A new supporting tool for pig handling in the breeding-slaughterhouse production chain

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Specific supporting tool.

Summary
This paper focuses on a research concerning the operational management of the pig-handling phase, during the period of breeding and before slaughtering. Given the behaviour of these animals during transfers, a particular tool has been designed to manage them in this phase. A total number of 48 animals, divided in 4 groups, were moved without use of the tool (control groups) and by using the tool described in this article. The time required by the control groups to leave the pen ranges from 21 to 125 seconds; while, when the proposed tool was used, the time for the movement of the animals ranged between 10 and 17 seconds. In particular, in the groups where the tool was deployed the 'waiting phase' (before the first animal goes out) lasted less than half of the time of the 'waiting phase' of the control group, thus showing a minimization of the effects of the 'panic phenomenon' among the animals. Thus, the studied device can be considered as valid guide technique, both for the quick exit of the first animal and for those that follow. Once the row has been formed, the animals continue neatly to leave the box. This study also shows that this solution can also be considered appropriate for reducing the identified critical issues in the traditional handling. The need of only 1 worker to move the group of pigs is important to achieve economic saving. The deployment of this tool, thus, make possible to consider the movement of animals no longer a 'critical stage', but as a routine step of the production cycle of pork's meat.

Un nuovo strumento agevolatore per la movimentazione dei suini nella filiera produttiva dall'allevamento al macello

Parole chiave
Attrezzo agevolatore specifico,
Benessere degli animali,
Gestione efficiente degli animali,
Movimentazione,
Suini .

Riassunto
Si riportano i risultati di una ricerca riguardante la gestione dei suini nella fase di movimentazione, sia durante l'allevamento che prima della macellazione. È stato progettato uno strumento specifico per agevolare tale fase, studiando il comportamento dei suini durante i trasferimenti. Un totale di 48 animali, divisi in 4 gruppi, sono stati spostati dai loro box, senza l'uso dello strumento e con lo strumento. Nel primo caso, i tempi totali richiesti da ciascun gruppo di animali per uscire sono inclusi in un ampio intervallo di valori: da 21 secondi a 125 secondi; al contrario, utilizzando lo strumento, questi tempi totali sono molto più bassi e simili tra loro: tra 10 secondi e 17 secondi dopo l'uscita del primo animale. In particolare, la durata della "fase di attesa" (prima che il primo animale esca) è più che dimezzata rispetto al caso precedente, mostrando una minimizzazione degli effetti del "fenomeno di panico" tra gli animali manovrati con l'uso del dispositivo studiato. Pertanto, il dispositivo studiato può essere considerato una valida soluzione tecnica per consentire una rapida uscita, sia del primo animale, sia dei soggetti che lo seguono; una volta che si è formata la fila, gli animali continuano a lasciare ordinatamente il box di stabulazione. In tutte le prove effettuate, la soluzione studiata è risultata idonea anche a ridurre le criticità che caratterizzano la gestione tradizionale, dovute al comportamento inopportuno della manodopera. Infine, la possibilità di impiegare una sola unità operativa è un fattore importante anche per l'efficienza economica del processo. In questo senso, la movimentazione degli animali, piuttosto che una "fase critica" e incontrollata, può essere realmente considerata come parte di un programma di gestione efficiente dell'intero ciclo di produzione di carne suina dall'allevamento alla macellazione.

Introduction

Public livestock producers and research scientists have shown an increasing interest in assuring proper animal care and handling. There is a corresponding increasing effort by research and educational institutions, government agencies (Vuolo *et al.* 2014), enterprise managers, health care providers, and others in developing and accessing information (Bianchi *et al.* 2015) that assists in creating appropriate management procedures and adequate conditions for animal handling and transportation (Von Borell and Schaffer 2005). Animals handling inside barns is always a critical phase, both for animals and handlers, so management methods and selection of the appropriate animals are being studied to minimize handling problems and the negative consequences for handlers and animals (Le Neindre *et al.* 1996). Several studies have demonstrated the importance of a positive human-animal relationship for reducing stress and facilitating high productivity in farming (Waiblinger *et al.* 2006, Hemsworth and Coleman 2011), while research has also shown that negative handling, for example using physical force, electric shock, shouting, and rapid movement has a severe impact on the health of animals (Fraser *et al.* 2013). Most of the negative effects of animal handling are likely due to fear. Animals can be stressed either for psychological reasons (restraint, handling, or novelty) or physical one (hunger, thirst, fatigue, injury, or thermal extremes) (Grandin 1997). Thus, reducing stress during handling will provide advantages of increasing productivity (Grandin 1998). The stress due to handling can be reduced by using well-maintained systems (Goddard *et al.* 2006). Consequently, the development of appropriate systems should be guided by the requirement to ensure high standards of animal welfare (Yardimci *et al.* 2013). In pigsties, we can observe many operations during which animals are moved. In all these case the animals' welfare depends on their physiological state and on organization's requirements. Usually, animal handling is carried out through traditional methods: the operator drives the group or the single animal, remaining behind it, and using frequently goads and blows. It is known that the handling of pigs can cause a stress response in the animal, which in turn affects meat quality. Studies investigating the influence of pig handling on subsequent meat quality have examined the handling of pigs during transportation from farm to the abattoir and at the abattoir itself. They have identified in transportation, loading and unloading of pigs, mixing of unfamiliar pigs, and use of an electrical stunning the major pre-slaughter stressors (Warriss *et al.* 1995, Küchenmeister *et al.* 2005, Bianchi *et al.* 2015). Most of the effects have been attributed to alterations in the rate and extent of postmortem pH decline. As a matter of fact, these indicators are related to muscle glycolytic potential (an estimate of muscle glycogen *in vivo*), and to induced stress increase in glycolysis (Hambrecht *et al.* 2005). Moreover, in pigs a myriad of both animal-related and environmental factors that can affect muscle metabolism, pH and temperature, and that predispose to the development of PortoSystemic Encephalopathy (PSE) syndrome have been observed (Hambrecht *et al.* 2003). Among such factors are genotype (Sellier 1988), nutrition (Coma 2001), feed withdrawal (Eikelenboom *et al.* 1991), transport, and lairage (Geverink *et al.* 1998). As mentioned above handling and processing in slaughter plants is well-known to have a large impact on meat quality (Hambrecht *et al.* 2003); stress immediately prior to slaughter (Van der Wal *et al.* 1999, Warris *et al.* 1994), stunning method (Channon *et al.* 2000) and chilling rate (Offer 1991) play important roles in the conversion of muscle to meat. Also the equipment used to handle animals can have important effects (Fraser *et al.* 2013). The most common hand-held moving devices used for pigs are electric prods, paddles, flags, etc. (McGlone *et al.* 2004). Overuse of electric prods when pigs are moved can cause severe stress, leading to increased lactate and glucose levels, and poorer pork quality if negative handling occurs just before slaughter (Hambrecht *et al.* 2005, Edwards *et al.* 2010). Studies have shown that negative handling of pigs by stock handlers (i.e. use of electric prodders) on-farm can result in marked reduction of growth and reproductive performance (Hemsworth *et al.* 1986, Hemsworth *et al.* 1987, Hemsworth and Barnett 1991, D'Souza *et al.* 1998) and, at the slaughterhouses, the use of a nose snare or electrical goad during pre-slaughter handling can affect meat quality (Küchenmeister *et al.* 2005). Both aversive and minimal handling of pigs can have negative consequences on their behaviour and productivity (Hemsworth and Coleman 1996). Conversely, sympathetic handling and provision of a more varied environment can have beneficial effects (Beattie *et al.* 1996). Abbott and colleagues (Abbott *et al.* 1997) observed that a combination of sympathetic handling and novelty in the environment in the weeks before slaughter can greatly improve the ease with which pigs can be moved, and may make them able to cope better with the stressing factors that they inevitably encounter during the pre-slaughter period. The novelty of an object is important for initiating exploration (Gifford *et al.* 2007) and has been reported to be intrinsically rewarding to pigs (Kittawornrat and Zimmerman 2010). Normally, when an animal sees something unknown, it becomes a reason of meditation that, if the animal is moving, implies a momentary stop (Hemsworth *et al.* 1996). Researchers observed that pigs, when stimulated, immediately look for the border lines of the place in which they are and, if the stimulus persists, they move along walls and partitions and only sporadically they go toward the source of stress. It has also been observed that in many cases blows or goads on animals did not cause any movement probably because pigs do not connect stimulus to the movement and so, instinctively, they wait. McGlone and colleagues (McGlone *et al.* 2004) noted that the use of electric prod and paddle often cause the pigs to vocalize, while some pigs became also aggressive. During handling, the most common behavioural indicators of stress are: open mouth breathing (panting), vocalization (squealing or barking), blotchy skin (reddish/purple color), stiffness, muscle tremors (animals begin shaking) increased heart rate, and increased body temperature (Anderson *et al.* 2002). In a research on the efficacy of moving devices for finishing pigs the authors showed that the use of the board was the most efficacious moving device when compared to electric prod, paddle or flag (Gentile 2013). A handler using a board required significantly less time (P_{value}<0.05) to move pigs compared that when using an electric prod or paddle. Pig vocalizations were similar after being touched with either the paddle or electric prod, but these devices caused more pig vocalizations than the board (Mc Glone *et al.* 2004).

In this study we investigated an appropriate handling method that allowed us to plan and assemble a particular tool to be used inside the pens, to support the pigs during the exit.

Materials and methods

Considering the concept of animal well-being and the rules that regulate it, the ethology and the behaviour of pigs, we have investigated a "more appropriate" handling method, from the operative point of view. A new tool was designed and assembled to be used inside pens, to support pigs during the handling and transfer procedures limiting their stress.

The tool was assembled using a cloth wrapped around a steel rod with a pivot welded on a right angled steel base (Figure 1); its base has been equipped with 2 wheels to easily move the tool (Figure 1B). On the top side of the rod the following parts are assembled: a metallic plate (with a hole in the center to allow the passage of the pivot, 3 holes for 3 screws to fix plate to the rod, 6 holes to stop the cloth at the desired length) (Figure 1B) and a hand grip, welded on the plate, to rewind the cloth after its use (Figure 1A). On the bottom part of the rod a metallic plate with the same hole in the center and 3 holes for screws is fixed to hold up the cloth and to simplify unwinding/rewinding operations. The upper part of the pivot is threaded to allow for screwing a locking tool to stop the cloth on required length (depending on the pen size), in correspondence of 1 of the 6 plates holes (Figure 1C). The cloth is 20.0 m long and 1.20 m high, much more than animal's height, to ensure that animals could not see what it is happening beyond it. The selected color is grey to have continuity with walls' color and a waterproof synthetic material was chosen, as it is easy to clean it (Figure 1A). Finally, the initial side of the cloth is stiffened with another rod to keep the cloth stretched and with an adjustable clamp to fix it to the wall.

The building size is 16.05 m x 38.50 m, with an inner surface of 617.925 m^2; inside building there are 19 pens of about 20 m^2 each, 8 on one side and 11 on the other, divided by the handling course, and all provided with dejections area (defecation) on the back side. The handling course is 38.50 m long × 1.00 m wide with solid walls (Figure 2). Doors are used to open and close the pen and, at the same time, to stop animals along the handling course. The pigsty used in this study is able to breed 300 animals. Pigs arrived in the pigsty at approximately the same age (about 2 months) and the same weight (about 20 kg) from a commercial unit and, therefore, had been subjected to normal (minimal) levels of interaction with humans.

The trial involved pigs that were not familiar with the presence of other humans, excluding the breeder, and with going in and out of their pens. A total of 89 pigs, weighing 130-150 kg, were used in this study. Pigs were moved from their pens to other free pens through the handling course. In each trial box, the number of animals was maintained without changing the cycle and the breeding density set in the farm.

The thesis under investigation consists in verifying the usefulness of the new tool in handling pigs when moving them out of their pen. The trials were divided into 2 main sets each with 4 groups (replicates).

The first set of trials was conducted without the tool ("NO TOOL" treatment) and it is the control set; while the second set of test was carried out using the tool ("TOOL" treatment).

The parameter used to evaluate whether the use of the tool improves effectively and significantly the handling operations is the time required by each animal to leave its pen.

To this end, 48 animals, divided in 4 groups (groups 1, 2, 3, and 4), were moved without use of the tool, by using 2 workers for pig housing. Fortyone animals, also divided in 4 groups (groups 5, 6, 7 and 8), were moved using the tool, with the aid of only 1 worker who operated the device remaining externally to the housing area, beyond the sheet separation.

During the both sets of tests, if pigs stopped moving

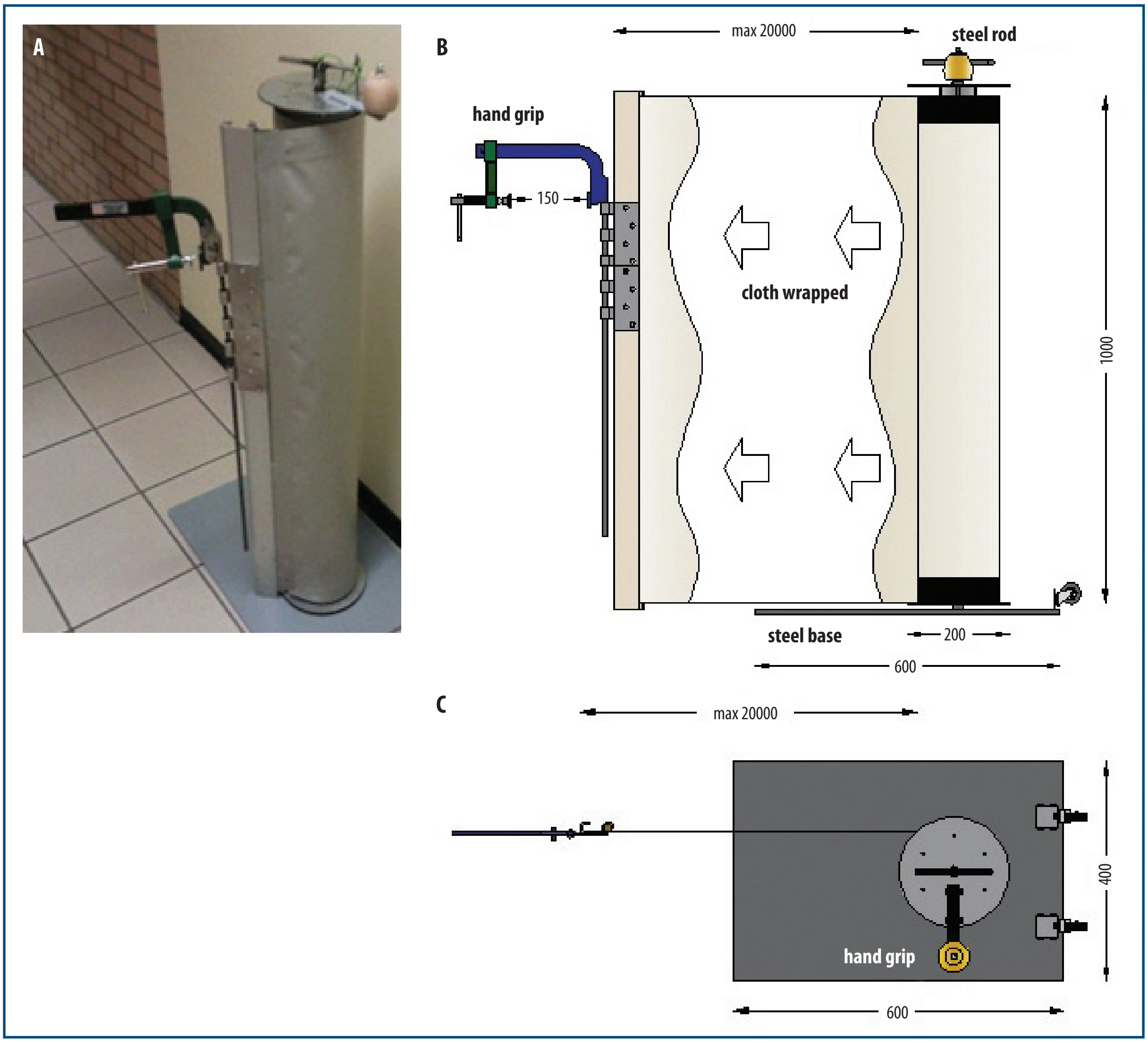

Figure 1. *Diagram of the used tool.* **A.** it can be seen the cloth wrapped around a steel rod, the hand grip, the locking tool, the metallic plates; **B.** Longitudinal view of the tool in the opening phase; **C.** Plan view. Images are drawn approximately to scale and measurements are in millimeters.

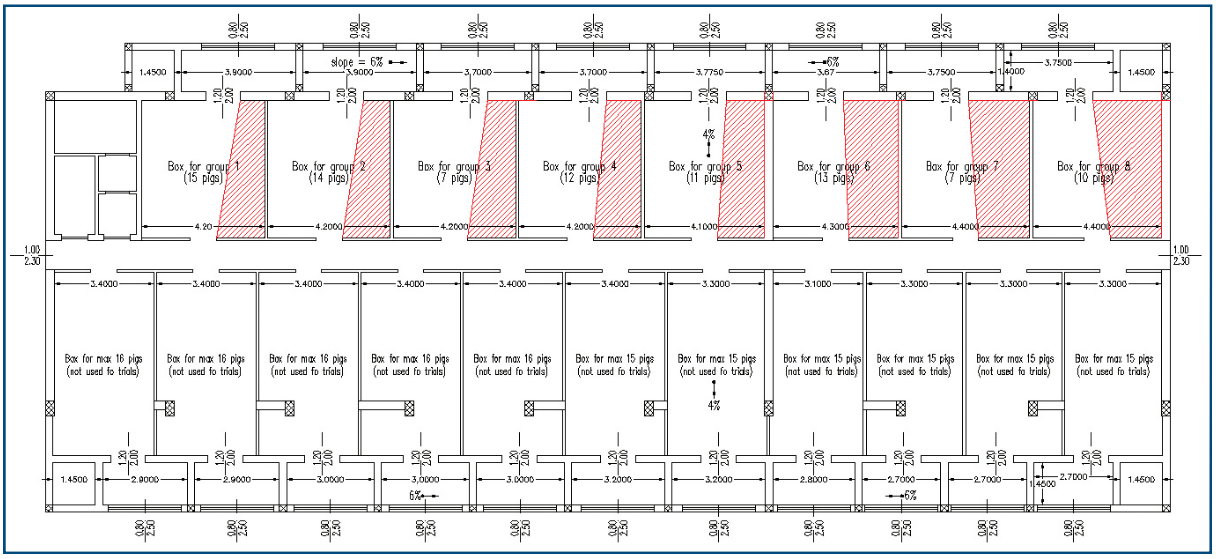

Figure 2. *Lay out of the piggery where the experimental tests were carried out; dashed line marks the prohibited area obtained opening the tool.* Images are drawn approximately to scale and measurements are in meters.

they were gently pushed with a sorting panel (board) to reinitiate movement and to drive them in the direction of the exit (Figure 3). In the context of test protocol, tests were carried out to verify whether the tool could be used properly to move pigs quickly and to assess the correct methodology for the final tests. In this phase, several spontaneous stops have been observed through the handling course and the reasons were animal curiosity and breeding organization (e.g. pen's gates that allow pigs to watch inside): pigs stopped every time they found something new/different to observe or to sniff along the way like feces, urines and/or other pigs. In order to assess correctly tool capabilities, the time registered durig the text accounts only for the amount of time necessary for the animals to move out from pens, the only place where the tool was used, and disregards pauses in the moving due to external factors.

A camera was used to detect the time used by animals to go out of their pens, to measure precisely the time between the beginning of the operations of animal moving and the release of each pig beyond the pen's door (Figure 3). When the tool was used in true operating conditions the time required to assemble it inside pens was not considered, this is mainly for 2 reasons: first of all, the time required for its assembly is negligible (about 10 s), except for a few trials, not considered here, in which the tool was damaged or difficult to roll out (only during the preliminary tests); second the main aim of the study was to evaluate the efficiency regardless of some desing details of the tools, which can be furthermore modified to adapt and optimize the tool to the various types of pens.

Total times were processed by non-parametric Kruskal-Wallis test to detect significant differences between groups having different number of samples (more than 5 samples in each group, which is the accepted definition of "too small"; McDonald 2009).

First of all a comparison was made between the control replicates to check the homogeneity of the treated groups without the tool ("NO TOOL" treatment). To determine whether there were significant differences between the averages of the exit times of these groups, the comparison was made 1 to 1.

Figure 3. *View of the realized device in true operating conditions.* It can be noticed the line of exiting animals.

Then the null hypothesis - no significant difference between control ("NO TOOL" treatment) and thesys ("TOOL" treatment) – was verified by comparing the averages of each replicate of the thesis with each control replicate (1 to 1 comparison).

Results and discussion

Data obtained were separated in two tables (Tables I and II):

- Table I: time of the first animal to exit the pen;
- Table II: total time required by all animals to leave the pen.

Table I and II show the results concerning respectively the first set of trials (control: "NO TOOL" treatment) and the second set of trials (investigated hipothesys: "TOOL" treatment).

In fact, in the experimental tests it was found a common dynamic of the movement of the animals from the box: once the paddock is open a "waiting phase" occurs before the exit of the first animal. The first pig is then followed by the other animals, according to a relatively orderly succession, in which the time intervals and the distance between the pigs are quite variable (Figure 3), especially in cases in which the exit is carried out in a traditional way, with the presence of at least 2 workers in the box. In Tables I and II, the time of the first animal exiting the pen is highlighted (bold character) for each group.

The activities carried out by workers may considerably affect the state of agitation of the animals and, in particular, the duration of the waiting phase. Examples of this type are found in both cycles of tests (Tables I and II), even though with different effects. In fact, for the animals in group 2 ("NO TOOL" treatment, Table I), and group 6 ("TOOL" treatment: Table II) the "waiting phase" was much longer than for the other groups. In both these cases, evidently, the movements of the personnel were more invasive than in the other cases scaring the animals, which thus headed toward the feed zone, rather than toward the exit.

As it can be noted from the data reported in Table I, pigs require similar times to begin to go out from the pens, with the exception of group 2 that showed significant difference when compared to groups 1, 3, and 4 (Table I), which are significantly homogeneous. As mentioned before, animals of group 2 were frightened by inappropriate movements of the operators in the housing area, which have been less attentive than in the other

Table I. *Time required by each animal moved without tool (control: "NO TOOL" treatment) and divided in four groups (Figure 2).* Bold characters indicate the time of the first animal which begins to go out of pens. Different letters in columns denote significant differences at p-value < 0.05.

Animal No.	Times of group 1[a] (s)		Times of group 2[b] (s)		Times of group 3[a] (s)		Times of group 4[a] (s)	
	Total Time	Relative Time	Total Time	Relative Time	Total Time	Relative Time	Total Time	Relative Time
1	**41**	0	**65**	0	**38**	0	**34**	0
2	42	1	66	1	40	2	35	1
3	45	4	81	16	41	3	39	5
4	45	4	88	23	42	4	39	5
5	45	4	88	23	51	13	40	6
6	46	5	92	27	58	20	45	11
7	47	6	97	32	59	21	46	12
8	47	6	106	41			47	13
9	48	7	106	41			59	25
10	48	7	118	53			60	26
11	49	8	118	53			74	40
12	49	8	120	55			91	57
13	56	15	155	90				
14	57	16	190	125				
15	76	35						

Table II. *Time required by each animal moved using the tool (investigated hipothesys: "TOOL" treatment) and divided in four groups (Figure 2).* Bold characters indicate the time of the first animal which begins to go out of pens. Different letters in columns denote significant differences at p-value < 0.05.

Animal No.	Times of group 5[c] (s)		Times of group 6[d] (s)		Times of group 7[e] (s)		Times of group 8[c] (s)	
	Total Time	Relative Time	Total Time	Relative Time	Total Time	Relative Time	Total Time	Relative Time
1	**21**	0	**34**	0	**16**	0	**19**	0
2	22	1	34	0	16	0	19	0
3	22	1	35	1	17	1	20	1
4	23	2	36	2	17	1	21	2
5	23	2	36	2	18	2	22	3
6	23	2	37	3	20	4	27	8
7	25	4	37	3	26	10	28	9
8	25	4	39	5			28	9
9	26	5	40	6			29	10
10	26	5	40	6			33	14
11	38	17	43	9				
12			44	10				
13			46	12				

tests. Initially, pigs of group 2 went in the dejection area, then stayed in the corner for some seconds and, only after 65 seconds, they started to go out of pen. Pigs of groups 1, 3, and 4 required on average 38 seconds to start exiting the pen (Table I). Shortly after the release of the first animal from the box with fewer animals (group 3) or when few pigs remain in the box (groups 1, 2, and 4), the interval between 2 consecutive exits increases quite a bit. Therefore, in larger spaces, the animals tend to be less ordered and fast in their movements.

The total time required by animals in the "NO TOOL" treatment groups to leave the pen ranges from 21 to 125 seconds (21 to 25 seconds considering only the homogeneous groups 1, 3, and 4).

From these data we can deduce that the handling of the animals from the box is not an operating condition allowing for both ideal conditions of individuals and high performance of human work. First of all, this type of management crucially depends on the behaviour of the workers and their movements in the box. These are variables that cannot be controlled in an optmized farm/slaughterhouse system. In addition, the wide range of time intervals with which the clearance of the animals occurred for these groups show a disorderly handling and, therefore, greater risk of fatigue, panic, and mechanical trauma that are reflected in the decrease of weight and increase of the wastes in the processing stages. Another operational

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consequence is the difficulty to program the use of labor, with a further increase of production costs.

Animals moved using the tool began to go out of pens more quickly than the others, with the exception of group 6 that had a start time (34 seconds) equal to the one of group 4 (Table II, bold character as for Table 1). Groups 5 and 8 show similar behaviour, while group 6 and 7 were slower and faster, respectively, than the previous one. The analysis of the time of the "waiting phases" (Table II) shows that the animals of group 6 were frightened. Although, the fear is much less evident. The absence of operators in the relaying area and the presence of only 1 person, also partially covered by the curtain, significantly limited the panic reactions of the animals. It is worthwhile noticing that even in situations of this type, the "waiting phase" is more than halved compared to the "NO TOOL" treatment (Tables I and II), thus showing a minimization of the effects of fear among the animals in the "TOOL" treatment groups.

All "TOOL" treatment groups showed significant difference of the total time required by each group to go out of pen (between 10 seconds and 17 seconds after the first animal goes out), when compared to the "NO TOOL" treatment groups. In fact, animals treated with the tool need (on average) about 1 second to leave the pen, while those traditionally handled require between 2 seconds – in the best case (group 1: but they begin quite late to exit) – and 8 seconds.

Moreover, even if the exit time of animals of group 6 ("TOOL" treatment groups) is similar to the one of group 4 ("NO TOOL" treatment) moved without tool, a closer analysis of the data and a comparison with those of group 1, 3, and 4 show a significant difference between the exit time of group 6 and 4 ($P < 0.05$) (Tables I and II): therefore the use of the tool also for group 6 still leads to a better behaviour (even if not so much as for the other 3 groups 5, 7, and 8).

It should also be noted that the use of the tool leads to substantially uniform (Table II) exiting times, with the result of having identified the potential impact of the available movement space (density housing in the box: each box has same area but different number of pigs inside) on the output rate of the animal.

It is, thus, evident that the proposed device constitutes a valid technically guide, both for the quick exit of the first animal and for those that follow; once the row has been formed, the animals continue neatly to leave the box.

Overall, in all the tests carried out, the studied solution can be considered appropriate for reducing the identified critical issues in the traditional handling permitting almost the total control of the variable due to the behaviour of the workforce. In this sense, the movement of animals is no longer a "critical stage", we can now consider it as a normal part of an efficient management program of the entire production cycle of pork's meat (breeding - slaughter - processing) aimed to the quality of the product, its standardization, and the best final cost. In particular, the homogeneity of the measurements highlights how this operating phase can be standardized in an advantageous way, by the correct definition of the operating times and the subsequent productive use of labor.

Conclusions

In this study we investigated an appropriate handling method that allowed us to plan and assemble a particular tool to facilitate pigs exit from the pen. This tool has been designed considering the behaviours of pigs during transfers.

To develop an effective tool we observed the surrounding environment trying to embrace the animals' perception. While a human being observes the passageway from (on average) 170 cm, pigs look at it from 45 cm from the ground. Hence, while for a human being the passageway is just a small construction inside the main building, but for animal it is the main construction. In the same way, the pen's door, when open, is not too different from the wall and animals, during handling/transfer procedures, often do not consider it and, moreover, they go toward the angle where they felt more protected.

The use of the tool during the trial, on the one hand confirmed several literature data relating to the behavior of animals in their movements and breeding in the slaughterhouse (Hemsworth *et al.* 1996, Mc Glone *et al.* 2004), on the other hand showed a positive effect on the time necessary for pigs to go out of pens. In fact, when the tool was used fewer stops were observed. More importantly, the tool required the presence of only 1 worker to help the animals to begin exiting. This facilitates the all process, the animals were calmer, and no squirrels/vocalizations have been recorded during the test; that is why they did not require of any external stimuli for going on and, additionally, they were less dangerous for workers also.

Finally, the need of 1 worker is an important factor impacting the economic efficiency of the process. In fact, a lower division of labour means less downtime and greater skill and specialization of labor, and it is also one of the main sources of economies of scale; which in turn, are decisive factors among those that affect the unit costs of a complex integrated pig production chain, from production to processing, set to meet quality standards, at the lowest cost per kg/meat.

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