



UNIVERSITI PUTRA MALAYSIA

**APPLICATION OF POLYSACCHARIDE-BASED EDIBLE COATINGS FOR
SHELF LIFE EXTENSION AND QUALITY RETENTION OF
FRESH-CUT PINEAPPLE**

NIMA AZARAKHSH

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By

NIMA AZARAKHSH

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirements for the Degree of Doctor of Philosophy**

June 2013

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This thesis is dedicated to my beloved:

Wife
Shohreh Azari

Mother
Mina Dastgheib

And my late father (1949-2005)
Hamid Azarakhsh

For their endless love, understanding and
support in my life

Abstract of thesis presented to the Senate of Universiti Putra Malaysia
in fulfilment of the requirement for the degree of Doctor of Philosophy

**APPLICATION OF POLYSACCHARIDE-BASED EDIBLE COATINGS FOR
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June 2013

Chair: Professor Azizah Osman, PhD

Faculty: Food Science and Technology

In the present study, polysaccharide-based edible coating formulations were investigated and optimised for fresh-cut pineapple (*Ananas comosus* L. cv. Jospine). The effects of alginate- and gellan-based coatings on respiration rate, physico-chemical properties, microbiological and sensory quality of fresh-cut pineapple during low temperature storage were determined. Finally, the effects of incorporation of natural antimicrobial agents in alginate-based coating on shelf life extension and quality retention of fresh-cut pineapple were evaluated. The coating treatment was carried out by dipping method. Five polysaccharide-based materials, namely chitosan, alginate, gellan, methyl cellulose and pectin, were screened as potential coatings for the fresh-cut fruit. Among these, alginate- and gellan-based coatings showed the most significant ($p < 0.05$) effect in reducing weight loss and respiration rate and also in maintaining firmness and sensory quality of fresh-cut pineapple. Response surface methodology was employed to optimise the most effective

composition for the two coatings. Results obtained indicate that alginate-based formulation containing 1.29% (w/v) sodium alginate and 1.16% (w/v) glycerol, and gellan-based formulation containing 0.56% (w/v) gellan and 0.89% (w/v) glycerol, were the best. The results also showed that optimised alginate- and gellan-based formulations significantly ($p < 0.05$) reduced weight loss and respiration rate, and maintained the firmness and colour of fresh-cut pineapple during low temperature storage (10 ± 1 °C; $65 \pm 10\%$ RH and 5 ± 1 °C; $85 \pm 10\%$ RH) as compared to the control (uncoated sample). Results on the effects of natural antimicrobial agents (lemongrass, palmarosa, limonene and vanillin) incorporated into the optimised alginate-based formulation at different concentrations (0.1%, 0.3% and 0.5% w/v) on shelf life and quality of fresh-cut fruit showed that the former formulation incorporated with 0.3% (w/v) lemongrass significantly ($p < 0.05$) reduced yeast, mould and total plate counts while maintaining its sensory quality. Total plate counts and yeast and mould counts of uncoated samples reached 10^6 CFU/g after 8 days of storage at 10 °C while using optimised alginate-based formulation incorporated with 0.3% (w/v) lemongrass extended the microbial shelf life of coated samples up to 12 days. Gas chromatographic-mass spectrometric analysis of volatile flavour compounds extracted from control and stored cut-fruits using solid-phase micro-extraction showed that the major volatile flavour compounds of Josapine pineapple were (i) methyl hexanoate; (ii) methyl 2-methyl butanoate; (iii) methyl 3-(methylthio)-propanoate; (iv) methyl octanoate and (v) methyl butanoate. Storage led to a significant ($p < 0.05$) reduction in the concentrations of major volatile flavour compounds in both coated and uncoated samples. However, this reduction in coated samples was significantly ($p < 0.05$) lower than uncoated samples. Images from scanning electron microscopy further demonstrated that the cell walls of coated

fresh-cut pineapple had an almost similar intact appearance to those of fresh pineapple, while more cell wall disruption and higher microbial growth were observed in stored but uncoated samples. Thus, it can be concluded that optimised alginate-based edible coating formulation incorporated with 0.3% (w/v) lemongrass has the best potential to extend the shelf life up to 12 days and maintain the quality of fresh-cut pineapple.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

**APLIKASI SALUTAN POLISAKARIDA-BOLEH DIMAKAN UNTUK
PEMANJANGAN JANGKA HAYAT DAN PENGEKALAN KUALITI
BAGI POTONGAN NANAS SEGAR**

Oleh

NIMA AZARAKHSH

Jun 2013

Pengerusi: Profesor Azizah Osman, PhD

Fakulti: Sains dan Teknologi Makanan

Dalam kajian ini, formulasi berasaskan salutan polisakarida-boleh dimakan telah dikaji dan dioptimumkan bagi potongan nanas (*Ananas comosus* L. cv. Josapine) segar. Kesan lapisan alginat dan gellan mengikut kadar pernafasan, sifat fiziko-kimia, mikrobiologi dan kualiti deria potongan nanas segar semasa penyimpanan suhu rendah telah ditentukan. Akhirnya, kesan gabungan agen semulajadi antimikrob dalam salutan berasaskan alginat telah dinilai dari segi jangka hayat dan pengekalan kualiti potongan nanas segar. Potongan nanas segar telah disalut dengan menggunakan teknik celupan. Lima polisakarida berasaskan bahan, iaitu chitosan, alginat, gellan, metil selulosa dan pektin telah dipilih sebagai lapisan yang berpotensi untuk buah-buahan segar yang dipotong. Antaranya, lapisan berasaskan alginat dan gellan menunjukkan kesan yang paling ketara ($p < 0.05$) dalam mengurangkan jisim dan kadar respirasi dan juga dalam mengekalkan kepejalan dan kualiti deria potongan nanas segar. Kaedah gerak balas permukaan telah digunakan untuk

mengoptimumkan komposisi yang paling berkesan untuk kedua-dua lapisan. Keputusan yang diperolehi menunjukkan bahawa formulasi berasaskan alginat yang mengandungi 1.29% (w/v) alginat natrium dan 1.16% (w/v) gliserol, dan gellan berasaskan formulasi yang mengandungi 0.56% (w/v) gellan dan 0.89% (w/v) gliserol, adalah yang terbaik. Keputusan yang signifikan pada ($p < 0.05$) juga telah menunjukkan bahawa formulasi optimum alginate dan gellan dapat mengurangkan jisim dan kadar pernafasan, serta mengekalkan kepejalan dan warna potongan nanas segar semasa penyimpanan di suhu rendah (10 ± 1 °C; $65 \pm 10\%$ RH dan 5 ± 1 °C; $85 \pm 10\%$ RH) berbanding sampel kawalan (tidak bersalut). Kesan jangka hayat dan kualiti potongan nanas segar bagi kesan agen semulajadi antimikrob (serai, palmarosa, limonene dan vanillin) yang dimasukkan ke dalam formulasi optimum berasaskan alginat pada kepekatan yang berbeza (0.1%, 0.3% dan 0.5% w/v) telah dikaji. Keputusan menunjukkan buah yang mempunyai formulasi dengan 0.3% (w/v) serai telah dapat mengurangkan yis, kulat dan jumlah hitungan plat dengan ketara pada ($p < 0.05$) selain dapat mengekalkan kualiti deria. Jumlah hitungan plat dan hitungan yis dan kulat bagi buah yang tidak disalut mencapai 10^6 CFU/g selepas penyimpanan selama 8 hari pada suhu 10 °C manakala jangka hayat mikrobial buah yang disalut menggunakan formulasi optimum berasaskan alginat yang dimasukan serai pada kepekatan 0.3% (w/v) dapat dipanjangkan sehingga 12 hari, Analisis menggunakan gas kromatografi jisim spektrometrik terhadap sebatian rasa meruap yang diekstrak daripada sampel kawalan dan potongan buah yang disimpan menggunakan fasa pepejal mikro pengekstrakan menunjukkan bahawa sebatian rasa meruap utama bagi nanas Josapine adalah (i) metil hexanoate; (ii) metil 2-metil butanoate; (iii) metil 3-(methylthio)-propanoate; (iv) metil octanoate dan (v) metil butanoate. Penyimpanan telah membawa kepada pengurangan yang signifikan ($p <$

0.05) dalam kepekatan sebatian rasa meruap utama dalam kedua-dua sampel bersalut dan tidak bersalut. Walau bagaimanapun, penurunan dalam kedua-dua sampel bersalut adalah lebih rendah secara signifikan ($p < 0.05$) berbanding sampel yang tidak disalut. Seterusnya, imej dari mikroskopi pengimbasan elektron menunjukkan bahawa dinding sel bagi potongan nanas segar yang bersalut mempunyai penampilan yang hampir serupa kepada nanas segar, manakala dinding sel bagi sampel yang disimpan tetapi tidak bersalut menunjukkan banyak gangguan dan pertumbuhan mikrob yang tinggi. Oleh itu, kesimpulan dapat dibuat bahawa formulasi optimum salutan berasaskan alginat boleh dimakan yang dipadankan dengan 0.3% (w/v) serai mempunyai potensi terbaik untuk melanjutkan jangka hayat sehingga 12 hari dan mengekalkan kualiti potongan nanas segar.

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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 Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Azizah Osman, PhD

Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Chairman)

Hasanah Mohd Ghazali, PhD

Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

Tan Chin Ping, PhD

Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

Noranizan Mohd Adzahan, PhD

Associate Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD

Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

NIMA AZARAKHSH

Date: 11 June 2013

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