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Killing methods, post-slaughter quality, part 3



2 November 2013 George J. Flick, Jr., Ph.D. David D. Kuhn, Ph.D.



## Fasting, post-mortem changes, transportation effects



Studies have shown that fasting fish species such as Atlantic cod for several weeks did not greatly affect filleting yield, but prolonged fasting typically causes some physical changes in color and shape.

The first two articles in this series reviewed various methods of fish slaughter and the effects on initial product quality. Also, ethical concerns with some of the slaughter methods were discussed. Part III of the series discusses how slaughter methods impact product quality from slaughter through consumption.

### Effects of fasting

It has been recommended that fish be fasted for several days prior to slaughter to clean their digestive tracts, thereby minimizing the risk of muscle contamination during gutting and processing. However, since proper feeding is an important component of animal welfare, longer fasting periods are not recommended as a commercial practice.

For research purposes, varied studies have examined the effects of longer fasting on post-mortem fish quality. One finding, for example, was that if fish are subjected to prolonged fasting, weight loss is more pronounced during the first four weeks and less thereafter. However, various fish species reflect different weight losses.

Typically, most of the initial weight loss occurs in the viscera and can account for 50 percent of the total weight loss. After the visceral loss occurs, the remaining loss comes from the body. It has been found that product yield can increase in fish subjected to various fasting schedules. Some studies have shown that some fish species, such as Atlantic cod (*Gadus morhua*) could be fasted for up to 10 weeks without affecting filleting yield. However, after prolonged fasting, processing yield decreases, and fish exhibit some physical changes in color and shape.

For many fish species, initial lipid loss during extended fasting occurs in the visceral fat and then in the liver and muscle tissue. As lipid is lost in muscle, it is replaced with water, since an inverse relationship exists between lipid and water. Lipid loss occurs at a slow rate during initial fasting but increases at a more rapid rate as the fasting period is extended. Also, saturated fat is lost first, resulting in a higher concentration of unsaturated lipid in the muscle tissue.

During extended storage, amino acids decrease within white muscle first, followed by red muscle and then connective tissue. Amino acid losses are similar to lipid content losses in that losses occur first in the viscera, then in the liver and finally the muscle tissue. While amino acid concentrations vary, in many fish species, protein content remains constant for an extended period. It has been observed that protein content in the white muscle may increase slightly before decreasing.

Depending upon the fish species, glycogen may or may not be metabolized before lipids and proteins. If glycogen is metabolized, the muscle tissue pH rises due to the production of lactic acid. When the glycogen content of muscle tissue is affected, fillets can become soft in texture, thus affecting product quality.

The external color of many fish does not change with fasting, except during extended storage times. However, the muscle tissue does undergo some changes in color, usually in the red range. The sensory quality of fish fasted for less than two weeks may exhibit only minimal changes in sensory appeal.

## Post-mortem changes

In research, two fish species were killed by three different procedures: stabbing in the spinal hub (instant killing), dipping in cold water (temperature shock) and leaving in the air to die (struggled killing). After death, the fish were stored at 0 degrees C for up to 34 hours.

The progress of rigor mortis; changes in concentrations of adenosine triphosphate (ATP), inosine monophosphate (IMP) and creatine phosphate; and shifts in the breaking strength of the dorsal muscles were the slowest in the instant killing group. The rates of change in the temperature shock group were similar to those in the struggled group. The differences were most pronounced during the first nine to 14 hours. After 14 hours, the rates of degradation were somewhat similar.

The total blood volume of fish customarily ranges from 1.5 to 3.0 percent of body weight. However, in some species, the blood volume can be up to 5.7 percent of the body weight. Only 20.0 percent of the blood is localized in muscular tissue, and the rest is in internal organs.

Because the white muscle is rather poorly vascularized, it has been assumed that blood distribution is little affected by exercise. However, when rested fish are exposed to stressors and exhibit escape behavior, blood flow is gradually redistributed from the viscera to the locomotory muscles to meet the increased oxygen demand of the white muscles. Moreover, when fish are subjected to handling stress, the plasma-clotting time is reduced. A 43 percent decline in blood clotting times has been observed 10 to 60 minutes after a stress incident.

This finding suggests that perimortem stress can lead to poorer blood drainage. However, it has been reported that stress during stunning normally promotes peripheral vasoconstriction thorough the action of catecholamines, resulting in a minimum of blood in the muscular tissues.

In further research, the bleeding efficiency of anesthetized and exhausted Atlantic salmon was studied. In all cases, the amount of residual blood in the fillets was modest, and blood was not considered a quality problem in terms of fillet appearance. Perimortem stress did not affect the residual blood content of prerigor filets. The low levels of residual blood were partly attributed to filleting shortly after killing, which allowed washing before the blood had time to coagulate.

It is a well-established fact that a beating heart does not play a significant role for effective blood drainage. Muscle activity during bleeding is not important to facilitate adequate drainage of blood. Although there is some disagreement as to what is the best bleeding method, it is apparent that immediate bleeding after capture or stunning is more important than the actual bleeding method. The major factor is that the blood should be removed prior to the initiation of coagulation.

In another study, rainbow trout (*Oncorhynchus mykiss*) were stunned by electrocution, exposure to elevated concentrations of carbon dioxide or a blow to the head, and subsequently bled. The fish were stored non-eviscerated in ice for up to 15 days, after which the changes in the textural properties of the fish flesh were measured objectively and subjectively. The differences in lactic acid concentrations, pH, water-holding capacity in muscle metabolites and fillet texture were not greatly different over time.

## Effects of transportation

Stress and muscle activity during the transport, netting and anesthesia of fish can shorten the time of rigor mortis onset, which is essentially triggered by depletion of glycogen and ATP in muscle cells. Handling and processing of fish during rigor mortis can result in a loss of quality and lower fillet yield. The prerigor period must be long enough to ensure that bleeding, gutting, washing, chilling and packing all occur before the onset of rigor mortis.

It has been shown that transport of salmonids for up to 11 hours at densities of 69-170 kg/cubic meter had only a minor effect on physiological responses. Changes in muscle metabolites and fillet texture after road transport of rainbow trout for 10.5 hours at 167 kg/m<sup>3</sup> had a limited effect on quality.

In a study, Atlantic salmon with a mean weight of 5.1 kg were transported live at 125.0 kg/cubic meter for 1.5 hours by a well boat from the sea cage to a processing facility and then kept in the well boat for four hours prior to slaughter. Anaerobic white muscle activity due to handling stress during fish loading at the cage, after shipment immediately before slaughter and after the fish had passed the slaughter line were evaluated using several biochemical parameters.

No dramatic effects of handling stress were found, indicating transport and slaughtering did not have an adverse effect on flesh quality. The results were attributed to the ability of the well boat to maintain acceptable seawater quality during transport, rapid netting of the fish from the well boat to the slaughter line and an efficiently maintained carbon dioxide anesthesia tank that minimized struggling prior to killing.

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The methods used to kill fish depend on many factors, including fish size and species, aquaculture production system, fish quantity, market preferences and effects on product quality. Also, some methods may not be approved in some countries, as with the use of anesthetics and regulations concerning the ethical treatment of animals.

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All methods of slaughter have issues related to animal welfare. However, approaches such as death in air or bleeding without stunning have been particularly cited as unacceptable.

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