

AQUA 10038

Short Communication

European farmed Atlantic salmon (*Salmo salar* L.) are safe from anisakid larvae

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(Accepted 8 July 1993)

ABSTRACT

3700 fillets of farmed Atlantic salmon (2–3 kg and 3–4 kg) from Norwegian and Scottish farms were examined using a candling method. No anisakid larvae were found, using this procedure. The results are considered in the light of other investigations, and prevalence is compared with that obtained for wild salmon. Furthermore, public health hazards of smoked and raw salmon dishes are discussed, and recommendations are made for farmers and processors.

INTRODUCTION

Larval anisakid nematodes, such as *Anisakis* sp., *Pseudoterranova decipiens* and *Contracaecum*-type larvae, are found in a variety of fish species. Larval anisakid nematodes are known to be responsible for human anisakiasis, and may be considered a potential public health problem.

Economic constraints resulting from fish flesh infection and the unappetizing appearance of worms, are well known in various Northern Atlantic countries such as Canada, the USA and Iceland but have not been a cause of concern in Europe until 1987 (Valdimarsson et al., 1985; Hubert et al., 1989; Möller, 1989; Deardorff and Overstreet, 1990). Since then, the economic problems with fish worms have grown significantly.

In recent years salmon sea-farming in pen-nets has become a growth industry in European countries such as Norway, Scotland and Ireland. Farmed

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salmon currently accounts for the major part of the fresh and processed salmon market in Europe. Smoked salmon is undoubtedly the most important of these products.

As a "ready-to-eat" and cold-smoked ($<23^{\circ}\text{C}$) product, smoked salmon could be a potential source of human anisakiasis. On the other hand, salmon (*Oncorhynchus* sp.) has been reported as one of the four common sources of this pathology in the United States (Deardorff and Overstreet, 1990). In France, an epidemiological study, from 1985 to 1987, revealed that transmission has been linked to "salmon" in 2 out of the 21 confirmed cases (Hubert et al., 1989).

Processors have been sensitive to the potential economic consequences arising from press commentaries when dealing with this subject, particularly after the events in Germany (Hubert et al., 1989). The present study, which was carried out with their participation, attempted to evaluate the infection level of farmed Atlantic salmon fillets from Norway and Scotland, by anisakid larvae.

MATERIALS AND METHODS

Materials consisted of 2832 and 867 fresh fillets of farmed Atlantic salmon from Norway and Scotland, respectively. Fillets were random-sampled from processing batches. Raw materials were of common processing size, and weighed about 3–4 kg (eviscerated weight). Salmon of this size are on average 3 years old. Only one sample of 2–3 kg salmon (approximately 2 years old) was investigated.

Norwegian salmon samples consisted of 372 fish of 2–3 kg and 2460 fish of 3–4 kg. Of the fillets, 1022 were studied in September and the remaining 1810 in November 1989. Samples were supplied from a large number of sea farms, all along the Norwegian coast.

In the case of Scottish farmed salmon, obtained from two trader companies, we could not confirm whether the fish came from one or from several farms. Except for 57 salmon examined in September, the materials were investigated in November 1989.

Previously skinned smoked fillets were examined for nematodes using a Baader® 500 candling box of 4000 lux (Baader GmbH, D-2400 Lübeck, Germany). This method is recommended by the *Codex Alimentarius* (Anon., 1983) for detecting parasites in white fish (Valdimarsson et al., 1985), but detection could be more difficult in coloured fillets. In such fillets, a larva appears as a slightly coloured and opaque spot, embedded in the flesh, and can be confused with a blood vessel, a bone, or an intermuscular septum. All of such "Anisakis-like" structures were investigated to confirm their identity.

Technical constraints on skinning fresh fillets prevented us from using raw Atlantic salmon fillets for examination. Smoked fillet is more coloured and

more opaque than raw flesh, and it seemed more appropriate to check the method prior to beginning the study.

RESULTS

The procedure for detection of the larval nematodes was tested first with 129 wild Pacific coho salmon (*Oncorhynchus kisutch*) of 1.5–2 kg and 111 of 3–4.5 kg, which were troll caught, eviscerated and frozen. Raw fillets were examined after skinning and individually labelled. A second examination was carried out after smoking. Of these wild Pacific salmon fillets, 34 were parasitized with anisakid larvae (range: 1 to 6 larvae per fillet). All larvae initially detected in the raw fillet were also found after smoking. An examination of several slices from these materials did not reveal any additional larvae.

None of the 2832 Norwegian farmed salmon and 867 Scottish farmed salmon fillets was found to be infested by anisakid larvae. From the statistical interpretation, the estimated probability of infection ($\alpha=5\%$) was, in the populations studied, less than 1.6×10^{-3} in Norwegian salmon, and less than 4.72×10^{-3} in Scottish salmon.

DISCUSSION

Infection by anisakid larvae appears to be a real problem for wild salmon fisheries, and this has been frequently reported in Pacific salmon (*Oncorhynchus* sp.), as well as in Atlantic salmon (*Salmo salar*). In wild Pacific salmon, investigations made in the United States usually emphasized high prevalence. In fresh commercial fish, prevalence reached 100% in sockeye salmon (*O. nerka*) and chum salmon (*O. keta*), 97% in pink salmon (*O. gorbuscha*), 79% in chinook (=king) salmon (*O. tshawytscha*) and from 36% to 98% in coho salmon (*O. kisutch*). Worms were found in the host's musculature in, respectively, 100% from sockeye and chum salmon, around 100% in coho salmon (from 98% to 100%) and pink salmon, and 79% from king salmon (Myers, 1978; Deardorff and Overstreet, 1990). Moreover, Rosset et al. (1982) studying commercial salmon from "supermarkets" reported a mean number of 79.3 larvae per kilogram of flesh. Unfortunately, they did not mention either the salmon species, or the number of investigated salmon.

As regards wild Atlantic salmon, Beverley-Burton and Pippy (1978) reported a mean of 8.78 larval *Anisakis simplex* per fish. The worms were found, using digestion method, in the host's musculature, in 39% of cases. In the viscera of Atlantic wild salmon from the Norwegian coast, Bristow and Berland (1991) reported a relatively high prevalence of *Anisakis* larvae in the intestinal cavity (64.5%, with a mean number of 7.0 larvae per fish), while infection was lower in the intestine and the stomach (respectively 3.2% and

2.5 larvae per fish; 4.8% and 2.0 larvae). Mattiucci et al. (1986) also reported the presence of *Anisakis* larvae in Atlantic salmon, without specific details.

In contrast, neither Bristow and Berland (1991), who examined more than 2000 farmed Norwegian salmon, nor Deardorff and Kent (1989), who investigated 237 specimens of three species of farmed salmon (coho salmon, chinook salmon, and Atlantic salmon) from the Washington coast, detected the presence of any anisakid larvae. Investigations by the Scottish Office Fisheries Department have never recorded infection by anisakid larvae in their farmed salmon. However, details of the method used have generally been omitted from laboratory certificates.

Using a candling method, we did not find any anisakid larvae in the studied samples of Atlantic farmed salmon fillets from Norway and Scotland, suggesting that the infection rate could be less than 0.16%. The examination of smoked salmon slices (thickness <0.4 cm) did not reveal any additional larvae. However, the possibility that some larvae were overlooked can not be discarded. Unfortunately, for financial reasons, it was not possible to use a digestion method.

Taking into consideration the results of Bristow and Berland (1991), the investigations by the Scottish Office Fisheries Department and this present study, infection of farmed Atlantic salmon from Norway and Scotland by anisakid larvae could be close to 0.1%, and indeed negligible. So far as a public health hazard is concerned, farmed salmon could obviously be considered a reasonably safe product, reflecting a high margin of safety from anisakid infections. However, the hazard of anisakiasis persists for fresh wild salmon, though wild salmon is usually traded as a frozen product, and therefore no larvae remain alive in such smoked product. On the other hand, salmon can easily be eaten raw, as sushi-like or sashimi-like dishes, and these inadequate culinary practices could be sources of possible transmission. Better informed consumers, as well as fishmongers, could probably produce better prophylaxis to reduce eventual health problems. Wild salmon, for example, should be eliminated from "made at home" smoked fish, and for use in raw or semi-raw preparations, without previous freezing. Furthermore, as prescribed by the European Sanitary Directive, 22 July 1991 (Anon., 1991), all industrial products using wild salmon or infested fish should be frozen during processing.

It seems that alimentary and zootechnical practices in intensive salmon sea-farming are thought to prevent the contamination of fish by anisakid larvae. However, according to Bristow and Berland (1991), *A. simplex* may represent a potential problem for sea-farming, in areas where cetacean hosts are present. At the same time, Deardorff and Overstreet (1990) have suggested that small herring and the variety of invertebrates covering the nets could be a source of transmission. Sea-farming is an effective means of reducing the probability of infection, by interrupting the anisakid life cycle, but there still remains a theoretical risk to be investigated.

Consequently, it seems necessary for farmers, as well as for processors, to comply with these two recommendations:

- fish farmers should ensure a systematic survey of potential infection, using, as far as possible, a digestion method; though, as Deardorff and Overstreet (1990) found more anisakid larvae in the flesh than in the viscera of sockeye salmon, studies should involve fillets and not only the viscera;
- fish processors, in accordance with the “Hazard Analysis and Critical Control Points” system, should ensure that farmed salmon are produced within established farm guidelines.

ACKNOWLEDGEMENTS

We thank Labeyrie Ets (France) and the Syndicat des Saleurs-Saurisseurs de Boulogne-sur-Mer (France) for permitting us to carry out our investigation and for their technical assistance, and Mr. R. Medeiros for advice in editing the manuscript.

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