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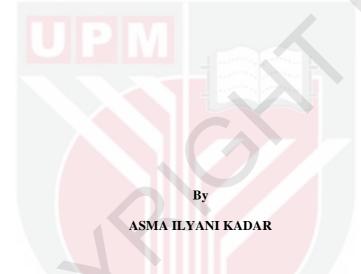
YIELD, PHYSICO-CHEMICAL AND NUTRITIONAL CHARACTERISTICS OF MR219 RICE MUTANTS AND THEIR EFFECTS ON GLYCEMIC INDEX AND RESPONSES IN BALB/c MICE

ASMA ILYANI KADAR

FP 2019 38



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



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

ТО

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MY LATE HUSBAND; MOHD FARHAN BIN REDWAN

AND

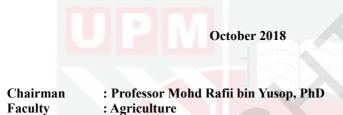


Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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

By

ASMA ILYANI KADAR



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 physic-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 (M_4) . Thirty-one M_4 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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Oktober 2018

Pengerusi: Profesor Mohd Rafii bin Yusop, PhD Fakulti: Pertanian

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 ciriciri 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 (M_4) . Tiga puluh satu mutan M_4 (ML1 hingga ML31) dinilai berdasarkan morfologi, hasil, komponen hasil, sifat fizikkimia 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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LIST OF ABBREVIATIONS

	0⁄0	Percentage
	γ	Gamma
	°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 30.2 years
	ANOVA	Analysis of variance
	AOAC	Association of Analytical Communities
	ВРН	Brown plant hopper
	Cu	Copper
	CuSO ₄	Copper sulphate
	DNA	Deoxyribose nucleic acid
	FAO	Food and Agricultural Organization
	GI	Glycemic index
	Gy	Gray
	H ₂ O	Water
	HCl	Hydrochloric acid
	H ₂ SO ₄	Sulphuric acid
	IAEA	International Atomic Energy Agency
	IRRI	International Rice Research Institute
	КОН	Potassium hydroxide
	K_2SO_4	Potassium sulphate
	LET	Linear energy transfer
	NaOH	Sodium hydroxide
	WHO	World Health Organization



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 M_4 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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BIODATA OF STUDENT

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

- Persidangan Pesawah Padi Kebangsaan 2019, Universiti Putra Malaysia. 6th 7th August 2019.
- 2nd International Conference on Green Agro-Industry and Bioeconomy, Universitas Brawijaya, Malang, Indonesia. 18th – 20th September 2018.
- 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.
- Food Crops Laboratory Manuscript Publication Workshop, Universiti Putra Malaysia. 2nd – 3rd February 2016.
- 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.
- Persidangan Padi Kebangsaan 2013, Sunway Carnival Convention Centre, Seberang Perai, Pulau Pinang. 10th – 12th December 2013.
- 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.
- 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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YIELD, PHYSICO-CHEMICAL AND NUTRITIONAL CHARACTERISTICS OF MR219 RICE MUTANTS AND THEIR EFFECTS ON GLYCEMIC INDEX AND RESPONSES IN BALB/c MICE

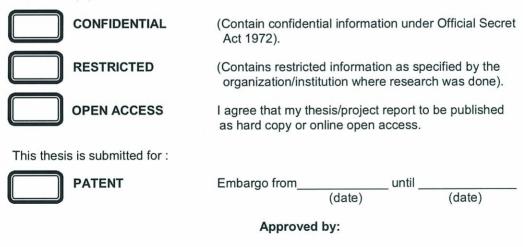
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