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Detection of parasites in walleye pollock (*Gadus chalcogrammus* Pallas, 1814) fillets marketed in São Paulo, Brazil

Detecção de parasitos em filés de polaca do Alasca (*Gadus chalcogrammus*, Pallas, 1814) comercializados em São Paulo, Brasil

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ABSTRACT

Introduction: Walleye pollock is the most caught fish worldwide and has been imported by Brazil as frozen fillets. This fish has its own parasitic fauna; however, the presence of parasites in the musculature may cause implications for food safety and repulsiveness. Objective: This work aimed to investigate and report the presence of parasite groups in commercial samples of frozen fillets of walleye pollock concerning the potential risk to human health and control methods. Method: A total of 44 samples of frozen fillets of walleye pollock collected from the retail trade of the metropolitan area of São Paulo were analyzed and the larval forms were isolated by dissection and observed under a stereoscopic and optical microscope. Results: One hundred thirty-three dead parasites were found from 68% of the samples. Trypanorhyncha cestodes were detected more frequently (88%), followed by nematodes from the anisakid group (Anisakidae/Raphidascaididae) (11%) and acanthocephalan (1%). Among them, anisakid has zoonotic potential, if ingested alive, and allergenic potential even after thermal processing. Conclusions: This is the first report of the presence of parasitic forms in commercial samples of walleye pollock fillets and the results alert to the need for improvements in relation to Good Practices in the production chain and the need for greater attention on the allergenic potential related to the consumption of these parasites on frozen fish fillets.

KEYWORDS: Fish; *Gadus chalcogrammus*; *Theragra chalcogramma*; Public Health Surveillance; Food Safety

RESUMO

Introdução: A polaca do Alasca, considerada a espécie de pescado marinho mais capturada mundialmente, é importada pelo Brasil como filés congelados. Apresenta uma fauna parasitária própria, porém a presença desses parasitos na musculatura pode causar implicações na segurança alimentar e repugnância. Objetivo: Este trabalho teve como objetivos investigar e relatar a presença de grupos parasitários em amostras comerciais de filés congelados de polaca do Alasca, considerando o potencial de risco à saúde humana e métodos de controle. Método: Foram analisadas 44 amostras de filés congelados de polaca do Alasca coletadas do comércio varejista da região metropolitana de São Paulo e as formas larvares foram isoladas por dissecção e observadas em microscópio estereoscópico e óptico. Resultados: Foram encontrados 133 parasitos mortos em 68% das amostras. Os cestódeos da ordem Trypanorhyncha foram detectados com maior frequência (88%), seguidos de nematódeos do grupo dos anisaquídeos (Anisakidae/Raphidascarididae) (11%) e acantocéfalo (1%). Dentre eles, os anisaquídeos apresentam potencial zoonótico, se ingeridos vivos, e alergênico mesmo após processamento térmico. Conclusões: Trata-se do primeiro relato da presença de formas parasitárias em amostras comerciais de filés de polaca do Alasca e os resultados alertam para a necessidade de melhorias com relação às boas práticas na cadeia produtiva e de maior atenção sobre o potencial alergênico relacionado ao consumo desses parasitos nos filés de peixes congelados.

PALAVRAS-CHAVE: Pescado; *Gadus chalcogrammus*; *Theragra chalcogramma*; Vigilância em Saúde Pública; Segurança dos Alimentos

INTRODUCTION

Walleye pollock, *Gadus chalcogrammus* Pallas, 1814, formerly known as *Theragra chalcogramma* Pallas, 1814, are teleost fish from the northern Pacific Ocean, which span from Alaska to the southern Sea of Japan[1]. Considered in 2017 the world's most caught species of marine fish, *G. chalcogrammus* lives in the wild and is an excellent source of protein, minerals and omega-3[2,3]. In 2018, Brazil imported 15,000 tonnes of frozen Walleye pollock fillets, 99% of which came from China and the remainder from the United States, Vietnam and Portugal[4].

Fish, as well as other vertebrates, have their own parasitic fauna in the natural environment, including several species of the main parasite groups[5]. Many authors in ecological studies have reported the presence of several parasites in Walleye pollock caught in Canada, Alaska, and Northern Japan, including the following nematodes: *Anisakis simplex* Rudolphi, 1809[6,7,8,9,10,11], *Pseudoterranova decipiens* Krabbe, 1878, *Contracaecum* sp. Railliet & Henry, 1912[6,12] and *Hysterothylacium* sp. Ward & Magath, 1917[6,13,12]; cestodes *Nybelinia surmenicola* Okada in Dolfus, 1929[6] and *Phyllobothrium* sp. Van Beneden, 1849[12]; and acanthocephalus *Corynosoma* sp. Luhe, 1904[12] and *Echinorhynchus gadi* Zoega in Müller, 1776[12].

Anisakis nematodes are natural gut parasites of piscivorous marine mammals and have teleost fish, cephalopod mollusks and small crustaceans[14] as intermediate hosts of their infective larval forms (L3). In this group of nematodes, some species of families Anisakidae and Raphidascarididae are capable of causing an accidental infection called anisakiasis[15,16], characterized by GI symptoms in the form of transient infection, due to the effect of live larvae on the digestive tube wall. Allergic manifestations may also be caused by exposure of susceptible individuals to this nematode's antigens, even with the ingestion of the dead parasite, with symptoms ranging from mild hives to anaphylactic shock[17,18]. Anisakiasis can be acquired by ingesting raw, undercooked, inadequately salted/smoked or insufficiently frozen fish[19] containing the infecting larva, but proper thermal processes like cooking or freezing may render it unviable for infection[20].

Other fish parasites, like cestodes of the Trypanorhyncha order and acanthocephalus, are not related to human health risk, with rare reports of accidental infection. Trypanorhyncha cestodes have as their definitive hosts stingrays and sharks and use teleost fish and various marine invertebrates as intermediate hosts. These parasites have hygienic and sanitary importance because of their potential to disgust consumers with the presence of larval forms in the muscles of several economically relevant species, causing significant losses[21,22].

Food surveillance works to preserve and promote the health of the population by controlling food quality. Therefore, this study aimed to investigate and report the presence of parasitic groups in commercial samples of frozen Walleye pollock fillets and to evaluate their potential public health risk, as well as control methods.

METHOD

We analyzed 44 commercial samples of frozen Walleye pollock fillets of 18 different brands, weighing between 0.5 kg and 2 kg, with about four to nine fillets per sample, totaling 47.8 kg of the product. Among the samples, 26 were collected by the Health Surveillance body for inspection analysis in a monitoring program (São Paulo State Program of Health Surveillance in Food) and 18 were acquired by the laboratory, all in retail stores of the São Paulo metropolitan area. The analyses were performed at the Morphology and Microscopy Center of the Adolfo Lutz Institute, Central Laboratory, from January 2017 to July 2018. According to the information described on the packaging label, 38 samples were from China, five from the United States and one from Vietnam.

The fillets were thawed and observed on a light table. The larval forms were isolated by dissection with the aid of forceps and scalpel. The larval forms were kept in a Petri dish containing distilled water. The nematodes were removed from the cyst and immersed in distilled water at 56°C to enable their distension and plate preparation. For the cestodes, the cysts were torn with tweezers whenever necessary. The parasitic forms were observed in a stereoscopic microscope, by Leica®, model MZ9.5, and a light microscope, by Nikon®, model Eclipse E200, and later preserved in 70% alcohol. The photomicrographs were performed under the Zeiss® Axio Scope.A1 optical microscope with the aid of the Axio Vision LE program.

The nematodes were identified according to Hartwich[23] and Felizardo et al.[24], the cestodes, according to Campbell and Beveridge[25], and the acanthocephalus, according to Amin[26]. As a viability criterion for parasites, the following parameters were adopted: physical integrity, spontaneous movement or stimulation, described in the *European Food Safety Authority Journal*[27].

Data on the parasite groups were analyzed in absolute frequency, relative frequency and range of variation between samples. The average density was obtained per kilo of fillet and comparisons between proportions were made using the chi-square test with a significance level of 95%. Microsoft Excel 2010 and GraphPad Software 2018 programs were used.

RESULTS AND DISCUSSION

Dead parasites were found in 68% of the samples, totaling 133 parasitic forms. The number of samples that presented any parasitic form (positive samples) and the number of isolated parasites in the total samples by parasite type are shown in the Table.

Trypanorhyncha cestodes (Figure 1) were detected more frequently ($p < 0.05$), with an average density of 3.9 parasites per kilo of fish and range of variation from one to 11 specimens in the samples. The Anisakis nematodes presented average density of one parasite per kilo of fillet, with range of variation of one to four specimens in the samples. Most were spirally encysted, but some were not encysted and others were in encysting process (Figure 2). The only specimen of isolated acanthocephalus was found without its posterior region (Figure 3).

Monoparasitic samples (80%) were significantly predominant ($p < 0.05$) in relation to samples that presented polyparasitism, containing more than one parasitic group (20%). Of these, one contained one larva of acanthocephalus and seven larvae of Trypanorhyncha, while another five contained larvae of Trypanorhyncha and Anisakis simultaneously.

The distribution of parasites in the fillets was diversified. They were found both on the surface and inserted in the muscle fibers. Although the location of the parasitic forms in the fillets was not tabulated, predominance was observed in the abdominal (ventral) region, but this data should be verified in future studies, with more samples. The possibility of detection methodology bias should also be considered, because although the fillets have been completely dissected, this region is thinner and enables better visualization in contrast with light.

The possibility of visual detection was not the object of this study, however, some parasite specimens could be seen with the naked eye, even without the aid of light, especially specimens of Anisakis and acanthocephalus. The Trypanorhyncha were visualized mainly by through contrast with white light.

This is the first report of detection of parasitic forms in commercial samples of frozen Walleye pollock fillets. Ecological studies with *G. chalcogrammus* (*T. chalcogramma*) show the natural occurrence of parasites, including the parasitic groups found in the present study, at variable sites of infection, such as mesentery, body cavity, intestinal wall, muscles, among others organs[7,12,8,11]. In the muscles of *G. chalcogrammus* (*T. chalcogramma*), captured in British Columbia and Alaska, researchers have found larvae of Anisakis nematodes (*Anisakis* sp.[12], *Anisakis simplex*[6,7] *and Pseudoterranova* sp.[12], *Pseudoterranova* decipiens[7]) and cestodes (*Nybelinia surmenicola*[6] and *Phyllobothrium* sp.[12]).

In Brazil, these same parasitic groups have been reported in several species of river and coastal fish like flounder, triggerfish, lookdown, among other[28,29,30]. Larvae of Anisakis nematodes have also been found in samples of dried and salted gutted cod sold in Brazil[31,32] and in Portugal[33].

Table. Frequency of positive samples and isolated parasites in Walleye pollock fillet samples, analyzed in the city of São Paulo, Brazil, between 2017 and 2018.

Type of parasite	Positive samples		Isolated parasites	
	n.	%	n.	%
Anisakis nematodes	10	23	15	11
Trypanorhyncha cestodes	25	57	117	88
Acanthocephalus	1	2	1	1
TOTAL	30*	68	133	100

* Six samples presented polyparasitism.

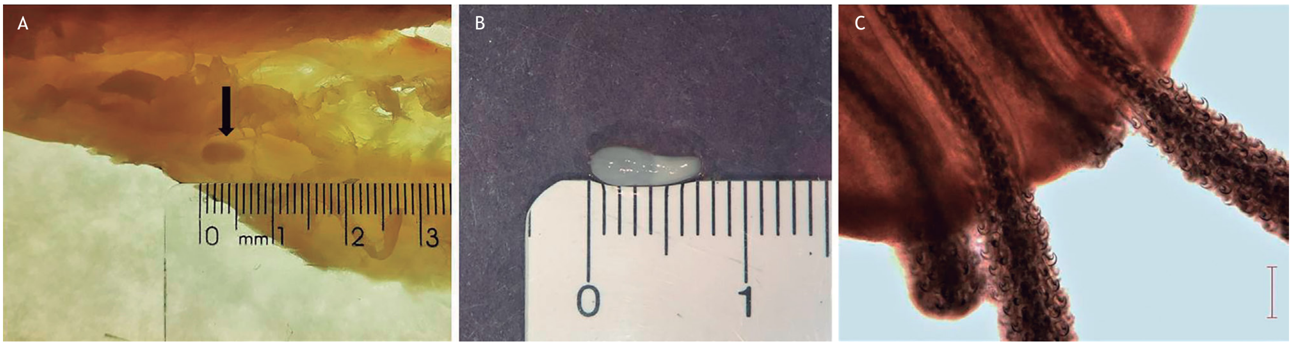

Figure 1. Cestodes of the Trypanorhyncha order isolated from *Gadus chalcogrammus*. (A) Macroscopic view of a specimen in a fillet on a light table. (B) Metacestoid observed under stereoscopic microscope. (C) Microscopic detail of the tentacle with hooks. Scale bar C = 100 µm.

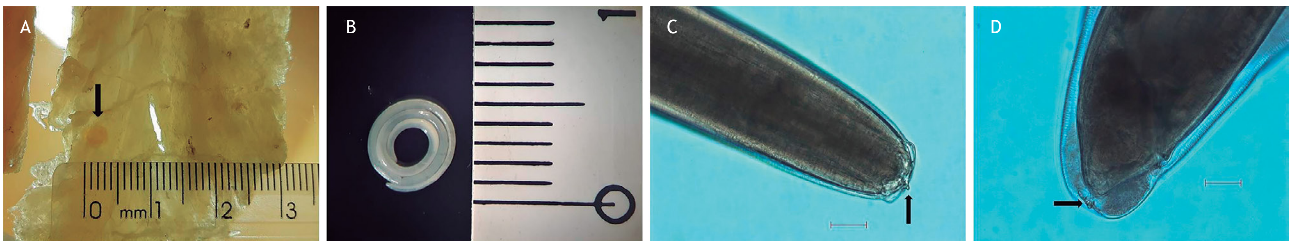

Figure 2. L3 Larvae of Anisakis nematodes isolated from *Gadus chalcogrammus*. (A) Macroscopic view of the larva in a fillet on a light table. (B) Larva removed from the cyst observed under stereoscopic microscope. (C) Microscopic detail of the anterior region with larval tooth (arrow). (D) Microscopic detail of the posterior region showing mucron (arrow). Scale bar C,D = 50 µm.

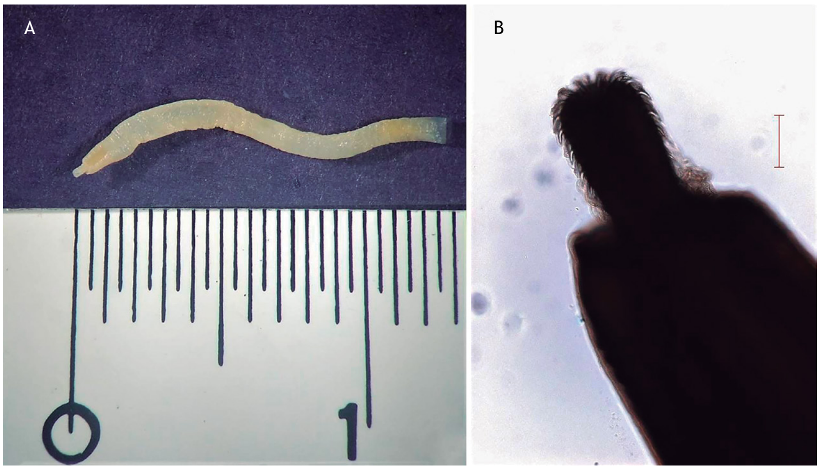

Figure 3. Acantocephalus larva isolated from *Gadus chalcogrammus*. (A) Stereomicroscope visualization. (B) Microscopic detail of proboscis with hooks at anterior extremity. Scale bar B = 100 µm.

The samples of Walleye pollock we analyzed underwent industrial evisceration, filleting, freezing processing and were subsequently selected for packaging. No information was found about the measures adopted to eliminate parasitic contamination in this product, but the results of the present study indicate that whatever was done was not enough to eliminate it completely, given the high percentage of positive samples.

The environment of wild fish like pollocks cannot be controlled, nor can their eating habits, so it is impossible to prevent them from acquiring lifelong parasites. However, the presence of parasites in the musculature is an aggravating factor, because it increases the possibility of ingestion. In this sense, good practices measures are necessary in the production chain, after the stage of capture, to reduce and/or eliminate parasitic contamination in the product that is provided to consumers, such as fillets. Many of these measures are contained in the Codex Alimentarius International Food Standards[34,35] and the Food and Drug Administration[36], as well as the Industrial and Sanitary Inspection Regulation for Animal Products[37] and the Technical Regulations of the Brazilian Ministry of Agriculture. Among them, fish evisceration is recommended right after capture to prevent the migration of Anisakis larvae to the musculature[38] and abdomen (belly) clippings, combined with visual inspection techniques using of light sources for the physical removal of parasites[34,35]. Cutting the ventral region may contribute to the reduction of parasitic contamination in Walleye pollock fillets, but the predominance of larval forms localization needs to be confirmed in further studies.

When fish still have parasitic forms even after processing and with the adoption of best practices, as may have occurred in the analyzed samples, thermal processes like freezing or cooking to inactivate the remaining larval forms and minimize the risk of transmission of parasitic infections are indicated. Nevertheless, the efficacy of these methods depends on the combination between appropriate time and temperature[36], since there are reports in scientific literature of survival of the L3 larva of Anisakis during the freezing process due to the use of insufficiently low temperatures and lack of temperature homogeneity within the freezer[39,40,41].

According to the Food and Drug Administration, freezing at at least -20°C for 7 days or at -35°C until solidification and maintenance of that temperature for a minimum of 15 h or after solidification and maintenance at -20°C for 24 h[36] would be sufficient to inactivate the parasites. According to the World Health Organization, cooking at temperatures above 70°C makes the fish safe for consumption[42]. Since the analyzed Walleye pollock fillets are imported and kept frozen for a long time until they are marketed, this process was enough to make the parasites unviable.

Although the larvae of the parasites found in the present study were dead, the risks of consuming Walleye pollock fillets containing Anisakis nematodes should be considered, since it has been found that proteins of nematodes like *A. simplex* are highly resistant to thermal processing and maintain their allergenic properties even after freezing[43,44,39]. Therefore, the findings may pose some risk due to the possibility of ingestion by sensitized individuals, who could have allergic reactions regardless of larval viability[45,46,47]. Furthermore, both exposure to small doses of antigens and repeated exposure to these allergens increase the risk of developing this condition[18]. In some species of cestodes of the Trypanorhyncha order, an allergenic potential has also been observed in mice with induction of immune sensitization and manifestation of allergic reactions, including anaphylaxis[48,49,50].

In Brazil there is only one case of anisakiasis reported in a patient who may have consumed raw seafood, with manifestation of gastrointestinal lesions[51], and there are no medical reports of allergic reactions caused by Anisakis. It is difficult, however, to determine if there were no cases or if they were not diagnosed. In addition to the issues related to human health arising from the consumption of fish fillets containing parasites, one must also consider the impact that this may have on consumers who get to see them, because, although dead, they have a disgusting appearance when present in food.

To prevent these occurrences, techniques for reducing parasitic contamination in processed fish must be improved and adopted to the maximum, thus contributing to the supply of high quality products in sanitary terms. Public sharing of information about the possibility of natural occurrence of parasites in extractive sea fish and about potential health risks also contribute to the understanding and prevention of any events.

CONCLUSIONS

Dead parasites were detected in 68% of the samples, indicating that there is a need for improvement regarding good practices in processing Walleye pollock to eliminate or reduce parasitic contamination in fillets intended for human consumption.

The presence of these parasites in frozen Walleye pollock fillets does not pose risks of infection to consumers, but this should be carefully evaluated by the competent bodies due to the allergenic potential of the Anisakis group larvae, as well as the possibility of causing disgust to consumers.

REFERENCES

1. Cohen DM, Inada T, Iwamoto T, Scialabba N. Gadiform fishes of the world (order gadiformes): an annotated and illustrated catalogue of cods, hakes, grenadiers and other gadiform fishes known to date. Rome: Food and Agriculture Organization of United Nations; 1990[acesso 26 fev 2019. Disponível em: http://www.fao.org/3/t0243e/t0243e09.pdf
2. Food and Agriculture Organization of United Nations - FAO. The state of world fisheries and aquaculture: meeting the sustainable development goals. Rome: Food and Agriculture Organization of United Nations; 2018[acesso 20 fev 2019. Disponível em: http://www.fao.org/state-of-fisheries-aquaculture
3. Strobel C, Jahreis G, Kuhnt K. Survey of n-3 and n-6 polyunsaturated fatty acids in fish and fish products. Lipids Health Dis. 2012;11:144. https://doi.org/10.1186/1476-511X-11-144
4. Ministério da Indústria, Comércio Exterior e Serviços (BR). Base de dados do Comex Stat. Brasília: Ministério da Indústria, Comércio Exterior e Serviços; 2019[acesso 5 mar 2019]. Disponível em: http://comexstat.mdic.gov.br
5. Luque Jl. Biologia, epidemiologia e controle de parasitos de peixes. Rev Bras Parasitol Vet. 2004;13(1):161-5.
6. Arthur JR, Margolis L, Whitaker DJ, McDonald TE. A quantitative study of economically important parasites of walleye pollock (*Theragra chalcogramma*) from British Columbian waters and effects of postmortem handling on their abundance in the musculature. Can J Fish Aquat Sci. 1982;39(5):710-26. https://doi.org/10.1139/f82-100
7. Arthur JR. A survey of the parasites of walleye pollock (*Theragra 370 chalcogramma*) from the northeastern pacific ocean of Canada and a 371 zoogeographical analysis of the parasite fauna of this fish throughout its 372 range. Can J Zool. 1984;62(4):675-84. https://doi.org/10.1139/z84-099
8. Umehara A, Kawakami Y, Matsui T, Araki J, Uchida A. Molecular identification of *Anisakis simplex* sensu stricto and *Anisakis pegreffii* (nematoda: anisakidae) from fish and cetacean in Japanese waters. Parasitol Int. 2006;55(4):267-71. https://doi.org/10.1016/j.parint.2006.07.001
9. Quiazon KMA, Yoshinaga T, Ogawa K, Yukami R. Morphological differences between larvae and in vitro-cultured adults of *Anisakis simplex* (sensu stricto) and *Anisakis pegreffii* (nematoda: anisakidae). Parasitol Int. 2008;57(4):483-9. https://doi.org/10.1016/j.parint.2008.06.003
10. Quiazon KMA, Yoshinaga T, Santos MD, Ogawa K. Identification of larval *Anisakis* spp. (nematoda: anisakidae) in alaska pollock (*Theragra chalcogramma*) in northern Japan using morphological and molecular markers. J Parasitol. 2009;95(5):1227-32. https://doi.org/10.1645/GE-1751.1
11. Quiazon KMA, Yoshinaga T, Ogawa K. Distribution of anisakis species larvae from fishes of the Japanese waters. Parasitology Int. 2011;60(2):223-6. https://doi.org/10.1016/j.parint.2011.03.002
12. Moles A, Heintz RA. Parasites of forage fishes in the vicinity of steller sea lion (*Eumetopias jubatus*) habitat in Alaska. J Wildl Dis. 2007;43(3):366-75. https://doi.org/10.7589/0090-3558-43.3.366
13. Morado JF, Mc Fee DA. Diseases and parasites of juvenile walleye pollock, theragra chalcogramma, from the gulf of Alaska, 1986-1988. In: Department of Commerce (US). NOAA technical report national marine fisheries service. Washington: USDC; 1996. p. 89-103.
14. Adams AM, Murrell KD, Cross JH. Parasites of fish and risks to public health. Rev Sci Tech Off Int Epiz. 1997;16(2):652-60. https://doi.org/10.20506/rst.16.2.1059
15. Kuraiem BP, Knoff M, Felizardo NN, Menezes RC, Gomes DC, São Clemente SC. Histopathological changes induced *by Hysterothylacium deardorffoverstreetorum larvae* (nematoda: raphidascarididae) in priacanthus arenatus cuvier, 1829 (actinopterygii). Rev Bras Parasito Vet. 2017;26(2):239-42. https://doi.org/10.1590/s1984-29612017017
16. Buchmann K, Mehrdana F. Effects of anisakid nematodes *Anisakis simplex* (s.l.), P*seudoterranova decipiens* (s.l.) and *Contracaecum osculatum* (s.l.) on fish and consumer health. Food Water Parasitol. 2016;4:13-22. https://doi.org/10.1016/j.fawpar.2016.07.003

17. Zuloaga J, Arias J, Balibrea JL. Anisakiasis digestiva: aspectos de interés para el cirujano. Cir Esp. 2004;75(1):9-13. https://doi.org/10.1016/S0009-739X(04)72265-4
18. Audicana MT, Kennedy MW. *Anisakis simplex*: from obscure infectious worm to inducer of immune hypersensitivity. Clin Microbiol Rev. 2008;21(2):360-79. https://doi.org/10.1128/CMR.00012-07
19. Acha PN, Szyfres B. Zoonoses and communicable diseases common to man and animals. 3a ed. Washington: PAHO; 2003.
20. São Clemente SC, Uchoa CMA, Serra Freire NM. Larvas de anisakideos em *Pagrus pagrus* (L.) e seu controle através de baixas temperaturas. Ver Bras Cienc Vet. 1994;1(1):21-4. https://doi.org/10.4322/rbcv.2015.006
21. Zuchinalli JC, Barros LA, Felizardo NN, Calixto FAA, São Clemente SC. Trypanorhyncha cestodes parasites of guaivira important in seafood hygiene. Bol Inst Pesca. 2016;42(3):704-9. https://doi.org/10.20950/1678-2305.2016v42n3p704
22. Felizardo NN, Knoff M, Diniz JB, Torres EJ, Calixto FAA, São Clemente SC. Pterobothrium crassicolle parasitizing *Paralichthys orbignyanus* (Osteichthyes, paralichthyidae) in Brazil. An Acad Bras Cienc. 2018;90(2):1605-10. https://doi.org/10.1590/0001-3765201820170323
23. Hartwich G. Ascaridida. In: Anderson RC, Chabaud AG, Willmott S. Keys to the nematode parasite of vertebrates. London: MPG; 2009. p. 309-23.
24. Felizardo NN, Knoff M, Pinto RM, Gomes DC. Larval anisakid nematodes of the flounder, P*aralichthys isosceles* jordan, 1890 (pisces: teleostei) from Brazil. Neltrop Helminthol. 2009;3(2):57-64.
25. Beveridge I, Campbell RA. New records and descriptions of *Trypanorhynch cestodes* from Australian fishes. Rec S Aust Museum. 1996;29(1):1-22.
26. Amin OM. Classification of the Acanthocephala. Folia Parasitol. 2013;60(4):273-305. https://doi.org/10.14411/fp.2013.031
27. EFSA Panel on Biological Hazards - Biohaz. Scientific opinion on risk assessment of parasites in fishery products. EFSA J. 2010;8(4). https://doi.org/10.2903/j.efsa.2010.1543
28. Fonseca MCG. Cestóides da ordem trypanorhyncha de importância higiênico-sanitária em linguados *Paralichthys patagonicus* (Jordan, 1889) e *Xystreurys rasile* (Jordan, 1891) na região neotropical, Brasil [dissertação]. Rio de Janeiro: Universidade Federal Fluminense; 2012.
29. Dias FJE, São Clemente SC, Knoff M. Nematoides anisaquídeos e cestoides trypanorhyncha de importância em saúde pública em *Aluterus monoceros* (Linnaeus, 1758) no Estado do Rio de Janeiro, Brasil. Rev Bras Parasitol Vet. 2010;19(2):94-7. https://doi.org/10.1590/S1984-29612010000200005
30. Fontenelle G, Knoff M, Felizardo NN, Torres EJL, Lopes LMDS, Gomes DC et al. Anisakidae and raphidascarididae larvae parasitizing *Selene setapinnis* (Mitchill, 1815) in the State of Rio de Janeiro, Brazil. Rev Bras Parasitol Vet. 2015;24(1):72-7. https://doi.org/10.1590/S1984-29612015010
31. Pereira AD, Atuí MB, Torres DMAGV, Mangini ACS, Zamboni CQ. Incidência de parasitos da família anisakidae em bacalhau (*Gadus morhua*) comercializado no Estado de São Paulo. Rev Inst Adolfo Lutz. 2000;59(1-2):45-9.
32. Prado SDPT, Capuano DM. Relato de nematoides da família anisakidae em bacalhau comercializado em Ribeirão Preto, SP. Rev Soc Bras Med Trop. 2006;39(6):580-1. https://doi.org/10.1590/S0037-86822006000600016
33. Ramos, P. Anisakis spp. em bacalhau, sushi e sashimi: risco de infecção parasitária e alergia. Rev Port Cienc Vet. 2011;106(577-580):87-97.
34. Codex Alimentarius International Food Standards – Caifs. Code of practice for fish and fishery products. Rome: Food and Agriculture Organization of the United Nations; 2013[acesso 22 out 2018]. Disponível em: www.fao.org/input/download/standards/10273/CXP_052e.pdf
35. Codex Alimentarius International Food Standards – Caifs. Guidelines on the application of general principles of food hygiene to the control of foodborn parasites. Rome: Food and Agriculture Organization of the United Nations; 2016[acesso 22 out 2018]. Disponível em: http://www.fao.org/fao-who-codexalimentarius/codex-texts/guidelines/en/
36. Office of Food Safety (US). Fish and fishery products hazards and controls guidance. 4a ed. Washington: USOFS; 2011[acesso 16 out 2017]. Disponível em: https://www.fda.gov/food/guidanceregulation/guidancedocumentsregulatoryinformation/seafood/ucm2018426.htm
37. Brasil. Decreto Nº 9.013, de 29 de março de 2017. Regulamenta a Lei Nº 1.283, de 18 de dez de 1950 e a Lei Nº 7.889, de 23 de nov de 1989, que dispõe sobre a inspeção industrial e sanitária de produtos de origem animal. Diário Oficial União. 30 mar 2017.
38. Abollo E, Gestal C, Pascual S. Anisakis infestation in marine fish and cephalopods from galician waters: an updated perspective. Parasitol Res. 2001;87(6):492-9.
39. Sánchez-Alonso I, Carballeda-Sangiao N, González-Muñoz M, Navas A, Arcos SC, Mendizábal A et al. Pathogenic potential of anisakis L3 after freezing in domestic freezers. Food Control. 2018;84:61-9. https://doi.org/10.1016/j.foodcont.2017.07.010
40. Adams AM, Ton MN, Wekell MM, MacKenzie AP, Dong FM. Survival of anisakis simplex in arrowtooth flounder (*Atheresthes stomia*) during frozen storage. J Food Prot. 2005;68(7):1441-6. https://doi.org/10.4315/0362-028X-68.7.1441
41. Wharton DA, Aalders O. The response of anisakis larvae to freezing. J Helminthol. 2002;76(4):363-8. https://doi.org/10.1079/JOH2002149
42. Rossi GAM, Hoppe EGL, Prata LF. Zoonoses parasitárias veiculadas por alimentos de origem animal: revisão sobre a situação no Brasil. Arq Inst Biol. 2014;81(3):290-8. https://doi.org/10.1590/1808-1657000742012

43. Moneo I, Caballero ML, Gómez F, Ortega E, Alonso MJ. Isolation and characterization of a major allergen from the fish parasite *Anisakis simplex*. J Allergy Clin Immunol. 2000;106(1),177-82. https://doi.org/10.1067/mai.2000.106732

44. Vidacek S, Heras C, Solas MT, Mendizábal A, Rodrigues-Mahilo AI, González-Munoz M et al. *Anisax simplex* allergens remain active after conventional or microwave heating and pepsin treatments of chilled and frozen L3 larvae. J Sci Food Agric. 2009;89(12):1997-2002. https://doi.org/10.1002/jsfa.3677

45. Mattos DPBG, Verícimo MA, Lopes LMS, São Clemente SC. Immunogenic activity of the fish tapeworm *Pterobothrium heteracanthum* (trypanorhyncha: pterobothriidae) in BALB/c mice. J Helmint. 2015;89(2):203-7. https://doi.org/10.1017/S0022149X13000795

46. Fontenelle G, Knoff M, Verícimo MA, São Clemente SC. Epicutaneous sensitization with nematode antigens of fish parasites results in the production of specific IgG and IgE. J Helmint. 2018;92(4):403-9. https://doi.org/10.1017/S0022149X17000633

47. Ribeiro J, Knoff M, Felizardo NN, Vericimo MA, São Clemente SC. Resposta imunológica a antígenos de *Hysterothylacium deardorffoverstreetorum* de peixes teleósteos. Arq Bras Med Vet Zootec. 2017;69(2):422-8. https://dx.doi.org/10.1590/1678-4162-9383

48. Gòmez-Morales MA, Ludovisi A, Giuffra E, Manfredi MT, Piccolo G, Pozio E. Allergenic activity of *Molicola horridus* (cestoda, trypanorhyncha), a cosmopolitan fish parasite, in a mouse model. Vet Parasitol. 2008;157(3):314-20. https://doi.org/10.1016/j.vetpar.2008.07.010

49. Vázquez-López C, Armas-Serra C, Bernardina W, Rodrıguez-Caabeiro F. Oral inoculation with *Gymnorhynchus gigas* induces anti-parasite anapyhylactic antibody production in both mice and rats and adverse reactions in challenge mice. Int J Food Microbiol. 2001;64(3):307-15. https://doi.org/10.1016/S0168-1605(00)00477-3

50. Mattos D, Verícimo MA, São Clemente SC. O pescado e os cestoides trypanorhyncha do aspecto higiênico ao potencial alergênico. Vet Not. 2013;19:127-39.

51. Cruz AR, Souto PCS, Ferrari CKB, Allegretti SM, Arrais-Silva WW. Endoscopic imaging of the first clinical case of anisakidosis in Brazil. Sci Parasitol. 2010;11(2):97-100.

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Conflict of Interest

Authors have no potential conflict of interest to declare, related to this study's political or financial peers and institutions.