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THERMAL TREATMENT OF NEW ZEALAND KING SALMON

(ONCORHYNCHUS TSHAWSCHA):

PHYSICO-CHEMICAL AND SENSORY PROPERTIES

AND THE ROLE OF ASTAXANTHIN IN LIPID OXIDATION

DANAÉ SONJA LARSEN

A thesis submitted in fulfilment of the requirements for the degree of doctor of philosophy, The University of Auckland, 2011.
ABSTRACT

New Zealand King salmon is an extensively farmed aquaculture species in New Zealand and around the world as Chinook. It is an excellent source of omega-3 fatty acids (ω-3 FA) and the potent antioxidant astaxanthin. Apart from the rising popularity of consuming raw salmon, in many Western countries such as New Zealand, King salmon is generally consumed after some type of thermal treatment. However, prior to this study there was no literature detailing the affect of thermal treatment on the ω-3 FA content, astaxanthin content and other physico-chemical and sensory properties, or the effect on the microstructure and lipid distribution in King salmon. Therefore, a comprehensive examination of the effect of the thermal treatments on these properties was conducted.

Farmed King salmon was prepared according to common thermal treatment technique; raw, poaching, steaming, microwaving, oven baking, pan frying and deep frying (in sunflower oil). The nutritional significance of King salmon was confirmed by the high levels of ω-3 FA that were well preserved regardless of thermal treatment method, which was in contrast to a comparison fish, Yellowtail kingfish. A hypothesis of internal protection of omega-3 long chain polyunsaturated fatty acids (ω-3 LCPUFA) in King salmon by the endogenous antioxidant astaxanthin was studied. The concentration of astaxanthin in King salmon flesh was not significantly decreased due to thermal treatment. Astaxanthin was also shown for the first time, to be an effective antioxidant in a fish meat model system and fish oil model systems. Astaxanthin was affected significantly by light and the presence of oxygen in the system, as it was most effective at preventing and slowing lipid oxidation in the closed fish oil model systems. The microstructure and lipid distribution of King salmon was studied using novel methods in the field of fish research, magnetic resonance imaging (MRI), confocal laser scanning microscopy (CLSM) and environmental scanning electron microscopy (ESEM). Microstructural changes occurred which were linked to the moisture content, total extractable lipid content and sensory properties and further enhanced the understanding of their effects to the consumer appeal of King salmon. Oven baked and pan fried King salmon had the greatest consumer acceptance with the highest overall degree of likeness (DOL) ratings in the sensory evaluation and interestingly were among the thermal treatment methods, which best preserved the ω-3 LCPUFA. This trend was also observed with the poached King salmon, which was least liked during sensory evaluation and had the lowest absolute amounts of the ω-3 LCPUFA among the thermal treatment methods.

Overall, the importance of King salmon as an aquaculture species has been confirmed. This study successfully applied novel techniques and ideas to the field of fish research to increase the understanding of the physico-chemical and sensory properties, microstructure and role of astaxanthin in lipid oxidation, ultimately highlighting the nutritional benefits and sensory acceptance for the consumer.
Dedicated to Wayne, Margaret and Alisha Larsen
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ABBREVIATIONS

2-thiobarbituric acid (TBA)
Aliphatic hydrocarbon (AH)
Alpha-linolenic acid (ALA)
Alpha-tocopherol (α-tocopherol)
Cholesterol (CHO)
Confocal laser scanning microscopy (CLSM)
Diaclyglycerol (DAG)
Degree of likeness (DOL)
Docosahexaenoic acid (DHA)
Docosapentaenoic acid (DPA)
Eicosapentaenoic acid (EPA)
Environmental scanning electron microscopy (ESEM)
Fatty acid (FA)
Fatty acid alcohol (FAI)
Free fatty acid (FFA)
Gas chromatography (GC)
Hours (h)
Hydrocarbons (HC)
Ketone (KET)
Magnetic resonance (MR)
Magnetic resonance imaging (MRI)
Malonaldehyde (MA)
Malonaldehyde equivalents (MA eq)
Mass spectrometric imaging (MSI)
Milliequivalents peroxides (meq)
Minutes (min)
Monoacylglycerol (MAG)
Monounsaturated fatty acid (MUFA)
National Heart Foundation of Australia (NHFA)
National Institute of Water & Atmospheric Research (NIWA)
National Oceanic and Atmospheric Administration (NOAA)
New Zealand (NZ)
New Zealand King Salmon Company (NZKS)
Omega-3 fatty acids (Ω-3 FA or ω-3 FA)
Omega-3 long chain polyunsaturated fatty acids (ω-3 LCPUFA)
Omega-6 fatty acids (ω-6 FA)
Peroxide value (PV)
Phospholipid (PL)
Polyunsaturated fatty acid (PUFA)
Principal component (PC)
Principal component analysis (PCA)
Region of interest (ROI)
Saturated fatty acid (SFA)
Seconds (s)
ThioBarbituric Acid Reactive Substances (TBARS)
Triacylglycerol (TG)
US Food and Drug Administration (FDA)
Waxy ester (WE)
World Health Organisation (WHO)