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Evaluation of the fitness for consumption of fish and some fish products

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The value of fish is often not fully realized. In a diet, fish has a nutritional value similar to that of meat. Some fish represent the cheapest source of animal protein and it should be the task of nutrition workers and dietitians to stimulate the demand for fish.

The principal nutritive constituent of fish is protein but the caloric value of different fish species depends chiefly on the amount of fat they contain. Fat replaces part of the water of the leaner fish; thus fat fish are better sources of energy than lean fish although not inferior to them in building material. According to the relative proportions of these components, fish may be conveniently divided into three groups:

1. lean fish — cod, pike
2. medium fat fish — redfish, tench, bream
3. fat fish — herring, salmon, halibut, eel, carp.

The investigations of the Food and Agriculture Organization of the United Nations show that the resources of the sea can make a big contribution towards the elimination of nutritional inadequacies in many parts of the world. It is believed that world fish production can be vastly increased, provided adequate attention is paid to the development of this field.

The Seventh Report of the Joint FAO/WHO Expert Committee on Nutrition (1) draws attention to the fact that despite the great efforts made during the last few decades to ease the world food shortage, the per capita world food production has actually decreased over the last 5 years. In connection with this, the Report advocates a full exploration of new sources of food, placing emphasis on the need to encourage all methods of food production and food utilization.

Although fish contribute only a small fraction of the total weight of the food eaten in our country, we can observe a steady increase in the amount of Polish caught fish. The investigations on the chemical composition and the nutritive value of fish and the most common Polish fish products conducted by the Department of Food Science of the Medical Academy in Gdańsk, have established the high nutritional quality of these products. Our work presents the analytical results with regard to the chemical composition of over 30 Polish fish products. The aim of these analyses was to determine the content of water, fat, protein, essential amino-acids, ash, and some mineral elements (Ca, P, Fe, Mn, F, NaCl). The vitamins A and D, as well as some vitamins of the B-group and the caloric

* *Note of the editor*
This work showing the interest taken in Poland in the nutritive value and in the quality standards of fish and fish products is published with great delay. We beg the author to excuse this late publication.

value, have also been determined (2, 3, 4, 5, 6). Moreover, in our biological investigations we used bone meal of raw and preserved fish as source of calcium and phosphorus. These biological experiments were carried out on four groups of young rats, receiving, in addition to the basic diet, 5 per cent raw fish-bone meal or 5 per cent preserved fish-bone meal. The basic feed was the Steenbeck diet No. 2935 (without $CaCO_3$) which served simultaneously as a control diet. The results of the experiments concerning the extent of calcification as well as the calcium and phosphorus content in rat bones allow conclusions to be drawn about good utilization of the said mineral salts from raw and preserved fish. Furthermore, our investigations show that industrial processing (sterilization) not only prolongs the period of edibility of fish, but also enables the use of some of the ordinarily inedible components of the fish body (7).

The presentation of satisfactory fish and fish products to the public is an important and difficult question. One of the problems is the keeping quality of fish and preservation methods are being studied. Fish very rapidly becomes unfit for consumption especially when exposed to bacterial infection. Sanitary conditions during the handling and distribution of fresh fish are the subject of investigations in many laboratories and are mostly based on bacteriological studies.

Microbial activity is very important as well as bacterial counts since other bacterial tests can be used to determine the quality and even to predict the shelf-life of fish under known storage conditions. Bacterial spoilage can produce some toxic substances which cause food poisoning. Poisonous substances can arise in the flesh of fish during putrefaction. Remembering this we should realize that in general the so-called fresh fish sold at retail markets is far from being truly fresh and there is very much room for improvement.

Although fish and fish products are rarely the cause of human infection in our country nowadays, a few outbreaks have in the past been traced back to infected processed fish (8). This encouraged us to study the stages of production of some canned fish — herring in oil and bullhead in tomato sauce (9, 10). The raw fish used for preserves exhibited a relatively small degree of contamination and thus good freshness. The degree of contamination varied with the season of the year and depended upon whether fresh or frozen raw fish were used. Frozen fish showed a higher degree of contamination throughout the production cycle. An increase in the amount of bacteria in the fish flesh tissue resulted in higher quantities of steam-volatile basic and acidic substances. The bacteriological and chemical data obtained and the inspection of the various stages of production led to four main conclusions:

1. Adherence to the required technological and sanitary conditions has an essential bearing on the quality of canned fish.
2. Every delay in a given production stage, especially prior to sterilization, favours the development of microorganisms and at the same time reduces the guarantee that the canned fish is completely sterilized.
3. Full sterilization of herring in oil is difficult to achieve. Incomplete sterilization of some cans is attributable to the oil packing medium, which is a poor

heat conductor. Incubation tests were negative and no swelling of the cans was observed.

4. Unlike herring in oil, the bullhead in tomato sauce is entirely sterile after conventional sterilization.

Changes in quality of fish during storage are dependent upon many factors such as chemical composition, time, conditions of storage, temperature, etc. The changes in chemical composition as a function of season and sexual maturity have been documented by many workers for several species (11, 12). It has been shown by *Castell* that cod exhibits a seasonal difference in its susceptibility to rancidity and is least sensitive during the summer months. *Love* (13) showed that the muscle of starved fish contained more water than that of well-nourished fish and this finding provided the basis of one method for measuring condition.

The prevention of undesirable deterioration of fish requires the application of many different techniques. Besides cooling, sterilization of the products should eliminate undesirable micro-organisms and reduce the hazard of poisoning from this source. If fish is properly frozen and kept at low temperature, it is still good after a few months. But there is a significant difference in behaviour between fatty and non-fatty species of fish, which appears to be related to the localization of lipids within their tissues. The fact that sterilization makes canned fish safe is a very convincing argument in its favour. In Poland we are increasing our annual output of frozen fish and canned fish. The trend towards increased frozen fish production will continue, the reason being the expansion of fishing in more distant waters and the need to store the catch. It is in order to ensure the supply of fish of good eating quality.

A thorough investigation of fish enzymes might help in the search for better means of controlling autolysis of fish and its deterioration. It may be assumed that enzymes of fish tissues cause the initial stages of deterioration. Besides the natural variation in concentration of enzymes, which is very marked between species but not too great among specimens of the same species, there is considerable variation in substrate concentration in the flesh and in intermediate and final product build-up. However, bacterial enzymes seem to be of major importance in bringing about deterioration in fish. According to *Liston* (14) little is known about the nature and activity of bacterial enzymes active in fish spoilage, or about the factors governing the production of such enzymes by bacteria growing at low temperature in fish tissue.

On the basis of the evaluation of the production line for frozen cod fillets, we — *Czarnowska, Ganowiak, Wierzchowski* (15) — have tried to establish indices for admissible contamination in such products. Proposed sanitary requirements for frozen cod fillets from the Baltic Sea are stated as follows:

total bacteriological count — less than 200 000 per g
coli index — higher than 0,1
enterococci index — higher than 0,1
pathogenic organisms (Salmonella, Shigella, coagulase-positive staphilococci and sprouting anaerobic bacilli) — excluded.

Frozen cod fillets must be prepared from fresh, sound fish of such quality that it may be sold fresh for human consumption.

It is obvious that any process of fish preservation implies a certain amount of waste. For this reason, any loss must be more carefully reduced. It will be noted that a great deal of loss is from proteins. Protein denaturation occuring in certain frozen fish has recently become a serious problem and some workers (16) underline the importance of further investigation. Decomposition of fish is principally a progressive proteolysis of the muscle tissue brought about by the action of micro-organisms.

The storage of fish at below — 10 ° C prevents bacterial growth but does not stop enzymic action and therefore fish stored at this temperature soon lose their normal flavour and take on unpleasant ones. Storage at lower temperatures (— 30 ° C) is required in order to limit changes of this nature over long storage periods. In fatty fish, oxidative rancidity is the most important «off» flavour. Also the amount of amino-acids present has an effect on the flavour and flavour changes may be due to loss of amino-acids. Likewise amino-acids can have a pronounced antioxidative effect in fish products, for instance, in the case of herring. Some research findings of *Marcuse* (17) show that histidine and tryptophane are the most effective amino-acids in this respect.

A considerable amount of interest has been displayed in vacuum packaging which can prevent the development of rancidity in these products, even at relatively high storage temperatures. The prevention of rancidity which develops during storage in any type of fish also needs more research work. Usually rancidity occurs along with the progress of desiccation of the skin of frozen fish and is thought to be characterized by peroxide formation when stored for long periods. On the margin of this might be mentioned the fact that in many parts of the world some people like the rancid taste of oxidized fish products but it is necessary to differentiate between the oxidized fatty taste or odour and the amine odour.

Lately, attention is being given to the importance of free fatty acids as a possible factor in protein denaturation of fish meat. Hydrolysis of lipids or phospholipids in various kinds of fish seems more important than was thought, even under freezing conditions. Besides the concentration of free fatty acids, also the type of fatty acid may affect the quality of frozen fish.

Recently we have reported — *Wierzchowski* and *Witowski* (18) — a method to determine the freshness of fish by paper chromatography procedures. The quality of different samples of fresh water fish analysed varied from good to poor. The content of some lower fatty acids showed a marked increase on storage. It was assumed that the appearance of butyric acid in fish meat indicates its decomposition. The presence of 5 mg/100 g of butyric acid in bream (Abramis brama), tench (Tinca vulgaris), pike (Esex lucius) and eel (Anguilla vulgaris) showed that the fish was unsuitable for consumption.

The decomposition of fish meat is above all a progressive proteolysis of the muscle tissue and it can lead to the formation of amino-acids from protein. The

objective of another of our studies — *Wierzchowski* and *Fuks* (19) — was to determine whether free amino-acids estimation in fish would supply adequate results for measuring the fitness of fish meat for consumption.

The fresh fish analysed were pike, bream and tench. Moreover, frozen cod was also studied. Paper chromatography was chosen as the most suitable method for establishing the quantity of amino-acids. During this study, the opportunity was taken to investigate the correlation between taste panel scores and the amino-acids concentration in the flesh of fish and certain other chemical indices.

The data obtained indicate that the amino-acid number varies with the different species of fish; changes in the amount of free amino-acids in the flesh of fish were followed during storage. A noticeable decrease of histidine and an increase of threonine was found in all specimens. In our opinion, the content of histidine and threonine in fish meat is of interest for sanitary purposes and, relying on data received, we propose for fish good for comsumption:

a) for all four species analysed — at least 20 mg/100 g of histidine
b) for pike, bream and cod — at the most 80 mg/100 g of threonine.

Difficulties met in the assessment of suitability for consumption of fish and fish products stimulated a search for new quality indices. The need for a satisfactory objective test for the determination of spoilage in fish and fish products is made evident by the large number of methods which have been published. From among many, we only mention that hypoxanthine and other purine-containing fractions in fish muscle can also serve as food indices of freshness. Adenosine-5-triphosphate (ATP) is degraded to hypoxanthine in chill-stored muscle and thereafter the purine ring is cleft. The accumulation of hypoxanthine results from both autolytic and bacterial activation in muscle so that measurement throughout storage time can be valuable.

There are several methods for determining hypoxanthine concentrations in extracts of fish muscle all of which differ in their accuracy, their ease and speed of execution and the amount of instrumentation required. The estimation of hypoxanthine concentrations in fish muscle by a rapid visual modification of the enzymatic (xanthine oxidase) assay procedure has been described by *Burt, Stroud* and *Jones* (20). An improved automated method of hypoxanthine determination was published by *Burt, Murray* and *Stroud* (21). The paper describes the automation of an enzymic method in which the reaction mixtures include an oxidation-reduction indicator dye (2,6-dichlorphenol indophenol). This method offers some advantages: a simple colorimeter can be used, time for estimation is reduced and there is no need for blank tests. According to the authors, results obtained using this method correlate very well with those from standard manual enzymatic assay procedures.

Finally, it is necessary to mention a new electronic method for rapid measurement of the degree of freshness of fish worked out and described by *Hennings* (22). This test has been checked for suitability in normal daily quality controls as well as commercial grading of wet fish by many workers. It would be of

great assistance to health authorities responsible for supervising the marketing of good eating quality fish if the «Intelectron Fish Tester» method could be used for the control of wet fish and thawed frozen fish. However, according to *Castell* (23) the results obtained by this method indicate that it cannot replace the organoleptic judgements of the fishery officers, but it could be a very useful supplement to the work of the controller.

On the basis of the investigations described, we can reach the idea that there are considerable difficulties involved in the development of a good single test to examine the freshness of fish and fish products. A test that could correlate well with freshness and quality would be of considerable value to health authorities and to industry. Such a test should mainly relate to the fitness of the product for consumption at the moment of inspection, but from the point of view of the technologist the shelf-life of the products will be very important. It is the general opinion that today any properly equipped laboratory should be able to make some determinations of chemical and microbiological indices.

Summary

Besides favouring the increase of world-wide fish consumption, this paper deals in a more general way with microbiological and biochemical problems encountered in the assessment of consumption quality standards and their maintenance in the fishing and fish products industries.

The bibliography refers to 23 papers in Polish (10 by the author et al., aiming at more specialized studies), in English and in German. Attention is drawn to quality-lowering factors during processing and storage. Analytical methods for routine quality tests are mentioned and the determination of purine-bases and of butyric acid is recommended. Some quality-standard figures are listed.

Résumé

Outre les raisons en faveur d'une plus large consommation globale de poisson, l'auteur expose de manière générale les problèmes bactériologiques et biochimiques qui se posent aux producteurs de produits de la pêche. Il propose d'établir des normes pour apprécier la qualité de ces produits.

La bibliographie fait mention de 23 articles en polonais (10 de l'auteur et al., visant à des études plus spécialisées), en anglais et en allemand. Divers facteurs pouvant diminuer la qualité des produits lors de leur production et en cours de stockage sont mentionnés. Des méthodes analytiques pour l'examen en série sont brièvement discutées; le dosage des bases puriques et de l'acide butyrique sont notamment recommandés comme indices de qualité.

Zusammenfassung

Nebst Werbung für vermehrten Fischkonsum in der Welt behandelt diese Publikation in mehr allgemeiner Weise mikrobielle und biochemische Probleme, wie sie der fischverarbeitenden Industrie beim Erstellen von Qualitäts-Standardwerten und deren Einhaltung begegnen.

Das Literaturverzeichnis führt 23 Arbeiten auf in Polnisch (10 vom Autor u. al., auf speziellere Untersuchungen hindeutend), in Englisch und Deutsch. Ferner wird auf qualitätsvermindernde Faktoren während der Verarbeitung und der Lagerung aufmerksam gemacht. Analytische Methoden zur routinemäßigen Qualitätskontrolle werden erwähnt und u. a. die Bestimmung von Purin-Basen und Buttersäure empfohlen. Einige Qualitätsmerkmale werden in Zahlen ausgedrückt.

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