UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF EXTRUDED GLUTEN FREE HARD PRETZEL FROM BREWER'S RICE

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By

MARYAM PAYKARY

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

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DEDICATION

This thesis is dedicated to my father who is always giving me his unlimited courage and support as well as to my mother who is always praying for my wellbeing.

I present this thesis to:

- **My beloved mother and father, and my brother for their unconditional love, patience and understanding**
- **My compassionate teachers who inspired me to love seeking for knowledge and be adventurous in life**

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

DEVELOPMENT OF EXTRUDED GLUTEN FREE HARD PRETZEL FROM BREWER'S RICE

By

MARYAM PAYKARY

April 2014

Chairman : Associate Professor Roselina Karim, PhD
Faculty : Food Science and Technology

Rice (*Oryza sativa*) is a staple food for nearly one-half of the world population. Its production and consumption is mainly concentrated in Asian countries by approximately 95% of the world's rice production. This amount of rice contributes to 40-80% of the Asian daily diet calories. The total world amount of harvested rice (paddy) was around 720 million tons in 2011. Broken rice which include chips and brewer's rice constitutes about 1-17% of the total amount of paddy produced depending on the milling process and conditions. The brewer's rice commercial usage, nowadays, is either for making wine or feeding livestock. The main goal of this study is to produce an extruded gluten-free pretzel-like snack for celiac people from brewer's rice which in turns resulted in value adding of brewer's rice, a low-value by-product of rice milling industry. Specifically, this study was conducted to re-optimize the basic materials in rice hard pretzel formulation and to improve the textural and physicochemical properties of the product by hydrocolloids addition. In the first part of the study, the main effect of seven basic materials on textural properties (cutting strength, breaking strength, crunchiness, and fracturability), surface color (L a and, b values), dimensional properties (lateral expansion, expansion ratio, and specific length), densities (bulk density, particle density, and material density), porosities (open porosity, close porosity, and total porosity), water reactions (water holding capacity, water solubility index, water absorption index), and oil reactions (oil holding capacity, oil absorption index) were studied in an attempt to choose the 20% of the most significant influential material to be optimized. Fresh yeast and sodium bicarbonate were the most significant factors affecting almost all of the properties studied. In the second part of the study, these factors were optimized in the new formula. Other formulation materials were fixed in order to obtain the required flavor. The result of RSM (Central Composite Design) showed that the best rice hard pretzel (optimal D = 47.22%) can be produced by adding 8.05g of fresh yeast and 2.59g of sodium bicarbonate for every 500g of brewer's rice flour. Changes in formulation did

not have any significant effect on pretzel surface colour ($p>0.05$). In the third part of the study, xanthan gum and hydroxy propyl methyl cellulose (HPMC) were added to the optimized basic formulation obtained from the first part of this study. Addition of soy lecithin as emulsifier at a concentration of 2% of the total fat was fixed throughout this section. Both the xanthan gum and HPMC were separately applied in a full factorial design with added water to determine the most suitable type and levels of hydrocolloid for producing the best rice hard pretzel. All the physico-chemical properties of the product as mentioned in part two above were evaluated. The HPMC was recommended as the most suitable hydrocolloid in this study due to wider application of concentration range compared to xanthan gum. The result showed that addition of 4.44-4.95g of HPMC and 153.5-178.6g of water for every 500g of brewer's rice flour produces rice hard pretzel with the best textural and physico-chemical properties ($p<0.05$; optimal D=100.0%). The optimal experimental values of all 18 different textural, and physic-chemical properties are as follows: cutting strength 12.392±0.747N, breaking strength 0.383±0.008N, crunchiness 14.334±1.528, fracturbility 3.533±0.0458mm, lateral expansion 52.11±1.57%, expansion ratio 1.547±0.006, specific length 7.774±0.194, bulk density 0.4663±0.0266g/ml, particle density 1.0987±0.0460g/ml, material density 1.4261±0.0092g/ml, open porosity 57.69±2.50%, close porosity 26.89±0.73%, total porosity 68.39±0.68%, WAI 6.3140±0.1087g/g, WSI 7.62±0.28%, WHC 4.5012±0.2339g/g, OAI 4.91±0.22ml/g, and OHC 0.83±0.04%. the final optimized gluten free rice hard pretzel formulation includes 67.633% brewer's rice flour, 3.219% corn starch, 3.246% shortening, 0.034% ammonium bicarbonate, 0.007% soy lecithin , 0.352% sodium bicarbonate, 0.676% sodium chloride, 1.089% yeast, 0.625% HPMC, and 23.119%water.

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

PEMBANGUNAN PRETZEL KERAS BERAS TANPA GLUTEN DARI TEPUNG TEMUKUT DENGAN MENGGUNAKAN KAEDAH PENYEMPERITAN

Oleh

MARYAM PAYKARY

July 2014

Pengerusi : Profesor Madya Roselina Karim, PhD
Fakulti : Sains dan Teknologi Makanan

Beras (*Oryza sativa*) adalah makanan ruji untuk hampir separuh daripada penduduk dunia. Pengeluaran dan penggunaan utamanya tertumpu di negara-negara Asia, dengan lebih kurang 95% daripada pengeluaran beras didunia serta menyumbang kepada 40-80% daripada kalori diet harian orang di Asia. Jumlah amaun padi yang dituai (beras) di dunia adalah kira-kira 720 juta tan pada tahun 2011. Beras hancur termasuk cip dan temukut, adalah lebih kurang 1-17 % daripada jumlah padi bergantung kepada proses dan keadaan pengilangan. Buat masa ini, secara komersialnya, temukut digunakan untuk membuat wain atau sebagai binatang ternakan. Objektif utama kajian ini adalah untuk menghasilkan pretzel keras beras tanpa gluten, suatu makanan ringan tersemprit untuk orang yang menghidap seliak, yang mana telah memberi nilai tambah kepada temukut, suatu hasil sampingan industri pengilangan beras yang bernilai rendah. Secara khususnya, kajian ini telah dijalankan untuk mengoptimumkan bahan-bahan asas untuk penghasilan pretzel keras beras menggunakan metodologi respons permukaan (RSM) dan untuk memperbaiki sifat-sifat tekstur dan fizikokimia produk dengan penambahan hidrokoloid. Dalam bahagian pertama kajian ini, kesan utama tujuh bahan asas terhadap pretzel keras beras (kekuatan pemotongan, kekuatan pemecahan, kegaringan dan keretakan), warna permukaan (nilai L, a dan b), ciri-ciri dimensi (pengembangan sisi, nisbah pengembangan dan panjang spesifik), ketumpatan (ketumpatan pukal, ketumpatan zarah dan ketumpatan bahan), keliangan (keliangan terbuka, keliangan dekat dan jumlah keliangan), tindakbalas dengan air (keupayaan memegang air, indeks penjerapan air, indeks penyerapan air), dan tindakbalas dengan minyak (keupayaan memegang minyak, indeks penyerapan minyak) telah dikaji dalam usaha untuk memilih 20% bahan yang paling berkesan untuk dioptimumkan. Yis segar dan natrium bikarbonat adalah faktor yang paling penting yang mempengaruhi hampir kesemua sifat-sifat yang dikaji. Oleh itu, faktor-faktor ini telah dioptimumkan dalam formulasi yang baru. Bahan-bahan formulasi lain ditetapkan untuk mendapatkan perisa yang diingini. Hasil RSM (Rekabentuk Komposit Pusat) menunjukkan bahawa formulasi yang terbaik boleh dihasilkan dengan menambah 8.05g yis segar dan 2.59g natrium bikarbonat bagi setiap 500g tepung temukut ke dalam formulasi (D optimum= 47.22%). Perubahan dalam formulasi tidak mempunyai sebarang kesan yang ketara terhadap

warna permukaan pretzel keras beras ($p>0.05$). Dalam bahagian kedua kajian ini, gam xanthan dan hidroksi metilselulosa (HPMC) telah ditambah kepada formulasi asas yang dioptimumkan di bahagian pertama kajian. Penambahan lesitin soya sebagai pengemulsi telah ditetapkan pada kepekatan 2% daripada jumlah lemak di sepanjang bahagian ini. Kedua-dua, gam xanthan dan HPMC telah digunakan secara berasingan dalam rekabentuk faktorial lengkap dengan penambahan air untuk menentukan jenis dan aras hidrokoloid bagi penghasilan pretzel keras beras yang terbaik. Semua sifat-sifat fizikokimia pada produk yang disediakan seperti yang dinyatakan di bahagian pertama telah dinilai. Keputusan menunjukkan bahawa penambahan 153.5-178.6g HPMC dan 4.44-4.95g air bagi setiap 500g tepung temukut menghasilkan pretzel keras beras dengan sifat tekstur dan fizikokimia yang terbaik ($p < 0.05$; D optimum= 100.0%). Nilai eksperimen optimum semua 18 tekstur yang berbeza, dan sifat-sifat fizik-kimia adalah seperti berikut: memotong kekuatan 12,392 ± 0.747N, kekuatan pecah 0.383 ± 0.008N, kegaringan 14,334 ± 1.528, fracturbility 3,533 ± 0.0458mm, pengembangan sisi 52,11 ± 1,57% , nisbah pengembangan 1.547 ± 0.006, panjang khusus 7.774 ± 0.194, berat isi 0,4663 ± 0.0266g / ml, ketumpatan zarah 1,0987 ± 0.0460g / ml, ketumpatan bahan 1,4261 ± 0.0092g / ml, keliangan terbuka 57,69 ± 2,50%, keliangan dekat 26.89 ± 0.73%, jumlah keliangan 68.39 ± 0.68%, WAI 6,3140 ± 0.1087g / g, WSI 7.62 ± 0.28%, WHC 4,5012 ± 0.2339g / g, OAI 4.91 ± 0.22ml / g, dan OHC 0.83 ± 0.04%. gluten dioptimumkan beras percuma formulasi pretzel keras final meliputi 67,633% tepung bir beras, 3,219% pati jagung, 3.246% shortening, 0,034% ammonium bikarbonat, 0.007% soya lesitin, 0.352% natrium bikarbonat, 0.676% natrium klorida, 1.089% ragi, 0,625 % HPMC, dan 23,119% air.

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I certify that a Thesis Examination Committee has met on 17 July 2014 to conduct the final examination of Maryam Paykary on her thesis entitled "Development of Extruded Gluten Free Hard Pretzel from Brewer's Rice" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the degree of Master of Science.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science.

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LIST OF ABBREVATIONS

A.D.	after death of Christ
ANOVA	analyze of variance
a- value	red to green (color parameter)
BD	bulk density
b- value	blue to yellow (color parameter)
CCD	central composite design
CD	celiac (coeliac) disease
CMC	carboxy methyl cellulose
Cor Total	corrected total
CP	close porosity
CRD	completely randomized design
D	desirability
Db	dry bulb
Df	degree of freedom
ER	expansion ratio
FAO	Food and Agricultural Organization
GFD	gluten free diet
H	Hour
HPMC	hydroxyl propyl methyl cellulose
HTST	high temperature short time
lb	Pound
LE	lateral expansion

L-value	lightness, blackness-whiteness (color parameter)
MC	moisture content
MD	material density
mm	millimeter
No.	number
ns	not significant
OAI	oil absorption index
OHC	oil holding capacity
OP	open porosity
pH	power of hydrogen ion
PD	particle density
R	correlation coefficient
rpm	revolution per minute
RSM	response surface methodology
SL	specific length
SMS	sodium metabisulphite
TP	total porosity
UK	United Kingdom
USA	United States of America
USD	United States of America Dollar
w	weight
WAI	water absorption index
WHC	water holding capacity
WSI	water solubility index

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa*), the staple food of nearly one-half of world's population, contributes to over 20% of the total calorie intake of man. Its production and consumption mainly concentrated in Asian countries by approximately 95% of the world's rice and provide 40-80% of the Asian daily diet calories (Bhattacharjee et al., 2002). The rice milling processes produce a byproduct known as very small broken rice (also known as chips or brewer's rice). The ratio of broken rice to whole grain depends on the process efficiency, ranges between 1% to 17% and it has much lower price when compared to the white rice (FAO, 2010; Hertrampf & Piedad-Pascual, 2000). The chemical composition of brewer's rice and polished rice is almost the same, except that the content of crude fat of brewer's rice is less than in polished rice and the N-free extract in brewer's rice is higher than that in polished rice. This means that the majority of brewer's rice composition is starch (80%) based on dry weight (Hertrampf et al., 2000). This characteristic makes brewer's rice a desirable ingredient for production of gluten free products to meet the increase demand of those who suffer from celiac disease (Gallagher, 2009).

Celiac disease (CD) is an immune-mediated enteropathy triggered by the ingestion of gluten in genetically susceptible individuals. Today, the prevalence of CD seems to occur in 1:200 or more of the population (Accomando & Cataldo, 2004; Gallagher, 2009). The symptom of CD may be varied and hard to define. An infant who is introduced to grain at an early age may show symptoms such as diarrhea, constipation, foul-smelling stool, fatigue, slow growth pattern, irritability, whereas an older adult frequently presents with anemia without apparent reason. At present, the only available treatment for CD is a strict gluten-free diet (GFD). Based on Codex Alimentarius requirement, gluten free food products must not contains any amount or derivatives of ingredients from gluten source and if there is any additional ingredients from gluten source, it should not exceed 200 ppm as a total amount of gluten in the mixture (Codex-Alimentarius-Commission, 2007; Gallagher, 2009).

Currently, after the lactose intolerance, CD is the most common issue facing food industry; therefore gluten free products are currently gaining the highest growth in the market (Gallagher, 2009; Kuntz, 2006) The retail gluten-free food market has grown to an estimate of 6.1 billion USD in 2011 and the number of new gluten free products offered to the market in the USA was 202 items in 2004 and it had reached to 636 in 2007. The most demanded products were snacks and bakery products with 27% and 15% of whole new products offered to the market, respectively (Gallagher, 2009; Mintel, 2012). One major area of concern that must be addressed is the high cost of the GFD. The average cost of a gluten-free food item compared with its gluten-containing counterpart is five

times as great. For instance, wheat cracker in the USA costs $1.63/lb while rice cracker is worth $9.12/lb (Gallagher, 2009).

Pretzels, which are a kind of cracker in bakery industry, are a popular snack in the USA, Germany and some other European countries (Francis, 2000; Lai & Lin, 2007). Pretzels are commonly produced from very stiff dough made from low protein soft wheat flour such as soft white winter wheat (Edwards, 2007; Lai et al., 2007). Nowadays, extrusion process became very popular for production of these products. Extrusion is a process of central importance and widespread application in the food industry (Berk, 2009). The extruder geometry, process conditions and ingredient composition interplay to bring about various physical, chemical and nutritional modifications of the food constituents (Cheftel, 1986). Extrusion is a commonly used process because it is a continuous and versatile process. An extruder comprised of a relatively compact machine and hence requires little floor-space and labor. In addition, the relatively short retention time of product in the extruder resulted in lower energy expenditure of extrusion cooking in comparison to other alternative processes (Berk, 2009).

In other part of the world, brewer's rice is widely used in the brewery industries for making rice wine (*sake*) or mixing with barley (FAO, 2010). However, in Islamic countries brewer's rice can be value-added as ingredients for the food industry rather than as low grade livestock feed. Accordingly, it can be used for production of gluten free products such as pretzel to meet the increase consumer demand of these products category and to reduce the cost of production by using rice milling process by-products as raw material. In achieving the above targets, thus the general and specific objectives of this work are outlined below.

The general objective is:

- To develop a new extruded gluten free rice hard pretzel from brewer's rice, a by-product of rice milling industry.

The specific objectives of this study are:

1. To identify the most critical ingredients in the basic formulation of gluten free rice hard pretzel
2. To optimize the critical ingredients in the basic formulation for gluten free rice hard pretzel using response surface methodology (RSM)
3. To improve the physicochemical properties of hard rice pretzel by addition of hydrocolloids.

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