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Improving the poultry shackle line

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Abstract

The most significant welfare problems associated with the current design of the shackle lines and water-bath stunners are the pain caused by compression of the birds' legs in the shackles, the stress caused by being inverted and suspended by the legs, poor or inadequate stunning caused by the commercial need to minimise carcase damage, and poor water-bath entry. Research is described in which some practical solutions to these problems were investigated. The aim is to identify solutions that individually, or jointly, could be retro-fitted to existing plants, or incorporated into the design of new, small processing plants to improve poultry welfare. The development and commercial availability of such systems would enable small, local and niche market poultry processing lines to continue operating following the implementation of EC Council Regulation No 1099/2009.

Keywords: *animal welfare, broilers, poultry, shackle line, slaughter, water-bath*

Introduction

The most widespread technique for slaughtering poultry in Europe is electric water-bath stunning followed by exsanguination. This approach, however, is associated with welfare problems. The most significant of these are: leg compression in the shackles; being inverted and suspended from the shackles; inadequate electrical stunning due to the need to protect carcase quality; and pre-stun shocks due to poor water-bath entry (EFSA 2004; FAWC 2009).

One solution to these problems seems to be the use of controlled atmosphere stunning, however this is suitable only for high throughput plants and requires a major equipment refit. The high capital and operating costs of these systems make them currently unsuitable for medium and small processing lines. Equipment manufacturers are also developing new electrical stunning solutions, however, the mechanical complexity of these systems is likely to limit their uptake. If small-scale, local, and niche market processing lines are to remain viable then relatively simple, cheap and robust systems offering an acceptable level of welfare need to become available. Rapid uptake of such systems would be enhanced if they could be retro-fitted to existing equipment rather than requiring a complete refit.

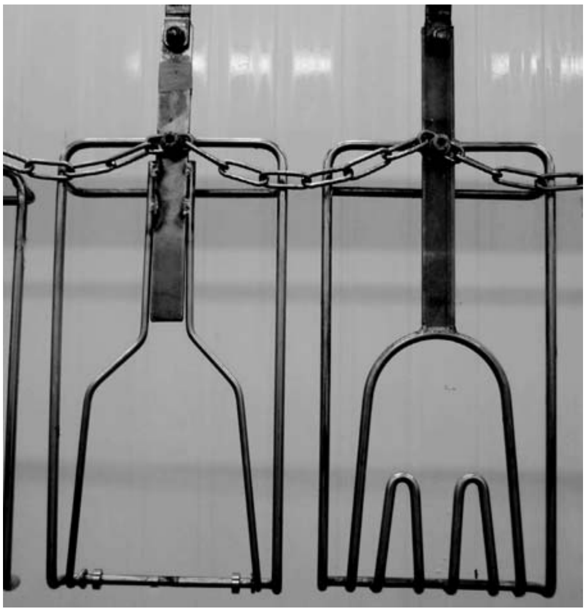
This paper describes three relatively simple techniques that have been investigated to improve poultry welfare at slaughter. Taken together, they are expected to address the main welfare problems associated with the traditional water-bath and shackle line. In many cases they could be retro-fitted to existing plants at relatively low cost, thus enabling small plants to achieve a higher standard of welfare and at an earlier stage than would be otherwise possible. The techniques have been tested and developed separately and to various stages. Each approach is described, its apparent benefits and problems described and the future development needs identified.

Compliant shackles

Compliant shackles are a simple and low cost concept aimed at avoiding the compression of the birds' legs while still maintaining good electrical contact. Sparrey (1995) reports that forces of five or ten times the birds' weight are frequently used to pull the birds into the tapering gap of the shackles resulting in severe compression of the bird legs by forces of around 180 Newtons (N). Gentle and Tilston (2000), have shown that the legs of poultry are well supplied with nociceptors and so conclude this leg compression is likely to be painful.

A trial set of compliant shackles was developed and tested in a small commercial poultry processing line dealing with free-range broiler chickens. Examination of a sample of legs from birds slaughtered in the plant showed that the mean leg width at the shackling point was 12.7 mm with a standard deviation of 0.55 mm. The shackles used in the plant had two available pairs of slots, one 11.3-mm wide designed for broilers and one 13.3-mm wide for turkeys. Assuming that the legs' sizes were normally distributed, this suggested that

Figure 1



Compliant shackle (left) and standard plant shackle (right) installed in processing plant.

only 5% of birds processed could be shackled using the narrow slots without their legs being compressed and that 15% of the broilers had their legs compressed even when shackled from the larger turkey slots. Observations during plant operation, however, indicated that in practice the large majority of broilers were shackled using the narrower slots.

Compliant shackles developed for testing were based on the shackles already in use but had only a single pair of slots, the inner rails of which were free to move in response to the leg width. To ensure the shackle remained robust, the maximum slot width was limited and the moving rails were held captive on the bottom rail (Figure 1).

Without a bird in the shackle the slot width in the compliant shackles is 10.5 mm. This slot size can increase up to 14.3 mm when pressed out by a leg. This maximum slot size is equal to the mean leg width plus 3 standard deviations and so should enable over 99% of birds to be shackled without compressing their legs. The spring rate of the shackles is 5 N mm^{-1} so when the shackles are open at their widest extent the restoring force is less than 20 N. This is substantially lower than the 180 N compression estimated by Sparrey (1995).

Five compliant shackles were installed on a commercial processing line and clearly marked to facilitate easy visual location. A sixth shackle, identical to the others, was further modified to enable the current profile through a bird on the compliant shackle to be measured. These measurements indicated a rapid rise in the current at the start of the stun and a constant uninterrupted flow of current until the bird reaches the end of the water-bath. These features are indicative of a good stun, and demonstrate that the compliant shackle design is able to provide a good electrical conduction pathway and so facilitate good stunning (Figure 2).

The test shackles were observed as they passed through the processing plant. Birds were stunned, killed and plucked on the shackles. No problems were observed during shackling and no differences between the compliant shackles and the normal shackles could be observed in the stun bath. In a sample of 28 birds observed, a leg of one carcase became disengaged during the plucking operation. No problems were observed elsewhere on the line. The leg-removing equipment failed to completely remove four legs from the compliant shackles, however, this could be easily rectified by adjustment of the leg-removal device.

Due to this successful initial assessment, the plant management agreed to allow the shackles to remain in use on the line. After the shackles had been in daily use for several months the plant management indicated that they remained happy with the shackles. Few birds, if any, were thought to have been lost and the shackles were in good condition.

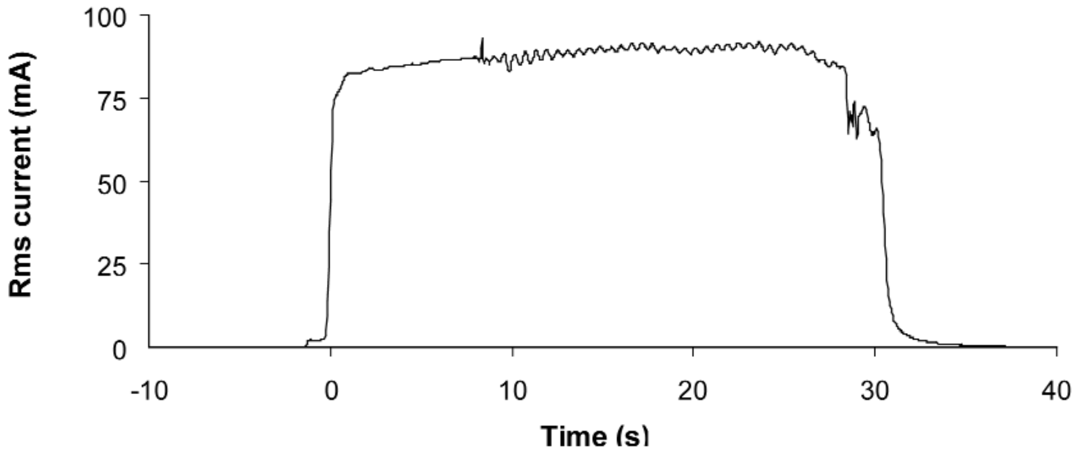
This far, the modified shackle design appears to be working well, reducing leg compression, delivering a good stun current profile and integrating with the rest of the processing line machinery without problems. This initial testing is not yet adequate proof that there are no problems associated with the design, it does, however, build confidence and indicate that this could be a workable solution. The next stage of development needed is to install a larger number of similar shackles on a larger, faster processing line to facilitate a more demanding test. It would also be useful to test the introduction of a slight keyhole shape in the shackle, where it holds the birds' legs, to guard against legs disengaging during plucking.

Breast-support conveyer

An approach to shackling which avoids the need to invert and suspend the birds from their legs has also been investigated. This approach uses a conveyor running underneath the shackle line allowing the birds to rest on their breasts, supported on a horizontal conveyor with their legs extended behind them and engaged in shackles. The birds are transported in this way from the point at which they are shackled to the point at which they enter the water-bath. At the water-bath entrance the conveyor ends, the birds swing off the end of the conveyor and their heads fall directly and rapidly into the electrical water-bath (Figure 3). A full report of this work is given in Lines *et al* (2011a).

There is some physiological evidence that broilers find being inverted and suspended from shackles, as on a traditional line, distressing, particularly as the length of the shackling period increases (Kannan *et al* 1997; Bedanova *et al* 2007). However, the most compelling evidence of the problem is the behaviour of the birds themselves: many are observed to struggle and flap their wings immediately after shackling. Jones *et al* (1998) point out that this struggling is not only an indication of a desire to escape but is also likely to be a cause of further distress due to the potential for broken, dislocated and bruised wings and causing distur-

Figure 2

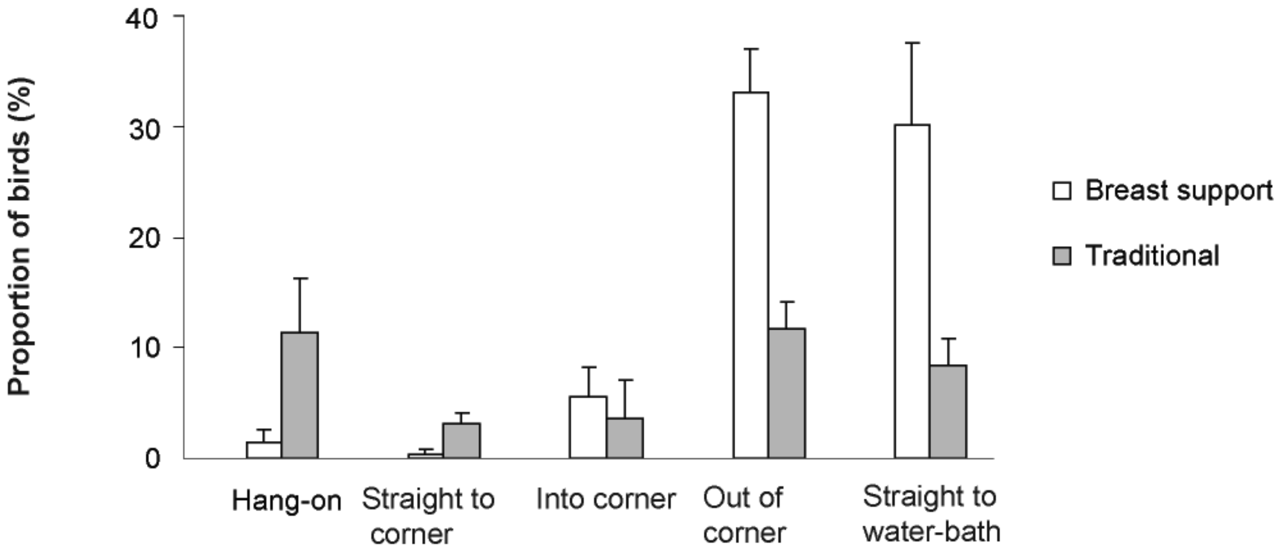


Stun current profile for bird in compliant shackle showing the measured root mean square (rms) current against time.

Figure 3

Water-bath entry from breast-support conveyor.

Figure 4



The proportion of birds struggling at the various sections on the breast-support conveyor shackle line (grey) and unmodified shackle line (white).

bance to adjacent birds. If the struggling continues to the water-bath entrance then it increases the chance of pre-stun shocks. To avoid this last eventuality, shackle lines are designed to be long enough to ensure that most birds have stopped struggling before they reach the water-bath.

To overcome these problems a breast-support conveyor was developed, installed and tested in a small commercial broiler processing plant where it was in use for seven months. The conveyor comprised a 0.5-m wide horizontal belt, of a type widely used in the food processing industry, positioned below the shackles and extending from before the point of shackling to the entrance of the water-bath. The path of the shackle line in the processing plant included a 90° corner which the conveyor followed. Although corners in shackle lines are known to disturb the birds, many older processing plants still have them so it was of interest to see how birds on a breast-support conveyor responded to a corner. The conveyor speed was adjusted to match to the speed of the shackle line.

Bird behaviour on the shackle line, both with the breast-support conveyor and in the original unmodified configuration, was assessed in a structured trial and post mortem comparisons of wing and leg damage were made. The results showed that with the breast-support conveyor significantly fewer birds struggled at the point of shackling and those that did tended to struggle for a shorter time. However, once the birds reached the 90° corner in the line there was more struggling on the conveyor than on the standard shackle line (Figure 4). Despite this problem, entry to the water-bath was significantly better for birds when the breast-support conveyor was used. Examination of the birds after slaughter and plucking showed that fewer birds from the conveyor had red wingtips or bruises at the first wing joint (Lines *et al* 2011a). Struggling at and after the corner was probably related to the contraction of the conveyor belt under the birds as it turned the corner and the relative change in position of the shackles in relation to the birds due to the different radii of curvature of the shackle line and the path of the birds on the conveyor.

The breast-support conveyor appears to be a practical concept which benefits the welfare of broilers on a shackle line both reducing struggling and promoting a cleaner entry into the water-bath. The conveyor could also provide a further welfare benefit by allowing the time from hang-on to stunning to be reduced since the birds do not require time to settle. Processing lines which run in a straight line from hang-on to the water-bath could introduce this equipment with relatively few other modifications, however, it does not seem to be suitable for lines with corners. The most important additional modification which may be needed to enable the breast-support conveyor to be used safely is the introduction of leg guards or other measures to prevent the birds from disengaging their legs from the shackle.

As a result of this research, breast-support conveyors have been installed in several small commercial turkey stunning lines. Turkeys also generally struggle when hung on a shackle line and then allow their wings to hang down so they enter the stun bath first. In contrast, turkeys on the breast support conveyor remain calm and alert while on the conveyor and enter the stun bath cleanly.

Further development of this concept should include the development of recommendations for the relative heights of the water-bath, conveyor and shackle line for various bird sizes. The introduction of a lateral slope on the conveyor which would allow the birds to rest more centrally on their breast bone should also be investigated. This would also tend to realign any birds that do struggle and so reduce the amount that they encroach on the space of neighbouring birds. During shackling, the conveyor requires that workers lift the birds a little further. The use of a twisted conveyor that is closer to vertical at hang-on and which twists up towards a horizontal position following shackling could solve this issue and should be investigated.

Head-only water-bath stunning

Traditional poultry lines which use electrical stunning pass a current from the bird's head, which is immersed in water, through the body and legs to the shackles. The current passing through the whole body frequently causes carcase damage. In selecting the stunning current, processors have to balance the probability of carcase damage against the probability that birds are not properly stunned. Stunning a bird by passing an electrical current across its head but avoiding its body, can result in a high quality stun without compromising carcase quality (Raj & O'Callaghan 2001, 2004). However, application of head-only stunning in a processing line is difficult because of the need to accurately locate and place electrodes on the head of every bird.

A method for applying a head stun has been investigated which uses a water-bath with an electrical current flowing from one side of the water-bath to the other. When a bird's head is dipped into the water-bath some of the current passes through the head, stunning the bird without the need to locate the head accurately. This is very similar to the approach used for electrically stunning fish in water (Lines *et al* 2003).

Intense wing flapping is normally observed when a bird is killed by neck dislocation or following an effective percussive or head-only electrical stun. If left unchecked this wing flapping can result in broken or dislocated wings. Such flapping does not occur with traditional water-bath stunning because of the immobilisation caused by tetany of the muscles from the current passing through the body. This immobilisation can, however, be produced using currents far lower than that required to actually stun the birds.

Following research described in more detail by Lines *et al* (2011b) it was established that the immersion of a broiler's head in water of conductivity 2.5 ms cm^{-1} supporting a 50 Hz, 20 V cm^{-1} electric field resulted in immediate and sustained unconsciousness with EEG signal suppression for at least 30 s. It was also shown that the wing flapping could be controlled by simultaneously passing a 2,000 Hz, 25–30 mA current through the body of the bird from the shackle to the water-bath. This is a far lower current than is used in a traditional electrical stunning system.

The use of an electric current through the body to suppress wing flapping would be both illegal and highly detrimental to bird welfare if the birds were not also rendered immediately insensible. However, because this body current cannot flow unless the bird's head is in contact with the water, the application of the body current and the stunning current are necessarily simultaneous. The approach is similar in principle to that of the traditional water-bath stunning, since in both, a stunning current and an immobilising current are simultaneously applied. The difference is that in traditional water-bath stunning the same current is used for both purposes whereas in this approach each current is specified to achieve its specific purpose.

Carcase quality trials were conducted in a commercial processing unit to examine the effect on carcase quality. These trials are described in more detail by Lines *et al* (2011c). The treatment birds were removed from the flock prior to shackling, individually stunned on a single shackle using the electrical parameters established above for 7 s. They were then bled, tagged and replaced on the processing plant shackle line in vacant shackles. Control birds were drawn from the birds passing normally through the plant at the same time. These were stunned using the normal water-bath stunner which was operated at a frequency of 610 Hz using a 30% duty cycle pulsed DC waveform with an rms voltage (ac + dc) of 59.3 V. The average stunning current for these birds was 63 mA rms (ac + dc) per bird and the birds remained in the waterbath for 9.3 s. This set of parameters results in acceptable carcase quality, however, they are substantially below those recommended by Raj (2006a,b) and lower than that which will be required in 2013 when new EU regulations come into force (EC 2009).

Following automated plucking, evisceration and chilling, and whilst still on the primary processing shackle line, the carcases of the treatment birds were scored for external quality. A similar score was also taken from the tenth bird on the shackle line following each treatment bird. This bird became part of the (unmatched) control treatment group. The external inspection focused on the carcase quality variables engorged wing veins, red wing tips, wing haemorrhages and shoulder haemorrhages, since these are known to be susceptible to stunning damage. A total of 284 carcases were scored for each of the treatment and control groups.

At the end of the primary processing line, the treatment and control birds were removed from their shackles and placed in a chiller for overnight storage. The following morning they were taken to a processing room for internal carcase quality inspections. The major fillets were assessed as a pair, examining both the dorsal and ventral aspect with the skin removed. The minor fillets were also examined as a pair, examining the dorsal aspect. The carcases were then examined for broken bones, in particular the furculum, scapula or coracoid.

The results of these examinations indicated that no aspect of the quality of the treatment birds was worse than that of the control birds, even though the treatment birds had received a much stronger stun. Barker (2006) compared the carcase damage associated with the typical industry stun as used for the control birds, to that resulting from application of the higher currents similar to those that will be required in 2013. This indicated a two-fold increase in the prevalence of haemorrhagic damage in minor breast fillets (increasing from 7 to 17%) and a three-fold increase in the prevalence of major breast fillet damage (from 4 to 12%).

These results indicate that a high quality stun can be achieved together with high quality carcases. Head-only electric stunning therefore has the potential to meet simultaneously, the commercial requirements of the processing industry for high quality meat, and the aspirations of society for a high standard of animal welfare at slaughter. Further laboratory-based development is, however, required before water-bath head-only stunning can be implemented on a processing line. In particular, further work is needed to explore alternative combinations of electrical stun parameters to enable the electrical power to be reduced.

Conclusion

The three developments described have been shown to ameliorate the four major welfare problems of the traditional shackle line. These developments could be applied separately or together and could be introduced into many existing poultry slaughter lines without the need for a major refit. Some further development or testing, however, is required for each component before it can be made fully commercially available. The three components have not been tested together. Whilst no problematic interactions are expected this aspect should also be examined. Funding and industrial support for the development of these concepts is currently being sought.

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