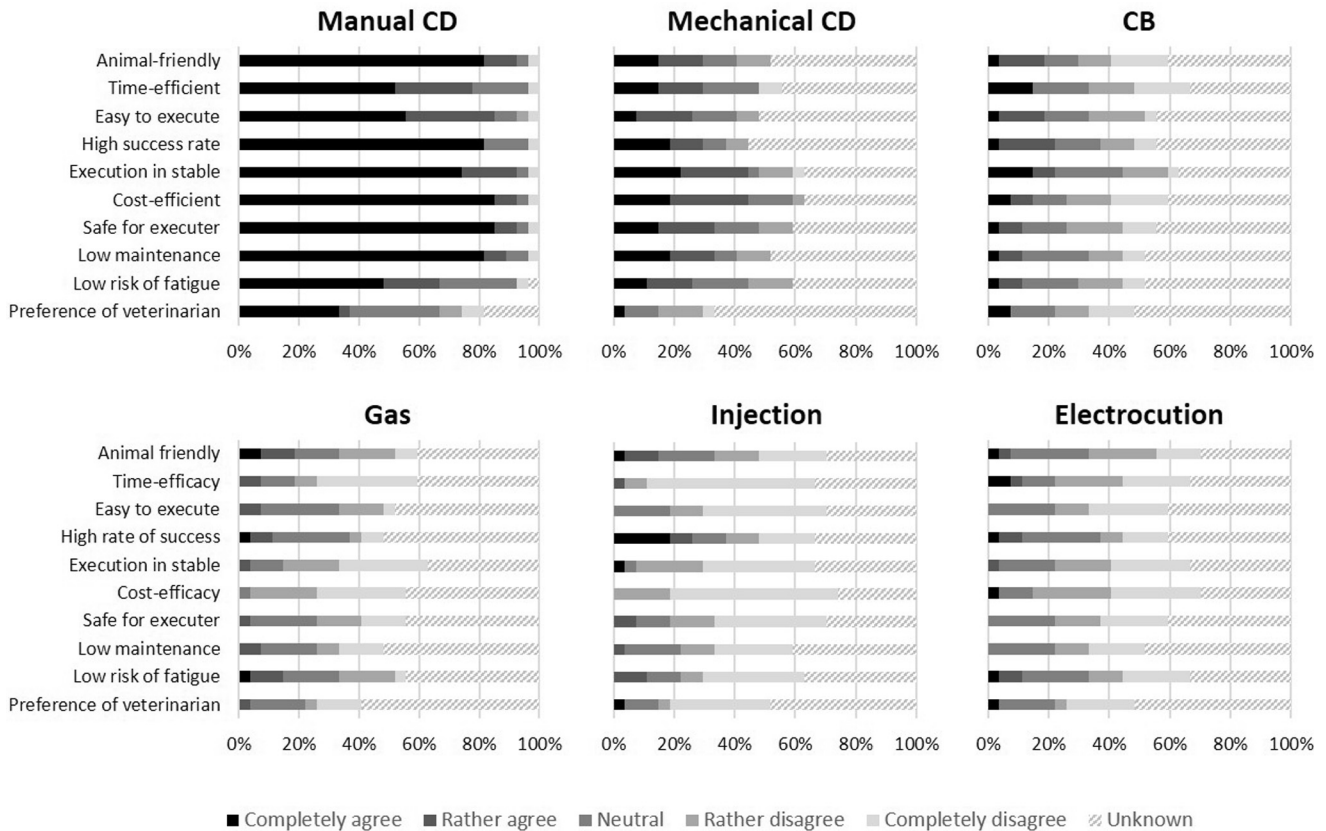
out anonymously, the response rate represented 16 and 5.5% of the Flemish turkey and broiler chicken sector, respectively. The survey revealed some interesting differences between groups of respondents and their opinion about poultry killing methods. Given the limited absolute number of respondents, for turkey producers in particular, the power for statistical testing was limited and the representativeness of the responses is limited.

Manual CD was the most commonly used killing method for both the Flemish veterinarian and the poultry producer respondents. Similarly, Sparrey et al. (2014) described manual CD as the most widely used method for poultry, such as laying hens, meat chickens, and even turkeys less than 14 wk of age because it requires no equipment and is easy to learn. Some turkey producers in our study also reported using blunt force trauma to the head or exsanguination, which are techniques that can be used for heavier animals.

Van de Ven et al. (2012) stated that the early killing of low-quality chicks is necessary for moral reasons, but those chicks are also a risk for infections, a higher feed conversion ratio, and lower flock uniformity. In the present study, respiratory and gastrointestinal problems seem to be less serious reasons for selection. Although these problems are frequently contagious, drug treatment can often bring relief. Veterinarians and chicken producers are more discerning in selecting birds than turkey producers. For the indicators listed in the survey, on average 55.5% of veterinarians and 49.4% of chicken producers would select the birds for killing,



**Figure 4.** The perception of veterinarians (n = 13) about captive bolt devices for killing poultry, according to 10 killing method properties, scored on a 5-point scale from completely agree to completely disagree, and unknown. Two veterinarians did not give a score for some properties.



**Figure 5.** The perception of chicken producers ( $n = 27$ ) about different devices for killing poultry (manual CD, mechanical CD, CB, gas, injection, and electrocution), according to 10 killing method properties, scored on a 5-point scale from completely agree to completely disagree, and unknown. Abbreviations: CB, captive bolt; CD, cervical dislocation.

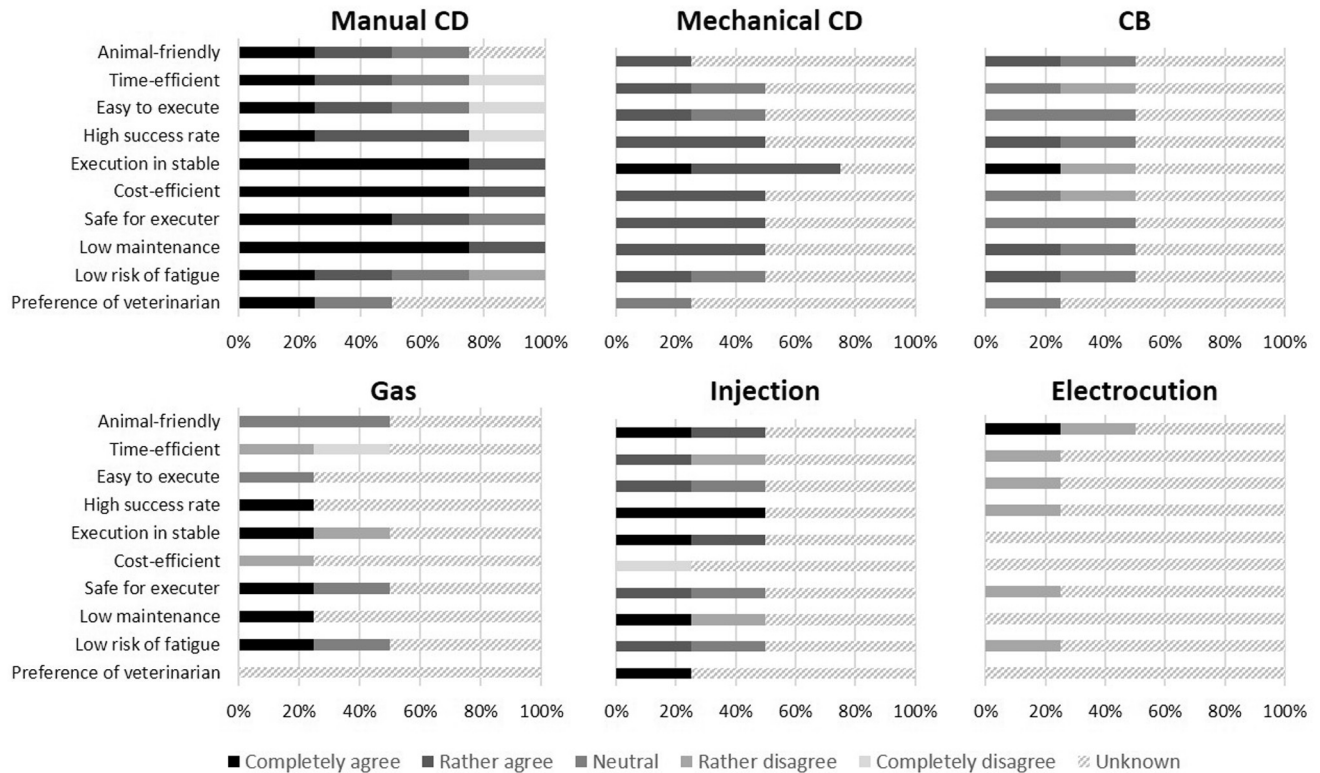
while it was only 27.1% for the turkey producers. Some turkey producers indicated that they rarely kill sick or injured turkeys. Instead of killing, they place the injured turkeys into a separated sick barn until slaughter age, then place the selected turkeys on transport to the slaughter house. Although the response rate of the turkey producers was low, these findings were confirmed by a turkey veterinarian (personal communication, May 30, 2018).

The reasons that turkey producers seem more reluctant than chicken producers to kill a bird were not explored in the survey but could relate to the higher economic loss and effort of killing a turkey, especially as they age. According to European legislation (European Union, 2005), all animals have to be fit for travel, meaning that injured animals cannot be transported. Jacobs et al. (2017) documented that unfit birds experience more transport stress under certain circumstances, such as pain from injuries.

EU legislation (European Union, 2009) imposes restrictions on methods for killing selected poultry, based on the BW of the birds and the number of birds to be killed per person per day. Most respondents to this study work with broiler chickens, which are usually slaughtered at BW under 3 kg (Aviagen, 2019) and do not need to consider BW to comply with legislation. Yet, this legislative restriction should be considered when selecting a killing method for turkeys. However, the

turkey veterinarian and 2 turkey producers indicated that they do not take BW into account. Consequently, depending on the used killing method, they violated the law when the birds' weight was above 3 or 5 kg. Moreover, when a method is not performed appropriately, the animal may suffer from a prolonged death struggle. Informing producers about the legislation could lower the use of unsuitable methods.

The legislative restriction that no person shall kill more than 70 animals per day by manual CD or percussive blow to the head is not commonly adhered to by either veterinarians (100%) or chicken (100%) and turkey producers (92.6%). This number was set to 70 by the European Council regulation based on an European Food Safety Authority report (EFSA, 2004; European Union, 2009), but without scientific evidence. Certainly, there is a limitation on the number of animals one can kill without getting tired, especially for methods that require physical strength. Stock workers who killed 100 birds by CD (1 bird/2 min) did not show evidence of a negative impact of sequential use of CD, suggesting that 100 birds per day for those stock workers did not result in fatigue or welfare concerns (Martin et al., 2018). However, the operators were not randomly distributed, and all stock workers were male with similar biometric measures (Martin et al., 2018). Although those operators were not representative for the current veterinarians or poultry producers (33% of the respondents



**Figure 6.** The perception of turkey producers ( $n = 4$ ) about different devices for killing poultry (manual CD, mechanical CD, CB, gas, injection, and electrocution), according to 10 killing method properties, scored on a 5-point scale from completely agree to completely disagree, and unknown. Abbreviations: CB, captive bolt; CD, cervical dislocation.

were female), it does suggest further research is needed regarding the 70-bird restriction.

In the survey, no distinction was made between knowing but nevertheless violating the legal restrictions for using certain killing methods depending on BW and number of animals to kill vs. not being aware of these restrictions. It could be useful to focus more on legislation and on which killing methods may be used under which circumstances during the training of poultry producers.

The ranking of desired killing method properties is similar among veterinarians, chicken producers, and turkey producers. Particularly for the less important properties (safety for operator, low maintenance, low risk of fatigue, and preference of the veterinarian/producer), the 3 groups of respondents share the same opinion. For the most important properties, there is some variation, although animal friendliness of the technique is ranked highly by all 3 groups. This is in line with survey results reported by [Tuytens et al. \(2014\)](#), in which animal welfare in general was considered as highly important by broiler producers.

Time-efficiency is considered a rather important parameter as well, by veterinarians in particular and to a slightly lesser extent by turkey producers. In contrast with veterinarians, both chicken and turkey producers indicated that the ability to execute the killing inside the stable was a less important requirement. A high workload and time pressure of a veterinarian could explain this finding. Moreover, the animal-friendly aspect might also be a possible reason. Holding birds

upside down is very stressful ([Kannan and Mench, 1996, 1997](#)). In that respect, it is better to kill the bird immediately in the stable. On the contrary, older turkeys are better killed outside the stable to reduce stress from wing flapping and convulsions.

The respondents' perception about specific desirable properties of the different killing methods was also investigated. Because of a human error that was discovered when the surveys had already been circulated online, veterinarians were only questioned about CB and not about the other 5 methods as was done for the poultry producers. As manual CD is the most commonly used technique, it is not surprising that this technique is judged rather positively for nearly all properties by producers. Producers also scored these properties rather positively for mechanical CD relative to alternative killing methods. The CB technique was considered to be easy to perform, to have a high success rate, to be feasible to perform in the stable, and to be animal-friendly among veterinarians and chicken producers. However, turkey producers in our study had doubts about the latter 2 properties. [Erasmus et al. \(2010\)](#) evaluated and compared a nonpenetrating CB device with manual and mechanical CD and blunt trauma for on-farm killing of turkeys. They concluded that CB and blunt trauma immediately induced insensibility, whereas the turkeys still showed signs of sensibility after CD. Chicken producers were less positive about the properties of the gas method, injection, and electrocution. The first 2 methods scored reasonably well among turkey producers, but



electrocution scored rather negatively. In addition, poultry veterinarians and poultry producers indicated that their knowledge about alternative killing methods is rather limited. Accordingly, more information about the legislation of current techniques and the advantages of alternative methods should be distributed among veterinarians and producers. As the survey was based on EU legislation, a comparable survey could be conducted in other EU countries to learn more about national differences in knowledge and compliance of the legislation.

In conclusion, our study confirms that manual CD is the most common method for killing poultry on-farm. Based on our limited sample, knowledge of and experience with alternative methods are very limited, although many respondents indicated a willingness to learn more about these techniques. Therefore, for both poultry veterinarians and producers, an introduction to alternative methods would give them more information on handling the devices, its cost, and feasibility on their farm. Knowledge about legislative restrictions, particularly the limitations on BW and number of birds that may be killed by one person per day, is rather low. According to the veterinarians and farmers, the ideal technique must be animal-friendly, time-efficient, easy to perform, and have a high success rate. Further research about the alternative methods for killing poultry on-farm has to be carried out to elucidate whether the alternative methods are animal-friendly and whether they are feasible on-farm.

## ACKNOWLEDGEMENTS

The authors would like to thank the Flemish Government for financing this project (LNE/STG/DWZ/16/07) and Michael Plante-Ajah (Animal Sciences Unit, ILVO, Melle, Belgium) for proof-reading the manuscript as a native English speaker.

Conflict of Interest Statement: The authors did not provide a conflict of interest statement.

## REFERENCES

- Aviagen. 2019. Pages 3–5 in Ross 308/Ross 308FF Broiler: Performance Objectives. Accessed July 2020. <http://eu.aviagen.com/tech-center/download/1339/Ross308-308FF-BroilerPO2019-EN.pdf>.
- EFSA. 2004. Welfare Aspects of Animal Stunning and Killing Methods. Pages 1–241 in Scientific Report of the Scientific Panel for Animal Health and Welfare on a Request from the Commission Related to Welfare Aspects of Animal Stunning and Killing Methods (Question N° EFSA-Q-2003-093). European Food Safety Authority Scientific AHAW/04-027. Accessed July 2020. <https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2004.45>.
- Erasmus, M. A., P. Lawlis, I. J. H. Duncan, and T. M. Widowski. 2010. Using time to insensibility and estimated time of death to evaluate a non-penetrating captive bolt, cervical dislocation, and blunt trauma for on-farm killing of turkeys. *Poult. Sci.* 89:1345–1354.
- European Union. 2005. Council Regulation (EC) No 1/2005 of 22 December 2004, on the protection of animals during transport and related operations and amending Directives 64/432/EEC and 93/119/EC and Regulation (EC) No 1255/97. *Official J. Eur. Union L* 3:1–44.
- European Union. 2007. Council Directive 2007/43/EC of 28 June 2007, laying down minimum rules for the protection of chickens kept for meat production. *Official J. Eur. Union L* 182:19–28.
- European Union. 2009. Council Regulation (EC) No 1099/2009 of 24 September 2009, on the protection of animals at the time of killing. List of stunning methods and related specifications. *Official J. Eur. Union L* 303:19–25.
- FAO. 2017. Food and Agriculture Organization of the United Nations. OECD-FAO Agricultural Outlook 2017–2026. Accessed July 2020. <http://www.fao.org/3/a-i7465e.pdf>.
- GAP. 2015. Global Animal Partnership. G.A.P.'s 5-Step® Animal Welfare Standards for Turkeys. Issued 27 April 2015 - v2.0. Accessed July 2020. <https://globalanimalpartnership.org/wp-content/uploads/2020/05/G.A.P.s-Animal-Welfare-Standards-for-Turkeys-v2.1.pdf>.
- GAP. 2018. Global Animal Partnership. G.A.P.'s 5-Step® animal welfare standards for chickens raised for meat. Issued 3 April 2018 - Updated 1 May 2020 - v3.2. Accessed July 2020. <https://globalanimalpartnership.org/wp-content/uploads/2018/04/GAP-Standard-for-Meat-Chickens-v3.1-20180403.pdf>.
- HSA. 2016. Human Slaughter Association. Practical Slaughter of Poultry – A Guide for the Smallholder and Small-Scale Producer. Accessed July 2020. <https://www.hsa.org.uk/downloads/publications/hsa-practical-slaughter-of-poultry.pdf>.
- Jacobs, L., E. Delezie, L. Duchateau, K. Goethals, D. Vermeulen, J. Buyse, and F. A. M. Tuytens. 2017. Fit for transport? broiler chicken fitness assessment for transportation to slaughter. *Anim. Welfare* 26:335–343.
- Kannan, G., and J. A. Mench. 1996. Influence of different handling methods and crating periods on plasma corticosterone concentrations in broilers. *Br. Poult. Sci.* 37:21–31.
- Kannan, G., and J. A. Mench. 1997. Prior handling does not significantly reduce the stress response to pre-slaughter handling in broiler chickens. *Appl. Anim. Behav. Sci.* 51:87–99.
- Martin, J. E., D. A. Sandercock, V. Sandilands, J. Sparrey, L. Baker, N. H. C. Sparks, and D. E. F. McKeegan. 2018. Welfare risks of repeated application of on-farm killing methods for poultry. *Animals* 8:39–52.
- McKeegan, D. E., H. G. Reimert, V. A. Hindle, P. Boulcott, J. M. Sparrey, C. M. Wathes, T. G. Demmers, and M. A. Gerritzen. 2013. Physiological and behavioral responses of poultry exposed to gas-filled high expansion foam. *Poult. Sci.* 92:1145–1154.
- NFACC. 2016. National Farm Animal Care Council. Pages 27–32 in Code of Practice for the care and handling of hatching eggs, breeders, chickens and turkeys. Section 5: Flock Health Management. Accessed July 2020. [https://www.nfacc.ca/pdfs/codes/poultry\\_code\\_EN.pdf](https://www.nfacc.ca/pdfs/codes/poultry_code_EN.pdf).
- Sparrey, J., D. A. Sandercock, N. H. C. Sparks, and V. Sandilands. 2014. Current and novel methods for killing poultry individually on-farm. *Worlds Poult. Sci. J.* 70:737–758.
- Tuytens, F., F. Vanhonacker, and W. Verbeke. 2014. Broiler production in Flanders, Belgium: current situation and producers' opinions about animal welfare. *Worlds Poult. Sci. J.* 70:343–354.
- USDA. 2019. United States Department of Agriculture. Animal Welfare Act and Animal Welfare Regulations – “Blue Book”. Issued May 2019. Accessed July 2020. [https://www.aphis.usda.gov/animal\\_welfare/downloads/bluebook-ac-awa.pdf](https://www.aphis.usda.gov/animal_welfare/downloads/bluebook-ac-awa.pdf).
- van de Ven, L. J., A. V. van Wagenberg, K. A. Uitdehaag, P. W. Groot Koerkamp, B. Kemp, and H. van den Brand. 2012. Significance of chick quality score in broiler production. *Animal* 6:1677–1683.