AQUI-S®

RESTED HARVESTING

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Rested harvesting is the practice of minimising the exercise experienced by the animals during harvest to conserve intra-cellular energy reserves and suppress the release of stress-related hormones. It means the muscle is not fatigued and intracellular energy reserves are available for post harvest metabolism. Effectively this delays the rigor process and the consequent breakdown processes for at least 18 to 20 hours. Rested harvesting allows for true pre-rigor processing and tissue is able to withstand the rigours of processing without gaping. As breakdown processes are delayed the product has a longer shelf life. Rested harvesting results in improved quality and consistency in the product.

THE CONCEPT

Most fish demonstrate a maximal emergency response when threatened in any way. This may follow a sudden disturbance from a net, a noise or other unexpected activity, or when they are removed from the water. The response usually involves a change in the heart rate; increased production of cortisol, adrenaline and noradrenaline; and vigorous muscle contractions. The increased exertion exhausts the normal aerobic energy resources of the muscle forcing the muscle to rely on anaerobic glycolysis for the production of ATP. An associated build-up of lactic acid results along with a reduction in muscle pH and an overall reduction in muscle energy reserves (Lowe et al. 1993).

Salmon being sedated with AQUI-S® during a rested harvest

BENEFITS

* **Improved physical appearance**: Fish are not agitated during the harvest process and are therefore less likely to sustain physical damage reducing scale loss and bruised tissue. In addition fish that have been harvested in a rested fashion retain their eye clarity and external colour for longer.

* **Improved bleeding process**: In fish that have undergone a rested harvested the heart will continue to beat for a period after death. This means fish have a very strong blood flow during bleed out, resulting in reduced occurrence of blood spot.

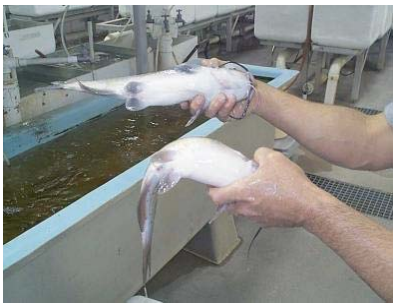
* **Stronger more elastic tissue**: Low physical activity of fish before and during the harvest conserves intracellular energy levels allowing for post harvest metabolism resulting in stronger more elastic tissue that is able to withstand the rigors of processing. This results in a reduction in gaping. Low physical activity also means that the myotome/myocomata junction is not strained also resulting in a reduction in gaping.

* **Increased shelf-life**: Rigor mortis is the process the body goes through once all energy stores have been depleted and indicates the cessation of metabolic processes in the tissues. This is physically seen as a stiffening of the body followed by a relaxation and from this point on autolytic spoilage occurs. Delaying the onset of rigor mortis delays the process of autolytic spoilage and preservation of flesh quality.

* **Product consistency**: As fish are not fatigued during harvest the quality of the unexercised tissue is similar amongst the fish. This results in the processor receiving product of a consistent quality and consistent high quality.

* **Humane**: The use of AQUI-S® in rested harvesting processes is regarded by many as the worlds most humane method for killing fish.

* **Selective harvesting**: AQUI-S® treatment is reversible as the handling step is not lethal. This means that fish not required or otherwise not suitable for harvesting can be returned to the water. This affords the farmer greater control over the harvesting operation and an ability to better meet the needs of the processor.



Channel catfish 7 hrs post harvest. Fish treated with AQUI-S (bottom) is still in rigor, fish treated with CO2 (top) was in rigor within 1 hr.

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using AQUI-S® for

RESTED HARVESTING

4a APPLICATION, FINFISH

QUALITY INDICATORS

Fish muscle that begins to spoil as a result of poor harvesting processes usually becomes increasingly soft and begins to gape which reduces its appeal to customers. It is the loss of muscle structural integrity that accounts for most of the progressive weakening of post-harvest fish muscle. Measurements can be made to evaluate the quality of harvested fish. Some of the indicators typically used in research and by the farmed salmon and trout industries are:

Figure 2. High quality harvested salmon

(i) MUSCLE pH & LACTATE

Measurements of the surface pH of freshly cut muscle provide a reliable method of estimating the lactate levels and corresponding rested state of the animal in the farm situation. Low pH values of less than approximately 7 indicate that significant exercise has occurred. Lactate levels are correspondingly high.

Values of pH 7.6 and above indicate a well rested animal. Most commercial applications using AQUI-S achieve pH values above 7.2 which is considered to be the minimum pH necessary to consistently obtain the benefits of rested harvesting.

(ii) COLOUR

Colour measurements include lightness, hue, chroma and Roche colour score. The Roche colour score is a subjective comparison of fillet colour against standard colour cards. The other measurements are made using a colour meter. Flesh translucency is maintained in rested flesh and the natural external colours and iridescences are maintained for a longer period.

(iii) GAPING

Gaping causes downgrading of fillets as it renders them unsuitable for smoking. Gaping is a consequence of the failure of the fibres and tissue connecting the muscle blocks along the fillet. This phenomenon is significantly reduced in fish that have been harvested in the rested state. However, it can also be affected by poor handling of the fillets. Gaping score is a subjective evaluation of the number and extent of separation of muscle blocks.

Figure 1 and 2 show the difference in fillet quality between a fish that has been rested harvested and a fish that has been slaughtered using CO_2, which is one of the most stressful fish slaughter methods. Notice the large amount of gaping and blood spotting that is occuring in the fillet harvested using CO_2.

Figure 3. AQUI-S harvested fillet 18 hours post harvest.

Figure 4. CO_2 harvested fillet 5 hours post harvest.

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(iv) RIGOR STIFFENING

Stiffening of the body after death indicates the cessation of metabolic processes in the tissues. This is a transitory state and the body relaxes once bonds at the cellular level have broken down. This breakdown results in gaping in the flesh with the tissue losing strength and elasticity. Rested harvesting results in a delay in the onset of rigor mortis, less intense rigor contractions and consequently a stronger, more elastic tissue after the rigor contractions have finished.

The state of rigor is often measured by supporting the body of the fish from the head to the pelvic fins and allowing the rest of the body to hang free. The angle made between the tip of the tail, the edge of the support surface and the horizontal is measured to determine the state of rigor. As rigor develops the angle of droop decreases.

Figure 4 shows that the fish treated with CO_2 is in rigor after 4 hours, whereas the fish rested harvested using AQUI-S is still pre-rigor.

Figure 4. AQUI-S® treated fish (front) and CO_2 treated fish (back)

(v) MUSCLE TENSILE PROPERTIES

The tensile properties of strips of muscle have been used to define the progressive deterioration of post-muscle quality. These measurements provide a less subjective measure of muscle structure compared with gaping scores.

(vi) MUSCLE EXCITABILITY

Muscle excitability can be determined by noting the response of the muscle tissue to electrical pulses. The ability of the tissue to respond to electrical activity indicates that the neuro muscular system is still physiologically active. Thus, the tissue of the animal retains the ability to react to external electrical stimulation producing a "twitch" reaction. The twitch response decreases prior to the onset of rigor contractions at a muscle pH of approximately 6.6 to 6.8.

Figure 5. Fish exposed to an electrical current showing a strong 'twitch' reaction.

(vii) CONCLUSIONS

Harvesting farmed fish with AQUI-S® provides a humane method of handling fish. It results in significant quality and consistency benefits compared with other harvesting methods. Fish that are harvested in a rested state show improved colour and appearance, reduced gaping, a delay in the onset and severity of rigor and improved firmness. Improved quality, consistency and yield translate into greater demand for the fish product and profits for the fish farmer.

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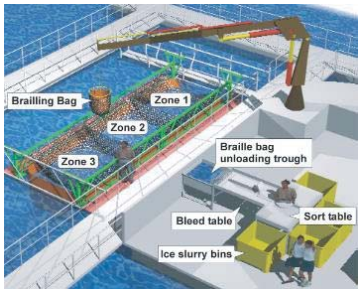
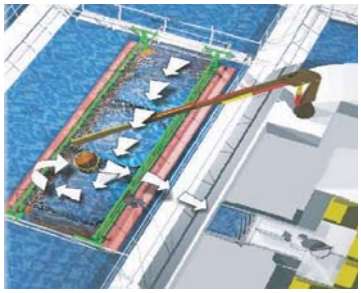
HOW TO CONDUCT A RESTED HARVEST

Rested harvesting can be applied to all types of operations. One system, commonly used in sea cages, pond or raceway operations employs a sedation bag with an internal net divider to separate the bag into three zones. In this way a continual flow operation is achieved with fish continually moving through the sedation bag having been exposed to AQUI-S® for the necessary time to achieve the desired sedation level. If fish are in a land-based tank, the water volume can be gradually drained to a suitable level before sedating fish with AQUI-S®.

CONTINUAL FLOW SYSTEM

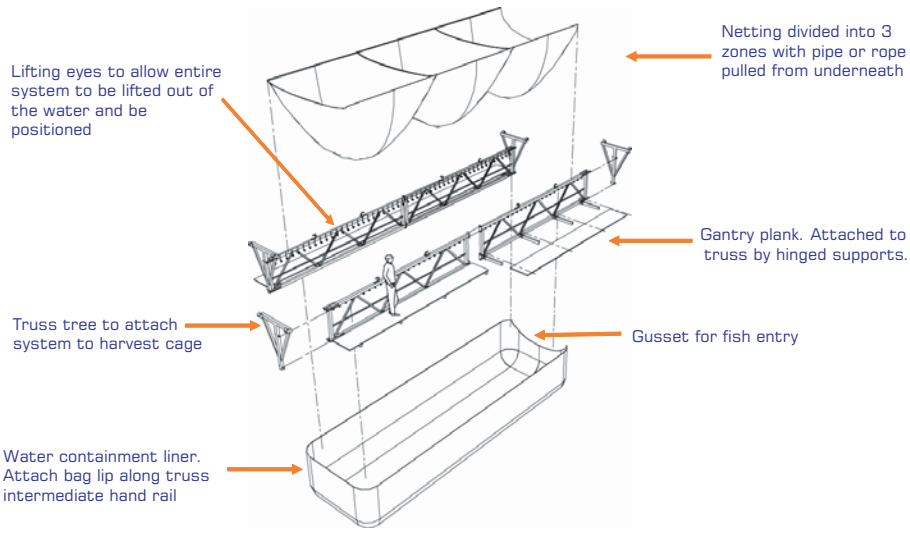
The most effective method to achieve a continual flow of fish to the handling table is to divide the treatment tarpaulin into 3 zones using a net. Fish remain in zone 1 for approximately five minutes. Then the net lining between zone 1 and 2 is lowered to allow fish to be moved to zone 2. The net lining between zone 1 and 2 is then raised and the gusset opening lowered to allow entry of more fish to zone 1. After 5 minutes continue the cycle of introducing new fish every 5 minutes while continually removing fish from zone 3.





DESIGN

This rested harvesting design has proven effectiveness and is being used successfully by finfish farms around the world. Farms using this system are able to have a continuous flow. The size and design of the system can be adapted to suit your particular requirements.



Sea-cage flow through system

Pond flow through system

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conducting an AQUI-S®

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PROCEDURE

Step 1 The crowd: The crowding of fish is the most crucial step involved in a rested harvest. If the crowd is conducted poorly it will adversely affect the flesh quality. A successful crowd involves careful marshaling of fish into the sedation bath. Fish should be exhibiting normal swimming behaviour during this process. There should be no escape response shown as evidenced by agitated swimming behaviour and excessive exercise.

AQUI-S® stock solution being dispersed using a pump sprayer

Step 2 Entry into bag: The gusset is slowly lowered to allow fish to be swum into the AQUI-S® bag where they are sedated. Fish should show no reaction on entry to the AQUI-S® bath.

Fish about to enter the bath

Step 3 AQUI-S® application: The AQUI-S® stock solution can be added directly to the water. This may be prior to the entry of the fish or once fish have entered the sedation bath. A garden sprayer fitted with an extra long wand can be used for the application of AQUI-S®. The tip of the wand

Sedated fish being moved to the end of the bag

Step 4 Movement inside the bath: As fish progress through the sedation bag they steadily become more sedated. Sedated fish can be easily moved within the sedation bag with the use of the internal net lining. As fish are sedated they do not fight against the movement of the bag.

Fish being removed by brail net

Step 5 Removal from the bath: If a brail net is being used it should be enclosed for minimal water loss. The brail is emptied into a tub containing AQUI-S® treated water on the harvest barge. The tub needs to have a return pipe running back to the sedation bag to conserve AQUI-S® treated water. If a fish pump is being employed it should have a return pipe running back to the sedation bag to conserve AQUI-S® treated water. Agitation of water due to pump action may cause some foaming.

Step 6 Slaughter: Fish can be killed by either percussion or iki jime. There has been significant progress on the design of automated killing methods and percussion stunners are currently the most effective available. The gill arches should then be cut and fish transferred to an ice slurry for bleeding.

Fish being bled in ice slurry

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