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by J. Wurziger and G. Dickhaut

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# Harmful substances in fatty fish preparations

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Harmful substances in fatty fish preparations

by

J. Wurziger and G. Dickhaut

From the Chemische- und Lebensmitteluntersuchungsanstalt im Hygiensichen Institut der Freien und Hansestadt Hamburg,

[Chemical and Food Testing Laboratory,

Institute of Hygiene of the City of Hamburg].

Hamburg, Federal Republic of Germany

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Summary - The presence of harmful substances in fish and fish preparations is reviewed. The discussions include mercery, DDT and PCB. Harmful substances can be removed from fish oils by intensive processing. It is demonstrated that oxidative changes in fish oils might indicate the presence of harmful substances. Relationships between the age as well as the length of the fishes and their mercury content are outlined. Examples are given, which show that it is not necessary to examine younger fishes and preparations of these fishes for harmful substances. Large and heavy, i.e. old fishes should be sorted out immediately after hauling and processed separately to yield oils that can be freed from harmful substances after refining and hardening.

UGF Lecture presented at the Conference of the German Association for Fat Research] in Hamburg, on 8 October 1975.

Address of the authors: Prof. Dr. J. Wurziger und Dr. G. Dickhaut, Chemische- und Lebensmitteluntersuchungsanstalt im Hygienischen Institut der Freien und Hansestadt Hamburg,

Gordh-Fock-Wall 15-17, 2000 Hamburg 36, Federal Republic of Germany

Translator's note - In order to assist in proper identification of the species, I have added the scientific names shown between square brackets. -

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Mechanical separation of fish oil from fatty fish preparations generally is associated with shifts in the distribution of the harmful substances. The usability of highly contaminated fatty fish parts could be improved by mechanical separation of fish oil. Conversion factors correlating processed fish to fresh fish are given for different species of fish treated in different ways.

The presence of harmful substances in the environment will inevitably lead to direct and indirect contamination of food; at higher concentrations, contamination will impair the usability of foodstuffs. By means of legal measures, like, for example, the mercury regulations of 6 February 1975 and the regulations on maximally acceptable concentrations in animal feedstuffs of 15 November 1973, it is possible to ensure that the consumer is not offered foodstuffs containing harmful substances above the permissible concentrations. In this connection, there also arises the question regarding the disposal or further processing, respectively, of excessively contaminated and, thus, no longer marketable foodstuffs. 166

The situation existing with regard to the harmuful substances mercury and dichloro-diphenyl trichloroethane (DDT), regulated by the laws relating to food processing and distribution, will be outlined in the present paper using different fishes as illustrations.

Fish oils are obtained during the preparation and processing of fishes and fish parts. The high fraction of polyunsaturated fatty acids, in connection with the industrial processing methods commonly employed, leads frequently to noticeable and, in particular, oxidative changes of the fats. Fish oils are not used in the untreated state in food preparations, and in the refined state, at best, in individual cases like, for example, as fish frying oils. Table 1 shows the results obtained in our investigations of industry-processed fish oils.

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<u>Table 1</u> - Alkali color numbers (ACN) and harmful substances (DDT and PCB) in fish oils. <u>Key:</u> 1, Description; 2, ACN; 3, Fish oil, crude; 4, Fish oil, deacified and bleached; 5, Fish oil, hardened; 6, Hardened fish oil, deacified; 7, Hardened fish oil, bleached; 8, Harden fish oil, steam-treated; 9, Present; 10, Traces; 11, Not detected.

| Bezeichnung                         | 2      | AFZ           | DDT<br>[ppm] | РСВ              |
|-------------------------------------|--------|---------------|--------------|------------------|
| Fischöl, roh                        | 3      | 5.0           | 0.31         | 9 vorhanden      |
| Fischöl, entsäuert und<br>gebleicht | 4<br>4 | 4.4           | 0.14         | 10 Spuren        |
| Fischöl, gehärtet                   | 2      | 0.40          | 0.03         | <b>10</b> Spuren |
| Gehärtetes Fischöl,<br>entsäuert    | 6      | 0. <b>2</b> 8 | < 0.01       | ų n. n.          |
| Gehärtetes Fischöl,<br>gebleicht    | 7      | 0.17          | < 0.01       | (f n. n.         |
| Gehärtetes Fischöl,<br>gedämpft     | 8      | 0.10          | < 0.01       | 🙌 n. n.          |

Table 2 - Age and average length of herrings. Key: 1, Description; 2, Age in years; 3, Average length, in cm; 4, Herrings.

| Bezeichnung | Alter in Jahren<br><b>2</b> | 3 mittlere Länge<br>[cm] |
|-------------|-----------------------------|--------------------------|
| Heringe 4   | 3                           | 26.1                     |
|             | 4                           | 28.7                     |
| 7           | 5                           | 30.7                     |
| "           | 6                           | 31.2                     |
| "           | 7                           | 52.3                     |
| 11          | 8                           | 32.7                     |
| "           | 9                           | 33.0                     |
| *           | <b>&gt;</b> <sup>9</sup>    | 34.4                     |

The oxidative fat changes have been expressed as ACN (1). DDT and its isomers as well as the polychlorinated biphenyls (PCB) were determined by thin-layer- and gas-chromatographic means (2). However, in the case of the PCB, we have not performed quantitative determinations. Our tabulation shows that the crude fish oil contained DDT and its isomers (calculated as DDT) as well as PCB. While deacidification (deoxidation) and bleaching decreased the oxidized fatty substances only minimally, the harmful substances could be largely removed by means of these steps. The hardened fish oils, on the other hand, neither yielded ACN worthy of note, nor did they contain DDT and PCB, independent of the processing stage. In crude fish oils prepared by industrial means, the ACN can be used not only as a measuring stick for the degree of fat oxidation, but also as indicator for the presence of certain harmful substances.

In the case of fish destined for human consumption, we must proceed in a different way. The fishes received by commercial fish-processing plants differ-independent of the species-with respect to size and, thus, age. The quantities of harmful substances taken up by fishes and deposited in the fat or in the muscular flesh are closely correlated with the age of the fishes. Young or juvenile fishes, thus, generally contain less harmful substances than full-grown or old fishes.

More than 80 per cent of the entire North-Sea herring catch consisted in 1971 - 1972 of juvenile herrings or pre-spawners. Investigations of herrings carried out so far indicate that the levels of the harmful substances under consideration are far below the permissible maximal values. Table 2 illustrates the relationship existing between the age and the length of herrings.

Herrings may reach a length of 42 to 45 cm. Herrings being processed usually measure between 12 and 30 cm in length; they are then up to five years old. This is not valid in the cases or herring races that do not reach the afore-mentioned lengths, like the Baltic herring, for instance.

According to the findings obtained in herrings, we are permitted to assume that many other species of fish also do not exhibit excessive levels of hermful substances up to that age.

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As sardines we describe the fishes of the species <u>Clupea pilchardus</u>, measuring less than 20 cm in length. These herring-like fishes, to be sure, can become 27 cm long. At first maturity, at the age of about two years, the sardines measure between 12 and 15 cm in length. Their fat content exhibits considerable variations, which, however, are closely related to the reproductive cycle. According to B. Seiffert (3), any fat content may be found at any fish length. The fish lengths, thus, are of no significance with respect to fat content, but are important for estimating the age of the sardines and the potential concentrations of harmful substances. During processing, sardines are sorted in accordance with their length. In consequence, commercial cans will contain between 2 and 12 sardines. Most frquently, the usual cans contain four to six sardines. On the basis of the number of sardines, we are then able to draw conclusions regarding the length and, thus, also the age of the processed sardines. Table 3 summarized the results obtained in our investigations of canned sardines.

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The fishes processed into "sardines in oil" usually are only up to 18 om long. The age of the majority of these fishes, thus, amounts to less than four years. The mercury values (4) were far below the permissible maximal values. Pre-cooking and sterilization reduce the weight of the fishes—independent of the fat content of the sardines—by about 25 per cent. In the edible part of the fresh fish, the mercury values are thus lower by that percentage. Since almost without exception refined vegetable oils are used as almost added oils in all processing regions, "sardines in oil" represent fish preparations containing very small quantities of mercury. It is therefore not necessary to examine such preparations for the presence of mercury.

Age determinations cannot be performed readily and reliably in all fish species. Table 4 provides data on ages of fishes, and on the lengths of fishes we may expect at certain ages.

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| l Bez     | cichnu         | ng       | 2. Inhalt<br>in Stück | 3Rückenlänge<br>[cm] | Quecksilber<br>V [ppm] |
|-----------|----------------|----------|-----------------------|----------------------|------------------------|
| Sardinen, | 197 <b>3</b> , | Portugal | 4                     | 7.5                  | 0.09                   |
| •         | n              |          | 4                     | 7.5                  | 0.11                   |
| n         | n              | 77       | 4                     | 7.5                  | 0.11                   |
| 17        | n              | n        | 4                     | 7.0, 7.5, 8.0, 8.3   | 0.12                   |
| n         |                | n        | 4                     | 7.0                  | 0.12                   |
| *         |                |          | 4                     | 7.5                  | 0.06                   |
| =         | 1974,          | n        | 4                     | 7.5 - 8.1            | 0.10                   |
| n         | **             |          | 6                     | 5.8                  | 0.14                   |
| Sardinen, | 1974,          | Spanien  | 9                     | 5.7 5.8              | 0,17                   |
| Sardinen, | 1974,          | Marocco  | 4                     | 8.5                  | 0.06                   |
| я         | n              | 33       | 4                     | 8.0                  | 0.05                   |
| <b>.</b>  | "              | n        | 4                     | 8.0                  | 0,05                   |
|           | *              |          | 4                     | 7.8                  | 0.06                   |

<u>Table 3</u> - Mercury contents of canned sardines. <u>Key:</u> 1, Description; 2, Number of sardines per can; 3, Length of back; 4, Mercury; <u>Sardinen</u>, Sardines; <u>Spanien</u>, Spain; <u>Marocco</u>, Morocco.

<u>Table 4</u> - Ages and lengths of species of fish. <u>Key:</u> 1, Rosefish (deep-sea ocean perch [i.e. <u>Sebastes marinus mentella</u>, the redfish found from 300 m to well below 600 m], average length, in cm; 2, Rosefish (Ocean perch [<u>Sebastes marinus marinus</u>]); 3, Rosefish (large ocean perch); 4, Common grenadier [or marlin-spike, <u>Nezumia bairdii</u>]; Description; 6, Ages of the fishes, in years.

| <b>S</b> Bezeichnung            | 6 Alter der Fische in Jahren |      |      |                      |              |      |      |              |      |      |
|---------------------------------|------------------------------|------|------|----------------------|--------------|------|------|--------------|------|------|
|                                 | 12                           | 15   | 16   | 18                   | <b>2</b> 0   | 23   | 27   | 29           | 35   | 36   |
| Rotbarsch (Tiefenbarsch)        |                              |      | ·    |                      |              |      |      |              |      |      |
| mittlere Länge in cm            | <b>32.</b> 0                 | 34.7 | 37.0 | 38.5                 | 41.1         | 44.7 | 48.5 | 49.5         |      |      |
| <b>2</b> Rotbarsch (Goldbarsch) | <b>32</b> .0                 | 36.4 | 38.1 | <b>4</b> 0. <b>2</b> | <b>4</b> 0.5 | 47.1 | 51.5 | 57.5         |      |      |
| 3 Rotbarsch (Riesen)            |                              | _    |      |                      | <del></del>  |      | 66.1 | <b>6</b> 9.9 | 78.5 | 79.8 |
| 4 Grenadierfisch                | 59. <b>9</b>                 | 70.2 | 76.3 | 81.9                 | 89.6         | 97.8 | _    |              | -    |      |

Relationships between the age and the length of the fishes are clearly indicated. Catches of ocean perch contain up to two per cent of fishes measuring between 60 cm and 85 cm in length, with the corresponding ages being 25 and 35 years. In this instance, we once again find that high concentrations of harmful substances are associated with advanced age or the fishes. Fishing of particularly individuals, of course, cannot be abandoned for that reason, but large fishes should be sorted out after hauling and processed separately. Fishes have been frequently examined with regard to their mercury content. If we disregard the different contaminating factors on individual fishing grounds, we are able to see the existence of a relationship also between live weight of the fishes and their mercury content.

Table 5 summarizes the results obtained in investigations of porbeagle shark fillets.

Porbeagle shark meat is exported in the deep-frozen state, for instance, from Japan and Norway chiefly to the Mediterranean countries. Due to its similarity to veal, this meat has found wide acceptance. The pinkish meat -reddish close to the vertebrae-occasionally is marketed also under misleading names like tuna, sea sturgeon or wild sturgeon. The porbeagle shark is a lean fish, and attains a length of 3.5 m and, in the Mediterranean Sea, even one of 6 m. The high age of adult fishes and the wide distribution of of this species over the seas of the world explain the varying, and occasionally high mercury contents exhibited by these fish fillets. On the basis of Table 5, the fat content does not have to be included in consideration. The water content indicates fresh meat, and a correction of the mercury values therefore is not required. However, whole fishes are only rarely available for testing. But it is not possible to draw conclusions regarding the age of the porbeagle processed on the basis of pieces of fillet. It then follows that we, in general, cannot omit testing of porbeagle fillets for the presence of harmful substances, and this, in particular, because excessive mercury concentrations do frequently occur in the porbeagle shark.

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Relationships between weight and mercury content have been established also in the case of tuna, for instance, in Italian (5) and Greek investigations (6). According to these studies, individuals with an average weight

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|          |  |   | [%]                      | [%]   | 4 Quecksilber<br>[ppm]  |
|----------|--|---|--------------------------|---|---|
| ngshai   | 3  |   |                          |   |   |
| us japa  | nische   | n Gewässern   | 77.2                     | 0.5   | 2.9   |
|          |  |   | 76.5                     | 0.3   | 1.3   |
| <b>n</b> | "  | ~   | 75.2                     | 0.4   | 1.0   |
| 71       | w  | "   | 76.0                     | 0.5   | 0.6   |
| 7        | "  |   | 75. <del>4</del>         | 0.2   | 0.6   |
| -        |  |   | 74.5                     | 0.2   | 0.6   |
| 79       | 77   | 7   | 74.4                     | 0.2   | 0.5   |
| ~        | 77   |   | 75.1                     | 0.3   | 0.5   |
| 77       | "  | "   | 74.3                     | Ũ.4   | 0.5   |
| -        | 'n   | n   | 74.7                     | 0.7   | 0.4   |
|          | ngshai<br>us japa<br>"<br>"<br>"<br>"<br>"<br>"<br>"<br>"<br>" | us japanische<br>n n<br>n n<br>n n<br>n n<br>n n<br>n n<br>n n<br>n | us japanischen Gewässern | us japanischen Gewässern 77.2<br>n n 76.5<br>n n 75.2<br>n n 76.0<br>n n 75.4<br>- 74.5<br>n n 74.4<br>n n 75.1<br>n 74.3 | us japanischen Gewässern 77.2 0.5<br>n n 76.5 0.3<br>n 76.5 0.3<br>n 76.0 0.5<br>n 76.4 0.2<br>n 74.4 0.2<br>n 74.4 0.2<br>n 74.8 0.4<br>74.8 0.4 |

Table 5 - Mercury content of probeagle shark [Lamma masus] fillets. <u>Key:</u> 1, Description; 2, Water; 3, Fat; 4, Mercury; 5, Probeagle shark, from Japanese waters.

<u>Table 6</u> - Investigation of albacore [<u>Thumnus alalunga</u>] meat. <u>Key:</u> 1, Fat, 2, Histamine; 3, Water; 4, Mercury; 5, Large albacore, 1 m; 6, Dark-red meat; 7, Pink meat; 8, Abdominal part, without skin; 9, Small albacore, 50 cm; 10, Description.

| <b>Ø</b> Bezeichnung          | Fett<br>[%] | Histamin<br><b>2</b> [ppm] | <b>3</b> Wasser<br>[%] | Quecksilber<br>¥ [ppm] |
|-------------------------------|-------------|----------------------------|------------------------|------------------------|
| <b>S</b> Großer Albacore, 1 m |             |                            |                        |                        |
| 6 dunkelrotes Fleisch         | 0.9         | 10                         | 72.1                   | 0.43                   |
| 7 hellrotes                   | 0.5         | 10                         | 72.5                   | 0.38                   |
| 8 Bauchlappen, ohne Hau       | t 2.1       | 10                         | 69.6                   | 0.87                   |
| ¶ Kleiner Albacore, 50 cm     | 1.0         | 20                         | 72.0                   | 0.85                   |

of 56 kg exhibited 0.38 p.p.m. mercury; 83 kg, 0.73 p.p.m.; 100 kg, 0.77 p.p.m.; 158 kg, 1.32 p.p.m.; and approximately 350 kg, 4.75 p.p.m. mercury. The particularly tasty, reddish meat of tunas is marketed in the form or cutlets, but also in the smoked state. However, under particular conditions, fresh meat rich in red muscle undergoes rapid, unfavorable changes due to the activities of a histamine producer (<u>Proteus morgagnii</u>) (7). Histamine arises due to decarboxylation of histidine, with histamine exerting a vagus-stimulating action in man. Histamine intoxications or, at least, allergies elicited by histamine, thus, occur most frequently where histidine is present in relatively large quantities. In addition to the red tuna, other tuna species like, for example, the white tuna or albacore are of commercial significance. Table 6 summarizes the results obtained in investigations of one relatively old, adult albacore, and of one younger, relatively small albacore from the same fishing ground.

The meat of these two individuals did not differ with respect to general composition, and differed only to an insignificant degree with respect to mercury content. It is, however, worthy of note that the meat of the small albacore contained twice as much histamine as the meat of the large specimen. That difference is explained largely on the basis of the treatment given these fishes. Large tunas, of course, are slaughtered, and then well bled. In the case of small tunas that apparently is generally not done. This particular example demonstrates that the advantage found in relatively small or younf fishes due to their small content of harmful substances is easily lost, if the small fishes are not processed just as carefully as the large ones.

The results of our investigations show that mercury was distributed over the fish body in rather uniform fashion. Since water and fat contents corresponded to fresh fish meat, there is no need to correct the mercury values obtained. However, the age of tunas cannot be estimated on the basis of parts of the fish—in particular, in that of fish fillet and tuna meat in preparations. In our country, we encounter most frequently processed tuna. For the conversion of processed fish to fresh fish it is, in general, adequate to include of loss of weight of 25 per cent in the calculation. No significantly higher losses occur in the course of the usual processing procedures.

Eel meat exhibits rather large variations in both protein and fat contents. For instance, the protein fraction varies between 10 and 25 per cent, and fat contents of eel meat, thus, may exceed 40 per cent. These large

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variations in the composition of the meat make difficult employment of an uniform correction factor in the conversion of processed to fresh eel meat. Table 7 summarizes the results obtained in the investigation of smoked eel fillets. The presence of mercury was tested.

These particular investigations were carried out in smoked ell preparations in aspic jelly. The fat determined, thus, came exclusively from the eel meat. The weight of the processed meat, as was to be expected, amounted to over 50 per cent of the total weight of the canned preparation. The protein fractions were calculated to amount to between 18 and 25 per cent. These findings indicate that heating of the canned eel meat did not lead to excessive loss of weight. In general, we are permitted to proceed on the basis that losses of weight exceeding 15 per cent do not have to be expected also in the case of eel preparations under the usual sterilizing conditions. The conversion of the mercury values determined to the fresh eel weight, thus, also provides data that are 25 per cent lower than those actually determined in the processed product. The aspic jelly was found to contain between 0.01 and 0.03 p.p.m. mercury, suggesting that, at best, traces of mercury get into the product by way of that ingredient. At the same time, however, that finding indicates that no mercury is released with the substances released from the eel meat during the sterilization procedure. It is worthy of note that the mercury values were relatively high in eel meat. Since eel meat in the processed state also does not permit conclusions regarding the length, the age and the developmental stage of the eel used, detailed investigations for the presence of harmful substances cannot be avoided in this instance. Careful testing is indicated already on the basis of the living conditions and the large differences in the contamination of the habitats of individual eels.

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<u>Table 7</u> - Investigation of canned smoked ell fillets. <u>Key:</u> 1, Description; 2, Net weight; 3, Weight of eel meat; 4, Fat content; 5, Water; 6, Mercury; 7, Smoked eel fillet in aspic jelly; 8, Aspic jelly from the cans.

| Bez            | eich  | <b>2</b><br>nung | Netto-<br>gewicht<br>[g] | 3Aalfleisch-<br>auswaage<br>[g] | <b>∀</b> Fett-<br>gehalt<br>[%] | <b>S</b> Wasser<br>[°/o] | <b>G</b> Queck-<br>silber<br>[ppm] |
|----------------|-------|------------------|--------------------------|---------------------------------|---------------------------------|--------------------------|------------------------------------|
| 7 Rauch        | aalfi | let              |                          |                                 | •                               |                          |                                    |
|                | in .  | Aspik            | 124.6                    | 72.3                            | 19.5                            | 58.5                     | 0.83                               |
| •              | "     | "                | 126.6                    | 72.1                            | 23.1                            | 55.4                     | 0.72                               |
| <b>g</b> Aspik | aus   | Dosen            |                          | _                               | -                               | 85.9                     | 0.03                               |
| 7 Rauch        | aalfi | let              |                          |                                 |                                 |                          |                                    |
|                | in .  | Aspik            | 119.8                    | 58.0                            | 17.9                            | 57.8                     | 0.48                               |
| ~              | n     |                  | 125.6                    | 67.4                            | 19.3                            | 57.2                     | 0.47                               |
| r              | 77    | -                | 129.4                    | 75,4                            | 28.4                            | 53.8                     | 0.71                               |
| *              | н     | "                | 124.8                    | 67.7                            | <b>2</b> 8.2                    | 53.2                     | 0.53                               |
| •              | "     | P                | 122.6                    | 64.3                            | 22.1                            | 55.1                     | 0.40                               |
| <b>8</b> Aspik | aus   | Dosen            | -                        | -                               |                                 | 83.9                     | 0.01                               |

<u>Table 8</u> - Mercury, DDT and PCB in different fish preparations. <u>Key:</u> 1, Description; 2, Net weight; 3, Weight of fish alone; 4, Mercury in the fish part (without oil); 5, Oil; 6, Fish without oil; 7, Smoked eel in oil; 8, Smoked salmon in edible oil; 9, Tuna in soybean oil; 10, Tuna in oil; 11, Tuna in vegetable oil; 12, Japanese tuna in oil; 13, Codfish [<u>Gadus morrhua</u>] liver in codliver oil; 14, Traces; 15, Not detected; 16, Not determined.

|                           |          | - 77 1                        | 4 Quecksilber                        | <b>S</b> Abtr | opföl            | <b>6</b> Fischanteil<br>nach Abtropfen<br>DDT PCB<br>[ppm] |                  |
|---------------------------|----------|-------------------------------|--------------------------------------|---------------|------------------|--|------------------|
| Bezeichnung               | [g]      | <b>3</b> Fischauswaage<br>[g] | [ppm]<br>im Fischanteil<br>(ohne Ul) | DDT<br>[ppm]  | PCB              |  |                  |
| Räucheraal in Ol          | 123.5    | 72.0                          | 0.27                                 | 1.10          | ++               | 0.64   | ++               |
| Räucherlachs in Tafelöl   | 8 85.8   | 40.3                          | 0.06                                 | 0.1           | н <sup>+</sup> + | 0.01   | ۱ <b>5</b> n. n. |
| Thunfisch in Sojaöl 9     | 94.9     | 61.1                          | 0.56                                 | 0.19          | Spuren           | <0.01  | Spuren           |
| Thunfisch in Ol           | 0 190.0  | 180.7                         | 0.33                                 | 0.1           | *                | < 0.01   |                  |
| Thunfisch in Pflanzenöl   | 136.9    | 97.5                          | 0.58                                 | <0.01         | ,,               | 0.01   | "                |
| Japan. Thunfisch in Ol 🕴  | 2 204.2  | 126,0                         | 0.53                                 | 0.04          | 77               | 0.02   | +                |
| Dorschleber in eigenem Öl | 13 116.3 | 62.0                          | 16 n.b.                              | ca. 1.0       | ++               | ca. 1.0  | ++               |
| Dorschleber in eigenem Öl |          | 102.8                         | 16 n.b.                              | 1.2           | +++              | 3.4  | ++=              |

In many cases, the cholesterol content of the fat or of the edible eel portion is suited for assessing the influences exerted by processing. Eel meat has not undergone any significant change in its general composition, if the edible eel fraction contains less than 200 mg cholesterol per 100 g. Table 8 summarizes the results obtained in investigations of various fat-containing fish preparations. In these cases we were dealing with both the oil of the fish concerned and the added vegetable oils. Following mechanical separation of the oil released from the fish and the added oil, the meat portion was tested for mercury, and both the oil and the meat fractions were tested for DDT and its isomers as well as for PCB.

The processed fish is what is left of the content of the can following mechanical separation of the oil. That fraction, as a rule, consists of more than 50 per cent of the total content. The mercury values reported were determined in that meat fraction. It was found that tuna meat was most strongly contaminated. On the other hand, we were able to find only minimal quantities of both DDT and PCB in tuna meat and -apart from one exception-also in the added oil. The investigations of preparations of codliver yielded far less favorable results. These preparations usually contain between 50 and 55 per cent oil. In general, more DDT and PCB were found in the oil released under the processing conditions than in liver parts containing less fat. Fish liver preparations very frequently exhibit rather high contents of harmful substances. That is valid also in the case of mercury. In general, more mercury is found in the liver than in the muscular meat of fishes. From the point of view of the laws relating to food precessing, however, the mercury content of high-fat fish livers-like codliver, for instance-usually must not be judged more severely than the fraction of fat-soluble harmful substances. The examples presented indicate that separation of the codliver into liver oil and a relatively low-fat, high-protein liver fraction generally leads only yo a shift in the distribution of the harmful substances in the fractions. That finding, however, suggests also that partial defattening of fish livers may well improve the general usability also of relatively heavily contaminated

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<u>Table 9</u> - DDT and PCB in different fish preparations. <u>Key:</u> 1, Description; 2, Smoked eel; 3, Codliver in codliver oil; 4, Atlantic mackerel [<u>Scomber</u> <u>scombrus</u>] in oil; 5, Smoked haddock [<u>Melanogrammus aeglefinus</u>] in oil; 6, Smoked trout; 7, Smoked whale meat; 8, Smoked porbeagle shark; 9, Traces.

| Bezeichnung                 | DDT [ppm]   | PCB             |
|-----------------------------|-------------|-----------------|
| Räucheraal 2                | 0.44        | +               |
| Räucheraal 2                | 0.05        | 9 Spuren        |
| Dorschleber in eigenem Öl 3 | 1.57        | +++             |
| Dorschleber in eigenem Ol 3 | 0.39        | +++             |
| Dorschleber in eigenem Ol 3 | 0.17        | +++             |
| Makrele in Ol 4             | 0.03        | +               |
| Schillerlocken in Ol 5      | 0.24        | +++             |
| Geräucherte Forelle 6       | 0.04        | <b>4</b> Spuren |
| Geräuchertes Walfleisch 7   | 0.01        | <b>9</b> Spuren |
| Geräucherter Heringshai 8   | <b>0.01</b> | 9 Spuren        |

<u>Table 10</u> - DDT and PCB in canned mussels. <u>Key:</u> 1, Drained oil; 2, Mussel meat without oil; 3, Edible common mussel [<u>Mytilus edulis</u>]; 4, Finest mussels; 5, Not detected; 6, Traces.

|                        | 1 Abtropföl  |                 |              | 2 Muschelfleisch<br>ohne Ol |  |
|------------------------|--------------|-----------------|--------------|-----------------------------|--|
|                        | DDT<br>[ppm] | PCB             | DDT<br>[ppm] | PCB                         |  |
| 3 Pfahlmuscheln        | 0.01         | <b>\$</b> n. n. | <0.01        | <b>5</b> n. n.              |  |
| *                      | <0.01        | <b>5</b> n. n.  | 0.01         | <b>\$</b> n. n.             |  |
| "                      | 0.11         | <b>6</b> Spuren | <0.01        | <b>s</b> n. n.              |  |
| 4 Feinste Muscheln     | <0.01        | <b>5</b> n. n.  | 0.1          | +                           |  |
| <b>1</b>               | 0.40         | +               | 0.02         | <b>6</b> Spuren             |  |
| <b>3</b> Pfahlmuscheln | <0.01        | <b>5</b> n. n.  | 0.04         | <b>6</b> Spuren             |  |

starting products of that type. If possible, the products now commonly available on the market would have to be replaced by other or newly developed ones, like pastes and/or dressings, for example. It appears, however, that hitherto only little use or no use at all has been made of the possibilites suggested.

Since fresh codlivers are used in the case of preparations like "codliver in codliver oil," no conversion factors are required.

Table 9 summarizes the results obtained in investigations of fish preparations also in their own oil or in added oil, respectively. These investigations were performed using the whole can content. DDT and PCB were determined. It is striking that preparations containing little DDT, as a rule, also contained little PCB. On the other hand, high levels of DDT were associated with high levels of PCB. It must however be noted that highly varying DDT contents were found in products like "codliver in codliver oil."

Table 10 summarizes the results obtained in investigations of canned 170 mussels of different proveniences. Mussel meat and added oil were separately tested for DDT and PCB. Mussels generally are low in fat. The exception is found in mussels from Spain, which rarely exhibit fat contents below 5 per cent, and usually exhibit contents exceeding 8 per cent. Spanish mussels, thus, must be described as being rich in fat. Small mussel fat contents exert no detectable influence in products with added vegetable oil. Our tabulation shows that DDT and PCB were very low in the mussel meat as well as in the separated oil. It is striking that the products identified as "finest mussels" were most strongly contaminated. In this instance, however, it cannot be excluded that a part of these harmful substances got into the products by way of the added oil. These particular examples illustrate, however, that these harmful substances are as yet not taken into consideration in the advertising and labelling of canned goods. In general, however, the results of our investigations indicate that mussels are not more severely contaminated than fishes of comparable age. A preconditions for such comparisons, however, is that the breeding or fishing grounds are also comparable.

Due to pre-cooking, mussels lose about 10 per cent of their weight, and the losses occurring during sterilization may amount to up to 15 per cent. A loss of weight of 25 per cent should be calculated in in the case of canned mussels in the conversion of the harmful substances from processed mussel to fresh mussel. As supplemental feature in our evaluations we may employ the water content of the mussels in connection with the cholesterol content of the mussel fat or the mussel meat, respectively.

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