OMEGA-3 DETERIORATION RATES AND FATTY ACID PROFILES OF SELECTED FRESHWATER AND MARINE FISHES KEPT AT DIFFERENT STORAGE TEMPERATURES

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DEDICATION

This dissertation is dedicated to:

My beloved and supportive husband Muhammad Nasir Azher and my beloved parents Zainol Akub and Manja Ali.

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Shelf-age of fish is determined from the time it was kept in the storage until its ready to be used or consumed by human. Lipid oxidation represents the major fish spoilage due to high composition of polyunsaturated fatty acids (PUFA) in fish flesh. Moving towards satisfying the growing industrial demand, fish needs to be store before being consumed, or before further processing. Post harvest techniques such as icing and freezing are important techniques used to slow down lipid oxidation and maintaining the quality of stored fishes. Therefore, this study was conducted with four main objectives. Firstly, to study profile of fatty acids and the profile's changes of six tropical fishes; *Oreochromis niloticus* (Red Tilapia), *Monopterus albus* (Freshwater Eel), *Pangasius hypophthalamus* (Silver Catfish), *Rastrellinger kanagurta* (Indian Mackerel), *Euthynnus affinis* (Mackerel Tuna) and *Epinephelus sp.* (Grouper) kept in ambient, ice and frozen storage. Secondly,

to study the deterioration rate of α -Linolenic acid (ALA), Ecosapentanoic acid (EPA), Docosahexanoic acid (DHA) and total Omega-3 of selected fishes kept at different storage temperature. Thirdly, to choose the best storage temperature to slow down the deterioration rate and maintaining the quality of stored fish and lastly to develop a simple Omega-3 deterioration model as a potential indicator to determine the shelf-age of fish kept at different storage temperature. Samples were divided into four batches that are for fresh (18 fishes), ambient (108 fishes), ice (126 fishes), and frozen storage (108 fishes). In ambient storage, samples were collected every 2 hours (at 2, 4, 6, 8, 10 and 12) for 12 hours, every 3 days (at 3, 6, 9, 12, 15, 18 and 21) for 21 days in ice storage, every 15 days (at 15, 30, 45, 60, 75 and 90) for 90 days in frozen storage. Fatty Acids Methyl Ester (FAMEs) were prepared by extracting the samples using Hexane, Boron Triflouride ($BF_{3)}$ and distilled water, and were identified by using gas chromatograph Agilent 6890N equipped with flame ionization detector. The fatty acids peaks were analyzed by comparing their retention time against the authentic standard Supelco 37 Component FAMEs Mix. During fresh condition the distribution of fatty acids in freshwater fishes follow the order of polyunsaturated fatty acids (PUFA) were higher than monounsaturated (MUFA) and saturated fatty acids (SFA), while in marine fishes saturated fatty acids (SFA) were higher than monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA). Palmitic acid (C16:0) and Oleic acid (C18:1n9) represent the major component of saturated and monounsaturated fatty acids in all species studied. Linoleic acid (C18:2n6) represent the major Omega-6, while Ecosapentanoic acid (C20:5n3) and Docosahexanoic acid (C22:6n3) represent the major component of Omega-3, which higher percentage were found in marine fishes compare to freshwater fishes. Each species

experienced lipid oxidation when kept in ambient, ice and frozen storage. The percentage of α–Linolenic acid (ALA), Ecosapentanoic acid (EPA), Docosahexanoic acid (DHA) and total Omega-3 decrease as the time in the storage increase. Deterioration of Omega-3 tends to be more rapidly when samples were kept in ambient storage compare to ice and frozen storage. The ratio of Omega-3 deterioration rate in ambient: ice is 3:1, while in ice: frozen is 3:1. Omega-3 deteriorates less than 50% of its original value when kept in frozen storage. Docosahexanoic acid (DHA) represents the most stable component of Omega-3 in ice and frozen storage which deteriorates less than 50% of its original value. The best storage temperature recommended to slow down lipid oxidation in fish is frozen storage at -40^0C. Model developed using relaxation model which is: $\mathbf{\%Omega\text{-}3=\%Omega\text{-}3_0 e^{-xt}}$, was able to predict the shelf-age of stored fish and able to applied in the fish industries.

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KADAR KEMOROSOTAN OMEGA-3 DAN PROFIL ASID LEMAK BEBERAPA JENIS IKAN AIR TAWAR DAN AIR MASIN YANG DISIMPAN PADA SUHU SIMPANAN YANG BERBEZA

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Umur ikan di dalam simpanan ditentukan bermula daripada ianya disimpan di dalam simpanan sehingga ianya sedia untuk digunakan atau dimakan oleh manusia. Pengoksidaan lemak menjadi salah satu punca utama kerosakan kepada ikan, kerana ikan mempunyai nilai kandungan asid lemak politaktepu yang tinggi. Sebagai memenuhi keperluan industri, ikan perlu disimpan sebelum dimakan atau sebelum melalui proses seterusnya. Teknik lepas tuai seperti penyimpanan di dalam ais dan sejuk beku adalah penting untuk melambatkan proses pengoksidaan dan mengekalkan kualiti ikan dalam simpanan . Oleh itu, kajian ini dijalankan berdasarkan empat objektif utama. Pertama, untuk mengkaji profil asid lemak enam jenis ikan tropika iaitu *Oreochromis niloticus* (Tilapia Merah), *Monopterus albus* (Belut Sawah), *Pangasius hypophthalamus* (Patin), *Rastrellinger kanagurta* (Kembung,) *Euthynnus affinis* (Tongkol) and *Epinephelus sp.*

*(*Kerapu) dan perubahan profilnya apabila disimpan di di dalam suhu bilik , ais dan sejuk beku. Kedua, untuk mengkaji kadar kemorosotan asid lemak jenis α –Linolenik (ALA), Ekosapentanoik (EPA), Docosahesanoik (DHA) dan kadar kemerosotan jumlah Omega-3 yang disimpan di dalam suhu yang berbeza. Ketiga, untuk memilih suhu simpanan yang terbaik bagi melambatkan kadar kemerosotan Omega-3 dan mengekalkan kualiti ikan dalam simpanan dan objektif yang terakhir ialah membina model keromerosotan Omega-3 sebagai satu petunjuk yang berpotensi untuk menentukan umur ikan yang disimpan dalam suhu simpanan yang berbeza. Eksperimen dijalankan dengan tiga replikasi menggunakan tiga ratus enam puluh sampel ikan dan semua sampel dibahagikan kepada empat kumpulan iaitu segar (18 ekor ikan), simpanan pada suhu bilik (108 ekor ikan), simpanan di dalam ais (126 ekor ikan) dan simpanan di dalam sejuk beku (108 ekor ikan). Sampel ikan di dalam suhu bilik disimpan selama dua belas jam dan sampel diambil setiap dua jam (pada jam ke-2, 4, 6, 8, 10 dan 12), setiap tiga hari (pada hari ke-3, 6, 9, 12, 15, 18, dan 21) selama dua puluh satu hari di dalam ais manakala sampel di dalam simpanan sejuk beku diambil setiap lima belas hari (pada hari ke-15, 30, 45, 60, 75, dan 90) selama sembilan puluh hari. Asid Lemak Metil Ester, disediakan dengan melakukan proses pengekstrakan terhadap sampel ikan dengan menggunakan Heksana, Boron Florida (BF_3) dan air suling dan dianalisa menggunakan gas kromatograpi jenis Agilent 6890N dilengkapi dengan nyalaan pengesan ion. Jenis asid lemak dianilisa dengan cara membandingkan masa asid lemak dikesan dengan piawai Supelco 37 FAMEs Mix. Semasa segar, taburan asid lemak di dalam ikan air tawar dibahagikan mengikut asid lemak poli taktepu lebih tinggi daripada asid lemak monotaktepu dan asid lemak tepu, manakala taburan asid lemak di dalam ikan air masin didapati asid lemak tepu, melebihi

kandungan asid lemak poli taktepu dan asid lemak monotaktepu. Asid lemak jenis Palmitik (C16:0) dan asid lemak jenis Oleik (C19:0) ialah komponen utama dalam asid lemak tepu dan asid lemak monotaktepu. Asid lemak jenis Linoleik (C18:2n6) merupakan komponen utama di dalam Omega-6 dimana peratusan yang tinggi dijumpai pada ikan air tawar berbanding ikan air masin. Asid lemak jenis Eikosapentanoik (EPA) dan Docosahesanoik (DHA) merupakan komponen utama di dalam Omega-3 dan peratusan yang tinggi dijumpai di dalam ikan air masin berbanding ikan air tawar. Semasa penyimpanan di dalam suhu bilik, ais dan sejuk beku, setiap jenis ikan yang dikaji mengalami proses pengoksidaan dimana kadar peraturasan asid lemak jenis α-Linolenik (ALA), Eicosapentanoik (EPA), Docosahesanoik (DHA) dan jumlah keseluruhan Omega-3 merosot, apabila masa di dalam simpanan dipanjangkan. Kadar kemorosotan kandungan Omega-3, lebih cepat berlaku apabila ikan disimpan di dalam suhu bilik berbanding ikan disimpan di dalam ais dan sejuk beku. Nisbah kadar kemerosotan Omega-3 apabila ikan di dalam suhu bilik :ais ialah 3:1, manakala nisbah kadar kemerosotan Omega-3 di dalam ais : sejuk beku ialah 3:1. Omega-3 merosot kurang daripada 50% daripada kandungan asal apabila ikan disimpan di dalam sejuk beku. Asid lemak jenis Docosahesanoik(DHA) merupakan asid lemak yang paling stabil dijumpai apabila disimpan dalam simpanan ais dan sejuk beku, di mana kemerosotannya kurang daripada 50% daripada peratusan asalnya. Model yang dibina iaitu $\mathbf{\%Omega\text{-}3=Omega\text{-}3_0\ e^{-xt,}}$ mampu untuk menjangkakan umur ikan di dalam setiap simpanan dan boleh digunakan di dalam industri perikanan .

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