The Case for Controlled-Atmosphere Killing of Poultry in Transport Containers Prior to Shackling as a Humane Alternative to Electrical Stunning

The practice of electrically stunning poultry, which is standard in North American slaughterhouses (Boyd 1994), results in both welfare and carcass-quality problems. With regard to welfare, the many variables and frequent process failures associated with electrical stunning methods make it difficult to ensure adequate stunning and result in pain and suffering for birds who experience pre-stun shocks, have their necks cut open, and are dipped in scalding-hot water, often while still fully conscious. Furthermore, the uncrating, shackling, and conveying of live birds that always precedes electrical stunning has been shown to cause severe stress and injury, which lead to a decrease in meat quality. On the other hand, the controlled-atmosphere killing of poultry—using a mixture of inert gases in air with no more than 2 percent residual oxygen by volume, preferably 80 percent nitrogen and 20 percent argon—helps to significantly alleviate many of these animal-welfare and carcass-quality issues and actually leads to increased revenue. Thus, this method should be adopted by producers immediately.

I. The Electrical Stunning Model

Dumping

Serious animal-welfare problems associated with the electrical stunning of poultry are painfully evident before stunning even takes place. In order to facilitate the process, birds are dumped from transport vehicles onto a conveyor before being subjected to a stressful procedure called "shackling." Birds awaiting shackling are sometimes overloaded onto the conveyor and end up suffocating to death as other birds are dumped on top of them. Extreme crowding and rough handling during unloading and dumping lead to a relatively high number of birds who are dead on arrival.

Shackling

During shackling, birds are hung upside-down by their legs on a line of shackles moving so fast—approximately 182 birds per minute at some plants—that it is impossible to humanely handle the birds. Leg deformities and other injuries typical of large broilers may exacerbate the pain as their sensitive periostea are pinched and compressed by the metal shackles. Gregory and Wilkins (1989) found that, after shackling, 3 percent of broilers had broken bones and 4.5 percent had dislocations. Another study by the same authors (1990), which looked at hens before and immediately after shackling, found a 44 percent increase in newly broken bones following shackling. Others conclude that shackling can, indeed, be both a physiologically and psychologically painful experience (Sparrey and Kettlewell 1994; Gentle and Tilson 1999).

Improper Stunning and Temporary Immobilization

After enduring the stress of being dumped and shackled, the birds proceed to the stunning area, where they are passed through an electrically charged water bath before having their throats cut. "Humane slaughter," as defined by law for most species in many developed countries, requires that animals be rendered unconscious and, thus, insensible to pain prior to slaughter. In order to make claims that slaughter is humane, it is critical that this be accomplished—without exception and with minimal stress to the animals involved. However, when using electrical stunning methods on chickens, it is almost impossible to ensure that every animal is rendered unconscious

because the varied nature of the birds hinders the effectiveness of the electrical settings. In other words, because each bird has a different weight, fat content, age, number of feathers, level of cleanliness, brain resistance, and leg size (which determines shackle-to-leg contact)—all of which influence the effectiveness of an electrical stun—it is nearly impossible to ensure proper stunning unless the settings are changed to accommodate each individual bird. Boyd (1994) concludes that "[t]he high occurrence of improper stuns is testimony to the difficulty of controlling all these variables," and as a result, "under many commercial conditions in poultry slaughterhouses, we have little reason to believe that proper electrical stunning is achievable consistently." This was confirmed by a Farm Animal Welfare Council report (Heath 1984) to the British minister of agriculture, which surveyed facilities in the United Kingdom and found that one-third of chickens were improperly stunned and not rendered insensible to pain during electrical stunning.

Although it has been argued that settings in excess of 120mA may induce unconsciousness in chickens if applied properly, others have called this theory into question. The most accurate indication of insensibility to pain is an isoelectric (flat) EEG pattern. Electrical stunning, however, does not immediately produce such a pattern. It has been hypothesized that the epileptiform brain activity that electrical stunning does induce in some animals is akin to a human *grand mal* epileptic seizure wherein the subject is unconscious. And while this argument may be appropriate for sheep and pigs, who display the high-frequency polyspike activity found in *grand mal* seizures after being electrically stunned, chickens present a markedly different reaction. In fact, in 90 percent of chickens, electrical stunning produces low-frequency polyspike activity that is "associated with *petit mal* epilepsy in humans and is not necessarily associated with unconsciousness" (Boyd 1994); this was also suggested by Gregory and Wotton (1987). Higher voltage settings do not necessarily remedy the problem by causing higher frequency polyspike activity, which implies that regardless of the electrical settings, chickens may not be rendered unconscious as a result of stunning unless they are killed (Gregory 1986; Gregory and Wotton 1987).

Furthermore, research presented at a recent symposium on the humane slaughter of farm animals (Gregory 1986) suggests that birds may still be able to experience pain after electrical stunning but are not able to display a pain reflex because of temporary paralysis. A study authored by four British poultry slaughter supervisors (Richards and others 1967, cited in Heath and others 1981) concluded that electrical stunning is fraught with problems and acknowledged that "electrical paralysis may occur under certain conditions in man and other animals, during which pain can be perceived but reaction to it is impossible." Other researchers (Katme 1986; Gerlis 1986) at the aforementioned symposium presented evidence that even the shock, which is supposed to render the animals unconscious, is, in fact, intensely painful immediately and painlessly.

In addition to the general efficacy problems of electrical stunning, even when conducted as planned, frequent system failures cause further complications. Pre-stun shocks are both painful and common, occurring, for example, when a bird's wing comes in contact with the stun bath before the bird's head. Testimony from the "McLibel" lawsuit revealed that, according to Dr. Neville Gregory, up to 13.5 percent of broilers at one particular slaughterhouse were being shocked before fully entering the stun bath (CIWF §3.2.3). Chief Justice Bell, who presided over the case, concluded that the pre-stun shocks were indeed cruel (Wolfson 1999).

Other birds are able to completely avoid the stun bath by lifting their heads or flapping their wings, and these birds are fully conscious when they are moved to the next area. Raj (1998b) explains that there is, indeed, "pain and distress experienced by some conscious birds which miss being stunned adequately (due to wing flapping at the entrance to the water bath stunners)." During the McLibel lawsuit, Dr. Gomez Gonzales, a meat-management technician for the McDonald's Corporation, testified that between 1 and 2 percent of chickens miss the stun bath in the company's U.S. slaughterhouses (Wolfson 1999). This has serious welfare consequences for birds who are conveyed to the killing area while still fully conscious.

The tendency for improper electrical stunning is even more pronounced in the United States where, despite studies showing that higher electrical settings do not "adversely affect the carcase appearance" (Griffiths and Purcell, 1985), most producers insist on keeping settings that are too low—significantly lower than the 120mA used at most facilities in the United Kingdom—to achieve anything more than temporary paralysis. A metastudy of electrical stunning methods (Boyd 1994) verifies that in North America, "the development and application of [electrical] poultry stunning had more to do with facilitating processing than with humane slaughter." In fact, one U.S. manufacturer of electrical stunning equipment wrote that "[t]he typical amperage used in stunning by our pulsating direct current pre-stunner is approximately 12 to 15 mA" (Austin 1994, cited in Davis 1996). Such low electrical settings have particularly dangerous consequences for birds who are paralyzed but still alert after passing through the stun bath and for those who miss the "killing machine" altogether and fully recover by the time that they reach the "killer" or scald tank.

Throat-Cutting

After being stunned—or rather, temporarily immobilized or even left entirely conscious after completely missing the stun bath because of avoidance behavior—birds are conveyed toward an automated spinning blade, commonly referred to as the "killing machine," which is designed to cut their necks. Some conscious birds are able to avoid this blade, as well, by lifting their heads or flapping their wings. Recent research (Boyd 1994) that examines the electrical stunning of poultry verifies that "birds dodge the knives, some completely, some partially, because they are not fully stunned." Gregory (1991) wrote that "problems associated with inefficient neck cutting [are] only too common in poultry processing plants." The McLibel lawsuit highlighted the high number of occasions during which broilers were still fully conscious during neck-cutting. For example, Chief Justice Bell estimated that based on the evidence presented during the trial, more than two birds per minute in the U.S. were fully conscious as their throats were cut (McSpotlight 1997). When Dr. Gomez Gonzales' estimate that between 1 and 2 percent of chickens miss the stun bath in McDonald's U.S. slaughterhouses (see previous section) is applied to U.S. Department of Agriculture statistics (USDA 2003) for a typical year (e.g., 8,716,099,000 chickens were slaughtered in the U.S. in 2002), it can be concluded that every year, up to 175 million chickens completely miss the stun bath and have their throats cut while they are still fully conscious.

After going through the "killing machine," birds usually pass by a knife-wielding manual killer, commonly referred to as simply "the killer," but with such fast-moving lines, it is impossible to ensure that every bird is dead, let alone unconscious, before proceeding to the scald tank.

Scalding
Birds are dipped into the scald tank, which contains scalding hot water, to facilitate feather removal. Heath and others (1981) determined that sentient birds are, indeed, sometimes scalded. Another survey (Griffiths and Purcell 1984), which examined various chicken processing plants in Australia, also concluded that some birds are "not killed before they reach the scald tank." At least two studies have concluded that "red-skin" chicken carcasses, commonly found when electrical stunning methods have been used, are caused by a physiological response to heat when live birds enter a scald tank (Heath and others 1983; Griffiths and Purcell 1984). Perhaps the most compelling evidence that live birds reach the scald tank on a routine basis in the U.S. comes from the USDA itself. On its Food Service Inspection Service (FSIS) Web site and in instructional materials used to train inspectors (FSIS 2001), the USDA states, "Poultry that die from causes other than slaughter are condemned under the cadaver category. These birds are not dead when they enter the scald vat. When submerged in the water, they drown." Furthermore, under a U.S. federal regulation (9 CFR, Ch III, Part 381, §381.90) titled "Cadavers," "carcasses of poultry showing evidence of having died from causes other than slaughter [i.e., in the scald tank] shall be condemned." According to USDA poultry slaughter statistics for a recent year (2002), more than 3.7 million chickens were classified as "cadavers" and had been either scalded to death or drowned in the scald tanks.

II. The Controlled-Atmosphere Killing Model

Improved Welfare
Clearly, electrical stunning methods result in severe welfare problems for billions of birds each year in the U.S. alone. On the other hand, the controlled-atmosphere killing of birds in their transport containers (prior to shackling)—using a mixture of inert gases, such as nitrogen or argon in air with less than 2 percent residual oxygen—has proved to be both far more humane and less likely to cause carcass degradation, two convincing reasons for producers to immediately adopt such systems. Under the most humane controlled-atmosphere killing model, birds are taken directly from the transport vehicles in their crates or modules, which are inserted into a chamber where controlled-atmosphere killing occurs. The dead animals are then shackled, cut, bled, scalded, and eviscerated. At no point during this process can the animals experience pain or suffering.

The switch from electrical stunning to controlled-atmosphere killing would result in such vast welfare improvements that according to one of the world's foremost experts on the subject (Raj 1998b), doing so would eliminate the "stress and trauma associated with removing conscious birds from their transport containers, in particular, under the bird handling systems which require tipping or dumping of live poultry on conveyors; the inevitable stress, pain and trauma associated with shackling the conscious birds, i.e., compression of birds' hock bones by metal shackles; the stress and pain associated with conveying conscious birds hanging upside down on a shackle line which is a physiologically abnormal posture for birds; the pain experienced by some conscious birds that receive an electric shock before being stunned (pre-stun shocks); … the pain and distress experienced by some conscious birds which miss being stunned adequately (due to wing flapping at the entrance to the water bath stunners) and then pass through the neck cutting procedure; [and] the pain and distress associated with the recovery of consciousness

during bleeding due to inadequate stunning and/or inappropriate neck cutting procedure." The Canadian Food Inspection Agency (1999a) also recently issued a news release stating that an "advantage of using [controlled-atmosphere killing] for poultry is that it eliminates uncrating and shackling of conscious birds and thus contributes to reduce stress to the birds. The procedure is fast, painless, efficient and there is no risk of recovery from unconsciousness."

The figure on the following page compares electrical stunning to controlled-atmosphere killing and gives an overview of the welfare consequences of each.

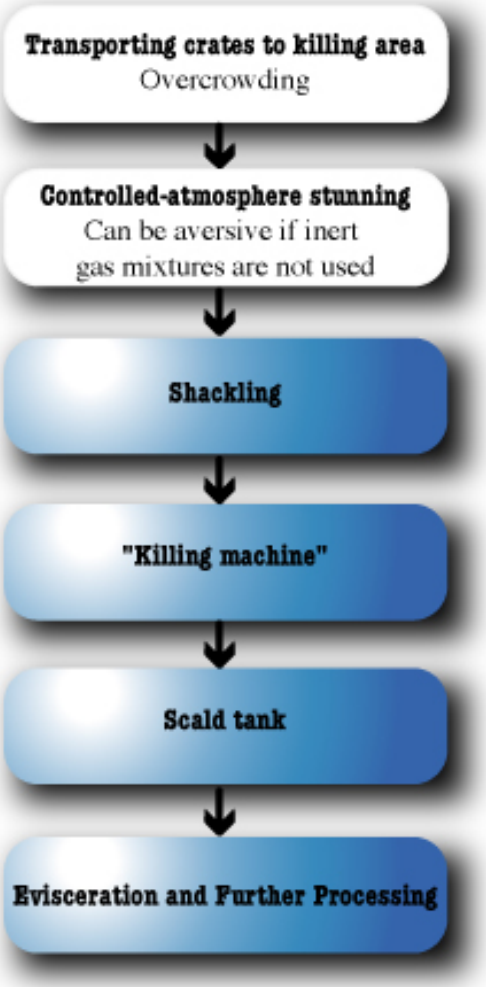
Inert Gases, Such as Nitrogen and Argon, Are the Most Humane

Research shows that inducing anoxia with inert gas mixtures—such as nitrogen or argon in air with no more than 2 percent residual oxygen—which can be breathed, undetected, by animals under the right circumstances, is the most humane controlled-atmosphere killing method available for poultry and can be used to create a non-aversive atmosphere where birds die painlessly. Raj (1994) reported that in one study, researchers observed that 100 percent of the tested hens voluntarily entered a feeding chamber filled with 90 percent argon, where they were killed by the gas without any detrimental effects. Raj (1996) also found that "because argon is an inert gas with no taste or odour, most of the turkeys did not detect its presence, and they didn't show any signs of respiratory discomfort before they lost consciousness." And after visiting a chicken slaughterhouse that employed a controlled-atmosphere killing system using inert gases, Duncan (1997) was compelled to write, "In my opinion, this is the most stress-free, humane method of killing poultry ever developed. The birds are quiet throughout the operation. They remain in the transport crate until dead and the killing procedure itself is fast, painless, and efficient. There is no risk of recovery from unconsciousness."

While both nitrogen and argon have been found to be suitable, nitrogen is gaining in popularity because it is typically less expensive and easier to distill from atmospheric air than argon. In fact, some plants are able to separate nitrogen from air on their own, enabling them to avoid buying it from external sources. In fact, even though argon is heavier and easier to contain, nitrogen's relative cheapness has enticed producers in Europe to the point that it has become the standard in poultry slaughterhouses that use gas. In the U.K., the Department for Environment, Food & Rural Affairs (DEFRA) recently amended legislation to allow the use of nitrogen in poultry slaughterhouses, and according to the European Commission (2003), "[T]here are at least 4 companies in the UK using a predominantly nitrogen based gas mixture for killing chickens and turkeys." In Canada, the Canadian Food Inspection Agency has also approved the use of inert gases to kill poultry (CFIA 1999b).

Electrical stunning model and potential welfare consequences

Controlled-atmosphere killing model and potential welfare consequences



Note: Shaded boxes represent stages where birds are dead and thus there are no welfare consequences

Carbon Dioxide Can Be Detrimental to Welfare

When inhaled, carbon dioxide has been shown to be highly aversive to humans (Gregory and others 1990) and birds. Raj (1998a) states that "[c]arbon dioxide is an acidic gas and is pungent to inhale at high concentrations. It is also a potent respiratory stimulant that can cause breathlessness before the loss of consciousness. The welfare implication of this is that birds could experience unpleasant sensations either during initial inhalation of carbon dioxide or during the induction phase." The European Commission's Scientific Committee on Animal Health and Animal Welfare (1998) explains that "while CO_2 is able to stun or kill, it is also [an] irritant, for example, to mucous membranes of the nose and mouth due to the formation of carbonic acid." In fact, in one study, Raj (1994) reports that researchers observed that while 100 percent of tested hens voluntarily entered a feeding chamber filled with 90 percent argon, where they were killed by the gas, fewer than half would even set foot in a chamber containing carbon dioxide. Raj (1996) also found that with a mixture containing high levels of carbon dioxide, turkeys displayed discomfort via head-shaking and gasping. The U.K.'s Department for Environment, Food & Rural Affairs (2001) confirms these findings by reporting that "[o]bservational studies have shown nitrogen and other inert gases to be less aversive to birds than carbon dioxide."

Other studies confirm that birds, as well as humans, can only tolerate carbon dioxide levels up to 30 percent (Gregory and others 1990; Raj 1998a). Therefore, if producers insist on using some carbon dioxide, the concentration must not exceed 30 percent, and it must be used in conjunction with inert gases, such as nitrogen or argon in air. Indeed, according to a European Commission draft document (EIPPCB 2003), this is by no means the optimal concentration as "research during 2001 indicated that the adoption of a gas mixture consisting of 80% by volume nitrogen and 20% by volume argon, is considered to be better than the carbon dioxide-argon mixture from bird welfare and meat quality points of view."

Close Monitoring Needed to Ensure That Birds Are Killed

The residual oxygen levels in an inert-gas-based system must be carefully maintained at less than 2 percent to ensure rapid brain-function loss, as several researchers have found that trapped air between birds or crates can raise the residual oxygen to levels that can prevent proper killing. Also, in order to ensure that recovery of consciousness does not occur, it is crucial that the birds be killed by the gas, not merely stunned, before being shackled. Studies examining the batch stunning of chickens using various gas concentrations found that many birds rapidly regained consciousness, suggesting that mere stunning may be unsuitable on welfare grounds. Raj and Gregory (1990) have recommended that "birds should be killed rather than stunned by the stunning gases" and that this "will not only obviate the recovery of consciousness, but subsequent operations such as uncrating and shackling of the birds and neck cutting would be performed more easily on the dead and hence relaxed carcasses."

III. Advantages of the Controlled-Atmosphere Killing Model for Producers

Improved Carcass and Meat Quality

In addition to the welfare benefits, controlled-atmosphere killing also provides producers with improved quality when compared to different types of electrical stunning methods, which are "frequently criticised on … meat quality grounds" (Raj and others 1997). The European Commission's Scientific Committee on Animal Health and Animal Welfare (1998) agrees, writing that "[a]nother advantage of gas stunning or gas killing methods, in comparison with electrical stunning, is that they may improve carcass and meat quality." These improvements

include fewer broken bones, less hemorrhaging, reduced bruising, reduced internal and external contamination, improved shelf life and quality, and unimpeded bleed-out rates:

***Fewer broken bones, less hemorrhaging, and reduced bruising*:** Researchers at the University of Bristol (Raj and others 1997) compared the carcasses of gas-stunned broilers with those of electrically stunned broilers and concluded that the incidence of broken bones and breast muscle hemorrhaging would be "substantially reduced by gas killing of broilers." Raj and Gregory (1991) also found this to be the case and concluded that "the advantages of gaseous stunning include improved meat quality, fewer broken bones and less muscle haemorrhaging." Another study at the University of Bristol (Raj and others 1990) found that "gaseous stunning of broilers produced relatively better quality carcasses and meat than electrical stunning and therefore may have commercial advantages." Specifically, gassed broilers had a lower incidence of broken bones and breast- and leg-muscle bruising. The authors suggested that the increased incidence of leg-muscle bruising during electrical stunning was a direct result of shackling live birds. Even industry journals recognize this problem; a recent article in *Poultry* (McGuire 2003) reports that "[d]uring processing, shackles can be too tight and the hanging of the bird too rough, which causes more severe bruising in the thigh areas." And the Canadian Food Inspection Agency (1999a) found that "the use of controlled atmosphere stunning in poultry reduces the incidence of broken bones, bruises and haemorrhages in muscle, all of which are commonly associated with electrical stunning."

Farsaie and others (1983) report that bruising may be found on up to 25 percent of broilers processed in the U.S., and according to the USDA (2002), in a recent year, almost a million carcasses were condemned. Controlled-atmosphere killing would significantly reduce both these problems, and the resulting reduction in bruising would have important implications for the producer because it would "improve the yield and the value of products" (EIPPCB 2003) and almost completely eliminate blood stains (Raj 2003).

***Reduced internal and external contamination*:** During electrical stunning, chickens tend to defecate and inhale water during the initial spasm from being electrically shocked. Gregory and Whittington (1992) examined this tendency by including a radioisotope in the stun bath and then looking at carcasses to determine whether internal radioactivity was detected. The results clearly showed that "chickens can and do inhale water during electrical stunning in a waterbath and that no remedy is available at the moment." The authors suggest that the respiratory tract could, thus, be contaminated with bacteria from the stun bath, which could leak onto the edible portions of the carcass during evisceration.

When using electrical stunning, chickens commonly enter the scald tank while they are still alive (see "Scalding" section above). When this happens, external contamination is a concern because of live birds' tendency to defecate in the scald tank. Subsequent birds are then dipped into the contaminated water, which necessitates excessive rinsing with water later down the line.

Furthermore, the dumping of live birds onto the conveyor under the electrical stunning model leads to scratches and wounds because the birds land on each other or otherwise struggle or panic as they try to regain their bearings. Raj (1998b) speculates that these skin wounds not only reduce the value of the carcass, but "can become a potential site for microbial attachment."

The controlled-atmosphere killing model would almost completely eliminate all three forms of potential contamination because birds would be killed in their transport containers rather than being dumped and would, therefore, be unable to inhale in the stun bath or defecate in the scald

tank. This has significant implications for producers since, according to the USDA (2002), in a recent year, almost 5.5 million chickens were condemned for being contaminated.

***Improved shelf life and quality*:** Raj (1998b) explains that using inert gases induces anoxia on the cellular level in carcass muscles, which can "change the oxidation/reduction (radox) potentials" and, thus, lead to "increased shelf-life of meat due to a slow rate of development of off-odours … and discoloration …" The Canadian Food Inspection Agency (1999a) states that controlled-atmosphere killing "is also reported to produce more tender breast meat than when electrical stunning is used." Taken together, these statements mean that controlled-atmosphere killing produces better-quality meat that lasts longer, in terms of smell and color, than electrically stunned birds.

***Unimpeded bleed-out rate*:** Raj and others (1997) looked into the concern that the bleed-out rate of controlled-atmosphere-stunned birds is not as good as that of electrically stunned birds and found that after one minute, the differences were "not sufficient to impede the bleeding efficiency of broilers." A European Commission draft document (EIPPCB 1998) also reports that gas killing "does not impede blood loss, therefore, residual blood in the carcase meat is low."

Increased Revenue

In addition to the carcass- and meat-quality improvements mentioned above, there are additional financial benefits that can be achieved through controlled-atmosphere killing, which result from such factors as increased meat yield; reduced refrigeration, energy, and labor costs; improved worker conditions and safety; and environmental benefits:

***Increased meat yield*:** The controlled-atmosphere killing model results in increased meat yield by reducing the number of broken bones and the amount of hemorrhaging and bruising. Even a small increase in meat yield per bird can lead to a significant increase in revenue. For example, with as little as a 1 percent increase in yield, Raj (1998) estimates that, for a plant that processes 1.3 million broilers per week—estimating the average dressed-carcass weight at 2 kg and the market value at $2.2 per kg of boneless breast meat—an additional $950,400 in revenue (or 1.402 cents per bird) can be gained per year.

Reducing the number of birds who are dead on arrival, which can be achieved by eliminating dumping and other areas of rough handling that are inherent in the electrical stunning process, will provide yet another source of increased revenue. It is also important to note that the significant rearing costs associated with each bird (i.e., feeding, housing, lighting, transport, etc.) are completely lost when a carcass is condemned or discarded. By increasing meat yield, producers who use controlled-atmosphere killing would be able to recoup these otherwise-wasted costs, providing yet another financial advantage.

***Reduced refrigeration and energy costs*:** Raj and others (1997) found that controlled-atmosphere killing causes a more rapid pH fall in the carcasses than electrical stunning, resulting in faster carcass-maturation times and enabling early filleting. This has important financial implications, as refrigeration can be significantly reduced, thus, saving on storage, energy, and refrigeration equipment and maintenance costs. The EIPPCB (2003) also reports that controlled-atmosphere killing results in "[r]educed energy consumption due to reduced refrigeration time and space requirements because it is no longer necessary to mature the carcases."

***Reduced labor costs*:** A reduction in bruising and broken bones lowers labor costs by reducing the need for carcass and fillet examination. This is significant, considering that Raj (1998b)

estimates that a typical U.S. slaughterhouse that processes 1.3 million broilers per week incurs more than $248,000 (figure adjusted for inflation from 1995 to 2002) per year in labor costs "associated with carcass handling." Also, the less problematic shackling of dead birds—as opposed to live, struggling ones—allows for more efficient labor and could reduce the number of shacklers needed to achieve the same rate.

***Improved worker conditions and safety*:** The Canadian Food Inspection Agency (CFIA 1999) concluded that "[t]he environment for the [personnel] working in the poultry stunning area is also very much improved with the use of controlled atmosphere stunning. Dust is reduced since unconscious birds are placed on the evisceration line." U.S. poultry slaughterhouse workers attest to the physical dangers of shackling live birds or trying to cut the throats of improperly shackled birds under the electrical stunning model. The use of controlled-atmosphere killing would mean that only dead birds would be shackled, which would completely alleviate these dangers and the frustrations associated with them—improving the physical work environment and reducing injury-related costs and lost time.

***Environmental benefits*:** Improved quality and yield from controlled-atmosphere killing leads to a "reduced by-product destined for disposal as waste," and "the increase in yield, in turn, leads to a tendency to store more of the slaughterhouse output in conditions which won't cause spillage or odour problems" (EIPPCB 2003). Also, reduced contamination means that less water is needed to rinse off carcasses—the electrical stunning model typically uses about 15 liters of water per bird (Raj 2003)—thus, there is less run-off and reduced water-treatment needs.

IV. Costs of the Controlled-Atmosphere Killing Model

The initial cost of switching from electrical stunning to controlled-atmosphere killing can be offset and surpassed by gains achieved from improving consumer perception through welfare improvements, improving carcass quality and meat yield, and lowering costs by reducing the need for refrigeration, storage, labor, and environmental cleanup. Raj (1998b) explains that there are also intangible benefits, that "[i]t will be unrealistic to put a price tag on improved bird welfare, opportunity to develop new process technology and the market lead," and that the additional revenue through increased meat yield (see "Increased meat yield," above) "should be considered in calculating the payback period."

Start-Up Costs

A European Commission draft document on the "Best Available Techniques in the Slaughterhouses and Animal By-products Industries" (EIPPCB 2003) estimates that the total cost for the complete installation of one controlled-atmosphere killing processing line using inert gases is around $1.3 million (all monetary figures in this paragraph have been converted to U.S. dollars using the exchange rates as of May 30, 2003, and have been adjusted for inflation from 1995 to 2002 using the *Columbia Journalism Review*'s "Dollar Conversion Calculator" Web site). Using figures from Anglia Autoflow Ltd. (www.aaflow.org), one of the leading European manufacturers of controlled-atmosphere killing systems designed to kill birds in transport crates prior to shackling, Raj (1998) broke down the total and estimated that in order to maintain a line speed of 70,000 birds per day, approximately 240 modules, holding 288 birds each, would be needed, at an approximate cost of $2,322 per unit or $557,280 for 240. The controlled-atmosphere killing equipment itself would cost approximately $387,095, and the loading machinery would cost another $387,095. It is important to note, however, that with the rapid improvements in equipment technology within this sector, it is expected that these costs would be even lower today (Raj 1998).

According to Anglia Autoflow's sister company, American Autoflow, Inc., which serves North and South America, the "average price for an in-plant Easyload system fitted with gas stunning; washer; automatic drawer loading and unloading is approximately 1.5 million USD" (Burgos 2003). Ian Taylor, sales director of American Autoflow (Taylor 2003), also explains that if the source of the live birds is in close proximity to the slaughterhouse, which is often the case, or if the producers already have a "drawer system" in place, as is reportedly the case with some major U.S.-based companies such as Perdue Farms, Inc., then loading modules can be double-shifted at no additional cost, allowing the system to process approximately 128,000 birds per day (two eight-hour shifts running at 8,000 birds per hour). However, if additional modules are required to double-shift the line, Taylor estimates that the added cost would be only about $350,000 more than the initial $1.5 million investment. Thus, according to this estimate, which was provided in September 2003, between $1.5 million and $1.85 million would be required to install a controlled-atmosphere killing line capable of processing more than 46.7 million birds per year (with two shifts running daily).

Operating Costs

According to the EIPPCB (2003), the estimated operating costs of using approximately 17 liters of gas mixture per bird—with an 80 percent nitrogen, 20 percent argon mixture—are between 58 and 97 cents per 100 birds (0.58 and 0.97 cents per bird). And in a recent article in *WATT Poultry USA*, Ian Taylor from American Autoflow estimates the gas cost of stunning to be between 0.5 and 0.75 cents per bird. For a line that processes 128,000 birds per day, these figures translate to between $640 and $1,241 per day. Once the benefits of using controlled-atmosphere killing and the current operating costs of using electrical stunning are subtracted, the costs of controlled-atmosphere killing are relatively insignificant. Raj (1998b) puts it into perspective when he describes the cost of controlled-atmosphere killing as "reasonable and affordable to improving welfare of billions of poultry slaughtered for human consumption."

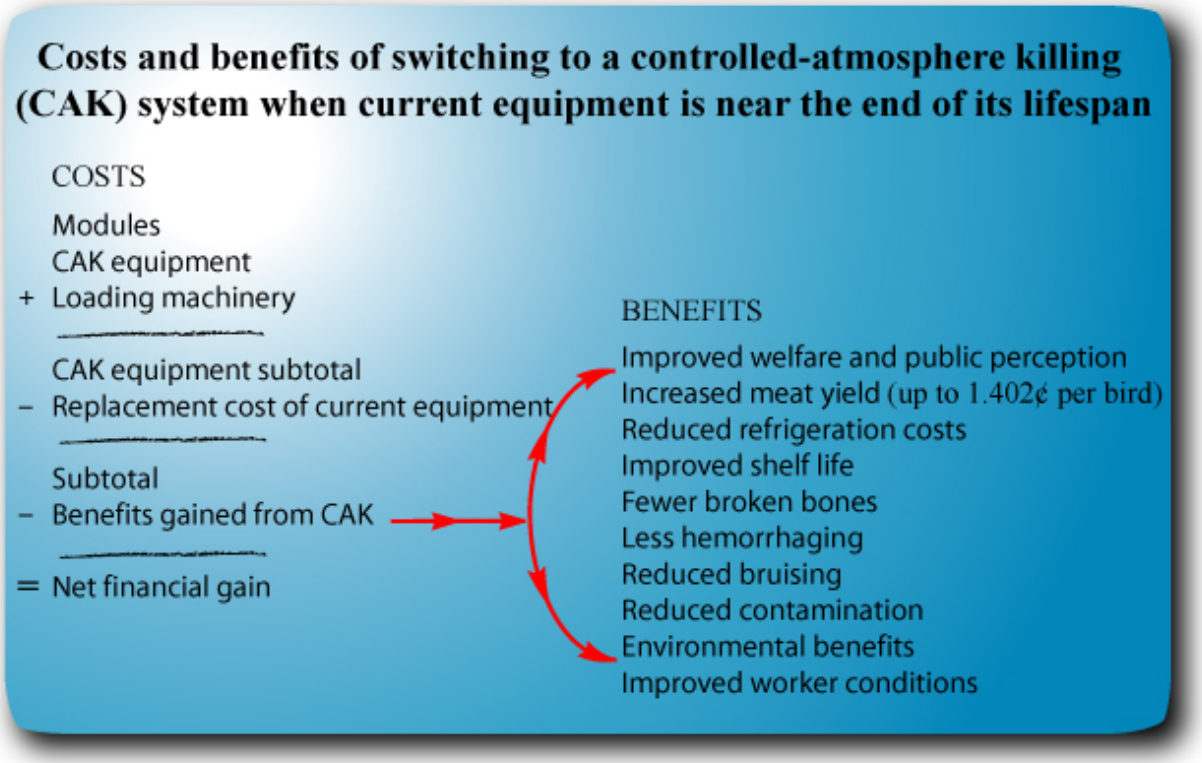
Payback Period

Considering the increased revenue created by improving meat quality and lowering operating costs, the initial costs of switching to a controlled-atmosphere killing system can be recouped quickly. Costs will be offset in an even shorter time period for plants that are using electrical stunning equipment that must be replaced anyway. Based on the estimates above, a plant that installs a controlled-atmosphere killing line at a cost of either $1.5 million (without extra modules) or $1.85 million (with extra modules), with a capacity to slaughter 128,000 birds per day (46,720,000 annually), would have yearly operating costs of as little as $233,600 and a yearly increase in revenue of $655,014 (46,720,000 x 1.402 cents) from increased meat yield. The added revenue from increased meat yield alone would pay for the controlled-atmosphere killing line in about 3.5 years if extra modules were not needed and in about 4.5 years if extra modules were required.

Once payback has been achieved, increased revenue can be expected at a rate of $9,020 per million birds ($14,020 in increased meat yield revenue minus $5,000 for the cost of gas). For a line capable of processing 128,000 birds per day, once the initial costs of the controlled-atmosphere killing system are recovered, this translates to an additional $421,414 in profit annually from improvements in meat yield alone when compared to an electrical stunning system, and these gains would continue for the life of the equipment. It is also important to note that when elements of the equipment have to be replaced, the subsequent costs will be significantly less than the initial purchase since certain components (e.g., modules) can have greater longevity than others.

Again, it must be emphasized that these payback periods have been estimated using increased meat yield alone, and when all the other benefits are factored in, producers using controlled-atmosphere killing systems will begin to realize significant economic savings over electrical stunning systems well before the 3.5- to 4.5-year mark. In fact, Raj (2003) estimates that, taking all the sources of increased revenue discussed above into account, the initial costs of implementing a controlled-atmosphere killing system could be recouped within a year.

The following figure summarizes the costs and benefits of switching to a controlled-atmosphere killing system using inert gases in which birds are killed in transport containers prior to being shackled:



V. Conclusion

It is clear that electrical stunning methods used in the U.S. do not lead to humane deaths for chickens. During this process, chickens endure the stress and pain of being dumped onto a crowded conveyer, where they sometimes suffocate; being hung upside-down by their legs in shackles and sometimes being ripped from the shackles when they are improperly hung; and experiencing painful pre-stun shocks from the stun bath.

Most birds are immobilized from the stun bath but fully conscious when they have their necks cut, and many are scalded alive. Controlled-atmosphere killing methods using mixtures of inert gases, preferably 80 percent nitrogen and 20 percent argon, help significantly alleviate these welfare problems and, at the same time, improve carcass quality and revenue for the producer. The initial costs for a complete controlled-atmosphere killing line can be recovered quickly—within 3.5 to 4.5 years based on improvements in meat yield alone and much faster as other benefits are realized. After payback, producers will experience even greater savings and will continue to profit at an accelerated rate as a result of the switch.

Several systems that use controlled atmospheres to kill birds with inert gases in transport containers prior to shackling are currently available for commercial use, and a number of large-scale systems have already been implemented in Europe, and even North America, with great success. The U.K.'s Animal Welfare Minister Elliot Morley put it best when he explained that adopting a controlled-atmosphere killing model for poultry has "the double advantage of offering the industry an opportunity to boost welfare standards and cut costs at the same time" (DEFRA 2001). Considering the many problems inherent in electrical stunning methods and the resulting animal suffering—especially in the U.S., where settings are kept disturbingly low—there is no reason for producers to delay researching and implementing a controlled-atmosphere killing system if industry claims that animal welfare is a priority are to be taken seriously.

This report was completed on October 8, 2003. Please direct any questions or comments to Noam Mohr at 757-943-0141, or e-mail NoamM@peta.org.

References

Austin W. 1994 Feb 1. [Letter from Simmons Engineering Company to Clare Druce]. In: Davis K. 1996. Prisoned Chickens, Poisoned Eggs: An Inside Look at the Modern Poultry Industry. Summertown Book Publishing Company.

Boyd F. 1994. Humane slaughter of poultry: The case against the use of electrical stunning devices. Journal of Agricultural and Environmental Ethics 7:221-36.

Burgos D. 2003. [Letter on behalf of American Autoflow, Inc., giving estimates for gas killing equipment for poultry in North America]. Located at: People for the Ethical Treatment of Animals, Norfolk, Va.

[CFIA] Canadian Food Inspection Agency. 1999a. Canadian Food Inspection Agency Liaison, Preparedness and Policy Coordination: Regulatory impact analysis statement. Located at: www.inspection.gc.ca/english/reg/appro/1999/97014riae.shtml.

[CFIA] Canadian Food Inspection Agency. 1999b. Canadian Food Inspection Agency Liaison, Preparedness and Policy Coordination: Regulations amending the meat inspection regulations, 1990. Located at: www.inspection.gc.ca/english/reg/appro/1999/97014e.shtml.

[CIWF] Compassion in World Farming. 2000. Animal welfare problems in UK slaughterhouses.

[DEFRA] Department for Environment, Food & Rural Affairs (UK). 2001 Dec 6. DEFRA action on inert gases boosts poultry welfare. [News release]. Located at: defraweb/news/2001/011206a.htm.

Duncan IJH. 1997. Killing methods for poultry: A report on the use of gas in the U.K. to render birds unconscious prior to slaughter. Campbell Centre for the Study of Animal Welfare.

[EIPPCB] European Integrated Pollution Prevention and Control Bureau (EC). 2003 Jan. Draft reference document on best available techniques in the slaughterhouses and animal by-products industries. Available from: EIPPCB; RHC/EIPPCB/SA_Draft_2.

Farsaie A, Carr LE, Wabeck CJ. 1983. Mechanical harvest of broilers. Trans ASAE 26:1650-3.

[FSIS] Food Safety and Inspection Service (US). 2001 Jun. Poultry postmortem inspection. Available from: www.fsis.usda.gov/OFO/hrds/SLAUGH/DepPoul/Postmortem_01.pdf; Module 4–703C/X, 904C/X.

Gentle MJ, Tilson VL. 1999. Nociceptors in the legs of poultry: Implications for potential pain in pre-slaughter shackling. Animal Welfare 9:227-36.

Gerlis LM. 1986. An up-to-date assessment of the Jewish method of slaughter. In: UFAW. Proceedings of the Humane Slaughter of Animals for Food Symposium; 1986; Potters Bar, Hertfordshire, England.

Gregory NG. 1986. The physiology of electrical stunning and slaughter. In: UFAW. Proceedings of the Humane Slaughter of Animals for Food Symposium; 1986; Potters Bar, Hertfordshire, England.

Gregory NG. 1991. Humane slaughter. Outlook on Agriculture 20:95-101.

Gregory NG, Raj ABM, Audsley ARS, Daly CC. 1990. Effects of carbon dioxide on man. Fleischwirtschaft 70:1173-4.

Gregory NG, Whittington PE. 1992. Inhalation of water during electrical stunning in chickens. Research in Veterinary Science 53:362.

Gregory NG, Wilkins LJ. 1989. Duration of wing flapping in chickens shackled before slaughter. Veterinary Record 121:567-9.

Gregory NG, Wilkins LJ. 1990. Broken bones in chickens: Effects of stunning and processing in broilers. British Poultry Science 31:53-8.

Gregory NG, Wotton SB. 1987. Effect of electrical stunning on the electroencephalogram in chickens. British Veterinary Journal 143:175-83.

Gregory NG, Wotton SB. 1987. Poultry stunning and slaughter. In: European Conference Group on the Protection of Animals. Pre-slaughter Stunning of Food Animals; 1987; Horsham, Sussex, England.

Griffiths GL, McGrath M, Softly A, Jones C. 1985. Blood content of broiler chicken carcases prepared by different slaughter methods. Veterinary Record 117:382-5.

Griffiths GL, Purcell DA. 1984. A survey of slaughter procedures used in chicken processing plants. Australian Veterinary Journal 61:399-401.

Griffiths GL, Purcell DA. 1985. The occurrence of red-skin chicken carcasses. British Veterinary Journal 141:312-4.

Heath GBS. 1984. The slaughter of broiler chickens. World's Poultry Science Journal 40:151-9.

Heath GBS, Watt DJ, Waite PR, Meakins PA. 1983. British Veterinary Journal 139:285.

Heath GBS, Watt DJ, Waite PR, Ormond JM. 1981. Observations on poultry slaughter. Veterinary Record 108:98.

Katme AM. 1986. An up-to-date assessment of the Moslem method of slaughter. In: UFAW. Proceedings of the Humane Slaughter of Animals for Food Symposium; 1986; Potters Bar, Hertfordshire, England.

McGuire, AR. 2003 Feb/Mar. Improving carcass quality. Poultry.

McSpotlight. 1997. McSpotlight [Transcript of trial verdict on CD-ROM]. Available from: www.mcspotlight.org.

O'Keefe T. 2003 Jun. Stunning developments. WATT PoultryUSA: 42-55.

Raj ABM. 1994. An investigation into the batch killing of turkeys in their transport containers using gases. Research in Veterinary Science 56:325-31.

Raj ABM. 1996. Aversive reactions of turkeys to argon, carbon dioxide and a mixture of carbon dioxide and argon. Veterinary Record 138:592-3.

Raj ABM. 1998a. Welfare during stunning and slaughter of poultry. Poultry Science 77:1815-9.

Raj ABM. 1998b. Untitled. Proceedings from inert gas: A workshop to discuss the advantages of using inert gas for stunning and killing of poultry. 1998 Mar 30; University of Guelph, Guelph, Canada.

Raj ABM. 2003 May 13. [Summary of telephone conversation]. Located at: People for the Ethical Treatment of Animals, Norfolk, Va.

Raj ABM, Gregory NG. 1990. Investigations into the batch stunning/killing of chickens using carbon dioxide or argon-induced hypoxia. Research in Veterinary Science 49:366.

Raj ABM, Gregory NG. 1991. Efficiency of bleeding of broilers after gaseous or electrical stunning. Veterinary Record, 128:127.

Raj ABM, Grey TC, Gregory NG. 1990. Effect of electrical and gaseous stunning on the carcass and meat quality of broilers. British Poultry Science 31:725.

Raj ABM, Wilkins LJ, Richardson RI, Johnson SP, Wotton SB. 1997. Carcass and meat quality in broilers either killed with a gas mixture or stunned with an electric current under commercial processing conditions. British Poultry Science 38:169-74.

Richards S, Sykes AH. 1967. Research in Veterinary Science 8:361.

Scientific Committee on Animal Health and Animal Welfare (EC). 1998 Jun 23. The use of mixtures of the gases CO2, O2, and N2 for stunning of killing poultry. Located at: europa.eu.int/comm./food/fs/sc/scah/out08_en.html. PJ.

Sparrey JM, Kettlewell PJ. 1994. Shackling of poultry: Is it a welfare problem? World's Poultry Science Journal 50: 167-76.

Taylor I. 2003. [Summary of phone conversation]. Located at: People for the Ethical Treatment of Animals, Norfolk, Va.

[USDA] United States Department of Agriculture. 2002 Apr. Poultry Slaughter 2001 Annual Summary. Available from: NASS; Pou 2-1(02).

[USDA] United States Department of Agriculture. 2003 Mar. Poultry Slaughter 2002 Annual Summary. Available from: NASS; Pou 2-1(03).

Wolfson DJ. 1999. McLibel. Animal Law 5(1):44.