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Short communication

Absence of parasitic nematodes in farmed, harvest quality Atlantic salmon (*Salmo salar*) in Norway – Results from a large scale survey

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ABSTRACT

A total of 4184 farmed Atlantic salmon (*Salmo salar*) were sampled and subsequently examined for nematodes between January 2014 and July 2015. The fish originated from 37 salmon farms along the coast of Norway and represented all salmon-producing counties. Samplings took place at processing facilities during regular slaughtering procedures and consisted of 3525 harvest quality salmon processed for human consumption and 659 discarded salmon including runts and fish discarded for other quality defects. Both viscera and musculature (fillets including belly flaps) of the salmon were screened by applying the UV-press method. No nematodes were found in any of the harvest quality salmon. The only nematode findings were from the viscera of three runts (loser fish) originating in southern or western Norwegian farms, and consisted of two *Anisakis simplex* (s.s.) larvae and three adults of the non-zoonotic species *Hysterothylacium aduncum*. The absence of nematodes in the harvest quality salmon relates most likely to the diet since healthy and normally developing salmon seem to rely exclusively on the heated and extruded dry-feed, which cannot contain any viable parasites. The runts, however, may feed opportunistically on whatever prey available in the cages, which apparently facilitates the transfer of nematodes. Thus, the present results suggest that the risk of any parasitic nematodes to occur in the flesh of farmed Norwegian salmon intended for human consumption is very low.

1. Introduction

Anisakid nematodes commonly occur in many commercially important marine fish species including wild stocks of Atlantic salmon (*Salmo salar*). From a food safety point of view, the most important anisakid species in Northeast Atlantic waters is *Anisakis simplex* since its larvae may cause acute gastrointestinal illness if accidentally eaten alive, or elicit allergic reactions among sensitized consumers (see reviews by Chai, Murrel, and Lymbery (2005) and Nieuwenhuizen and Lopata (2013), respectively). The current EU legislation (Regulation (EU) No 1276/2011) that deals with zoonotic fish parasites highlights the so-called freezing requirement to ensure that fishery products do not contain any viable parasites. However, farmed fish in general and farmed Atlantic salmon in particular, have not been regarded at risk to acquire anisakid nematodes. The assumption rests on the results of several major surveys of farmed Atlantic salmon for parasitic nematodes conducted in France (on salmon produced in Norwegian and Scottish farms) (Angot & Brasseur, 1993), Norway (Lunestad, 2003), Scotland (Wootten, Yoon, & Bron, 2010), Pacific North America (Deardorff & Kent, 1989; Marty, 2008) and Chile (Sepúlveda, Marín, & Carvajal, 2004). Consequently, freezing need not be carried out for products derived from farmed fish that are cultured from embryos and have been fed exclusively on a diet that cannot contain viable parasites. In Norway, the exception of farmed Atlantic salmon from the freezing requirement has been practised for many years. However, findings of *A. simplex* and the non-zoonotic nematode species *Hysterothylacium aduncum* in runts (loser fish) from a salmon farm in southern Norway (Mo et al., 2014), raised concern about the rationale behind the freezing exception, although no nematodes were found in salmon processed for human consumption. Moreover, since the actual runts originated from just a single location in southern Norway, the need became clear to establish knowledge on the nematode situation in salmon produced in the other regions and counties, as well. Thus, the present investigation aimed to establish the epidemiological baseline regarding the possible presence of anisakid nematodes in farmed Atlantic salmon in Norway by including representative samples from all salmon-producing counties. A secondary goal was to investigate any

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geographical or seasonal trends with respect to the possible presence of anisakids in runts of farmed Atlantic salmon.

2. Material and methods

2.1. Salmon samplings

In total 4184 farmed Atlantic salmon were sampled and subsequently examined for nematodes between January 2014 and July 2015. The fish originated from 37 conventional sea net-pen salmon farms scattered along the coast from the South at approximately 58°N 7°E to approximately 71°N 25°E in the Northeast of Norway, and represented all salmon producing counties. The sample size per county reflected roughly the salmon production volume of each county as percentage of the total Norwegian salmon production volume in 2012. Fig. 1 indicates the geographical location of the actual farming localities. The samplings took place at processing facilities during regular slaughtering procedures and consisted of 3525 salmon processed for human consumption and 659 discarded fish including 395 runts; the occurrence of the latter varied greatly with farm origin and season. Information on sampling month/year, sample size per region/county and salmon quality category, along with body weight of both harvest quality salmon and runts, is provided in Table 1.

At each sampling, a representative of our laboratory picked the salmon personally at the first sorting point of the processing line, after initial flushing of the fish but before they were bled and eviscerated. Additionally, salmon were also gathered from the discard bin during each sampling, the number of which however, varied greatly, sometimes reaching 22% of the total sample. Since the fish were usually sampled at an early stage during processing, the average body size of the salmon taken from the processing line did not necessarily reflect the average body size of the actual batches (see also comment in Table 1). This is probably due to the tendency of comparatively smaller salmon to be the first to emerge after starting the transporting belt carrying the salmon from the flushing basin onto the processing line. Fish taken from the discard bins consisted of runts and/or specimens that were discarded due to other quality defects such as external sores, bleedings or anomalous body shape. Runts were identified as such at our laboratory by comparing individual body size and general appearance with other fish taken from the discard bins. Fulton's condition factor K ($K = W_{(g)} * 10^5 / L^3_{(mm)}$) proved sometimes inappropriate as criterion for reliable identification of runts since some fish which at first sight appeared to be runts, had seemingly adequate K-value and body shape but were considerably smaller than the average harvest quality salmon. Fig. 2 illustrates the difference between a typical runt and other fish that were discarded due to various other

Fig. 1. Farming localities (red dots) by county, of Atlantic salmon (n = 4184) examined for the possible presence of parasitic nematodes. (For interpretation of the references to colour in this figure caption, the reader is referred to the web version of this article.)