UNIVERSITI PUTRA MALAYSIA

MODIFICATION OF WHEAT, SAGO AND TAPIOCA STARCHES BY IRRADIATION AND ITS EFFECT ON THE PHYSICAL PROPERTIES OF FISH CRACKERS (KEROPOK)

NORANIZAN BINTI MORD ADZAHAN

MODIFICATION OF WHEAT, SAGO AND TAPIOCA STARCHES BY IRRADIATION AND ITS EFFECT ON THE PHYSICAL PROPERTIES OF FISH CRACKERS (KEROPOK)

By

NORANIZAN BINTI MOHD ADZAHAN

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

January 2002

Specially dedicated to all my family members…

…Abah, Ummi, Abang Yuz, Kakak and Zuf

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

MODIFICATION OF WHEAT, SAGO AND TAPIOCA STARCHES BY IRRADIATION AND ITS EFFECT ON THE PHYSICAL PROPERTIES OF FISH CRACKERS (KEROPOK)

By

NORANIZAN BINTI MOHD ADZAHAN

January 2002

Chairman: Dzulkifly Mat Hashim

Faculty: Food Science and Biotechnology

The effect of starch irradiation on the properties of fish crackers in relation to microstructure of starch in 'keropok' was investigated. Wheat, tapioca and sago starch were used. Linear expansion of 'keropok' was best when the swelling of granules, leaching of amylose and amylopectin were high. Irradiation has been investigated as a means of degrading the starch polymers, which leads to an increase in the amount of soluble materials leached. Microwave, electron beam and gamma ray irradiation were used to degrade the starch polymers. The Brabender Viscograph, Texture Analyser (TAXT2-*i*), Falling Ball Viscometer and Haake Rheometer were used to determine the rheological properties of the starch pastes and gels. Results showed that irradiation caused an increase in leaching, a concomitant drastic reduction in swelling volumes of starch granules, and rate of gelation. It also showed that the strength of starch gels, viscosity, viscoelasticity and intrinsic viscosity decreased as the levels of irradiation was increased, indicating a decrease in the molecular weight of starch polymers. These changes were due to the cleavage of the amylose and amylopectin fractions by radiation energy. Fish crackers made from irradiated wheat starches expanded significantly better than the native starch and

were crispier. However, after a certain level of irradiation, the expansion decreased although the values remained higher than the expansion values for 'keropok' from native starch. The expansion of some of these wheat and sago starches improved greatly as the values exceeded the acceptable level *i.e.*, 77% expansion. 'Keropok' from microwave irradiated tapioca starch expanded significantly better than its native starch. On the other hand, electron beam and gamma irradiated tapioca starches seemed to produce 'keropok' with poor expansion properties and worse than the native starch. Good expansion was found in 'keropok' made from starches with high amounts of leaching and high molecular weight. Irradiated starch fish crackers were found to fracture at lower energy and had better crispiness properties despite that some crackers did not expand well. As a conclusion, irradiation of starch can improve the expansion and crispiness of fish crackers as it increases the leaching of amylose and amylopectin from the starch granules. The amylose and amylopectin can then be involved in the formation of starch-fish network, which allows the entrapment of water and will aid expansion during frying. The presence of higher molecular weight amylose and amylopectin will further contribute to better formation of this network. The ratio of amylose and amylopectin in the leachate would play a role in expansion, where higher amounts of amylopectin would give a better expanded fish crackers. High swelling ability and protein contents in starch are also contributing factors to expansion.

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

PENGUBAHSUAIAN KANJI GANDUM, SAGU DAN UBI KAYU MENGGUNAKAN RADIASI DAN KESANNYA KE ATAS CIRI-CIRI FIZIKAL KEROPOK IKAN

Oleh

NORANIZAN BINTI MOHD ADZAHAN

Januari 2002

Pengerusi: **Dzulkifly Mat Hashim**

Fakulti: **Sains Makanan dan Bioteknologi**

Kesan radiasi kanji ke atas ciri-ciri keropok ikan dari segi mikrostruktur kanji dalam keropok telah dikaji. Kanji gandum, ubi kayu dan sagu digunakan. Pengembangan linear keropok adalah paling baik apabila pengembangan granul kanji dan larut lesap amilosa/amilopektin adalah tinggi. Radiasi merupakan suatu cara memendekkan polimer kanji yang akan membawa kepada penambahan amaun bahan terlarut yang telah terkeluar dari granul. Gelombang mikro, pancaran electron dan sinar gamma telah digunakan untuk memendekkan polimer kanji. Brabender Viscograph, Texture Analyser (TAXT2-*i*), Falling Ball Viscometer dan Rheometer telah digunakan bagi menentukan ciri-ciri aliran pes dan gel kanji. Keputusan yang diperolehi menunjukkan bahawa radiasi telah menyebabkan pertambahan lelehan, pengurangan isipadu pengembangan granul yang ketara serta pengurangan kadar pembentukan gel secara serentak. Keputusan juga telah menunjukkan bahawa kekuatan gel kanji, kelikatan, ciri-ciri viskoelastik dan kelikatan intrinsik berkurang dengan peningkatan paras radiasi. Ini menandakan pengurangan berat molekul polimer kanji. Perubahan-perubahan ini adalah disebabkan pemotongan fraksi amilosa dan amilopektin menerusi tenaga radiasi. Keropok ikan yang diperbuat daripada kanji

gandum yang telah dikenakan radiasi kembang dengan nyata, lebih baik dari pengembangan oleh keropok yang diperbuat dari kanji gandum biasa. Keropok dari kanji gamdum teriradiasi ini lebih rangup berbanding kanji gandum biasa. Walaubagaimanapun, selepas paras tertentu semasa radiasi, pengembangan keropok merosot sungguhpun nilainya masih lebih tinggi dari keropok kanji biasa. Pengembangan sesetengah kanji gandum dan sagu meningkat dengan baik sehingga melebihi paras yang boleh diterima iaitu pengembangan 77%. Keropok daripada kanji ubi kayu yang telah dikenakan gelombang mikro didapati kembang lebih baik daripada kanji pengembangan kanji biasa. Sebaliknya, kanji ubi kayu yang dikenakan radiasi elektron dan sinar gamma menghasilkan keropok yang pengembangannya kurang baik berbanding kanji biasa. Pengembangan yang baik didapati disumbangkan oleh kandungan lelehan yang tinggi serta berat molekul yang tinggi. Keropok dari kanji teriradiasi didapati lebih mudah pecah dengan tenaga yang rendah serta rangup. Sebagai kesimpulan, rawatan radiasi ke atas kanji boleh memperbaiki pengembangan dan kerangupan keropok ikan kerana ia meningkatkan lelehan amilosa dan amilopektin dari granul kanji. Amilosa dan amilopektin akan terlibat dengan pembentukan jaringan kanji-ikan yang akan memerangkap air bagi tujuan pengembangan semasa menggoreng. Kehadiran amilosa dan amilopektin yang mempunyai berat molekul yang tinggi akan seterusnya menyumbang kepada pembentukan jaringan yang lebih baik. Nisbah amilosa dan amilopektin di dalam lelehan akan memainkan peranan dari segi pengembangan yang mana amaun yang tinggi akan menghasilkan keropok yang baik pengembangannya. Kebolehan untuk granul mengembang dengan baik dan kandungan protein dalam kanji yang tinggi adalah merupakan penyumbang kepada pengembangan keropok.

ACKNOWLEDGEMENTS

All praise due to Allah, the most gracious and merciful, for giving me the strength, health and determination to complete this research study. I would like to express my deepest appreciation and gratitude to the Chairman of my supervisory committee, En. Dzulkifly Mat Hashim for his patience, invaluable guidance and suggestions throughout the planning and extension of this research. I am eternally grateful to my co-supervisor, Assoc. Prof. Dr. Sharifah Kharidah Syed Muhammad and the coordinator for graduate studies in the faculty, Prof. Hasanah Mohd Ghazali for their attention, support and constant encouragement. I would like to express my sincere gratitude to Assoc. Prof. Dr. Russly Abdul Rahman, Dr. Zulkafli Ghazali and Dr. Kamarudin Hashim for their guidance, suggestions and insightful comments as members of the supervisory committee. I wish to acknowledge with thanks the staff of MINT, Electron Microcopy Unit, and Faculty of Engineering, UPM for the facilities and technical assistance provided. I would also like to thank all my friends especially Liyana, Benchamaporn and Choo Wee Sim for their support and cooperation throughout the whole period of this study. Appreciation is extended to Mr. Kyaw Zay Ya, En. Azman, Pn. Jamaliah, En. Amran, En. Soib, En. Mohd. Noh and En. Mustafa for their assistance in making this project possible. Finally, I would like to express a special note of appreciation to my beloved parents for their help in editing and providing ideas, advice and support throughout the duration of the project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF SYMBOLS AND ABBREVIATIONS

Symbols

α	alpha
γ	Gamma
μm	micrometer
kGy	kiloGray
Co	Cobalt

Abbreviations

AM	Amylose
AML	Amylose leaching
AP	Amulopectin
APL	Amylopectin leaching
BU	Brabender Units
CHO	Carbohydrate
CHOL	Carbohydrate leaching
EB	Electron beam
G’	Elastic Modulus
G”	Loss Modulus
SAS	Statistical Analysis System
SEM	Scanning Electron Microscope

CHAPTER 1

GENERAL INTRODUCTION

Fish crackers or 'keropok' is a high-protein snack food popular in ASEAN countries. In Malaysia, its production was reported as the third largest industry (12%) that was listed under the processed marine fish products with 12,801.43 weight in tonnes (Department of Fisheries Malaysia, 1998). 'Keropok' is made from gelatinised starch pastes, which are dried and then puffed by frying in hot oil (Siaw *et al.*, 1985). The type of starch used is normally sago or tapioca starch and the type of fish used should contain more than 200g/kg protein (Malaysian Food Act, 1985). The quality of fish crackers is judged from their crispiness, which can be determined mechanically or through sensory evaluation. In this study, mechanical determination is used to measure crispiness. Linear expansion of 'keropok' is also a measure of crispiness. The type of starch used in the system mainly influences expansion and crispiness. Different types of starch give different properties to the 'keropok'.

In the processing of fish crackers, sago or tapioca starch is often used. These starches give the cracker its good expansion property. Wheat starch has never been used due to its poor expansion property. The main differences between sago or tapioca starch with wheat starch are the leaching and swelling ability during cooking. In wheat starch, the naturally existing amylose-lipid complex inhibits swelling of the granules. This leads to inhibition of leaching of the starch polymers: amylose and amylopectin.

Wheat starch is among the most abundant starch. The world production in 1999 was reported to be 597.8 million tonnes, about 12% of the overall starch production (FAO, 1999). It has been widely utilized in the baking industry and is a by-product of the paper industry. Wheat starch has the A-type starch properties such as low swelling and leaching ability, opaque and moderate gel strength, and high in lipid and protein contents. The swelling ability was inhibited by the high lipid and protein contents. When swelling is inhibited, granules could not imbibe water and leaching of the starch polymers was limited. In wheat starch, most of the amylose will be solubilized before leaching of amylopectin begins but in oat starch co-leaching of amylose and amylopectin; or amylose and intermediate material occurred (Doublier et al, 1987). However, not all amylose leaches out during cooking. Some of it remains in the granules ("ghost" structure), that consist of mainly amylopectin (not in crystalline order).

The ratio of amylose to amylopectin leaching in starch greatly influences starch expansion and in the end affects the extent of puffing and texture of fried or extruded starch-based products. Besides amylose and amylopectin ratio in the granule, lipid content is also a factor influencing the swelling and leaching property of starch. Lipid forms complexes with amylose to inhibit swelling and leaching. This would affect the end product of a particular food. The consequence has been proven in fish crackers made from wheat, sago and tapioca starches. The amount of leaching varies for different types of starch and follows the order: sago (29.23%) > tapioca (26.83%) > wheat (16.43%) (Kyaw, 1999). The subdued leaching is attributed to the amylose-lipid complex in wheat starch that inhibits swelling. Sago and tapioca starches contain very small amount of lipid, therefore no inhibition to swelling and leaching occurred. Sago, wheat and tapioca starches contain 27%, 25% and 17% amylose,