



UNIVERSITI PUTRA MALAYSIA

**YIELD, PHYSICO-CHEMICAL AND NUTRITIONAL CHARACTERISTICS
OF MR219 RICE MUTANTS AND THEIR EFFECTS ON GLYCEMIC
INDEX AND RESPONSES IN BALB/c MICE**

ASMA ILYANI KADAR

FP 2019 38



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By

ASMA ILYANI KADAR

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in
Fulfillment of the Requirement for the Degree of Master of Science**

October 2018



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DEDICATION

THIS THESIS IS SPECIALLY DEDICATED

TO

MY PARENTS; HJ. KADAR BIN DAYAT AND HJH. ASRIAH BINTI MAIDIN

MY LATE HUSBAND; MOHD FARHAN BIN REDWAN

AND

BELOVED FAMILY



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

YIELD, PHYSICO-CHEMICAL AND NUTRITIONAL CHARACTERISTICS OF MR219 RICE MUTANTS AND THEIR EFFECTS ON GLYCEMIC INDEX AND RESPONSES IN BALB/c MICE

By

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October 2018

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Rice is the most important food in Malaysia. Large efforts have been undertaken towards new variety development, technology improvement and innovation. Mutation technique is a conventional breeding method and it is very effective in improvement of main crop characteristics such as yield traits, resistance to diseases and pests and nutritional qualities. The continuous increase in rice consumption on daily basis due to increase in human population causes health related issues among diabetic's patients. As the awareness of the general public as related to healthy food increases, diabetic patients are constantly in search of rice variety suitable for their diet. Thus, this study was undertaken to determine the genetic variations among quantitative traits such as physico-chemical, nutritional and yield characteristics of MR219 mutant lines and their glycemic responses in relation to diabetic conditions. In this study, MR219 seeds were treated with carbon ion radiation (60 Gray) by AVF-Cyclotron at the National Institute of Quantum and Radiological Science and Technology (QST), Japan and were planted at the Malaysian Nuclear Agency up to forth mutant generation (M₄). Thirty-one M₄ mutant lines (ML1 to ML31) were evaluated on vegetative, yield and yield components, physico-chemical characteristics and nutritional composition in comparison with the parental variety, MR219. Analysis of variance revealed that there was a significant difference among the mutant lines in culm height, days to flowering, number of tillers, number of panicles, 1000-grain weight, total grain weight, moisture content, total of dry matter, alkaline spreading value, gel consistency, amylose content, ash, protein, fat, dietary fibre, carbohydrate and energy. Mutant line ML21 had the best performance in majority of yield components and vegetative traits as compared to other mutant lines and parental variety. For nutritional composition, mutant lines namely ML31, ML21, ML10, ML19 were improved in crude protein content, dietary fibre and carbohydrate content. The phenotypic coefficient of variation of vegetative, yield and yield components were found higher than their genotypic coefficient of variation. These indicated great environmental effects in this population. The estimation of glycemic

index revealed two mutant lines namely ML3 and ML30 had significantly lower glucose reading (5.49mmol/L and 5.47mmol/L, respectively) than parental variety and other mutant lines. The normal glucose reading in ML3 and ML30 also resulted in moderate GI values (65% and 66%, respectively) and could be suggested for further breeding programme to develop low GI rice. In this study, ion beam irradiation had significantly induced genetic variability in yield and yield components, physico-chemical characteristics and nutritional composition which also affected the glycemic index of the rice.



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

**CIRI-CIRI HASIL, KIMIA-FIZIKO DAN NUTRISI MUTAN PADI MR219
DAN KESANNYA KE ATAS INDEKS GLISEMIK DAN TINDAKBALAS
PADA TIKUS BALB/c**

Oleh

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Padi adalah makanan yang paling penting di Malaysia. Usaha besar telah diambil ke arah pembangunan varieti baru, peningkatan teknologi dan inovasi. Teknik mutasi adalah teknik pembiakan konvensional dan sangat berkesan dalam meningkatkan ciri-ciri tanaman utama seperti ciri-ciri hasil, rintangan kepada penyakit dan perosak dan kualiti pemakanan. Peningkatan penggunaan beras secara berterusan pada setiap hari kerana peningkatan populasi manusia menyebabkan masalah berkaitan kesihatan di kalangan pesakit kencing manis. Oleh kerana kesedaran orang ramai berkaitan dengan makanan yang sihat telah meningkat, pesakit diabetes sentiasa mencari jenis beras yang sesuai untuk diet mereka. Oleh itu, kajian ini telah dijalankan untuk menentukan variasi genetik di antara ciri-ciri kuantitatif seperti kimia-fiziko, ciri-ciri pemakanan dan hasil mutan MR219 dan tindak balas glisemik padi mutan untuk tujuan penggunaan oleh pesakit kencing manis. Dalam kajian ini, benih MR219 telah dirawat dengan radiasi Karbon ion (60 Gray) oleh AVF-Cyclotron di National Institute of Quantum and Radiological Science and Technology (QST), Japan dan telah ditanam di Agensi Nuklear Malaysia sehingga generasi mutan keempat (M₄). Tiga puluh satu mutan M₄ (ML1 hingga ML31) dinilai berdasarkan morfologi, hasil, komponen hasil, sifat fizik-kimia dan komposisi nutrisi dan telah dibandingkan dengan varieti asal, MR219. Analisis varians menunjukkan terdapat perbezaan yang signifikan di antara mutan untuk tinggi jelaga, hari berbunga, bilangan anak padi, bilangan tangkai, 1000 berat bijian, jumlah berat bijian, jumlah bahan kering, nilai sebaran alkali, kekonsistenan gel, kandungan kelembapan, kandungan amilosa, abu, protein, lemak, serat, karbohidrat dan tenaga. Mutan ML21 mempunyai prestasi yang terbaik dalam majoriti komponen hasil dan ciri-ciri vegetatif berbanding mutan lain dan varieti asal. Untuk komposisi nutrisi, terdapat penambahbaikan pada mutan ML31, ML21, ML10, ML19 dalam kandungan protein mentah, serat dan kandungan karbohidrat. Pekali variasi fenotip vegetatif, hasil dan komponen hasil didapati lebih tinggi daripada pekali variasi genotip mereka. Ini menunjukkan kesan alam sekitar yang besar di kalangan populasi ini. Anggaran indeks glisemik mendedahkan bahawa dua mutan iaitu ML3 dan ML30 mempunyai bacaan

glukosa yang lebih rendah (5.49mmol/L dan 5.47mmol/L, masing-masing) berbanding varieti asal dan barisan mutan yang lain. Bacaan glukosa yang normal pada ML3 dan ML30 juga menghasilkan nilai GI yang sederhana (65% dan 66%, masing-masing) dan boleh dicadangkan bagi program pembiakbakaan seterusnya untuk membangunkan beras dengan nilai GI yang rendah. Dalam kajian ini, penyinaran sinar ion telah menyebabkan keteraruhan kepelbagaian genetik yang ketara dalam komponen hasil dan hasil, ciri-ciri fiziko-kimia dan komposisi nutrisi yang turut mempengaruhi indeks glisemik beras.



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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;

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TABLE OF CONTENTS

	Page
ABSTRACT	i
ABSTRAK	iii
ACKNOWLEDGEMENTS	v
APPROVAL	vi
DECLARATION	viii
LIST OF TABLES	xiii
LIST OF FIGURES	xv
LIST OF APPENDICES	xvi
LIST OF ABBREVIATIONS	xvii
CHAPTER	
1 INTRODUCTION	1
2 LITERATURE REVIEW	3
2.1 Rice origin	3
2.2 MR219 rice variety	3
2.3 Mutation breeding and its history	4
2.4 Mutagenic treatments	5
2.5 Types of mutagenic treatments	5
2.6 Implementation and the outcome from mutation in rice breeding	6
2.6.1 Agronomic characters	6
2.6.2 Texture	8
2.6.3 Nutrition	8
2.6.4 Improvement of lodging resistance	9
2.6.5 Pests and diseases	10
2.7 Glycemic response and glycemic index	10
3 VEGETATIVE, YIELD AND YIELD COMPONENTS, PHYSICO-CHEMICAL CHARACTERISTICS AND NUTRITIONAL COMPOSITION OF MR219 RICE MUTANTS	12
3.1 Introduction	12
3.2 Materials and Methods	13
3.2.1 Background of planting materials	13
3.2.2 Experimental site and design	13
3.2.3 Data collection	16
3.2.3.1 Vegetative traits	16
i. Culm height	16
ii. Flag leaf area	16
iii. Days to 50% flowering	16
iv. Days to maturity	16
3.2.3.2 Yield and yield components	16
i. Number of tillers per plant	16

	ii. Number of panicles per plant	17
	iii. Panicle length	17
	iv. Total grains per panicle	17
	v. Filled grain (%)	17
	vi. 1000-grain weight (g)	17
	vii. Total grain weight (g/plant)	17
3.2.3.3	Physico-chemical characteristics and nutritional composition	17
	i. Dry matter	18
	ii. Equilibrium water content	18
	iii. Alkaline spreading value	18
	iv. Gel consistency	19
	v. Amylose content	19
	vi. Moisture content	20
	vii. Ash	20
	viii. Protein and total nitrogen	21
	ix. Crude fat	21
	x. Dietary fibre	22
	xi. Carbohydrate	23
	xii. Energy	23
3.2.4	Statistical analysis	24
	3.2.4.1 Analysis of variance (ANOVA)	24
	3.2.4.2 Heritability, genotypic and phenotypic coefficient of variation, and Pearson correlation coefficient	24
3.3	Results and discussion	26
	3.3.1 Vegetative characters	26
	3.3.1.1 Analysis of variance (ANOVA)	26
	3.3.1.2 Means comparison of vegetative characters among mutant lines	26
	3.3.2 Yield and yield components	30
	3.3.2.1 Analysis of variance (ANOVA)	30
	3.3.2.2 Means comparison of yield and yield components among mutant lines	30
	3.3.2.3 Variance components and broad-sense heritability of vegetative characters, yield and yield components	35
	3.3.2.4 Correlation coefficient among vegetative characters, yield and yield component traits	36
	3.3.3 Physico-chemical characteristics	38
	3.3.3.1 Analysis of variance (ANOVA)	38
	3.3.3.2 Means comparison of physico-chemical characteristics among the mutant lines	39
	3.3.4 Nutritional composition	41
	3.3.4.1 Analysis of variance (ANOVA)	41
	3.3.4.2 Means comparison of nutritional composition among the mutant lines	41

3.4	Conclusion	44
4	EVALUATION OF SELECTED MR219 MUTANTS RICE ON GLYCEMIC RESPONSES IN BALB/c MICE	45
4.1	Introduction	
4.2	Materials and Methods	45
4.2.1	Animal model and experimental design	46
4.2.2	Preparation of food samples	46
4.2.3	Oral feeding and glucose monitoring of blood in mice	47
4.2.4	Estimation of Glycemic Index (GI)	49
4.3	Results and discussion	50
4.3.1	Analysis of variance (ANOVA)	50
4.3.2	Means comparison and blood glucose response among treatments	50
4.3.3	Glycemic Index (GI)	52
4.4	Conclusion	53
5	GENERAL CONCLUSION AND RECOMMENDATION FOR FUTURE RESEARCH	54
5.1	General conclusion	54
5.2	Recommendation for future research	55
	REFERENCES	56
	APPENDICES	67
	BIODATA OF STUDENT	71
	LIST OF PUBLICATIONS	72

LIST OF TABLES

Table		Page
2.1	Agronomic characteristics of Manawthuka and Lone Thwe Hmwe and their derived mutant lines	7
2.2	Comparative agronomic performance of mutant varieties with their parent varieties	7
3.1	List of evaluated lines	14
3.2	Category of gelatinization temperature	18
3.3	Classification of gel consistency	19
3.4	Amylose content grouping	20
3.5	Food product factor	21
3.6	Analysis of variance (ANOVA) Key-Out	24
3.7	Mean squares of ANOVA for vegetative characters	26
3.8	Means (\pm SE) for vegetative characters	28
3.9	Mean squares of ANOVA for yield and yield components	31
3.10	Means (\pm SE) for yield and yield components	32
3.11	Variance components, broad-sense heritability, genotypic and phenotypic coefficient variation values for vegetative characters, yield and yield components	36
3.12	Correlation coefficient among vegetative characters and yield and yield components	37
3.13	Mean squares of ANOVA for physico-chemical characteristics	38
3.14	Means (\pm SE) for physico-chemical characteristics	39
3.15	Mean squares of ANOVA for nutritional compositions	41
3.16	Means (\pm SE) for nutritional compositions	42

4.1	Mean square of ANOVA for blood sugar test	50
4.2	Mean value for glucose reading among treatments	51
4.3	Amylose content (%) and glycemic index (%) in selected mutant rice variety	52



LIST OF FIGURES

Figure		Page
3.1	Seedlings sown in trays	15
3.2	Rice plants growing in troughs at the Malaysian Nuclear Agency, Bangi, Selangor.	15
4.1	The 8 weeks old female BALB/c mice	46
4.2	Blood collection direct from the tail	47
4.3	Oral feeding on BALB/c mice	48
4.4	Close up of oral feeding technique on mice	48
4.5	Blood glucose response curve of tested foods in two hours' time	51

LIST OF APPENDICES

Appendix		Page
A1	Useful rice mutants derived from mutation breeding programmes in Malaysia	67
A2	Rotary filter (Fibertec System E, 1023 Filtration Module Foss Tecator) used to determine the dietary fibre content	68
A3	The MR219 mutants	68
A4	Long panicle of mutant ML10 as compared to parent variety MR219	69
A5	Swollen grain, incomplete and narrow collar from alkaline spreading value test was categorized in intermediate gelatinization temperature group	69
B	Characteristics of aromatic rice variety MRQ74	70

LIST OF ABBREVIATIONS

%	Percentage
γ	Gamma
$^{\circ}\text{C}$	Degree celcius
^{60}Co	A radioisotope of cobalt having a half-life of 5.27years
^{137}Cs	Radioactive material cesium with half-life of 30.2years
ANOVA	Analysis of variance
AOAC	Association of Analytical Communities
BPH	Brown plant hopper
Cu	Copper
CuSO_4	Copper sulphate
DNA	Deoxyribose nucleic acid
FAO	Food and Agricultural Organization
GI	Glycemic index
Gy	Gray
H_2O	Water
HCl	Hydrochloric acid
H_2SO_4	Sulphuric acid
IAEA	International Atomic Energy Agency
IRRI	International Rice Research Institute
KOH	Potassium hydroxide
K_2SO_4	Potassium sulphate
LET	Linear energy transfer
NaOH	Sodium hydroxide
WHO	World Health Organization



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CHAPTER 1

INTRODUCTION

Rice, one of the most grown cereals in the world is the staple food of nearly half the world's population. It is a rich source of carbohydrates and a range of nutrients (Saikrishna *et al.*, 2018). Malaysia was among the developing country caught in the chaotic situation given its dependency on rice imports, especially from Thailand and Vietnam over the years. The struggle in securing constant supplies on the back of soaring international rice price had driven the government to seriously re-evaluate and tighten its food security policy as a measure to guarantee sufficient supply of food, especially in boosting rice production in Malaysia. Rice production in Malaysia is concentrated in major irrigated areas to sustain the targeted self-sufficiency level of 72% (Chamhuri *et al.*, 2014).

According to the United Nation estimates, the world population will grow to 8.5 billion in 2030. Since 97% of the rice is produced and consumed by developing countries, it is estimated that rice production must increase by 30% to feed the rice consumers by 2030. To meet this challenge, the need for rice varieties with higher yield potential, greater yield stability and higher micronutrient content has become the main focus. In rice breeding, mutation breeding is used to complement conventional breeding, since the technique is very effective in improving major traits such as yield and yield components, resistance to pests and diseases and grain physical characteristics and eating quality (Mohamad *et al.*, 2006). Induced mutation has been used in rice more than any other crop as expressed by the 815 rice mutant varieties listed in the FAO/IAEA Mutant Varieties Database (Oladosu *et al.*, 2016). Mutation breeding may result directly in the introduction of new cultivars or may lead to improve products suitable for further breeding programmes.

The assessment of nutritional component is an important factor in improving rice quality. Besides targeting on the yield production, other important characteristic such as the amylose content is highly desirable in improving the eating quality. High amylose content rice is beneficial for human health and has low glycemic index (GI) which serves as an indicator of sugar release in the blood. The awareness of the general public related to healthy foods has been on the rise recently and people are looking for the right variety of rice for diabetic patients (Ashish *et al.*, 2012). Numerous studies showed that carbohydrate rich foods including rice significantly increase the risk of obesity, type 2 diabetes and chronic diseases such as cardiovascular disease and some cancers (Salmeron *et al.*, 1997; David *et al.*, 2000; Liu *et al.*, 2000; Augustin *et al.*, 2001; Francheschi *et al.*, 2001; Gross *et al.*, 2004). An improvement in the quality of rice would go far beyond eliminating some of the worst and widespread of the deficiency diseases and would therefore raise the general health standards among the people. The dietician and nutritionist nowadays face a challenging problem to supply a sufficient quantity of diet of the highest possible food value.

Malaysia is still depending on imported rice from Thailand and Vietnam to fulfill the demand due to the shortage of the rice yield including specialty rice such as brown and fragrant rice. Because MR219 is one of the most common cultivated rice variety in Malaysia, covering about 17% of the granary areas (DOA, 2016), efforts are constantly being made to increase its yield potentials. Despite MR219 is the common rice variety grown in Malaysia, the data on its physical properties and proximate composition are still lacking. Other than that, very little information available on rice grain quality developed from mutation breeding in Malaysia especially the glycemic index value. Furthermore, breeding for specialty rice for chronic patient like diabetes is very essential in Malaysia. Therefore, in this study, the yield and grain quality of 31 mutant rice lines of M₄ MR219 induced by carbon ion beam were evaluated.

The objectives of this study were:

- i. To determine the yield and yield components, physico-chemical characteristics and nutritional composition of the 31 mutant lines derived from MR219 rice variety.
- ii. To evaluate the MR219 mutant lines for glycemic responses through *in vivo* studies.
- iii. To identify the superior mutant lines that will be useful for further breeding program.

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The student was born in Kuala Kubu Bharu, Selangor on 17th December 1987. She is the daughter of Mr. Haji Kadar Kayat and Mrs. Hajah Asriah Maidin. She completed her primary school from Sekolah Kebangsaan Tanjong Sepat, Selangor in 1999 and secondary school from Sekolah Menengah Kebangsaan Batu Laut in 2004. She obtained a Diploma in Agriculture from Universiti Putra Malaysia Bintulu campus and Bachelor in Agricultural Science from Universiti Putra Malaysia Serdang campus in 2008 and 2012, respectively. In 2012, she once again admitted at Universiti Putra Malaysia for Master of Science program in Genetics and Plant Breeding. She attended some conferences, workshops and seminar around Malaysia and presented a poster in National Paddy Conference 2013 and IPIMA Agricultural Forum 2017. She also presented her research findings in Nuclear Malaysia R&D Seminar 2014 and in the University Consortium Graduate Forum 2018 at Universitas Brawijaya, Indonesia. Her research innovation of Functional Mutant Rice for Diabetic and Obesity has won Silver Awards in Malaysian Agricultural Innovation Challenge 2014. She can be contacted through E-mail; asmailyani87@gmail.com.

LIST OF PUBLICATIONS

- Asma Ilyani K.,** Sobri H., Rahim H.A., Fazliana M.S., Anna, L.P.K, Koh, R.Y., Rusli, I., Khairuddin, A.R., Shafii, K., Rafii, M.Y. and Atsushi, T. (2014). Yield traits, physico-chemical characteristics and nutritional composition of MR219 M₃ generation and its effect on glycemic index and responses in animal model. In: Research and Development Seminar 2014, Malaysia. *International Atomic Energy Agency*. 46(33): 1-6.
- Asma Ilyani, K.,** Rafii, M.Y., Sobri, H., Anna, L.P.K., Rahim, A.H., Mahmud, T.M.M., Siti Zaharah, S., Asfaliza, R., Oladosu, Y. (2019). Physicochemical characteristics and nutritional compositions of MR219 mutants rice and their effects on glycemic responses in BALB/c mice. *International Food Research Journal*. Accepted on 20th June 2019.

Academic Programmes Attended

1. Persidangan Pesawah Padi Kebangsaan 2019, Universiti Putra Malaysia. 6th – 7th August 2019.
2. 2nd International Conference on Green Agro-Industry and Bioeconomy, Universitas Brawijaya, Malang, Indonesia. 18th – 20th September 2018.
3. The 4th University Consortium Graduate Forum (UCGF) 2018 in Sustainable Development of Tropical Resources: Issues, Challenges and Recommendations, Universitas Brawijaya, Malang, Indonesia. 18th – 19th September 2018.
4. Forum Pertanian IPIMA 2017, Universiti Putra Malaysia. 6th – 9th November 2017.
5. Food Crops Laboratory Manuscript Publication Workshop, Universiti Putra Malaysia. 2nd – 3rd February 2016.
6. Malaysian Agricultural Innovation Challenge 2014 for the innovation of 'Functional Mutant Rice for Diabetic and Obesity' (Silver Award), Malaysia Agro Exposition Park Serdang (MAEPS). 6th – 8th November 2014.
7. Persidangan Padi Kebangsaan 2013, Sunway Carnival Convention Centre, Seberang Perai, Pulau Pinang. 10th – 12th December 2013.
8. Workshop on DNA Sequence Data Management and Phylogenetic Analysis in conjunction with 10th Malaysia Genetics Congress, Biometry Lab, Faculty of Agriculture, Universiti Putra Malaysia. 2nd December 2013.
9. International Conference for Crop Improvement (ICCI2013): Issues and Prospects for Biotechnology Intervention, Institute of Tropical Agriculture UPM, Equatorial Hotel, Bangi, Malaysia. 25th – 26th November 2013.
10. Workshop on Care and Use of Laboratory Rodents and Rabbits in Research, Universiti Kebangsaan Malaysia. 20th – 22nd August 2013.
11. 1st Plant Breeding Seminar: Advances in Plant Improvement 2012, Agro-Biotechnology Institute (ABI), Serdang, Selangor, Malaysia. 3rd – 5th July 2012.



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