UNIVERSITI PUTRA MALAYSIA

PROPERTIES OF PRE-GERMINATED RICE GRAIN, FLOUR AND STARCH, AND USE OF THE FLOUR AS TEXTURE MODIFIER IN CRACKERS

SARITA ANDIAPPAN

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PROPERTIES OF PRE-GERMINATED RICE GRAIN, FLOUR AND STARCH, AND THE UTILISATION OF ITS FLOUR IN CRACKERS

By

SARITA A/P ANDIAPPAN

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

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

PROPERTIES OF PRE-GERMINATED RICE GRAIN, FLOUR AND STARCH, AND THE UTILISATION OF ITS FLOUR IN CRACKERS

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June 2013

Chairperson: Assoc. Prof. Sharifah Kharidah Syed Muhammad, PhD
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Consumers preferred white or milled rice that has lost most of its nutrients in the milling process. Therefore, an effort in enhancing the nutritional value of the rice through pre-germination which is a natural processing method was studied. The effects of pre-germination on the functional properties of the rice were also studied. Rice of MR 219 and MR 220 varieties were pre-germinated by soaking paddy in water for 24 hours at room temperature, followed by incubation of the soaked paddy on filter paper for 48 hours at 30ºC for growth of embryonic radical up to 0.5 mm. The physical properties of the pre-germinated rice such as grain dimension, color and 1000 kernel weight did not fulfill the specifications of rice grains from varieties MR 219 and MR 220. However, the results indicated that cooking qualities such as cooking time, grain elongation and texture of the pre-germinated rice grains were improved. Less cooking water was required and less solid content was lost during cooking. As the pre-germination process caused a decline in the physical properties of the rice grains, the pre-germinated rice grains were ground into flour and the nutritional and functional properties of the flour was studied. Increased contents of dietary fiber, magnesium, potassium, vitamin B2, vitamin B3, vitamin B6, total phenolics and antioxidants together with medium glycemic index resulted in the pre-germinated rice flour. The carbohydrate, protein, fat and ash contents as well as the functional properties of the rice flour were reduced after pre-germination. In addition, the high yield of pre-germinated rice starch (96%) obtained using water extraction method proposed its utilisation as a value added ingredient in food applications. The amylose content of the pre-germinated rice starch was significantly reduced due to its utilisation for growth of radicle while resistant starch content was increased by 15%. The results also showed that the extracted pre-germinated rice starch gelatinised easily upon heat treatment and formed soft gel that was less viscous. The pre-germinated rice starch was then utilised in the preparation of rice crackers to evaluate its ability to behave as a texture modifier. The hardness, fracturability and crispiness of the rice crackers were improved and were

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significantly correlated with the proximate composition and starch properties of the pre-germinated rice flour. All the findings were similar for both rice varieties (MR 219 and MR 220). In conclusions, the pre-germination process degraded the physical properties of rice but enhanced the flour and starch properties for the production of softer rice crackers.

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Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
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CIRI-CIRI BIJIAN, TEPUNG DAN KANJI BERAS PRACAMBAH SERTA PENGGUNAAN TEPUNGNYA DALAM KRAKER

Oleh,

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2013

Pengerusi: Prof. Madya Sharifah Kharidah Syed Muhammad, PhD
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Pengguna lebih gemar memakan beras (nasi) putih yang telah kehilangaan kebanyakkan nutrien daripada proses pengilingan. Oleh itu, usaha untuk meningkatkan nilai pemakanan beras melalui proses pra-cambahaan yang merupakan salah satu kaedah pemprosesan secara semulajadi telah dikaji. Selain daripada itu, kesan pra-cambahan terhadap ciri fungsian beras juga dikaji. Varieti padi MR 219 dan MR 220 telah di pra-percambah dengan merendam padi di dalam air selama 24 jam pada suhu bilik, diikuti oleh proses pengeraman selama 48 jam pada suhu 30ºC untuk pertumbuhan embrio radikal sehingga 0.5 mm panjang. Ciri fizikal beras pra-bercambah tersebut iaitu dimensi bijian, warna dan berat 1000 bijian tidak memenuhi spesifikasi bijian beras varieti MR 219 dan MR 220. Walau bagaimanapun, keputusan menunjukkan bahawa kualiti pemasakan seperti tempoh waktu masak, pemanjangan bijirin dan tekstur beras pra-bercambah telah diperbaiki. Kandungan air yang kurang diperlukan dan kurang kandungan pepejal yang hilang semasa masak. Oleh itu, proses pra-bercambahan menyebabkan ciri fizikal bijian, bijian beras pra-bercambah tersebut telah dikisar menjadi tepung dimana nilai pemakanan dan ciri fungsiannya telah dikaji. Peningkatan kandungan serat diet, magnesium, kalium, vitamin B2, vitamin B3, vitamin B6, jumlah fenolik dan antioksidan serta nilai indeks glisemik yang serderhana diperolehi dalam tepung beras pra-bercambah. Selain daripada itu,kandungan karbohidrat, protein, lemak, dan abu serta fungsi-fungsi beras merosot semasa proses pra-percambahan. Selain itu, hasil kanji beras pra-bercambah yang tinggi (95%) diperolehi melalui kaedah pengekstrakan air yang sesuai boleh digunakan sebagai ramuan tambah nilai dalam aplikasi makanan. Kandungan amilosa kanji beras pra-bercambah berkurangan secara signifikan disebabkan oleh penggunaannya untuk pertumbuhan radikal manakala kandungan kanji rintang meningkat sebanyak 15%. Keputusan juga menunjukkan kanji beras pra-bercambah yang diekstrak mudah mengelatin apabila dipanaskan dan membentuk gel yang lembut dan likat. Malah, kanji beras pra-bercambah telah digunakan dalam penyediaan biskut beras untuk menilai kemampuannya sebagai

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pengubahsuai tekstur dan berhubung kait dengan komposis proksimat dan pencirian tepung kanji beras pra-cambah. Proses pra-percambahan bagi beras telah menjejaskan kualiti bijian beras, tetapi ia juga membaiki nilai pemakanan dan ciri fungsian tepung beras tersebut. Tepung kanji beras pra-cambah telah membaiki kekerasan, kerapuhan, dan kerangupan kraker beras tersebut. Semua penemuan adalah sama untuk kedua-dua varieti beras (MR 219 dan MR 220). Kesimpulannya, proses pra-cambahan telah menjejaskan ciri fizikal tetapi ia telah meningkatkan kualiti tepung dan ciri kanji untuk penghasilan kraker yang lebih lembut.

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I certify that a Thesis Examination Committee has met on 26 Jun 2013 to conduct the final examination of Sarita a/p Andiappan on her thesis entitled "Properties of Pre-germinated Rice Grain, Flour and Starch and the utilisation of its flour in Crackers" 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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TABLE OF CONTENTS

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LIST OF TABLES

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LIST OF FIGURES

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LIST OF APPENDICES

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LIST OF ABBREVIATIONS

GABA	Gamma aminobutyric acid
PGBR	Pre-germinated brown rice
PGWR	Pre-germinated white rice
PGRS	Pre-germinated rice starch
FAO	The *Food and Agriculture Organization* of the United Nations
FAOSTAT	The FAO Statistical Database
IRRI	International Rice Research Institute
FELCRA	Federal land consolidation and rehabilitation authority
BERNAS	Padibernas Nasional Bernas
MARDI	*Malaysian Agricultural Research and Development Institute*
U.K.	United kingdom
U.S.A	Unites State of America
DP	Degree of polymerization
US$	Unite state dollars
RM	Ringgit Malaysia
UNICEF	The United Nations Children's Fund
AOAC	Association of Official Analytical Chemists
AACC	*American Association of Cereal Chemists*
GAE	Gallic acid equivalent
DPPH	2,2-diphenyl-l-picrylhydrazyl
TE	Trolox equivalent
GI	Glycemic index
DRI	Dietary Reference Intakes
EA	Emulsion activity
ES	Emulsion stability
RVU	Rapid visco units
Ti	Initial viscosity
PV	Peak viscosity
Pt	Time at initial viscosity
HPV	Hot paste viscosity
BV	Breakdown viscosity
CPV	Cooled paste viscosity
SBV	Setback viscosity
DSC	Differential scanning calorimeter
T_o	Onset temperatures
T_p	Peak temperatures
T_c	Conclusion temperatures
Tg	Glass transition temperatures of gelatinization
ΔH	The enthalpy of gelatinization
J/g	Joules per unit of dry weight
RC	Relative crystallinity

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CHAPTER 1

INTRODUCTION

In Asian countries, rice is usually consumed in the form of milled (white) rice rather than the non milled (brown) form. The brown rice differs from white rice by the presence of bran and germ that were removed during the milling step. In the course of milling rice, major content of proteins, fats, vitamins, and minerals that are concentrated in the germ and bran (Itani *et al.*, 2002; Juliano, 1985) are removed. Consumers prefer white rice to brown rice because of their superior cooking quality (Roberts, 1979). White rice is rich in starch, and starchy food contributes to health problems, such as obesity and diabetes mellitus (Anthony, 2002; Granfeldt *et al.*, 1996). In line with the demand for nutritious and healthier rice, pre-germination process can be a natural and traditional processing method to yield value-enhanced rice. Robert *et al.* (2007) showed that some of the advantageous bio-active compounds such as gamma aminobutyric acid (GABA) and oryzanols that were generated as a result of the pre-germination process are beneficial to human health.

Pre-germinated rice has the potential to be an alternative source of staple meals for type 2 diabetic patients (Marlett *et al.*, 2002; Kayahara and Tukahara, 2000) since it contains less calories (carbohydrates) due to starch utilisation during the pre-germination process. Apart from that, pre-germinated rice was also reported to aid in lowering blood pressure and improving brain functions, which can prevent Alzheimer's disease (Mamiya *et al.*, 2007). Besides that, pre-germinated rice can also relieve some symptoms of menopause, prevent headaches, relieve constipation, and prevent some cancers, including colon cancer and leukaemia (Kayahara and Tukahara, 2001).

Pre-germination is usually difficult to differentiate from germination due to uncertainty in cellular and molecular events occurring during the seedling process, or even the ongoing process of growing plants (Nonogaki *et al.*, 2010). The seedling process occurs when a seed is hydrated and results in breaking its dormancy. The pre-germination process involves the growth of embryonic root within 0.5 mm long while the germination process is the growth of tiny embryonic shoot after the growth of root (Nonogaki *et al.*, 2010; Koornneef *et al.*, 2002; Paul, 2000; Derek, 1997). Thus, the seed has become a plant by utilising all the essential macronutrients and micronutrients at the end of a germination process, while the pre-germinating process utilise only certain nutrients, but enhancing huge amounts of other vital nutrients, which can be utilised for the benefit of human health (Ken'ichi *et al.*, 2004).

Pre-germinated rice is consumed in some Asian countries, mainly in Japan (Komatsuzaki *et al.*, 2003; Kayahara and Takamura, 2001) for health purposes regardless of the rice grain quality. Even though the health benefits of the pre-germinated rice are promising, the processing method to produce pre-germinated

brown rice (PGBR) and pre-germinated white rice (PGWR) may affect the physical and cooking qualities of the pre-germinated rice grain.

Besides consuming rice as grains, it can also be milled into flour for the production of rice-based product or extracted to produce rice starch, which can be exploited as an ingredient for pharmaceutical and food industry applications. Pre-germinated rice starch (PGRS) can replace control sample since the hydrolysing process during pre-germination can mask the disadvantages of control sample. Control sample lack the versatility to function adequately under rigorous industrial processing of a food system, which can be overcome by the PGRS mainly in the aspect of its ability to modify the texture of a product apart from affecting the cooking and eating quality (Blazek and Copeland, 2008). Even though pre-germinated rice flour and starch may have potential advantages, they are still underutilised in food applications.

The conventional way of preparing snacks, such as cookies and biscuits is by using wheat or corn flour as the major source of ingredient. However, as new products evolve, other basic ingredients, such as rice were explored as potential raw materials in snack foods (Kadan *et al.*, 2001). Rice based snacks gained less attention from consumers due to their less favourable texture that affected their overall acceptability compared to that made from wheat flour. For example, rice crackers made from pre-germinated rice flour may have the potential of its texture to be modified crispier due to the hydrolysed starch properties of the flour.

Although pre-germinated and germinated rice had been reported to be healthier, yet the physical properties and cooking qualities of pre-germinated rice grains, chemical and nutritional properties of pre-germinated rice flour and starch, and their applications in the food industry have still not been investigated. Therefore, the aim of this study was to determine the effect of pre-germination on the rice grain, flour and starch properties of both brown and white rice varieties MR 219 and MR 220.

The specific objectives of the study were:

1. To determine the effect of pre-germination on the physical characteristics and cooking qualities of brown and white rice grains.
2. To determine the effect of pre-germination on the nutritional and functional properties of rice flours.
3. To extract and determine the characteristics of pre-germinated rice starch.
4. To correlate the proximate composition and starch properties of pre-germinated rice flour with the texture of rice crackers.

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APPENDICES

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PUBLICATION

Sarita Andiappan , Balakrishnan Shammugasamy, Yogeshini Ramakrishnan , Jamilah Bakar, Roselina Karim and Kharidah Muhammad. Physicochemical, antioxidant and cooking properties of rice from germinated Malaysian MR219 paddy". *Journal of Tropical Agricultural Science. – Submitted*

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