PROPERTIES OF FOAM-MAT DRIED JAPANESE THREADFIN BREAM [*Nemipterus japonicus* (Bloch, 1791)] MINCED MEAT POWDER

By

ABDULRAHIM ABUBAKAR MOHAMED

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

January 2021

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DEDICATION

This thesis is dedicated to my mother Mana Mohamed and my siblings for their constant do'a, endless love, encouragement and support.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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January 2021

Chairman : Professor Jamilah Bakar, PhD
Faculty : Food Science and Technology

This study aimed to determine the effect of drying temperature and amount of foaming agent incorporated on the properties of foam-mat dried (FMD) threadfin bream minced meat powder; and to evaluate the effect of the selected additives on the rheological properties of FMD fish powder by conducting the frequency sweep test. Japanese threadfin bream (*Nemipterus japonicus*) minced meat was mixed with methyl cellulose (MC) as a foaming agent at 0.0, 0.5, 1.0 and 1.5% w/w and dried at 70 and 80℃. The FMD fish powder was then transferred to bottles and stored at 4℃ until analysis. The fish powder was tested for proximate composition, lipid quality, physico-chemical and functional properties. Drying time was 3 h longer for 70℃ than 80℃ to achieve the same level of moisture content of 3 – 4.5%. The crude protein of the fish powder dried at 70°C (84.70) was significantly higher (p<0.05) than 80°C (81.25%) as well as the pH values. A significantly lower water activity (p<0.05) was observed for powder dried at 70°C than 80°C, and the water activity of all powders was <0.40. The fish powder had an attractive yellowish-brown color. The L^*, a^*, b^* and whiteness values of the FMD fish powder were found to be in the range of 78.80 – 81.02, 1.67 – 2.90, 22.66 – 24.99 and 67.10 – 70.40, respectively. An increase in particle size was observed upon increased the drying temperature and MC concentration, and the values were 116.22 – 126.95 and 124.34 – 131.80 μm for powders dried at 70°C and 80°C, respectively. The powders showed good - fair flowability and are within the acceptable range. Both protein solubility and water holding capacity had an inverse correlation with the drying temperature (r = -0.943) and (r = -0.749), respectively. Increased drying temperature and decreased MC concentrations resulted in increased emulsification property. Gelation was only obtained in the control sample dried at 70°C. FMD threadfin bream meat powder dried at 70°C was observed to have less thiobarbituric acid reactive substances (TBARS) and free fatty acid (FFA) compared to powder dried at 80°C (p<0.05). On the overall, FMD threadfin bream meat powder dried at 70°C showed better properties. Next, the rheological

properties (elastic and viscous), gel stability and gel attribute of FMD fish powder at 70°C were determined by adding various additives at different concentrations, which were sodium chloride (0.7, 1.4 and 2.1% w/w) and sodium triphosphate (0.2 and 0.4% w/w). The results revealed that the storage modulus (G') of the FMD fish powder added with any type of the additives was higher than the loss modulus (G"). The highest G' value was obtained from powder added with NaCl, indicating a higher and stronger structured network. FMD fish powder containing MC was found to have a low gel strength even when the selected additives were added, which sample with 1.5% MC displayed the lowest gel strength. A better gel quality was obtained from FMD fish powder containing 1.0% of MC added with 2.1% NaCl.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

SIFAT SERBUK DAGING CINCANG IKAN KERISI JEPUN [*Nemipterus japonicus* (Bloch, 1791)] YANG DIKERING TIKAR-BUSA (FMD)

Oleh

ABDULRAHIM ABUBAKAR MOHAMED

Januari 2021

Pengerusi : Profesor Jamilah Bakar, PhD
Fakulti : Sains dan Teknologi Makanan

Kajian ini bertujuan untuk mengetahui kesan suhu pengeringan dan jumlah agen pembuih yang terdapat pada sifat pengeringan tikar-busa (FMD) serbuk daging cincang ikan kerisi Jepun, serta untuk menilai kesan aditif terpilih terhadap sifat reologi serbuk ikan FMD dengan menjalankan ujian sapuan frekuensi. Daging cincang ikan kerisi Jepun (*Nemipterus japonicus*) dicampurkan dengan metil selulosa (MC) sebagai agen pembuih pada kepekatan 0.0, 0.5, 1.0 dan 1.5% w/w dan dikeringkan pada suhu 70 dan 80°C. Serbuk ikan FMD kemudian dipindahkan ke botol dan disimpan pada suhu 4°C sehingga analisis. Serbuk ikan diuji bagi mengetahui sifat-sifat komposisi proksimat, kestabilan lipid, fizikokimia dan fungsinya. Waktu pengeringan lebih 3 jam bagi suhu 70°C daripada suhu 80°C untuk mencapai tahap kandungan kelembapan yang sama iaitu 3 – 4.5%. Protein kasar serbuk ikan yang dikeringkan pada suhu 70°C (84.70) jauh lebih tinggi (p<0.05) daripada 80°C (81.25%) serta nilai pH. Tiada perbezaan yang signifikan (p>0.05) bagi lemak dan abu kasar antara kedua-dua serbuk yang dikeringkan pada suhu 70°C dan 80°C. Aktiviti air yang jauh lebih rendah (p<0.05) diperhatikan bagi serbuk yang dikeringkan pada suhu 70°C daripada 80°C, dan aktiviti air semua serbuk adalah <0.40. Serbuk ikan mempunyai warna coklat kekuningan yang menarik. Nilai-nilai L^*, a^*, b^* dan keputihan serbuk ikan FMD didapati masing-masing berada dalam lingkungan 78.80 – 81.02, 1.67 – 2.90, 22.66 – 24.99 dan 67.10 – 70.40. Peningkatan ukuran saiz zarah dapat diperhatikan seiring dengan peningkatan suhu pengeringan dan kepekatan MC, dan nilai masing-masing adalah 116.22 – 126.95 dan 124.34 – 131.80 μm bagi serbuk yang dikeringkan pada suhu 70°C dan 80°C. Serbuk menunjukkan sifat keteraliran yang baik - wajar dan berada dalam julat yang boleh diterima. Kedua-dua kelarutan protein dan daya tahan air mempunyai korelasi terbalik dengan suhu pengeringan (r = -0.943) dan (r = -0.749), masing-masing. Peningkatan suhu pengeringan dan penurunan kepekatan MC mengakibatkan peningkatan sifat pengemulsian. Gelasi hanya diperoleh dalam sampel kawalan yang dikeringkan pada suhu 70°C. Serbuk daging ikan kerisi

Jepun FMD yang dikeringkan pada suhu 70°C didapati mengandungi kurang bahan reaktif asid tiobarbiturik (TBARS) dan asid lemak bebas (FFA) berbanding dengan serbuk yang dikeringkan pada suhu 80°C (p<0.05). Secara keseluruhan, serbuk daging ikan kerisi Jepun FMD yang dikeringkan pada suhu 70°C menunjukkan sifat-sifat yang lebih baik. Seterusnya, sifat-sifat reologi (elastik dan likat), kestabilan gel dan kekuatan gel serbuk ikan FMD pada suhu 70°C ditentukan dengan menambah pelbagai bahan tambahan pada kepekatan yang berbeza, iaitu natrium klorida (0.7, 1.4 dan 2.1% b/b) dan natrium trifosfat (0.2 dan 0.4% b/b). Hasil kajian menunjukkan bahawa modulus penyimpanan (G') cecair tepung ikan FMD yang ditambahkan dengan sebarang jenis aditif lebih tinggi daripada modulus kehilangan (G'). Nilai G' tertinggi diperoleh daripada serbuk yang ditambahkan dengan NaCl, menunjukkan rangkaian berstruktur yang lebih tinggi dan kuat. Cecair tepung ikan FMD yang mengandungi MC didapati mempunyai kekuatan gel yang rendah walaupun bahan tambahan yang dipilih ditambahkan, dengan sampel yang mengandungi 1.5% MC menunjukkan kekuatan gel yang paling rendah. Kualiti gel yang lebih baik diperoleh dari serbuk ikan FMD yang mengandungi 1.0% MC ditambah dengan 2.1% NaCl.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Jamilah binti Bakar, PhD
Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Chairman)

Ismail Fitry bin Mohammad Rashedi, PhD
Senior Lecturer
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

Rozzamri bin Ashari, PhD
Senior Lecturer
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

ZALILAH MOHD SHARIFF, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 10 February 2022

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) were adhered to.

Signature: _____
Name of Chairman of Supervisory Committee: Professor Dr. Jamilah Bakar

Signature: _____
Name of Member of Supervisory Committee: Dr. Ismail Fitry Mohammad Rashedi

Signature: _____
Name of Member of Supervisory Committee: Dr. Rozzamri Ashari

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LIST OF ABBREVIATIONS

FAO	Food and Agriculture Organization
AOAC	Association of Official Analytical Chemists
FMD	Foam-mat drying
h	Hour
min	Minute
sec	Second
g	Gram
mL	Milliliter
µ	Micro
µm	Micrometer
nm	Nanometer
mol/l	Moles per liter
w/v	Weight per volume
w/w	Weight per weight
wb	Wet basis
Pa	Pascal
Hz	Hertz
t	Time
pH	Negative log of the hydrogen ion concentration
ANOVA	Analysis of variance
MC	Methyl cellulose
HCl	Hydrochloric acid
EDTA	Ethylenediaminetetraacetic acid
TEP	1,1,3,3-Tetraethoxypropane

TBA	Thiobarbituric acid
NaOH	Sodium hydroxide
NaCl	Sodium chloride
$Na_2S_2O_3$	Sodium thiosulphate
$Na_5P_3O_{10}$	Sodium triphosphate/tripolyphosphate
Eq.	Equation
G'	Storage modulus
G"	Loss modulus
G'_o	Energy stored per cycle of sinusoidal shear deformation
G''_o	Energy loss per cycle of sinusoidal shear deformation
ω	Frequency (rad/s)
rad/s	Radian per second

CHAPTER 1

INTRODUCTION

Fish is a highly nutritious food that contains high protein, omega-3 fatty acids, various vitamins and minerals. However, the fresh fish is perishable unless it is kept at low storage temperatures. About 35% of global fish catches are wasted or lost within a few days owing to the lack of effective storage methods and therefore not utilized (FAO, 2018). Postharvest quality of fish alters rapidly. Chemical reactions such as lipid oxidation, microbiological and autolytic changes during storage cause spoilage. Hence, preventing fish waste by producing a safe and good quality fish product to meet consumer demand is highly needed.

An increase in the consumption of fish products in the last few years has been accompanied by growing demand for production efficiency, high quality and more convenient product at a competitive cost. The conversion of fish meat into a dried form makes it available throughout the year, convenient for storage and product formation could be more versatile. The fish powder is used as a protein supplement and can provide the nutritional needs of certain population sectors such as pre-school-age children and high protein formulations for athletes. Dried fish meat powder can be added to different types of foods such as rice and wet yellow noodles to increase their protein content and to enhance the nutritional value of cereal proteins.

There are many methods of processing to develop and extend the shelf life of fish and fish products. Drying is one of the most common technique used to process fish into a more stable commodity. Traditional and modern techniques for the drying of fish have been used in the past, each with their drawbacks. Foam-mat drying (FMD) has been selected in this study because this technique has many advantages, such as simple and rapid drying at the lower temperatures being suitable for heat-sensitive materials, retention of nutritional quality and very economical (Sangamithra et al., 2015b). The drying rate of this technique is relatively fast, thus a product with minimum quality changes will be obtained (Javed et al., 2018). This study will provide a helpful approach to understand the process of producing and evaluating the properties of the foam-mat dried fish powder.

Foam-mat drying (FMD) is a process of drying liquid foods by mixing them with foaming/stabilizing agents followed by whipping to produce a stable foam and subsequently drying in hot air temperature of 40 – 90°C (Hardy and Jideani, 2017). Proteins, gums, and various emulsifiers are usually used as foaming agents. Methyl cellulose (MC) is an effective polysaccharide foaming agent with excellent foaming properties, thus, MC was chosen as the foaming agent for drying of threadfin bream minced meat. An adequate amount of foaming agent must be added during foam production for stability. Foam collapsing during drying may

cause the dried material to stick to the tray, which is a drawback of the foam-mat drying (Azizpour et al., 2013). Relatively abundant literature can be found on the application of foam-mat drying of fruit and vegetable purees which are high in fiber and low in protein. FMD has been applied recently to protein-rich foods which provide different challenges when compared to drying of fruit and vegetable purees. However, previous literatures on protein-rich food FMD are still lacking. FMD of shrimp slurry had been reported by Azizpour et al. (2016), in which the optimum temperature for drying of shrimp foam was between 75 and 90°C. Hamzeh et al. (2019) produced a higher quality shrimp powder with lower drying temperatures. However, the shrimp meat composition is not similar to finfish meat, thus, making this research important.

In this study, FMD was applied to the threadfin bream (*Nemipterus japonicus)* (Bloch, 1791) fish. It is a group of fish belonging to the family *Nemipteridae. N. japonicus* is a common marine species caught in Southeast Asian waters and also widespread in the Red Sea and eastern shores of Africa to Japan (ElHaweet, 2013). Threadfin bream has white meat and smooth texture which makes it suitable as a raw material for the development of new products.

The ultimate objective of this study is to develop FMD process parameters for the fish slurry to be converted to powder form. To achieve this goal, the minced threadfin bream was foam-mat dried at 70 and 80°C using 0.0, 0.5, 1.0 and 1.5% methyl cellulose (MC) as the foaming agent. The dried product was tested for proximate composition, physico-chemical and functional properties as well as lipid stability. The best FMD fish powder was selected for the next analyses. The second objective was to determine the rheological properties of the selected samples by adding various additives such as sodium chloride and sodium triphosphate to evaluate the behavior of foam-mat dried fish powder during product formulation.

Accordingly, the problem statement, hypothesis and objectives of this study are as follows:

Problem statement:

- Temperature and time are critical factors for the drying process, which may cause the loss of protein functional properties of fish products. Minced fish meat may be difficult to be converted into a good stable commodity due to the presence of unsaturated lipids which are easily oxidized.

Hypothesis:

- Through the foam-mat drying process, it is possible to produce fish powder of high quality and acceptable shelf life for future application and product development. Drying at low temperatures with shorter time was hypothesized to be beneficial in lowering the chemical degradation of unsaturated lipids in fish meat.

Therefore, the objectives of this study are:

1. To determine the effect of foam-mat drying process parameters (temperature of drying and amount of methyl cellulose) on the properties of the minced fish meat powder.
2. To determine the rheological behavior of the best FMD fish powder in the presence of sodium chloride and sodium triphosphate at different concentrations.

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