UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF EXTRUDED PUFFED CORN-FISH SNACK FROM SILVER CARP (Hypophthalmicthys molitrix)

HAMIDREZA SHAHMOHAMMADI

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By

HAMIDREZA SHAHMOHAMMADI

Thesis Submitted to the School of Graduated Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Doctor of Philosophy

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DEDICATION

To my loving family whose never ending support and encouragement helped me to believe in myself and discover that I can accomplish anything with such self-belief.

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

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June 2013

Chairman: Professor Jamilah Bt. Bakar, PhD

Faculty: Food Science and Technology

Corn-based snacks are generally well accepted but low in protein content due to the limited protein–based ingredient incorporated in the formulations. This is because the common extrusion technology used to produce the snack is basically developed for starch-based dough formulation. Incorporating fish protein in the formulation could result in several problems relating to extrusion condition, textural properties and the stability of the snack itself. Therefore, in order to overcome these constraints, the present study was aimed at developing a nutritious puffed corn-fish snack by (i) enhancing the nutrition value and texture of the snack (ii) optimizing the extrusion conditions for enhanced textural properties (iii) and evaluating the storage stability of the developed snack. Extruded puffed corn-fish snack was produced from corn grits containing 0 to 30% of Silver carp (*Hypophthalmicthys molitrix*). This was followed by

optimizing the composition of the snack using Response Surface Methodology. The optimum formulation was obtained at 85% corn and 15% fish. Improvement of textural characteristics of the puffed corn-fish snack was studied by nucleating materials (calcium carbonate, magnesium silicate, sodium bi-carbonate and bran) which were incorporated at 1 to 2% for the first three nucleating agents and at 5 and 10% for bran. The results showed that all nucleating agents significantly enhanced the texture of the puffed snack except for bran. Among the four studied nucleating agents, magnesium silicate at 0.5% was the best texture modifier. Microstructure of the puffed corn-fish snack, which was examined by Scanning Electron Microscope showed that the air cell diameter in the snack which containing 0.5% of magnesium silicate was reduced 7.32 times while the number of cells per unit area was increased 4.76 times compared to the control. In order to optimize the extrusion conditions, RSM experimental design was performed. The optimum extrusion condition was determined to be at 116ºC, 1107 g/min feed rate and 148 rpm screw speed. Storage stability of the developed snack both unseasoned and seasoned packed in Biaxillary Poly Propylene films were studied over a storage period of 30 weeks. Microbial conditions were evaluated at 0, 15 and 30 weeks of storage while chemical and sensory parameters were carried out at six weeks intervals for 30 weeks. It is concluded that the shelf-stable, nutritious crispy puffed corn-fish snack containing 15% fish, 84.5% corn and 0.5% magnesium silicate (w/w) can be produced, packed under air atmosphere conditions with metalized BOPP and well accepted for a storage period of 28 weeks.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PEMBENTUKKAN SNEK JAGUNG-IKAN DARIPADA IKAN KAP PERAK (*HYPOPHTHALMICTHYS MOLITRIX*) DENGAN MENGGUNAKAN TEKNIK PENYEMPERITAN.

Oleh

HAMIDREZA SHAHMOHAMMADI

Jun 2013

Pengerusi: Professor Jamilah Bt. Bakar, PhD

Fakulti: Sains dan Teknologi Makanan

Snek berasaskan jagung secara umumnya diterima baik tetapi kandungannya yang rendah protein disebabkan oleh bahan-bahan terhad yang berasaskan protein telah ditambah dalam formulanya. Ini semua adalah kerana teknologi penonjolan yang biasa digunakan untuk menghasilkan snek adalah secara asasnya dibangunkan untuk formula doh yang berasaskan kanji. Mencampurkan protein ikan dalam formula tersebut menyebabkan beberapa masalah yang berkaitan dengan keadaan penonjolan, sifat tekstual dan kestabilan snek itu sendiri. Oleh yang sedemikian, dalam usaha mengatasi kekangan ini, kajian ini bertujuan untuk membangunkan snek jagung –ikan yang berkhasiat dengan (i) meningkatkan nilai nutrisi dan tekstur snek (ii) mengoptimumkan proses

penonjolan untuk memperbaiki sifat tekstur (iii) dan menilai kestabilan bagi penyimpanan snek yang telah dibangunkan tersebut. Snek jagung-ikan yang penuh khasiat telah dihasilkan daripada tepung jagung mengandungi 0 hingga 30% isi ikan kap perak (Hypophthalmicthys molitrix). Ini diikuti pula dengan mengoptimumkan komposis snek menggunakan Metodologi Respon Permukaan. Formula optimum telah diperoleh pada 85% jagung dan 15% ikan. Penambahbaikan bagi karekteristik tekstur bagi snek penuh jagung-ikan telah dikaji dengan penukleusan bahan (kalsium karbonat, magnesium silikat, sodium bikarbonat dan bran) yang mana telah dicampurkan pada 1 hingga 2% untuk 3 agen penukleusan yang pertama dan pada 5 dan 10% bagi bran. Dapatan ini menunjukkan yang kesemua agen penukleusan secara signifikannya memperbaiki tekstur bagi snek yang penuh kecuali kepada bran. Di kalangan emapat agen penukleusan yang dikaji, magnesium silikat pada 0.5% adalah pengubah tekstur yang terbaik. Struktur mikro bagi snek jagung-ikan yang penuh yang telah dikaji dengan Mikroskop Elektron Scanning menunjukkan yang diameter udara sel yang mengandungi 0.5% magnesium silikat telah dikurangkan sebanyak 7.32 kali ganda manakala bilangan sel per unit telah bertambah 4.76 kali ganda berbanding dengan pengawalan. Dalam usaha untuk mengoptimumkan keadaan penonjolan, rekabentuk eksperimen RSM telah dijalankan. Keadaan penonjolan yang optimum telah ditetapkan pada 116ºC, 1107 g/min kadar suapan dan 148 rpm kelajuan skru. Kestabilan penyimpanan bagi snek yang dibangunkan bagi kedua-dua tidak berperisan dan berperisan dibungkus dalam filem berbesikan Biaxillary Poly Propylene telah dikaji bagi tempoh penyimpanan selama 30 minggu. Keadaan bermikrob telah dinilai pada minggu 0, 15 dan 30 bagi penyimpanan manakala parameter berkimia dan bersensor telah dijalankan pada interval enam minggu bagi 30 minggu. Ianya dapat disimpulkan yang snek jagung-ikan penuh khasiat rangup tahan simpan mengandungi 15% ikan, 84.5% jagung dan 0.5% magnesium silikat (w/w) boleh dihasilkan dipekkan dibawah keadaan atmosfera yang berbesikan BOPP dan diterima baik bagi tempoh penyimpanan bagi 28 minggu.

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Finally, I would like to express my appreciations to all those who have contributed towards the success of this research in so many ways, big and small.

APPROVAL

DECLARATION

I declare that the thesis is my original work except for quotations and citation, which have been duly acknowledged. I also declare that it has not been previously or currently submitted for any other degree at Universiti Putra Malaysia or any other institutions.

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HAMIDREZA SHAHMOHAMMADI

Date:

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
Ave.	Average
a_w	Water activity
BD	Bulk Density
BOPP	Biaxillary-Oriented Poly Propylene
CC	Calcium carbonate ($CaCO_3$)
cc	Cubic centimeter
CCD	central composite cubic design
cfu/g	colony forming units per gram
CON	Control
^0C	Degrees centigrade
D	Diameter
ER	Expansion ratio
FAO	Food and Agriculture Organization
FFA	Free Fatty Acid
FO	Fish Odour
FR	Feed rate
g	Gram
h	Hour
Hz	Hertz
IFRO	Iranian Fisheries Research Organization

ISIRI	Institute of Standards and Industrial Research of Iran
kg	Kilogram
L	Length
LD	Linear distance
M	Molar
MAP	Modified atmosphere packaging
MDA	Malondialdehyde
Meq	Milliequivalent
MF	Maximum Force
mg	Millligram
min	Minutes
mL	Milliliter
mm	Millimeter
MS	Magnesium Silicate ($MgSio_3$)
N	Normality
N_2	Nitrogen
NB ($NaHCO_3$)	Sodium bicarbonate or sodium hydrogen carbonate
NFPRC	National Fish Processing Research Center
No.	Number
OA	Overall acceptability
OPP	No-metalized Biaxillary-Oriented Poly Propylene
OTR	Oxygen transmission rate

p	Probability
PC	Peaks count
PV	Peroxide value
R^2	Coefficient of determination
RH	Relative humidity
rpm	Revolution per minute
RSM	Response surface methodology
SC	Sensory crispness
SD	Standard deviation
SS	Screw speed
ST	Sensory texture
TBA	Thiobarbituric acid
T	Temperature
TVB-N	Total volatile basic nitrogen
UPM	University Putra Malaysia
W	Weight
WB	Wheat bran
µm	Micrometer

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Extrusion cooking has been shown to be the most efficient technology, in which we can break down raw food ingredients to a well cooked and pre-digested form. This process can increase storage stability from a few weeks to 9-12 months and the product can be consumed in a convenient, ready-to-eat form by the final consumer (Kazemzadeh, 2011). Classic extruded foods and snacks composed of cereals, starches, sugars and oils are believed to be low nutrient-dense food with wide range of consumers, particularly children and young people. They are known as "junk food" due to their high fat and carbohydrate and low protein content (Nurtama & Sulistyani, 1997). However, the global snack food market has developed remarkably in recent years and is expected to reach US$334.7 billion by 2015. Nowadays the market demand for more nutritious snacks is rising considerably. Therefore, there is an increasing trend for some animal proteins to be mixed with grains to produce a complex matrix, using extrusion technology that would meet the needs of the new market demand (Jose, 2012).

Fish species are known to provide high content of important constituents for the human diet such as nutritional and readily-digestible proteins, lipid-soluble vitamins, microelements and polyunsaturated fatty acids (Friedman, 1996). However, it is not a major part of the diet for most Middle-Eastern people. Besides, in the seafood industry, 30-80% of the fish catch, depending on species, is not utilized for human consumption. Extrusion technology can provide a method to utilize fish muscle recovered from underutilized fish (Choudhury & Gogoi, 1996). Restructuring the fish proteins together with a carbohydrate matrix using extrusion technology, can result in a valuable ready-to-eat food that adds value to an underutilized fish species such as silver carp. Extrusion is the best method to eliminate anti nutritional factors. Furthermore this treatment is the most effective method to improve protein and starch digestibility (Alonso, Aguirre, & Marzo, 2000).

Its beneficiaries would be consumers, producers as well as suppliers. The combination of carbohydrates and fish proteins is excellent from the nutritional point of view (SR18, 2005). By combining complementary proteins, the overall quality of the protein as well as its digestibility will be increased. However, to bring this idea to fruition following problems need to be considered.

1.2 Problems statement

I. Cereal extruded snacks are high-calorie and low-protein food.

II. Silver carp (*Hypophthalmicthys molitrix*) is cultured in abundance but it is under-utilized. In spite of having white flesh muscle advantage and the potential of providing a good source of nutritious foodstuff, its abundance of tiny bones makes it unpopular for filleting and direct consumption particularly when the fish are small (less than 1kg).

III. Since extrusion processes are normally designed for starch-based snacks, incorporation of fish muscle in extrusion feed could be problematic from different points of view e.g. technical, consumer acceptability and quality attributes.

IV. The incorporation of minced fish as an ingredient of extruded puffed snack may affect the storage stability of the product.

Therefore, the present research was aimed at developing an extruded puffed corn-fish product with the following hypothesis and objectives.

1.3 Hypothesis

I. Extrusion technology can be used to produce a nutritious extruded puffed corn-fish snack with an acceptable combination of corn and minced fish (silver carp).

II. Nucleating agents such as inorganic salts are able to enhance the texture of the puffed corn-fish snack by compensating the negative effect of high moisture content of minced fish.

III. Formulated snacks should have an acceptable storage stability due to its low a_w and low moisture.

Therefore the objectives of the study are as below:

1.4 Objectives

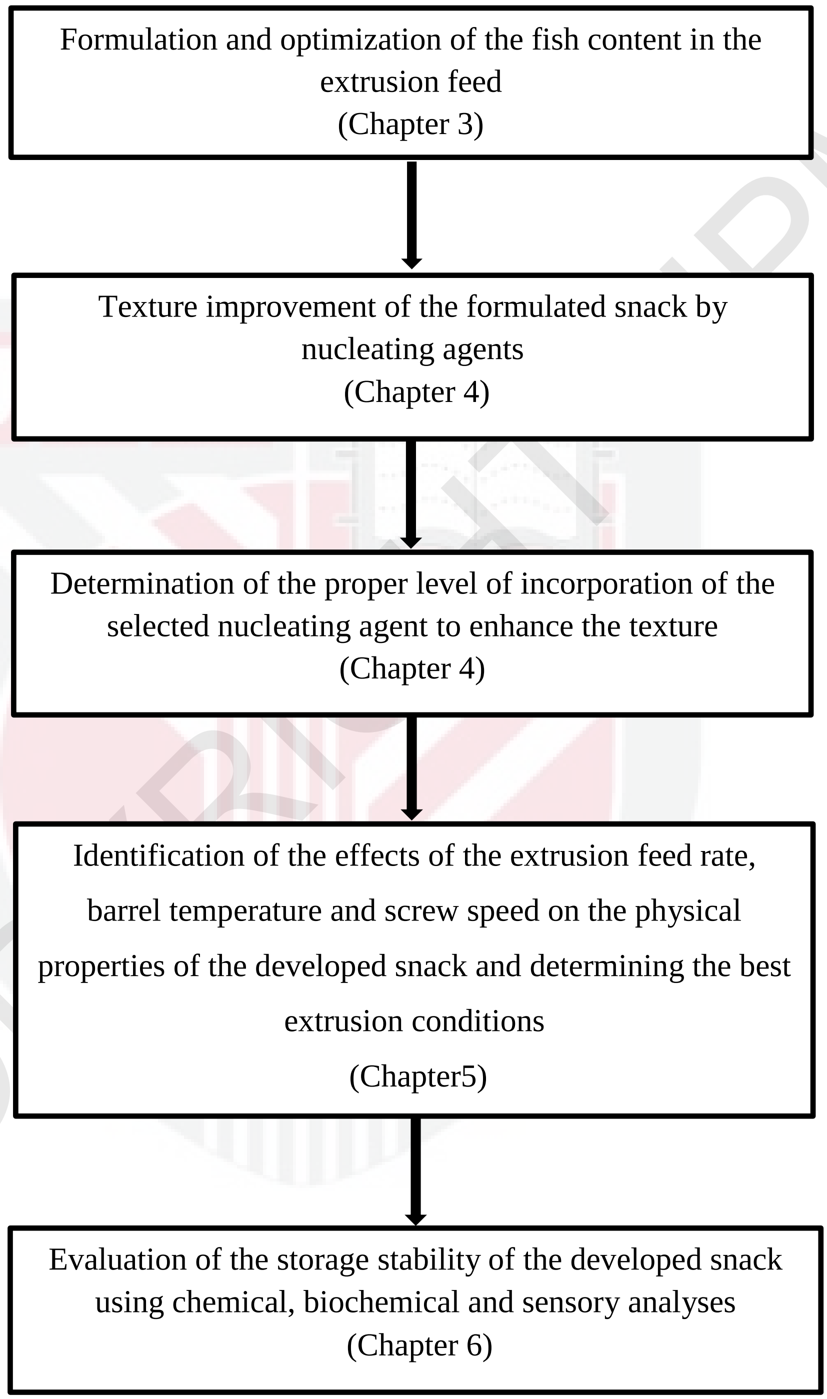
I. To develop an acceptable formulation for extrusion process and optimizing the fish content of the puffed corn-fish snack.

II. To determine the effects of nucleating substances on the texture of the extruded corn-fish puffed snack, in order to enhance the texture, as well as determine a suitable additive and its proper level.

III. To study the effects of process conditions on textural properties and to optimize feed rate, screw speed and barrel temperature of the developed puffed corn-fish snack.

IV. To investigate quality changes during storage, determining storage stability and evaluating the effects of fish incorporation and packaging conditions on storage stability.

1.5 Overall research flow diagram



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