UNIVERSITI PUTRA MALAYSIA

APPLICATION OF PULSED LIGHT TREATMENT ON QUALITY RETENTION AND SHELF LIFE EXTENSION OF FRESH-CUT YARDLONG BEAN

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FSTM 2016 28

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By

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

October 2016

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

APPLICATION OF PULSED LIGHT TREATMENT ON QUALITY RETENTION AND SHELF LIFE EXTENSION OF FRESH-CUT YARDLONG BEAN

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October 2016

Chairman: Associate Professor Noranizan Mohd Adzahan, PhD
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Fresh-cut or minimally processed vegetables are in high demand as it is convenient and have fresh-like quality. However, fresh-cut processing promotes faster physiological deterioration, biochemical changes and microbial degradation which may affect the quality of fresh-cut vegetables. In this study, the effect of pulsed light fluences on microbiological stability and quality changes of selected dimension of fresh-cut yardlong bean were investigated. Selected combined ascorbic acid (ASA) or calcium chloride ($CaCl_2$) dipping treatment with pulsed light treatment formulation for quality retention and shelf life extension of fresh-cut yardlong bean were also optimised using RSM. In addition, the effect of pulsed light combined with dipping treatment on quality (microbiological stability, respiration rate, physicochemical and sensory properties) and shelf life of fresh-cut yardlong bean were evaluated. Pulsed light treatments were carried out using an automatic laboratory flash lamp system (Steribeam XeMaticA-2L Kehl, Germany) at four different fluencies (1.8 J/cm^2, 5.4 J/cm^2, 9.0 J/cm^2 and 12.6 J/cm^2). Microbiological and shelf life quality (color, headspace gas composition and textural changes) of fresh-cut yardlong beans stored at 4±1°C were monitored over 16 days. Among these fluencies, 9.0 J/cm^2 showed the most significant ($p<0.05$) effect in reducing total aerobic, yeast and mold counts but slightly affect the firmness and color of fresh-cut yardlong bean. Response surface methodology was employed to optimise the most effective formulation (concentration and dipping time) of ASA or $CaCl_2$ combined with pulsed light treatment. The effect of pulsed light treatment combined with ASA or $CaCl_2$ dip on the storage quality and shelf life of fresh-cut yardlong bean stored at 4±1°C for 20 days were evaluated. The optimum condition for dipping and pulsed light treatment is (0.1% (w/v), 1 min) for ASA and (0.1% (w/v), 1 min) for $CaCl_2$. This combined treatment significantly ($p<0.05$) reduced the total aerobic, while maintained its sensory quality. Untreated sample reached the limit log 7 CFU/g (total aerobic counts) and log 5 CFU/g (yeast and mold counts) after 7 days of storage at 4±1°C while combined treatments extended the microbial shelf life up to 18 days. The morphology of the cell walls of fresh-cut yardlong bean treated with pulsed light combined with ASA or $CaCl_2$ were similar to that of fresh yardlong bean while cell wall and tissue disruption were observed in control (untreated sample). It can be

concluded that the combined treatment of pulsed light (9 J/cm^2) with $CaCl_2$ (0.1% w/v, 1 min) have potential to extend the shelf life up to 18 days while maintain the sensory quality of the fresh-cut yardlong bean compared to pulsed light alone which less than 14 days.

Abstrak tesis yang dikemukan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Sarjana Sains

APLIKASI RAWATAN CAHAYA DENYUT UNTUK PENGEKALAN KUALITI DAN PEMANJANGAN JANGKA HAYAT POTONGAN KACANG PANJANG SEGAR

Oleh

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Potongan sayuran segar atau sayuran yang telah diproses secara minima mendapat permintaan tinggi disebabkan ianya mudah didapati dan mempunyai kualiti yang sama seperti sayuran segar. Namun begitu, pemprosesan potongan segar menggalakkan kemerosotan fisiologi, perubahan biokimia dan degradasi mikrobiologikal yang mana akan menjejaskan kualiti potongan sayur-sayuran segar. Dalam kajian ini, kesan pelbagai dos cahaya denyut terhadap kestabilan mikrobilogi dan perubahan kualiti bagi dimensi potongan kacang panjang segar terpilih telah dikaji. Kombinasi rawatan askorbik asid/ kalsium klorida bersama rawatan cahaya denyut bagi pengekalan kualiti dan pemanjangan jangka hayat potongan kacang panjang segar juga telah dioptimumkan menggunakan RSM. Kesan gabungan rawatan cahaya denyut yang digabungkan bersama rawatan askorbik asid/ kalsium klorida terhadap ciri kualiti (kestabilan mikrobiologi, fizikokimia dan penilaian deria) dan jangka hayat potongan kacang panjang segar juga telah dinilai. Rawatan cahaya denyut telah dijalankan menggunakan sistem automatik sinaran lampu makmal (Steribeam XeMaticA-2L Kehl, Jerman) pada empat dos berbeza (1.8 J/cm^2, 5.4 J/cm^2, 9.0 J/cm^2 and 12.6 J/cm^2). Bilangan mikrob dan kualiti (warna, komposisi gas dan perubahan tesktur) potongan kacang panjang segar yang disimpan pada suhu 4±1°C diawasi selama lebih 16 hari. Antara dos-dos tersebut, 9.0 J/cm^2 menunjukkan kesan paling signifikan ($p<0.05$) dalam mengurangkan jumlah bilangan aerobik, yis dan kulat disamping memberikan kesan yang minima terhadap tekstur dan warna potongan segar kacang panjang tersebut. Kaedah gerak balas permukaan telah digunakan untuk mengoptimumkan komposisi (kepekatan dan masa rendaman) yang paling berkesan untuk gabungan askorbik asid (ASA) atau kalsium klorida ($CaCl_2$) bersama rawatan cahaya denyut. Kesan rawatan cahaya denyut bersama askorbik asid ataupun kalsium klorida terhadap kualiti dan jangka hayat potongan kacang panjang segar yang disimpan pada suhu 4±1°C selama 20 hari telah diuji. Keadaan optimum bagi rendaman dan rawatan cahaya denyut adalah (0.1% (w/v), 1 min) ASA dan (0.1% (w/v), 1 min) $CaCl_2$. Gabungan rawatan ini telah mengurangkan jumlah bilangan aerobik, yis dan kulat dengan signifikan ($p<0.05$) disamping mengekalkan kualiti sensori. Sampel yang tidak dirawat telah melibihi

had log 7 CFU/g (jumlah bilangan aerobik) dan log 5 CFU/g (bilangan yis dan kulat) selepas 7 hari disimpan pada suhu 4±1°C manakala kombinasi rawatan cahaya denyutan bersama ASA mahupun $CaCl_2$ mampu memanjangkan jangka hayat kepada lebih 18 hari. Morfologi dinding sel potongan kacang panjang segar yang dirawat dengan cahaya denyut bersama ASA ataupun $CaCl_2$ mempunyai kualiti sebaik kacang panjang segar, manakala kerosakan dinding sel dan tisu dapat diperhatikan pada sampel kawalan (sampel yang tidak dirawat). Ianya dapat disimpulkan bahawa gabungan rawatan cahaya denyut (9.0 J/cm^2) bersama $CaCl_2$ (0.1% w/v, 1 min) mempunyai potensi untuk memanjangkan jangka hayat lebih 18 hari disamping mengekalkan kualiti deria potongan kacang panjang segar berbanding dengan rawatan cahaya denyut yang mana kurang daripada 14 hari.

ACKNOWLEDGEMENTS

In the name of Allah, the Benevolent, the Merciful

First and foremost, I would like to thank to ALLAH S.W.T because with His blessing, I had complete this research after a few years of struggles. Special thanks and gratitude to Associate Professor Dr. Noranizan Mohd Adzahan, the chairman of my supervisory committee for her understanding, assistance, advice, patience, encouragement and excellent guidance during my master study. I would also like to express my appreciation to Associate Professor Dr. Roselina Karim, the member of my supervisory committee for her valuable support and assistance.

I would also like to acknowledge all staff and laboratory members in the Faculty of Food Science and Technology, especially Mrs. Suraya Saad, Mr. Azman Asmat, Mrs. Asmawati Mantali, Mrs. Jamaliah Ahmad and Miss Nur Fatihah Noor Musa for their assistance during my lab work. Deep thanks and appreciation are also dedicated to all my friends especially those in Laboratory of Fruits and Beverages Technology, Food 1 (Sew, Aini, Siti Zaharah, Chia Ming and Koh) for their true friendship, help, support and motivation during my study.

Finally, I would like to express my deepest gratitude to my beloved family especially my husband, Wan Al-Junaidi bin Jamil, my mother, Mahazan Abdul Mutalib and my sisters Nor Hamizah and Nor Hairina for their endless love, understanding, supportive and always be on my side especially during my hard time.

I certify that a Thesis Examination Committee has met on 20 October 2016 to conduct the final examination of Nor Hasni binti Hambali on her thesis entitled "Application of Pulsed Light Treatment on Quality Retention and Shelf Life Extension of Fresh-Cut Yardlong Bean" 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 Master of Science.

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This is to confirm that:

- The research conducted and the writing of this thesis was under our supervision;
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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
ASA	Ascorbic acid
CCD	Central Composite Design
$CaCl_2$	Calcium chloride
CO_2	Carbon dioxide
CFU	Colony Forming Unit
DNA	Deoxyribonucleic acid
FAMA	Federal Agriculture Marketing Authority
FDA	Food and Drug Association
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis Critical Control Point
h^o	Hue angle
IFPA	International Fresh-cut Produce Association
J	Joules
MAP	Modified Atmosphere Packaging
O_2	Oxygen
PCA	Plate Count Agar
PDA	Potato Dextrose Agar
POD	Peroxidases
PPO	Polyphenol oxidase
RSM	Research Surface Methodology
SRBRE	Self-Regulated by Regulated Entities

USDA	United State Department of Agriculture
UV	Ultraviolet

CHAPTER 1

INTRODUCTION

Yardlong bean is one of Southeast Asia's top ten vegetables (Borlang *et al.* 2006). It is widely grown in the Philippines, Thailand, Indonesia, Vietnam, Bangladesh, Malaysia and India. It is the second most harvested vegetable in Malaysia with a yearly production of about 40,000 metric tonnes from the year 2004 to 2009 (Buku Perangkaan Agro Makanan, 2009). In Malaysia, fresh-cut yardlong beans are usually consumed raw as 'ulam' and eaten with plain rice and 'sambal' (chili paste). Yardlong bean is a highly nutritious vegetable with a good source of protein, vitamin A, thiamin, riboflavin, iron, phosphorus, and potassium. Furthermore, it is also has an excellent source of vitamin C, folate, magnesium, and manganese.

Demand for the fresh-cut vegetables has increased rapidly as it offers consumers a highly nutritious, convenient and has fresh-like qualities (Gil et al., 2006; Soliva-Fortuny et al., 2003; Ramos-Villarroel et al., 2011). Fresh-cut industry allows the consumer to buy only the amount of vegetables needed in an easy-to-eat form with a broad range of option in a single package. In order to meet the increasing demand for ready-to-eat fresh vegetables, the quality of fresh-cut vegetables needs to be improved. Fresh-cut industry facing a big challenge to maintain the quality and freshness of vegetables and to extend the shelf life for distribution to market placed (Ahvenainen, 1996). Fresh-cut vegetables exposed to injured, wounded cells through slicing or cutting process. This processing activities damage vegetable tissues and increase physiological, physicochemical and microbiological changes which resulting in quality loss and short shelf life (Ahvenainen, 1996). Yardlong beans are commonly contaminated with *campylobacters* and so poses a health risk to consumer (Norzaleha et al. 2003; Chai et al. 2007). 333

Several techniques have been studied to overcome these challenges (Gonzàlez-Aguillar et al., 2010). Strategies to minimize the risks associated with the consumption of fresh-cut vegetables ('ulam') includes electron beam, gamma irradiation, hot water, ozone and vacuum-steam has been studied to enhance the quality and prolong the shelf-life of fresh-cut vegetables (Gonzalez-Aguilar et al., 2010). Pulsed light technology has the potential to decontaminate the surface of fresh-cut vegetables. Pulsed Light (PL) technology is non-thermal emerging treatment for killing pathogenic and spoilage microorganisms in foods, including bacteria, yeasts, molds, and viruses, thus extending their shelf life (Ramos-Villarroel et al., 2012).

The application of pulsed light treatment on fresh-cut vegetables is still limited. In the pulsed light processing, treatments fluencies have to be optimised for different food products to extend its shelf life while maintaining the quality (Aguiló-Aguayo et al., 2013). Gemma oms-oliu et al., 2010 reported that the application of pulsed light at 4.8 J/cm² could extend the shelf life of fresh-cut mushrooms without dramatically affecting texture and antioxidant properties. High fluencies (12 J/cm²) were required to reduce 3 and 2 log growth of *Escherichia coli* and *Listeria innocua* in fresh-cut mushrooms (Ramos-Villarroel et al., 2012). Experiment with carrot

slices suggested that the application of pulsed light may reduce loads of *Saccharomyces cerevisiae* inoculated on that product by about 3-4 log cycles (Kaack and Lyager, 2007).

Fresh-cut yardlong bean is nutritious however its shelf life is limited to only 7 days (Coker et al., 2007). The process of cutting increases the respiration rate, color changes, weight loss, microbial growth and off-flavour during the storage resulting in quality loss and shorter shelf life. As mentioned earlier, pulsed light have potential to overcome these problems during storage of fresh-cut fruits and vegetables. In this study, the potential of pulsed light treatment for quality retention and shelf life extension of fresh-cut yardlong beans were evaluated. Thus, the specific objectives of the present study were:

i. To investigate the effect of pulsed light fluences on microbiological stability and quality changes of selected dimension of fresh-cut yardlong beans.

ii. To optimise ASA/$CaCl_2$ dipping treatment with pulsed light treatment for quality retention and shelf life extension of fresh-cut yardlong beans using response surface methodology (RSM).

iii. To determine and compare the effects of ASA/$CaCl_2$ dip combined with pulsed light treatment on the microbiological quality, headspace gases composition, physicochemical, sensory properties and shelf life of fresh-cut yardlong beans.

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