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THE EFFECT OF HOUSEHOLD SMOKING ON THE INFESTIVENESS OF *DIPHYLLOBOTHRIUM LATUM* FROM FISH TO MAN*)

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The small-scale smoking of fish at home and out of doors is becoming increasingly important from the point of view of infestation by the fish tapeworm, *Diphyllobothrium latum*. The following factors contribute to the popularity of smoking: it is an easy method of preparing fish even in outdoor circumstances, the necessary implements are simple, and correctly smoked fish is delicious. Insufficiently heated fish may, however, contain viable tapeworm larvae and thus be hazardous. Since the data on the effect of smoking on the infestiveness of *Diphyllobothrium latum* are incomplete, the present study was carried out to provide additional information. Three common commercially available types of smoke box were used in the experiments. This study is an extension of previous investigations concerning the effect of customary heat preparation methods on the infestiveness of *D. latum* (1). The estimate of the adequateness of smoking is based on the lethal temperature/time exposure of 56°C/5 min. of the fish tapeworm larvae (1, 2).

MATERIAL

Description of the smoke boxes

Box A (manufactured by AB Urfabriken, Svängsta, Sweden) is equipped with a drip-tray at the bottom of the box, and a lattice at a height of 2.4 cm from the bottom. The tight-fitting

*) This study was supported by the National Research Council for Medical Sciences in Finland.

lid slides horizontally. A 7.5 cm high casing, open at one end and of the same length and breadth as the box, is placed under the box during operation. For heating the oven a 70 ml fuel container and asbestos wick belong to the set. Methylated spirit is used as fuel, according to the recommendations given by the manufacturer. After approximately 10 min. the fire is automatically extinguished when 60 ml spirit is used. The maximum burning time observed was 13 min. when the container was filled to the brim. The maximum temperature observed in the box during smoking was about 210°C. An instruction leaflet with a selection of fish and other food preparation suggestions is included in the outfit.

Table 1. The inner dimensions, volume and thickness of the metal of the smoke boxes.

	Length cm	Breadth cm	Height cm	Volume dm ³	Thickness of the metal, mm
Box A	27.3	15.8	7.4	3.2	0.7
Box B	40.0	22.3	13.0	11.6	0.75
Box C	39.8	23.8	12.5	10.0	0.6 (lid)
		15.2			0.72
		at bottom			

Box B (manufactured by Erämetalli, Helsinki, Finland) has a drip-tray at the bottom and two lattices at a height of 3.9 cm and 8.0 cm from the bottom. The tight-fitting lid slides horizontally. The maximum temperature observed in the box during smoking was about 160°C.

Box C (manufactured by Lehtovuori ky, Lahti, Finland) has the lattice at a height of 4.5 cm from the bottom, resting on the tapering lower part of the walls. The lid is removed by lifting vertically. The maximum temperature observed in the box during smoking was about 140°C. The box is placed at a height of 9.0 cm from the ground by means of a stand of approximately the same size as the box.

Fish

The trials were carried out on local marine fish caught on the average 1—2 days earlier. A total of 71.5 kg fish was used.

Of these 66.5 kg were pike and 5.0 kg perch. The weight of pikes varied between 440 g and 2150 g, and that of the perches between 320 g and 750 g.

METHODS

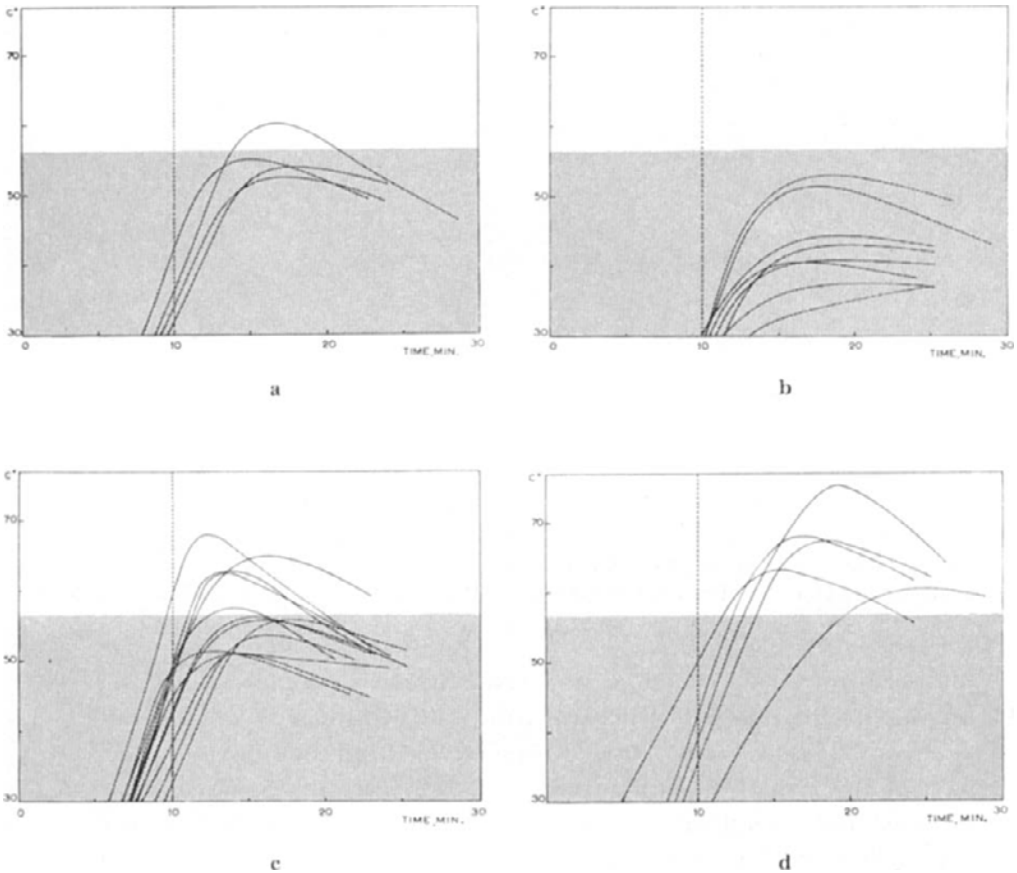
The fish to be used in the experiments were weighed and the viscera and head removed. The fish were smoked unscaled. An even layer of sawdust was sprinkled on the bottom of the smoke boxes. The fish were placed on the lattices and the thermocouples located in the fish, at the sites of least temperature change known from the previous studies (1). The lattices were put into position and the lid shut. One to three fish were smoked simultaneously, utilizing the whole capacity of the boxes. The heating device used was the alcohol burner for box A, and a gas flame of constant intensity for boxes B and C.

A constant smoking time, i. e. the time the alcohol fire burned, was used for box A. For boxes B and C, which are not equipped with a heating device, smoking was continued until each point of the fish had been subjected to the critical exposure of tape-worm larvae, when the flame was turned off. The boxes were opened within 1 min. and the fish removed from the box. The temperature measurement was carried out according to the method described in (1). The recording was continued after the removal of the fish from the boxes, until the temperature at each point of the fish had reached the maximum value.

After each test an organoleptic testing of the fish was carried out independently by at least two persons. The criteria for the organoleptic testing were those described in (1).

RESULTS

The results of the experiments are presented in Figs. 1 a—d and 2 a—b. In Figs. 1 a—c temperature changes at the sites of least temperature rise in pikes weighing less than 500 g (a), 500—750 g (b), and in perches weighing less than 500 g (c), smoked in box A, are shown. The lid of the smoke box was opened and the fish removed within 1 min. after the spirit flame had been extinguished. In Fig. 1 d the corresponding temperature changes in pikes in the range of 500—750 g, when the lid was opened and the fish removed 10 min. after the spirit fire was extinguished, are shown. Fig. 1 a shows that only in one of the



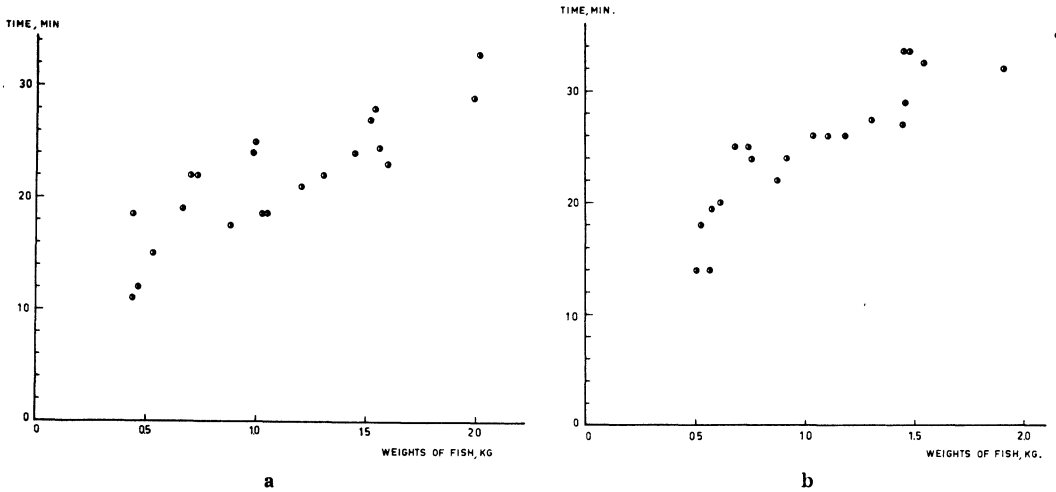
Figures 1 a, b, c and d. Temperature changes at the sites of least temperature rise during smoking in box A.

- a) pikes, weights less than 0.5 kg
- b) pikes, weights 0.5—0.75 kg
- c) perches, weights less than 0.5 kg
- d) pikes, weights 0.5—0.75 kg

The lid was opened and the fish removed from the box within 1 min. after the fire was extinguished (a—c), or after 10 min. (d).

Dark area: temperatures below 56°C, where according to in vitro tests the plerocercoids may survive a 5 min. treatment. Dotted line: the moment when the flame was extinguished.

pike under 500 g did the temperature rise over 56°C. Fig. 1 b shows that none of the fish tested in this group reached the temperature of 56°C. The experiments carried out with perches, described in Fig. 1 c, showed that out of the total of 12 fish the



Figures 2 a and b. The correlation between the weights of the fish and the smoking times needed in order to subject the site of least temperature change in the fish to a $56^{\circ}\text{C}/5$ min. exposure in box B (a) and box C (b). Each point represents the result of one separate test.

temperature rose over 56°C in 7 fish. In conclusion it seems that during the investigated heating time of 10 min. it is only in the smallest fish that the temperature rises high enough for each part of the fish to be subjected to a $56^{\circ}\text{C}/5$ min. exposure, while in most fish weighing less than 500 g and in all fish weighing over 500 g the larvae would probably survive the smoking treatment, if the lid were opened and the fish removed from the box immediately. From Fig. 1 d it can be seen, how the temperature rises as the fish is left in the box for an additional 10 min. period.

Table 2. The practical smoking times for boxes B and C in order to reach the critical exposure of tapeworm larvae in fish.

	Fish weight, kg	Smoking time, min.
Box B	less than 0.5	20
	0.5—1.0	25
	1.0—1.5	30
	1.5—2.0	35
Box C	less than 0.5	25
	0.5—1.0	30
	1.0—2.0	35

In all the pikes studied in the weight range of 500—750 g the temperature rose well over the critical limit of 56°C.

Figs. 2 a—b show the smoking times needed in order to subject the site of the least temperature change in the fish to a 56°C/5 min. exposure in boxes B and C. The smoking times observed to be effective in box B vary between 11 and 33 min. for fish weights between 0.44 and 2.0 kg, and for box C the corresponding times are 14 and 35 min. for fish weights between 0.50 and 2.1 kg. On the basis of the longest smoking times needed for the desired effect in the tests, the data from Table 2 can be used for advice and instruction concerning these boxes.

Organoleptic testing of the smoked fish showed that fish in which all parts had been subjected to a 56°C/5 min. exposure was cooked.

DISCUSSION

In the present study the effect of smoking on tapeworm larvae was considered to depend only on the high temperature; the possible effect of the constituents of smoke were considered to be of minor importance.

Small-scale household smoking can be carried out in smoke boxes of the most heterogenous construction. For this study some typical commercially available boxes were selected and the obtained results are valid only for them. The results are, however, directive, since they are in accordance with the conclusion of the previous studies, that in well cooked fish the tapeworm larvae have been killed. Specially reliable criteria for well smoked fish are the following: the consistency of the flesh is firm and the muscle bundles can be divided; the fish bones, especially the vertebral column, are easily detachable from the flesh, and not even tiny bits of flesh stick to the bones. On the contrary, the colour of the surfaces and the typical taste of raw fish are masked by the smoke. The effect of smoking in boxes of other types may be estimated on the basis of the given criteria.

The instructions given by the manufacturer of box A seem to give misleading information. According to the instruction leaflet, "in only 8 minutes you will get delicious, warm, newly-smoked fish of all kinds." The given period of time of 8 min. refers to the burning time of the spirit stove, and the reader is induced to think that in 8 min. the fish would be ready for the table. However, as has been shown, with this treatment all

parts of the fish are not subjected to the 56°C/5 min. exposure, and consequently some may contain viable larvae, even if the instructions to fillet fish weighing over 0.5 kg are followed. The result may be a tapeworm infestation due to insufficient instructions given by the manufacturer. Thus it seems imperative to add to the instructions a warning not to open the lid or remove the fish from the box until a sufficient time, preferably 10 min., has elapsed since extinction of the fire. By this method, fish weighing less than 750 g are safe as far as the risk of tapeworm infestation is concerned. This is practically the largest fish that the box can take. Alternatively, an alcohol burner with a longer burning time should be used.

The boxes B and C represent the typical conventional smoke box construction. The observed differences in the smoking times for smaller fish with these boxes can be explained as depending on their structure. The temperature in box B rises more quickly than in box C, because the lid of the former is tight, while that of the latter seems to become warped leaving a gap between the lid and the wall of the box, which results in a loss of smoke and heat. This can be prevented by putting a load on the lid to keep it even. The longer smoking time for box B for larger fish is accounted for by the greater amount of fish that can be smoked in box B than in box C. Box B is equipped with two lattices, both of which were utilized in the experiments; box C, on the other hand, has only one lattice and consequently space for a smaller amount of fish.

In the tests the fish was not removed from boxes B and C until the temperature in the fish had risen to 56°C. The temperature was, however, observed to rise in the interior of the fish by at least 5°C after the smoking was over, and consequently the final temperature of the fish tested always rose well over 60°C. Thus, as a rule of thumb covering both boxes B and C, fish weighing less than 2 kg is safe after 30 min. smoking.

REFERENCES

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SUMMARY

The effect of household smoking, as carried out with three commercially available smoke boxes, on the infestiveness of *Diphyllbothrium latum* was investigated. The temperature changes in fish during the smoking were measured and the effect on tapeworm larvae estimated on the basis of a lethal temperature/time exposure of 56°C/5 min. For all the boxes smoking treatments sufficient to destroy the tapeworm larvae are suggested. The obtained results confirm the conclusion, made in previous studies on other heat preparation methods of fish, that well cooked fish in which all the parts have been subjected to a 56°C/5 min. exposure is safe with regard to the risk of *Diphyllbothrium latum* infestation.

SAMMANFATTNING

Effekten av hemrökning av fisk på Diphyllbothrium latum's förmåga att invadera människa.

I arbetet undersöktes effekten av hushålls-rökandet på infektiviteten av *Diphyllbothrium latum* med tre i handeln förekommande rökugnar. Temperaturförändringarna i fisken under rökningen mättes, och effekten på binnikemasklarverna bedömdes på grund av en letal temperatur/tid 56°C/5 min. För alla rökugnar föreslås behandlingar, som är tillräckliga för att döda binnikemasklarven. De erhållna resultaten bestyrker slutsatsen man gjort i tidigare undersökningar av andra värmebehandlingsmetoder av fisk, att väl upphettad fisk, vars alla delar blivit utsatta för 56°C/5 min. exponering, är ofarlig med hänseende på risken för *Diphyllbothrium latum* infestation.

(Received October 17, 1969).