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Protein quality and amino acid profiles of fish products available in Poland

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ABSTRACT

Chemical analyses were carried out on 18 of the most popular varieties of fish products in the Polish market (canned, smoked, salted and marinated fish of different species), produced by the largest manufacturers and distributors in the country. The contents of the nutritive substances in the fish products (proteins, amino acids, and fats) were determined. To assess the nutritional quality of proteins in these products, the protein digestibility was determined, which ranged from 77.0% to 98.7%, and the amino acid composition of each of these groups of products was compared with that of a standard protein recommended by the World Health Organization (WHO). In addition, protein digestibility-corrected amino acid scores (PDCAAS) were calculated. Relative to the WHO protein standard, most of the fish products tested scored very high, with values ranging between 0.9 and 1.0. This study confirmed that in terms of both quantity and quality, fish products in the Polish market could serve as a significant source of essential amino acids and that the sulphur-containing essential amino acids and lysine present in fish products could supplement the corresponding deficiency in plant proteins. However, it was also indicated that drastic thermal processes, such as sterilisation, could influence the protein digestibility.

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1. Introduction

The low consumption of fish and fish products in Poland as compared to that in other European countries (6.4 kg/per capita, including about 1.5 kg of canned fish) (Szostak, Kuzebski, & Budny, 2006) is due, amongst other reasons, to inadequate promotion and a lack of sufficient information regarding their nutritional qualities.

Fish is known to be a source of protein rich in essential amino acids (lysine, methionine, cystine, threonine, and tryptophan) (Sikorski, 1994), micro- and macroelements (calcium, phosphorus, fluorine, iodine), fats that are valuable sources of energy, fat-soluble vitamins, and unsaturated fatty acids that, amongst other benefits, have a hypocholesterolemic effect (antiarteriosclerosis) (Fernandez & Venkatrammann, 1993; Ismail, 2005).

The Testing Laboratory at the Sea Fisheries Institute undertook projects aimed at supplying comprehensive data regarding the nutrient and pollutant content of the fish products prevalent in the Polish market to arrive at a reliable assessment of the quality and safety of these products and to entice consumers to enrich their diet with fish products. The contents and roles of nutrients such as polyunsaturated fatty acids, micro- and macroelements, and fat-soluble vitamins, in addition to the contents of chosen pollutants, such as pesticides, polychlorinated biphenyls, polychlorinated dibenzo-*p*-dioxins and dibenzofurans, polybrominated diphenyl ethers, and metals were presented in previous papers (Usydus et al., 2008; Usydus et al., submitted for publication). In this report, data on the contents and quality of fish proteins, some of the most important nutrient components, are presented. To assess the nutritional quality of the protein in the products tested, the digestibility and composition of the protein were determined. The amino acid composition of each of these groups of products was compared with that of a standard protein recommended by the World Health Organization (FAO/WHO., 1991).

Amino acids play a central role as the building blocks of proteins and as intermediates in metabolism and further help to maintain health and vitality. There are 20 amino acids that can be found in the human body, 18 of which are important in human nutrition. Eight amino acids cannot be synthesised de novo by humans and other mammals and hence must be supplied in the diet; therefore they are called essential amino acids (Hryniewiecki, 2000). The essential amino acids are lysine, methionine, threonine, tryptophan, isoleucine, leucine, phenylalanine and valine. Failure to obtain enough of even one of the essential amino acids results in the degradation of the muscle proteins in the body. Moreover, there is a group of amino acids which are not normally required in the diet but which must be exogenously supplied to specific populations under special conditions, such as intensive growth, stress, or in some disease states. Such amino acids have been classified as semi-essential. This group includes histidine, serine and arginine. The remaining amino acids (alanine, cystine, glycine, aspartic acid, glutamic acid, proline and tyrosine) are synthesised by the organism in sufficient amounts and hence are classified as nonessential amino acids. In addition, cystine and

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tyrosine are regarded by some authors (Boisen, Hvelplund, & Weisbjerg, 2000) as semi-essential amino acids as they are synthesised from methionine and phenylalanine, respectively. Therefore, the total amino acid requirements should include the sum of methionine + cystine (sulphur-containing amino acids) and phenylalanine + tyrosine (aromatic amino acids). Fulfilling the requirements as above, equivalent to the summed quantities alone, may not be sufficient because methionine and phenylalanine cannot be synthesised from cystine and tyrosine, respectively (Boisen et al., 2000).

The nutritive quality of any food protein is determined by the following factors:

- the content of essential and nonessential amino acids;
- the mutual proportions of specific essential amino acids, which preferably – should be similar to that found in the proteins of the body;
- the energy supplied, which is essential for protein synthesis in the body;
- the digestibility of the protein (Hryniewiecki, 2000).

The quality of the proteins can be determined in relation to the composition of a standard protein, which is recognised as the most relevant for the assessment of the protein quality in the nutrition of all populations. The amino acid composition of a WHO standard protein has been modified by the Joint Expert Committee of the FAO in 1991 (FAO/WHO, 1991), with relevance to the present knowledge. The evaluation of protein quality is carried out on the basis of the amounts of limiting amino acids. These are the essential amino acids found in foodstuffs in the smallest quantities in comparison with a standard protein. The limiting amino acid content profoundly affects the net protein utilisation, which is the ratio of the mass of amino acids converted to proteins against that of amino acids supplied. Therefore foodstuffs that have different deficiencies in their essential amino acid profiles in comparison with a standard protein should be mixed for consumption. For example, the proteins of cereal products are characterised by a low content of lysine and hence should be supplemented with proteins rich in this amino acid so as to optimise the utilisation of the proteins supplied in the diet.

A cross-sectional consumer survey has been carried out in November–December 2004 in five European countries Belgium, Denmark, The Netherlands, Poland, and Spain, and subsequently, a representative sample for age and region, consisting of 4786 consumers within each country, has been obtained. The results show that fish has an overall "healthy image" amongst a very large majority of the population. Consumers perceive fish, regardless of the species, as a very healthy and nutritious food and consider eating fish as essential for a balanced and healthy diet (Pieniak, Verbeke, Brunsø, & Scholder, 2007). In conjunction with the above studies and other earlier related reports (Usydus et al., 2008; Usydus et al., submitted for publication), this study proposes to confirm the positive opinion and support it with comprehensive data.

2. Materials and methods

2.1. Samples and analysis

As many as 240 samples of canned, smoked, salted, and marinated fish were tested in 2005 and 2006. These were the most popular of the fish products in the Polish market. The samples were purchased from large supermarkets, grocery stores, or directly from the manufacturers. The following assortments of fish products were chosen for testing:

Canned fish	
Sprat in tomato sauce	10 samples
Sprat in oil	20 samples
Herring in tomato sauce	20 samples
Herring in oil	20 samples
Tuna in oil	10 samples
Mackerel in tomato sauce	10 samples
Mackerel in oil	10 samples
Sardine in oil	10 samples
Paprykarz (fish spread with rice)	10 samples
Smoked fish	
Smoked mackerel	10 samples
Smoked sprat	10 samples
Smoked herring	10 samples
Smoked Baltic salmon	10 samples
Smoked Norwegian salmon/farmed	10 samples
Smoked trout	10 samples
Salted fish	
Salted herring fillets	30 samples
Marinated fish	
Marinated herring fillets	20 samples
Fried mackerel in vinegar	10 samples

Mackerel, sprat, herring, and trout were hot-smoked whereas salmon was cold-smoked.

Each pooled sample comprised eight to 10 items (cans, pots, or barrier-flexible trays) from one lot or from 3 kg of unpacked products. In the case of canned fish, the samples consisted of the entire content in the cans. In the case of other fish products, the samples consisted of skinless fillets, with the exception of sprat samples that consisted of fillets with skin.

The determinations of the crude protein and fat, dry matter and ash, as well as the protein digestibility assays, were carried out at the Accredited Testing Laboratory of the Sea Fisheries Institute in Gdynia. The chemical compositions of all the samples were determined by the following AOAC (1990) procedures: dry matter, by drying in an oven at 103 °C for 8 h; crude fat, by Soxhlet extraction with ether; crude ash, by incineration in a muffle furnace at 580 °C for 8 h; crude protein (N ×6.25), by the Kjeldahl method after an acid digestion; nondigestible proteins, by Kjeldahl method after enzymatic hydrolysis of the digestible protein with pepsin; finally, digestible proteins were obtained as the difference between the crude and nondigestible proteins.

Amino acid determinations were carried out in the Central Laboratory of the National Research Institute of Animal Production in Krakow. Amino acids in the freeze-dried samples were analysed after acid hydrolysis in 6 N HCl for 22 h at 110 °C in glass tubes under nitrogen. Cystine and methionine were determined as cysteic acid and methionine sulphone, respectively, by performic acid oxidation before their digestion using 6 N HCl (Blackburn, 1968; Moore 1963,). Tryptophan was determined by the method of Landry, Delhaye, and Jones (1992), after alkaline hydrolysis of each sample. Chromatography analysis was carried out using the Beckman-System Gold-126 AA, equipped with an ion-exchange column and a UV–VIS detector; and postcolumn derivatization with ninhydrin was carried out. All analyses were conducted in duplicate for each sample. Quantification was obtained by using external standards, and the results were corrected for the recoveries.

Protein digestibility-corrected amino acid scores (PDCAAS) of the samples were calculated by multiplying the lowest amino acid

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