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Food Chemistry 96 (2006) 524–531
Food Chemistry
www.elsevier.com/locate/foodchem

Nutritional composition of blubber and meat of hooded seal (*Cystophora cristata*) and harp seal (*Phagophilus groenlandicus*) from Greenland

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Received 19 July 2004; received in revised form 19 July 2004; accepted 7 March 2005

Abstract

Seal blubber and skin are widely used, but the utilisation of blubber and meat for human consumption is limited. The aim of this study was to evaluate the nutritional composition of seal blubber and meat. The fatty acid composition, selected minerals and trace-elements, vitamins, amino acids and proximal composition of blubber and meat from hooded seal (*Cystophora cristata*) and harp seal (*Phagophilus groenlandicus*) from the "West Ice" near Greenland were analysed. The results showed that seal blubber is an excellent source of long- and very long-chain (VLC) $n-3$ polyunsaturated fatty acids (PUFAs), in addition to long- and VLC monounsaturated fatty acids (MUFAs). Eicosapentaenoic acid (EPA) content contributed to a clear separation between blubber and meat from the two species. The blubber of harp seal showed the highest EPA (9.2%), whereas the muscle of harp seal showed the lowest EPA (3%) content. Seal meat is lean with less than 2% total fat, mainly composed of MUFAs, long- and VLC $n-3$ PUFAs. In addition, the meat contains a high amount of proteins with a well-balanced amino acid composition. The trace-element content of seal meat is very high, particularly iron (379 μg/g muscle in hooded seal) and zinc (30 μg/g muscle in harp seal), as also is the vitamin content, especially vitamins A, D_3 and B_{12}. The seals included in this study varied greatly in age and size, which in turn may be the principal reason for the great individual variation observed in nutritional composition. On average, however, consumption of only 40 g seal meat covers the recommended daily intakes of iron and vitamin B_{12} for young women. In conclusion, as long as the products fulfil the amending legislations regarding contaminants, both seal blubber and meat, from the present species, represent high quality food regarding nutrients and bioactive components beneficial for human health.

Keywords: Hooded seal; Harp seal; Seal blubber; Seal meat; Human nutrition; $n-3$ Fatty acids; EPA; DPA; DHA; Minerals; Trace-elements; Essential amino acids

1. Introduction

The main components of seals are carcass (44%), blubber (29%), viscera (18%) and skin (8%) (Shahidi, 1998). The limited consumption of seal meat may partly be due to lack of public knowledge about the nutritional quality. It may also be due to its dark colour, which is related to the high myoglobin and haemoglobin contents of the muscle tissues, and also to flavour deterioration as a consequence of oxidation of unsaturated fatty acids (Shahidi & Synowiecki, 1996). In addition, a negative pressure from animal rights and wild life organisations may also contribute to the restricted use of seal meat. The lipids in seals are mainly stored as subcutaneous fat, also known as blubber. Blubber primarily functions as a body stream-liner, insulator and buoyancy adjuster. In addition, lipids are found in smaller amounts in the

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0308-8146/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodchem.2005.03.005

muscle, liver, kidney, heart and other internal organs. The presence of $n-3$ polyunsaturated fatty acids (PUFAs) influences the *post-mortem* storage stability of blubber and meat, due to rapid lipid peroxidation during processing and storage. However, seal blubber oil is more resistant to lipid peroxidation than is cod (*Gadus morhua*) liver oil (Shahidi, Wanasundara, & Brunet, 1994).

Eicosapentaenoic acid (EPA, 20:5$n-3$), docosapentaenoic acid (DPA, 22:5$n-3$) and docosahexaenoic acid (DHA, 22:6$n-3$), long- (i.e. fatty acids with 20–22 carbons in the backbone) and very long-chain (VLC, i.e. fatty acids with 22 or more carbons in the backbone) $n-3$ PUFAs, are present in high amounts in fish oil and seal oil. Long- and VLC $n-3$ PUFAs have been shown to possess many health-promoting effects, including modulating effects on inflammatory mechanisms, and on the immune response in general (Calder, 1998; Empey, Garg, & Fedorack, 1989; Kremer, 2000; Wallace, Keenan, & Finn, 1980). Administration of seal oil to patients with inflammatory bowel disease (IBD) and IBD-associated joint pain, reduces disease activity and joint pain (Arslan et al., 2002; Bjørkkjær et al., 2004). Consumption of seal blubber and meat may therefore contribute with beneficial nutrients. With this in mind, a study, with emphasis on the nutritional value of seal blubber and meat, especially regarding their usage as rich sources of long- and VLC $n-3$ PUFAs, was undertaken.

Long- and VLC $n-3$ PUFAs of seal blubber are located mainly at the end positions (sn-1 or sn-3 positions) of the triacylglycerol (TAG) molecule, whereas they are located mainly in the middle position (sn-2) in fish oils (Brockerhoff, Hoyle, Hwang, & Litchfield, 1967; Wanasundara & Shahidi, 1997; Yoshida et al., 1996). During digestion and throughout the circulation, fatty acids are liberated, primarily from the sn-1 and sn-3 positions of the TAG, by position-specific pancreatic and lipoprotein lipases (Small, 1991). Thus, long- and VLC $n-3$ PUFAs from seal oil may be more readily available for lipolysis than those from fish oils, and may therefore have important and different impacts on both inflammation and on the immune system.

Typical western diets contain excessive amounts of $n-6$ fatty acids, in particular linoleic acid (LA, 18:2$n-6$). LA is the precursor of arachidonic acid (AA, 20:4$n-6$), which in turn is the main precursor of eicosanoids (Gil, 2002). High levels of AA may promote the pathogenesis of many diseases, such as autoimmune and inflammatory diseases (Simopoulos, 2002a, 2002b). Regular intake of seal blubber (oil) and seal meat will provide a diet high in long- and VLC $n-3$ PUFAs and an increased amount of long- and VLC $n-3$ PUFAs may exert suppressive effects on, e.g., autoimmune and inflammatory diseases (Gordon & Ratiff, 1992; Simopoulos, 2002a).

Seal meat is also an excellent source of trace-elements and minerals, particularly iron and zinc, potassium and phosphorus, respectively. Furthermore, it is a good source of vitamins, especially vitamin B_{12}, and generally it has a higher content of B vitamins than do meats from other animals (Shahidi & Synowiecki, 1993). The crude protein content of seal meat (27%) is higher than those of pork (21%), beef (20%), autumn mackerel (*Scomber scombrus*) (19%) and cod (17%) (Botta, Arsenault, Ryan, & Shouse, 1982), and it is a rich source of nutritionally valuable proteins with a well-balanced amino acid composition (Shahidi, 1998). The content of nucleic acids in the meat is low compared to, e.g., beef (Arasu, Field, Kruggel, & Miller, 1981; Synowiecki & Shahidi, 1992).

The aim of this study was to evaluate and compare the positive nutritional composition of seal blubber and meat of two different seal species, namely hooded seal (*Cystophora cristata*) and harp seal (*Phagophilus groenlandicus*), with common foodstuffs. Since seals range high in the food chain, the accumulation of potentially harmful compounds should also be of concern regarding seal blubber and meat for human consumption, but is outside the scope of the present paper.

2. Materials and methods

2.1. Seal samples

Blubber and meat samples from two different seal species, hooded seal and harp seal, were provided by the Institute of Marine Research (IMR), Bergen, Norway. IMR carried out a research cruise in "The West Ice" near Greenland in March/April, 1999. Samples of blubber and muscle were taken by a standardised procedure. Both blubber and meat samples were taken from deep inside the central dorsal region. The weight of all samples was approximately 100 g. All samples were taken from sexually mature females during the breast-feeding period, aged 4–21 years. The mean weight of the hooded seals was 103 kg (range 81–123 kg) and the mean weight of the harp seals was 135 kg (range 110–173 kg).

2.2. Analytical methods

The fatty acid composition, selected trace-elements and minerals, some lipid- and water-soluble vitamins, amino acid content and proximal chemical composition were determined in blubber and/or muscle from the two seal species. The seal samples were kept frozen at −20 °C for six months prior to analysis.

The fatty acid compositions of the total lipids were determined according to Lie and Lambertsen (1991). The fatty acid composition was calculated using an