ABSTRAK

Coating pada buah ditujukan untuk menurunkan laju respirasi sehingga kematangan buah dapat ditunda hingga sampai ke tangan konsumen masih dalam kondisi segar. Keberhasilan coating buah tergantung pada pemilihan film atau coating yang memberikan komposisi internal gas sesuai dengan yang diinginkan untuk produk tertentu. Jika coating terlalu tebal memberikan efek yang merugikan karena menyebabkan komposisi gas O_2 internal yang terlalu rendah dibawah toleransi buah dan komposisi gas CO_2 yang tinggi di atas toleransi kritisnya, sehingga menimbulkan respirasi anaerob. Biopolimer yang potensial digunakan untuk coating buah adalah kitosan. Tujuan penelitian ini adalah merumuskan metode sistematis untuk mendapatkan formula larutan coating kitosan yang akan menghasilkan penghambatan respirasi optimum pada buah dengan permukaan kulit tertentu berdasarkan parameter wettability. Tujuan kedua adalah merumuskan korelasi antara karakteristik larutan coating kitosan dan karakter film coating kitosan berupa permeabilitas O_2 dan CO_2 untuk memprediksi konsentrasi O_2 dan CO_2 buah dengan coating sehingga dapat ditentukan waktu terjadinya respirasi anaerob.

Tahap penelitian dan pengambilan data pada penelitian ini meliputi karakterisasi kitosan; pembuatan dan pengambilan data karakteristik larutan coating kitosan dengan penambahan NaCl, gliserol dan tween 80; pembuatan film coating kitosan dan pengambilan data untuk pengukuran permeabilitas film terhadap gas O_2 dan CO_2; aplikasi coating pada buah pisang dan tomat. Selama penyimpanan pada buah dengan coating dilakukan pengambilan data respirasi buah (perubahan O_2 dan CO_2), perubahan kualitas fisik buah pisang dan tomat yang diberi coating kitosan dan kontrol yaitu data perubahan O_2 dan CO_2 selama buah melakukan respirasi, perubahan kualitas fisik buah (kekerasan, warna dan susut bobot), dan perubahan kualitas kimiawi buah (gula total, pati, dan kadar air). Keterkaitan ketebalan film dari larutan coating yang menempel pada permukaan buah ketika kering, permeabilitas film, perubahan komposisi gas O_2 dan CO_2, dan perubahan kualitas kimiawi buah selama penyimpanan

dimodelkan. Model matematis tersebut digunakan untuk memprediksi O_2 dan CO_2 internal buah, kandungan kimiawi (pati, gula, kadar air) buah yang dicoating sehingga selama penyimpanan dapat ditentukan waktu terjadinya respirasi anaerob. Hal tersebut dapat membantu untuk memprediksi keberhasilan coating sebelum proses coating berlangsung.

Hasil penelitian menunjukkan karakterisasi kitosan dari limbah rajungan (produk lokal) adalah derajat deasetilasi tinggi > 80% berat molekul 978 kDa, dan viskositas 50 – 100Cp. Pengendalian larutan coating kitosan untuk mendapatkan sudut kontak yang mendekati nol dapat dilakukan dengan menambahkan aditif pada larutan kitosan 1% dengan NaCl pada kisaran maksimum 0,2 M, gliserol maksimum 0,6 % (w/v) dan tween pada kisaran 0,03 – 0,05 % (w/v).Larutan coating yang diaplikasikan pada pisang dan tomat menunjukkan kecenderungan sudut kontak yang mendekati nol menunjukkan laju respirasi yang lebih lambat dengan nilai Vmo dan Kmo yang lebih rendah sedangkan Kio lebih tinggi. Kualitas fisik buah pisang dan tomat yang dicoating dengan larutan coating mendekati nol juga menunjukkan perubahan kerusakan yang lebih lambat. Pengendalian permeabilitas film coating kitosan dilakukan dengan mengatur formula penambahan aditif pada larutan coating kitosan. Nilai permeabilitas O_2 film kitosan berkisar 9,46 x 10^{-14} hingga 1,81 x 10^{-10} mol/ cm.mmHg.s dan permeabilitas CO_2 berkisar 1,80 x 10^{-13} hingga 2,51 x 10^{-11} mol/ cm.mmHg.s. Hasil analisis dimensi untuk menentukan ketebalan film yang dibuat dari larutan coating dengan viskositas, tegangan permukaan dan densitas tertentu menghasilkan parameter K sebesar 1,2 x 10^{-4} dan C4 sebesar 0,126 dan hasil tersebut valid untuk memprediksi ketebalan film dari larutan coating kitosan. Model respirasi yang dikembangkan dapat digunakan untuk memprediksi konsentrasi O_2 dan CO_2 pada buah secara general baik yang diberi coating maupun tanpa coating. Berdasarkan rangkuman hasil, terdapat tiga output penting dalam penelitian disertasi ini yaitu : 1) model matematik untuk memprediksi ketebalan film coating kitosan, 2) batasan-batasan parameter untuk memperoleh coating yang baik adalah wettability yang dinyatakan dengan sudut kontak antara larutan coating dan permukaan kulit buah, dan permeabilitas gas dari film coating kitosan, 3) model matematis untuk memprediksi laju respirasi dan kandungan kimiawi buah dengan coating selama penyimpanan.

ABSTRACT

This dissertation presented a systematic method to preserve fruit freshness by applying edible coating formulated of chitosan and some additives. The application of the edible coating was aimed to decrease the respiration rate in order to postpone the ripening process. The delay of ripening process was essential to ensure that the fruit was still fresh when it reached the prospective customers. The success of this coating was dependent on the choice of film or coating materials which would lead to the best composition of internal gas in a particular product. When the coating was somehow too thick, it would decrease the level of the internal O_2 gas below the tolerable limit and triggered anaerobic processes. At the same time, the increasing amount of CO_2 as a result of the anaerobic activities also quickly passedits critical limit.

There have been several choices ofpotential biopolimersto be used in the coating process, one of which was called *chitosan*. The goal of the research was to formulate one systematical method to obtain the optimum compositon of the chitosan coating which will result in the controlled delay of respiration process in fruits,The characteristics of the chitosan coating solution was expressed based on the parameter of wettability. Another goal of this research was to formulate the correlation between two factors significantly affecting the quality of coating, namely chitosan chemical solution characteristic and chitosan film thickness. The respiration was modeled using mathematical expression in order to predict the concentrations of O_2 and CO_2 in fruit so that the limit for anerob process of respiration couldbe estimated and could be used to predict the film thickness required for a particular fruit.

The experimental design included identification of the physical properties of chitosan solution with respect to wettability characteristics; modification of chitosan solution characteristic by adding NaCl, gliserol and tween 80; measurement of film permeability toward O_2 and CO_2 gas; and coating application on banana and tomato. The respiration process during

storage was measured as the change of O_2 and CO_2 compositions, the change of physical quality of fruit (hardness of skin, color and decrease of weight), and the change of chemical quality of fruit (total glucose, starch, and water level). As the prediction tool, dimensionless group correlation was used to correlate film thickness and chitosan solution physical properties. Correlations for film permeability, O_2 and CO_2 gas composition change, and also fruit chemical quality change during storage were developed. The mathematical models were used to predict internal O_2 and CO_2 composition change in coated fruit during the storage time so the critical time when the anerob respiration took place could be estimated. This estimate would be used to calculate the coating thickness required and finally to determine the composition of the chitosan solution to be prepared.

Experiments showed that chitosan derived from crab shell disposal (local product) with high deasetilation degree above 80% and molecul weight 978 kDa would result in solution with viscosity ranged of 50 – 100 cP. Addition of NaCl up to 0.3 M had a tendency to decrease surface tension, while at the same time the NaCl addition above 0.3 M causes the repellence force of electrostatic dissapeared. It could be concluded then that the addition of NaCl under the level of 0.3 M resulted in better contact angle (close to the ideal value of 0). It was also observed that the addition of gliserol up to 0.6 % (w/v) shows contact angle closed to zero (better wettability). With more than 0.6% (w/v) contact angle coating solution deviated farther from zero. The addition of tween up to 0.05 % (w/v) decreased surface tension in order to reach zero tendency contact angle although it did not happen adversely since the addition of tween for more than 0.05% (w/v) result in opposite condition. Permeability of O_2 chitosan film ranged from 9,46 x 10^{-14} to 1,81 x 10^{-10} mol/cm.mmHg.s and permeability of of CO_2 ranged from 1,8 x 10^{-13} to 2,51 x 10^{-11} mol/cm.mmHg.s. Based on data fitting, it wasobtained that physical and chemical quality of both chitosan coated banana and chitosan coated tomato decreased at lower rates to be compared to control. It proved that chitosan coating applied to banana and tomato postponed the ripeness of fruit significantly to be compared to the control. The dimensionless group correlation was considered valid enough to predict the thickness of film based on the physical properties ofchitosan coating solution. The mathematical model used to predict the concentration of O_2 and CO_2 in chitosan coated fruit was also fitted well with the experimental data.

Based on the aforementioned summary, this dissertation presents three important outputs, which are: 1) mathematical model to predict film thickness, 2) the constraints of major parameter to guarantee successful coating including chitosan solution contact angle and film permeability, and 3) mathematical model to predict respiration rate. With those three important components, this research outlines a novel method to design fruit coating process in a systematic way (not trial and error). This method can be applied on various fruits beyond banana and tomato tested in this research. For a particular fruit, farmers can target how long they want to keep them fresh. Starting from this target, using the respiration model, one can determine the rate of respiration required to achieve the targeted storage duration. The respiration rate will define the thickness of the film needed to delay the normal respiration. Finally, by means of the dimensionless group correlation, one can accurately decide the formulation of the chitosan coating solution to guarantee the thickness of the film.