Improving the welfare of Nile tilapia – slaughter

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Compassion in World Farming recommendations

All animals killed for food should be slaughtered humanely. This means that they must be effectively stunned, rendered instantaneously insensible, and remain unconsciousness until death supervenes.

For Oreochromis niloticus and other tilapia species:

- The use of a single method (i.e. electrocution) that both stuns and kills is recommended above other methods when it is commercially available.
- Electrical stunning followed by use of ice slurry, decapitation, gill cutting or spiking/coring is acceptable provided that the stun is effective and lasts until death supervenes (i.e.: the fish do not regain consciousness).
- Leaving tilapia to asphyxiate and the use of ice slurry, exsanguination or decapitation without previous effective stunning are unacceptable killing methods and must be phased out. Similarly, wet markets where tilapias are sold alive are not acceptable since transport and holding conditions raise welfare risks and humane slaughter cannot be guaranteed.

Introduction

Fish are sentient beings capable of feeling pain and suffering (Chandroo *et al*., 2004). As such, they are entitled under European animal welfare law (European Council Regulation No 1099/2009) to a humane slaughter that minimises suffering and renders them unconscious as quickly as possible, a state that must extend until death. The guidelines of the World Organisation for Animal Health (WOAH, founded as OIE) on the stunning and killing of farmed fish (World Organisation for Animal Health (WOAH), 2022) provide information on humane methods of slaughter outside the European Union (EU); however, many producers are using slaughter methods considered inhumane by the WOAH. Subsequently, food companies are increasingly incorporating fish welfare into their corporate social responsibility policies and practices. This document provides information on the humane slaughter of Nile tilapia (*Oreochromis niloticus*) and other species of tilapia, including:

- An overview of the welfare issues associated with pre-slaughter procedures: fasting, harvesting methods, crowding and moving fish.
- An overview of the main methods of slaughter in use commercially.
- Recommendations for corporate animal welfare policies and practices.
- Methods to assess welfare at slaughter.

Information given in this document is described for Nile tilapia (*Oreochromis niloticus*) but we consider that it can also be applicable to other tilapia species (Table 1) as they are often farmed and slaughtered using the same methods, and their biology is similar. More research is needed to provide more species-specific information.

Table 1: Species of tilapia reared worldwide with their known common names in English, Spanish and Portuguese.

Common name (English)	Common name (Spanish)	Common name (Portuguese)	Scientific name if available
Nile tilapia; Mango fish; Nilotica; Boulti	Mojarra; Tilapia; Tilapia del Nilo	Tilapia-do-nilo; Tilápia	*Oreochromis niloticus*
Hybrid tilapia; Blue-Nile tilapia, hybrid	-	-	*Oreochromis niloticus x Oreochromis aureus, Hybrid*
Mozambique tilapia; Black tilapia; Blue kurper	Tilapia de Mozambique; Tilapia mosambica	-	*Oreochromis mossambicus*
Tilapia shiranus; Shire tilapia	-	-	*Oreochromis shiranus*
Three-spotted tilapia; Threespot tilapia; Threespot bream	-	-	*Oreochromis andersonii*
Longfin tilapia; Greenhead tilapia; Greenhead bream; Mango fish	-	-	*Orechromis macrochir*
Redbreast tilapia; Blue tilapia; Redbreast bream	Mojarra Mojarra; Mojarrita; Tilapia	Tilápia; Tilápia-rendali; Acará tilápia	*Coptodon rendalli*
Blue tilapia; Israeli tilapia; Golden tilapia; Jordan St. Peter´s fish; Tilapia	Tilapia azul	-	*Oreochromis aureus*
Blackchin tilapia; Silvery tilapia	-	-	*Sarotherodon melanotheron*
Mango tilapia; St. Peter´s fish	-	-	*Sarotherodon galilaeus*
Redbelly tilapia; Zille´s redbreast tilapia; Zill´s tilapia; St Peter´s fish	Mojarra; Mojarrita; Tilapia	-	*Coptodon zillii*

Pre-slaughter procedures

In order for the slaughter process to be carried out properly, it is important that the animal is totally unconscious, which relies on an adequate stunning method. Inducing insensibility instantaneously, preventing recovery from stunning and monitoring effectiveness by observation or neurophysiological measurements are the basis for a good stunning procedure (Robb & Kestin, 2002).

Other pre-slaughter procedures like fasting, harvesting, procedures, crowding and fish transportation - that can last up to several hours - can cause important stress to fish. Critical welfare hazards during pre-slaughter procedures have already been identified for Nile tilapia in Brazil, including extremely low dissolved oxygen in water, fin and skin lesions and prolonged air exposure (Pedrazzani et al., 2020). It is important to note that the humane slaughter of fish can only be fully achieved by minimising the stress and injuries from the moment the fish are removed from the rearing enclosure, until the moment the fish are killed. Table 2, extracted from (Pedrazzani et al., 2020), summarises the health, environmental and behavioural indicators that should be considered during pre-slaughter procedures for Nile tilapia.

Welfare indicators at pre-slaughter

Health	Eyes, jaws, operculum Skin, fins, gills Blood glucose Scales in water Consciousness
Environmental	Temperature, pH Stocking density Shading Air exposure Light exposure
Behavioural	Respiratory frequency Swimming Response to light Response to air exposure Loss of consciousness

Fasting

Fasting fish before slaughter is a very common practice in aquaculture to reduce the metabolic rate - lowering the oxygen demand - and the physical activity of the fish before handling and live transport. Fasting fish also helps to empty the digestive system prior to slaughter, which reduces water fouling caused by undigested feed, faeces, and microorganisms during transport, and aids hygienic processing. However, although a short period of food deprivation may not have a significant impact on fish homeostasis, a consideration of fishes' motivation to eat is also essential for their welfare. Therefore, tilapia should never be fasted for longer than necessary on welfare grounds, and especially not for presumed flesh quality benefits. The duration of food restriction caused by fasting should be based on the species-specific feeding habits (Smith, 2000). For Nile tilapia, the average time for gastric emptying is dependent upon dietary composition but can take up to 13.5 hours (Lanna et al., 2004). However, Costa (2019) suggests that adequate fasting periods should be below 24 h to achieve a humane pre-slaughter process.

In a survey conducted in Brazil, about 47% of the interviewed facilities declared a fasting period for Nile tilapia that varied from 10 to 48 hours, with a median of 24 hours. This is much longer than the 13.5 hours period mentioned by Lanna et al. (2004) and clearly unnecessary (Coelho et al., 2022). Prolonged fasting can cause welfare issues including stress and weight loss (Hoseini et al., 2019; Jørgensen et al., 2002). Whilst wild fish may not feed for long periods, farmed fish are used to receiving feed at regular and short intervals, and prolonged periods without food are likely to negatively impact their welfare. Therefore, the reported pre-slaughter fasting periods commonly used for Nile tilapia in Brazilian farms can negatively affect the welfare of this species in a far more complex way than just limiting feed intake and, consequently, is a major welfare risk that should be mitigated.

Harvesting methods

Tilapia farming is dominated by small-scale rural farms and is typically marketed in rural areas and local markets in developing countries, either fresh or iced, with little handling and processing (El-Sayed, 2020). There is no specific harvesting method for farmed tilapia and the information available on harvesting methods is very limited (El-Sayed, 2020). Tilapia are commonly reared together with other aquatic species in a polyculture, which makes it even more difficult to adopt specific harvesting techniques for Nile tilapia (El-Sayed, 2020). However, the global tilapia market is growing rapidly, not only in producing countries, but also in many non-producing regions, such as the USA, Europe and Australia (El-Sayed, 2020).

According to the FAO, complete harvests of Nile tilapia are necessary in ponds because remaining fish can predate on the fry of the subsequent spawning period, increasing the stress experienced by the newly introduced fish. Harvests in ponds are usually accomplished by seining followed by slaughter, in combination with draining which creates the conditions for crowding with consequences like injuries, stress or even asphyxiation (FAO, 2009). The harvesting process has a variable duration depending on the size of the enclosure and the technical skills of the farmers. A complete harvest is not possible by seining alone because Nile tilapia are adept at escaping seine nets (FAO, 2009). Furthermore, when tilapias are raised in ponds, it is recommended to dry the pond between production cycles, meaning any hiding fish would asphyxiate, or treat with pesticides to kill remaining fish, thus avoiding carryover to the next production cycle (FAO, 2009). Both methods are cruel and unacceptable practices that should be prevented to avoid unnecessary suffering and killing of fish.

As part of the harvest procedure, the pond should be carefully inspected and any fish left stranded during draining should be swiftly transferred to water or humanely killed. Partial harvests in other farming systems like tanks, raceways and recirculation systems are carried out to maximise production, and are accomplished with grader bars to capture the largest fish (FAO, 2009), which is another source of stress, especially if it is done repeatedly.

However, harvesting methods depend on pond size, culture systems and levels of technology applied (El-Sayed, 2020). For instance, in many parts of Africa and Asia, small-scale tilapia farmers do not have easy access to harvesting nets and other equipment necessary for complete harvesting of their ponds (El-Sayed, 2020). Thus, many farmers adopt partial harvesting techniques, using locally available gear (Brummett, 2002). On the other hand, large-scale tilapia producers adopt more advanced harvesting tools, such as winches, because they generally prefer batch harvesting (El-Sayed, 2020). Taking this into account, it is relevant to consider that poor handling and holding conditions, inadequate processing and the use of inappropriate processing methods can seriously affect the welfare and the quality of Nile tilapia and increase post-harvest losses (El-Sayed, 2020).

Furthermore, according to FAO (2009), Nile tilapia must be tested for flavour before they are accepted for processing and marketing in receiving countries to avoid the off-flavour caused by the presence of geosmin and 2-methulisoborneol. They are organic compounds produced by actinomycetes and cyanobacteria in water and soil that enter the tilapia body, mostly through the gills (Gutierrez et al., 2013). If the off-flavour is detected, the fish are purged of these compounds in clean water for 3-7 days in holding tanks or ponds, during which fish are generally not fed to combine the pre-slaughter fasting period with the purging. Feeding is recommended during this purging period, not only for welfare reasons, but also because it has been shown that feeding strongly reduces the off-flavour depuration time (Schram et al., 2021). This procedure is generally not practised for the tilapia consumed within the producing countries where the use of spicy seasonings in the cooking conceals any off-flavour.

Nile tilapia left to asphixiate

Crowding

Harvesting techniques commonly involve crowding conditions for fishes, like the conditions created by the combination of seining and draining. Although Nile tilapia are known to tolerate a high stocking density and can withstand extreme crowding conditions (El-Sayed, 2020), these conditions also stress these fish. This pre-slaughter procedure implies that fish are submitted to high stocking densities that can last for long periods of crowding and even exposure to air. In fact, it has already been demonstrated that Nile tilapia express physiological stress responses even when under crowding conditions, for example, of a duration of 48 hours (Jun et al., 2015). It is also possible that Nile tilapia feel fear under these conditions due to a perceived risk of predation.

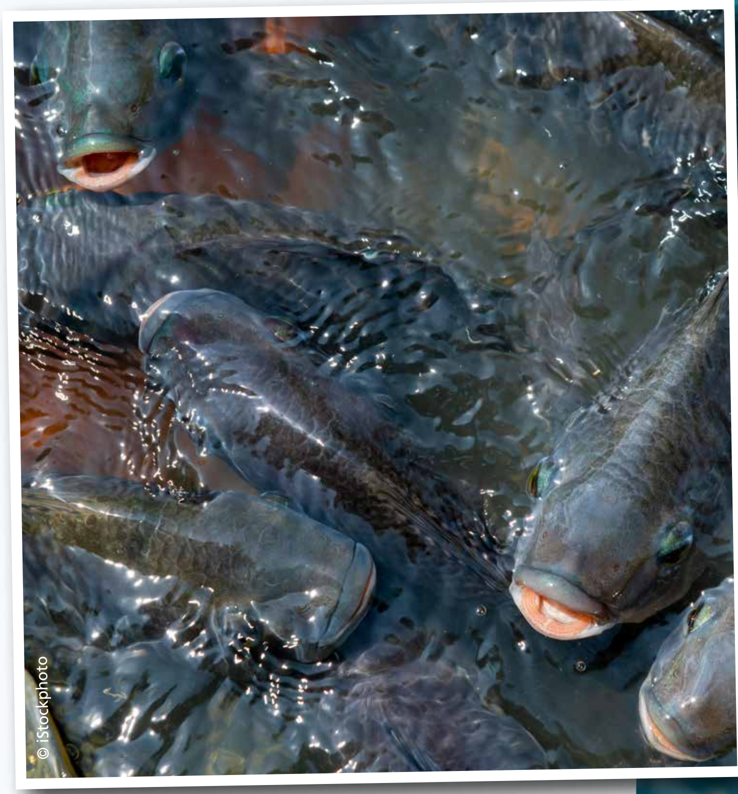
Moreover, welfare may be further impacted by poor water exchange - especially in pond systems, where there can be low oxygen levels, and fish waste accumulation generating accumulated toxic ammonia in the water during harvesting. Tilapia caught and slaughtered the last will experience an even more stressful situation, as they face repeated attempts at catching and more prolonged periods of crowding. Therefore, severity and duration of crowding should be reduced as much as possible, and crowding should never occur for longer than 2 hours.

Moving fish

Transporting fish causes stress, so moving fish should be avoided as much as possible. Ideally, Nile tilapia should be slaughtered on site or as close to the rearing area as possible so that they can be moved directly from the enclosure to the slaughtering facility. Unfortunately, this is currently not the standard practice for Nile tilapia. Considering transportation management, Nile tilapia are usually hauled live to processing plants for slaughtering (FAO, 2009), which is an important source of stress and causes serious welfare issues (Lines & Spence, 2014). The stress response elicited by transportation can even result in diseases leading to fish mortality. In fact, mass mortality of Nile tilapia originating from a parasitic and bacterial co-infection with *Enterogyrus spp*. and *Aeromonas jandaei* following transport stress was already reported (Assane et al., 2022). The first fish deaths occurred on day 1 post-transport, while cumulative mortality reached up to 90% by day 10 post-stocking (Assane et al., 2022).

Nile tilapia transported for 6 to 8 hours in plastic bags expressed high cortisol level concentrations (Félix et al., 2021; Hohlenwerger et al., 2016; Teixeira et al., 2018) and elevated ventilatory rate (Teixeira et al., 2018), both indicators of stress for the Nile tilapia. Although stress responses can be reduced by using different anaesthetics during transportation (Félix et al., 2021; Navarro et al., 2016), their use is not allowed in fish that might enter the food chain in some countries (European Food Safety Authority, 2004).

Moreover, alternative methods have also proved to be helpful to reduce the stress experienced by the transported tilapia. A conditioning period of 24h before packing (i.e., fasting in combination with continuous aeration and water exchange), salt-treated water, and blue background colour improved the survival of Nile Tilapia fingerlings during transport (Manliclic et al., 2018). Although the use of several essential oils (*Aloysia triphylla and Lippia alba*) has indicated a certain improvement of fish conditions during transport, they were not able to reduce the increase in cortisol levels of Nile tilapia (Hohlenwerger et al., 2016; Teixeira et al., 2018).



Crowded Nile tilapia

Humane slaughter methods for nile tilapia

Currently, the vast majority of Nile tilapia are killed inhumanely, without a proper or effective stunning procedure. Stunning is defined as "any intentionally induced process which causes loss of consciousness and sensibility without pain, including any process resulting in instantaneous death" (*Council Regulation (EC) No 1099/2009 of 24 September 2009 on the Protection of Animals at the Time of Killing (Text with EEA Relevance)*, 2009). A recent review showed that, despite all Brazilian interviewed slaughterhouses and fish farms reported pre-slaughter stunning of Nile tilapia, live chilling was mentioned to be the most used method being used in 82% of the facilities interviewed. However, live chilling cannot be considered as a stunning procedure as it does not cause immediate loss of consciousness (Coelho et al., 2022).

Furthermore, after not being properly stunned in most cases and thus potentially conscious, Nile tilapia is reported to be slaughtered by exsanguination (bleeding) and decapitation in around 40% of the Brazilian facilities (see Text box 1; Coelho et al. (2022)). Moreover, as other interviewed slaughterhouses and farms did not report a slaughter method, it is probable that in about 60% of those facilities, Nile tilapia are left to asphyxiate in air or die by further processing (see Text box 2; Coelho et al. (2022)). These methods are aversive and cause an immense suffering for extended periods (minutes to hours) before consciousness is lost. An alternative method, the use of electrical stunning before decapitation or gill cutting, can provide a humane death when performed correctly for Nile tilapia.

Electrical stunning

When performed correctly, electrical stunning can cause instant insensibility (B. Lambooij et al., 2008; Van De Vis et al., 2003). However, consciousness will usually be recovered after a period of time, and so in order for it to meet the requirements of humane slaughter, electrical stunning must be followed by another method to kill. Electrical stunning methods and their effects are studied (Farm Animal Welfare Committee, 2014; E. Lambooij et al., 2008; Robb & Kestin, 2002) and applied in some farms for Nile tilapia (Eurofish Magazine, 2011). Automated electrical stunning machines for fish, and specifically for Nile tilapia, are already available for commercial use and in operation (Ace Aquatec, n.d.). The most effective method achieves stunning after 5 seconds of electrical current (50Hz AC, 1 A_{rms}/dm^2) using an in-water method, which had an over 88% chance of an effective stun (based on observations in 24 individuals) in research settings, followed by chilling for 15 minutes in ice slurry, which showed neither behavioural nor brain response to painful stimuli for that duration (based on Farm Animal Welfare Committee (2014) and B. Lambooij et al (2008)). However, Nile tilapia can take longer than 20 min to die in ice-slurry (Gonzalez, 2021). Therefore, further research is needed to confirm that unconsciousness is continuous during the whole slaughtering process, and electroencephalograms are needed to ensure that the lack of behavioural movements are due to unconsciousness and not only to paralysis induced by hypothermia.

- The specific electrical parameters used are critical in ensuring that electrical stunning is effective. When the electrical current or voltage is too low, or the application duration too short, there may be ineffective stunning. This can be painful and cause injuries to conscious fish (Van De Vis et al., 2003). Alternatively, it can mean fish regain consciousness during some stage of the killing or processing procedures, during which they may experience significant pain and suffering. When the electrical current or voltage is too high, it can result in carcass damage such as haemorrhages, blood spotting, and spinal fractures (Kestin et al., 2002; Lines et al., 2003).
- Ineffective electrical stunning can go unnoticed as it can lead to physical immobilisation only, whereby the body is motionless and unresponsive in reflex tests but the fish remains conscious (as shown by brain activity measures) and sensible to pain (Zampacavallo et al., 2015). To prevent this, it is important that the parameters used in electrical stunning systems are based on recommendations from research that has validated parameters using measurements of brain activity (via electroencephalograph (EEG) measurements) and not just based on behavioural signs.

Dry stunning is thought to reduce the amount of carcass damage and injuries sustained by the fish (van de Vis et al., 2014) when compared to in-water stunning. However, in-water stunning is preferable in terms of fish welfare as fish need not be restrained, handled, or removed from the water (all being stressors) before they are stunned, as is the case in dry stunning (Lines et al., 2003; Robb et al., 2002).

a. In-water electrical stunning: Fish are exposed to an electric current in water, either within a water tank (batch system) or while pumped through a pipe (continuous flow system) which allows for faster processing. For in-water electric stunning, the voltage gradient in the water or electric field strength (measured as volts per metre) is the important parameter to consider rather than the total current.

The electrical current passes not only through the fish but also through the water surrounding it so the current is dependent on the electrical conductivity of the water and on the amount of water around the fish.

It is difficult to provide general recommendations on the best electrical parameters to use in electrical stunning systems as so much depends on the individual set up of the system, the size and number of fish being slaughtered, as well as water conductivity, and other factors.

b. Dry-electrical stunning:
Fish are removed from water and passed over a conveyor belt which acts as one of the electrodes, with a chain of plate electrodes (steel flaps) hanging above, acting as the other to complete the circuit. In some systems fish are sprayed with water between removing them from water and stunning, and this is referred to as semidry stunning.

It is crucial that the fish enter dry stunning machines correctly – entering head-first and without excessive struggling. Incorrect orientation of fish brings a significant risk of pre-stun shocks and ineffective stunning, meaning that the process is inhumane because fish may feel the electricity for a few seconds before the electrodes reach the head. With correct orientation, dry electrical stunning has the potential to be humane, providing suitable parameters are developed and it is followed-up by a suitable killing method.

We recommend that any new equipment used for slaughter should be developed by an independent research institution and tested using the method described by van de Vis et al. (2014), before being used commercially. Firstly, conditions to achieve stunning need to be set in a lab setting, using electroencephalogram and electrocardiogram to determine the stunned conditions. Then, the system should be tested in a commercial setting and controlled via behavioural

Mechanical spiking

A new experimental stunning method tested in Nile tilapia is mechanical spiking, which induced immediate loss of consciousness without recovery in 95% of tested fish (20 individuals), when the procedure was performed on the lateral of the head (Gonzalez, 2021). However, this method needs to be validated for aquaculture settings and further research is needed to ensure unconsciousness via electroencephalography.

Unacceptable slaughter methods for nile tilapia

Text box 1

Exsanguination (bleeding) without adequate stunning: unacceptable slaughter method

Nile tilapia are frequently (around 40%) slaughtered by exsanguination conducted by decapitation or gill cutting without adequate stunning, that is, whilst still conscious (Coelho et al., 2022). Exsanguination without effective pre-stunning process, regardless of whether by gill cutting or decapitation, is not a humane killing method for any species of animal because the brain continues to function for a considerable time, and it is unclear whether animals remain sensible during that period (Lines & Spence, 2014). Van de Vis et al. (2003) have shown from electroencephalogram (EEG) measurements that some eel brain function continues for up to 13 minutes following decapitation. Clearly, any method of exsanguination without proper stunning results in poor fish welfare (World Organisation for Animal Health (WOAH), 2022) and should not be used.

Nile tilapia left to asphixiate.

Text box 2

Air asphyxiation or further processing: unacceptable slaughter methods

In Brazil, almost 60% of farms or slaughtering houses slaughter Nile tilapia by air asphyxiation after removal from water or even by further processing of the fishes (Coelho et al., 2022). These killing methods cause immense suffering and stress for these fishes, with an extremely prolonged period before reaching unconsciousness and death. It has already been demonstrated in behavioural studies that fish typically make violent attempts to escape, whereas cortisol and meat quality studies also indicate high physiological stress responses (Ashley, 2007; Poli et al., 2005). The time to loss of consciousness and death is species-dependent and there is currently little data specifically related to Nile tilapia. Regardless of that, the use of these methods means that there is a long period of prolonged suffering before death and even that fish may be processed while still alive, and thus should be avoided.

Text box 3

Selling at wet markets: unacceptable place of slaughter

Live tilapias have become an important product in the market in many parts of the world where consumers prefer to buy live fishes rather than iced or frozen fishes ((Singh & Daud, 2001) *apud* El-Sayed (2020)), even paying higher prices in order to get live fish (El-Sayed, 2020). Therefore, it is becoming common to find live tilapia in display tanks and aquaria in seafood restaurants and supermarkets in several countries like Singapore, Thailand and Malaysia ((Singh & Daud, 2001) *apud* El-Sayed (2020)). In Malaysia, the price of live tilapia is 37–40% higher than that of chilled tilapia ((Singh & Daud, 2001) *apud* El-Sayed (2020)). However, live food systems require effective support systems, including live holding containers, specially equipped trucks, live holding centres and other infrastructure components (El-Sayed, 2020). In these systems, fish can also suffer. The fish sold at these markets are usually kept in crowded conditions for long periods while the water quality degrades, exposing the fish to low quality environmental conditions. Furthermore, when a fish is selected by a buyer, it is usually handled out of water, often roughly and potentially causing injuries. It is then often exsanguinated (see Text box 1) or left to asphyxiate (see Text box 2) without prior stunning. Therefore, this practice causes long periods of stress, pain, and suffering. Thus, Nile tilapia should not be sold at wet markets.

Tilapia sold alive in plastic bag.

Recommendations for Corporate Policies on Humane Slaughter of Nile tilapia

1. All animals killed for food should be slaughtered humanely. This means that they must be stunned, rendered instantly insensible, and they should not regain consciousness before dying. For Nile tilapia, the use of exsanguination/bleeding without pre-stunning and asphyxiation in air are unacceptable and should be phased out. Effective electrical stunning before decapitation, gill cutting or spiking/coring is instead recommended, as this can enable humane slaughter and there are commercial systems available. This may change.

2. The killing of animals by bleeding without the use of pre-slaughter stunning is not considered a humane method of slaughter. Corporate animal welfare policies should stipulate that all fish products in the supply chain come from fish that have been subject to pre-slaughter stunning.

3. Fish removed from the production line (i.e. sick or injured fish, or those who do not fit market criteria) must be killed humanely.

4. All systems for killing animals should be effectively managed and monitored. This includes:

   - The development and use of Standard Operating Procedures (SOPs) for all live animal operations.
   - Effective training of all staff involved in live animal operations.
   - Designating a member of staff responsible for animal welfare in the slaughterhouse, an "Animal Welfare Officer", whose role it is to monitor operations to ensure SOPs are followed and to require remedial action be taken if non-compliance or other issues are found.
   - Use of CCTV in all live animal handling areas, with effective monitoring of the footage.
   - Effective measurement and proactive management of welfare outcomes at slaughter.

5. Pre-slaughter fasting periods should be no longer than is required for fish welfare benefits (i.e. to reduce oxygen requirements and waste accumulation in the water) and should not exceed 13.5 hours for all fish. Procedures should be in place to ensure that this maximum time is adhered to for every fish in the pen. For example, where multiple harvests/days are required to slaughter all fish in a pen, the fish should be segregated so that fasting times can be adhered to. Records of the dates and duration of fasting should be kept.

6. Crowding time and intensity should be minimised:

   - Narrow, deep nets should be used as they are more welfare-friendly than wide shallow nets for crowding fish.
   - Crowding should be carefully monitored and managed so that the crowd remains calm, with very few fish showing signs of distress, such as leaping or thrashing. If this occurs, it is a sign that the fish are too crowded.
   - The fish should not be crowded for longer than 2 hours and repeated crowding should be avoided.
   - Oxygen levels in the water should be monitored throughout the crowding process and producers must ensure that oxygen saturation stays above 4 mg/l. If fish show behavioural signs of stress, frequently air-breathe, or oxygen levels fall below 4 mg/l then fish should be given more space by releasing the nets. Additional oxygen can be supplied to the water. Keeping nets clean also help, as fouled nets can reduce the water flow.

7. Movement of fish to the point of slaughter should be carefully managed to minimise stress.

   - Only healthy fish should be transported, and a health check should be done before transporting fish.
   - If hand-nets are used (e.g. to remove sick fish from the cage), they should be used to remove small numbers of fish only. Nets should have a smooth surface and should be used carefully, with fish being out of water for a maximum of 15 seconds.
   - Braille nets should not be used to move fish out of water. Instead, pumping systems should be used to move fish in-water, and these must be carefully designed and managed to ensure gentle movement of fish through pipes. The following points are important:
     - An even flow of fish should be achieved, rather than a pump which delivers fish in bursts.
     - Fish must move through the pipes at a suitable speed - fish should not be able to swim against the pumping current as this risks injury and exhaustion of fish and keeps them inside the pipe for longer than necessary. However, if the pumping current is too strong the fish may be at risk of injury either inside the pump or on exit.
     - Pipes should be dimensioned to accommodate the size of the fish and the number of fish being pumped, and should have a smooth surface on the inside, including at the point of any joins between pipes.
     - Pipes should be as short and straight as possible.
     - All fish should be cleared from the pipes/pumps before any break/stop in pumping, and fish should not spend any longer in the pipes than necessary. Oxygen is quickly depleted inside the pipes and fish will die quickly if stuck in the pipes.
     - If injuries occur (e.g. fin damage, skin damage, wounds on the snout, bruising etc.) inside the pipe, measures must be taken to investigate and correct any flaws in the system.

8. If fish are dewatered before slaughter this should be well designed so that fish are moved with the least impact and risk of injury. The time that fish are exposed to air should be kept to a minimum; 15 seconds should be the maximum.

9. If well boats or trucks are used to transport fish, the water conditions should be monitored and controlled, ensuring that oxygen levels do not fall too low, and the ammonia and other waste products are not accumulating to damaging levels.

10. Electrical stunning systems:

    - Compromises to the welfare of the fish should not be made for the sake of product quality. Electrical parameters should be chosen that result in an effective stun which lasts until death and that minimises the risk of electro-immobilisation (fish being paralysed but still conscious). The parameters should be appropriate for the size and number of fish being slaughtered, equipment set-up and water conductivity.
    - In dry and semi-dry systems, all fish must enter the machine head-first. Operators should be present to orient fish manually and check that every fish is correctly aligned.
    - In dry and semi-dry systems, the time out of water should be kept to a minimum (the Humane Slaughter Association recommends a maximum of 15 seconds from dewatering to stunning) to minimise stress and prevent aversive movements which may affect their smooth entry into the electric stunner.
    - A kill method (immersion in ice slurry, decapitation, percussive blow or spiking) must be performed as soon as possible following stunning and must prevent recovery of consciousness before death occurs.
    - For in-water systems it is important to clean and maintain electrodes daily as corrosion can build up quickly, especially in saltwater systems, which can affect the amount of current delivered to the fish and result in an ineffective stun.

11. All fish must be observed post-stun by a trained operator. If any fish show signs of recovery, such as opercular movement or eye roll, or in the case of stunner equipment failure, a contingency plan must be in place to immediately stun and kill the fish, e.g. with manual percussion and gill cutting, or spiking.

Welfare outcomes at slaughter

In order to proactively monitor and improve animal welfare at slaughter, it is necessary to start by identifying appropriate measures of welfare. Whilst it is important (and in many cases mandatory) to record non-animal-based measures, such as electrical stunning parameter data, it is also important to look at the animal. Welfare outcomes are animal-based measures which give a more direct insight into the animal's experience than can be achieved by measuring 'inputs' such as husbandry resources. They are influenced by several factors and corrective action may require investigating a range of potential solutions.

Corporate policies on animal welfare should stipulate that welfare outcome measures are used at slaughter. Recommended welfare outcome measures for Nile tilapia during slaughter are listed in the following table.

Welcome Outcome	Detail
Activity during crowding	WHAT: A qualitative assessment of the activity of fish during crowding. WHY: The activity of the fish during crowding, as seen at the surface of the water, is an indicator of the stress experienced during this time. HOW: This measure should be continuously recorded. Their activity can be scored on a 5 point scale, described here: https://www.hsa.org.uk/downloads/publications/harvestingfishdownload-updated-with-2016-logo.pdf TARGET: 100% of the crowding procedures to be scored 1.
Indicators of consciousness	WHAT: An assessment of consciousness performed during the time interval between stunning and death. WHY: For slaughter to be considered humane, fish must be effectively stunned (rendered unconscious) so that they do not experience pain or stress during the process. HOW: This measure should be continuously recorded. Assess indicators of consciousness post electrical stun (see later table for a full list of potential indicators that can be used) and record the number and percentage of fish that show signs of recovering consciousness. Also record the action taken when fish showing signs of consciousness are detected. TARGET: 0% of fish to show signs of returning to consciousness (HSA, 2016). *If signs of consciousness are seen, fish must be immediately re-stunned or stunned with an alternative, back-up method.*
Pre-stun shocks	WHAT: Fish may receive electric shocks upon entry to a dry electrical stunner, which are not sufficient to cause unconsciousness, but which cause pain. These can be caused, for example, when a fish is moving vigorously and contacts one but not both of the electrodes, or due to tail-first entry to the stunner. WHY: The fish are still conscious and therefore these pre-stun shocks cause pain. Pre-stun shocks indicate that the stunning machine is poorly designed and/or operated. HOW: This measure should be continuously recorded. The incidence of fish entering the stunner head-first and calm (not thrashing) can be recorded. TARGET: 100% of fish to enter the stunner head-first and without thrashing movements.
Post-mortem flesh quality	WHAT: Time to rigor mortis and gaping of the muscle tissue. WHY: Post-mortem flesh quality can give a valuable insight into pre-slaughter treatment of the fish. When fish are stressed before (i.e.: when crowded) and during slaughter they can become very active and use up their energy reserves, causing an increase in lactic acid. This has a negative impact on flesh quality, i.e.: time to rigor decreases (decreasing yield and shelf life) and flesh gaping increases (reducing yield and making it less appealing to consumers). HOW: Record time to rigor and gaping from a sample of carcasses.

Welcome Outcome	Detail
Post-mortem haemorrhages	WHAT: Haemorrhages on the flesh of the fish. WHY: Physical damage post-mortem can give a valuable insight into pre-slaughter treatment of the fish. Haemorrhages are areas of flesh that have been damaged causing blood to leak into the area. Haemorrhages can occur if fish fall or are dropped from the dewaterer or braille, or if poorly maintained and operated pumps and pipes are used. They are also typically seen in the tail region if a fish has been lifted or held tightly by its tail prior to slaughter. HOW: Record incidence of haemorrhages from a sample of carcasses.
Post-mortem snout damage	WHAT: Snout damage such as bleeding and/sore areas. WHY: Physical damage post-mortem can give a valuable insight into pre-slaughter treatment of the fish. Snout damage occurs when pre-slaughter crowding is not well managed, and fish are swimming into the nets and each other. HOW: Record incidence and level of snout damage from a sample of carcasses.
Peri-mortem skin and fin discolouration	WHAT: Red discolouration of the mouth, fin and belly areas. WHY: Acute stress is seen to result in immediate discolouration of the mouth, fin and belly areas. These changes are often seen prior to slaughter due to stressful handling, crowding and transportation procedures. HOW: Record incidence and measure the percentage of fish displaying red belly or mouth at each stage of the pre-slaughter and slaughter process.

Welfare outcome measures

Welfare outcome measures should be used as part of a proactive programme of measurement and continuous improvement, including target setting. A programme should involve a continuous cycle of:

Regular monitoring of welfare outcomes enables swift detection of problems, implementation of corrective action and continuous improvement to be achieved. Some measures should be continuously recorded (as indicated in the table above). For the other measures, it is recommended that they are recorded on a representative sample of a minimum of 50 fish per harvest. Target setting should be used for all measures, to drive improvement.

Indicators of consciousness

It is difficult to reliably determine unconsciousness of fish (and therefore that stunning is effective) during industrial slaughter (EEG are required and this can only be measured in the lab) but it is important to ensure that there are no signs of consciousness after stunning. If any of the following signs of consciousness are observed, then stunning is likely to have been ineffective. If in any doubt as to whether a fish is unconscious, do not hesitate to repeat the stun or use an alternative, back-up method.

Table 3: Summary of signs of consciousness during slaughter at a commercial setting (*Ferreira et al., 2018*)

Signs of an ineffective stun	Comment	Stunning methods applicable to
Breathing	Regular opercular movements indicate the fish is likely to be conscious.	All
Eye roll	The vestibulo-ocular reflex (VOR), known as "eye roll", refers to the movement of the eyes in the head as the fish moves. In a conscious fish, the eye rotates dorso-ventrally when the fish is rocked from side to side.	All
Coordinated behaviour	Coordinated behaviour such as swimming or attempts to escape is a sign that fish is conscious.	All
Behavioural response to tail pinch	Behavioural response such as movement away from the stimulus indicates the fish is likely to be conscious.	All
Ability to achieve equilibrium	If a fish is able to achieve equilibrium after being inverted in water, then it is likely to be conscious.	All

Disclaimer

We will incorporate new scientific information regarding humane slaughter for fish into subsequent versions of these resources. Some of this research may alter our understanding of current established practice. Last update: March 2023

Specifically for Nile tilapia, Pedrazzani et al. (2020) suggested a scoring system for criteria that should be considered to ensure that there are no signs of consciousness after stunning, which were based on (Noble et al., 2018) and are shown in Table 4 below:

Table 4: Scores used to classify each criterium that should be observed during slaughtering process to certify that fishes are in fact unconscious, adapted from Atlantic salmon to Nile tilapia by Pedrazzani et al. (2020) (based on Noble et al. (2018)). The lower the score, the better for fish welfare.

Score	Criteria (Conscious indicators)
1	Instantaneous loss of VOR, OR, EQ, and TGR
2	Total loss of VOR and OR in ≤10 s, instantaneous loss of EQ and TGR
3	Total loss of VOR and OR in ≤100 s, instantaneous loss of EQ and TGR
4	Total loss of VOR and OR in ≤1,000 s, progressive loss of EQ and TGR

The indicators for the evaluation of tilapia consciousness included the clinical reflexes: opercular rate (OR), vestibulo-ocular reflex (VOR), equilibrium (EQ) and the tail-grab-reflex (TGR).

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