APPLICATION OF HOT WATER DIP IN REDUCING CHILLING INJURY OF BANANA CV. BERANGAN DURING LOW TEMPERATURE STORAGE

By

MUHAMMAD TAUFIQ RATULE

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

October 2006

DEDICATION

This Thesis is ESPECIALLY dedicated to my beloved:

Wife Rosmiati Said, SKM, M.Kes,
Daughter Rifka Annisa Taufiq (Ika),
Son Gilang Nurjihad Taufiq (Ilang),
And my Parents,

For the unconditional patient, love and support.

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

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Chairman: Associate Professor Azizah Osman, PhD

Faculty: Food Science and Technology

'Berangan' banana (*Musa sapientum* cv. Berangan), being an extremely perishable commodity, requires low temperature storage before sale or consumption. However, chilling injury (CI) symptoms were exhibited when exposed to very low temperatures. Hot water dip (HWD) has been recognized able to alleviate CI symptoms. The reduction of sensitivity to CI by HWD could be due to the induction of heat shock proteins (HSP) and polyamines (PA) which protected the lipid peroxidation in membrane lipids. In the present study, the CI symptoms developed in Berangan banana were characterized. The banana was then treated with HWD in order to reduce the CI development. The HSP and PA contents were identified to determine the causal factor contributing to CI reduction in HWD-treated banana. The peroxidation of membrane lipids in relation to reduction of CI in HWD-treated banana was also assessed.

The results obtained in this study showed that peel colour (L*, C* and h^o) decreased significantly ($P \leq 0.01$), while peel firmness (PF), weight loss (WL), degree of browning (DOB), peel electrolyte leakage (PEL) and soluble solids concentration (SSC) increased significantly ($P \leq 0.01$) when Berangan banana fruits were exposed to 5 ^oC. However, there was only a significant ($P \leq 0.01$) decrease in peel colour (L*, C* and h^o), and a significant ($P \leq 0.01$) increase in DOB and SSC when banana fruits were exposed to 10 ^oC.

Banana treated with HWD at 48 ^oC for 8 min showed significantly ($P \leq 0.05$) lower peel colour (L*, C* and h^o) and DOB values when exposed to 10 ^oC as compared to the control. However, HWD has no significant effect on the SSC of these fruits. The results of this study indicated that HWD at 48 ^oC for 8 min could be considered as an optimum treatment combination in reducing CI development in Berangan banana. Nevertheless, the treatment did not sufficiently prevent CI development in Berangan banana stored for 16 days at 10 ^oC.

Since there was no new synthesis of protein in banana exposed to HWD treatment, HSP was probably not involved in the reduction of CI. However, the reduction of CI was followed by a significant ($P \leq 0.05$) increase in PA, especially putrescine (PUT) and spermidine (SPD) after 8 days storage at 10 ^oC. This indicated that PUT and SPD could be involved in the reduction of CI development in Berangan banana. The increase in PUT and SPD could be associated with the reduction of peroxidation in the membrane lipids.

As indicated by the HWD treatment results, there was no significant decrease in fatty acids composition, especially linolenic and arachidonic acid, as compared to the control fruit which showed a significant ($P \leq 0.05$) decrease. There was also no significant increase of lipoxygenase (LOX) activity which was reported to be responsible for the fatty acids degradation. These results might then contribute to the retaining of unsaturated to saturated (U/S) ratio of fatty acids in HWD-treated banana. There was a significant ($P \leq 0.05$) increase observed in the malonaldehyde (MDA) content of both the HWD-treated and control banana. However, the increase was found to be significantly ($P \leq 0.05$) higher in the control banana. The significant ($P \leq 0.05$) decrease of fatty acids (linolenic and arachidonic) and the significant ($P \leq 0.05$) increase of both LOX activity and MDA content in control fruits suggested significant ($P \leq 0.05$) higher lipid peroxidation as compared to that of HWD-treated banana. Therefore, the reduction of CI development in HWD-treated banana could be related to the increase of PUT and SPD in the fruits, which then contributed to the reduction of lipid peroxidation. It can be concluded that HWD could reduce CI development in Berangan banana due to retardation of lipid peroxidation which was in turn due to the increase in PUT and SPD contents.

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

APLIKASI CELUPAN AIR PANAS BAGI PENGURANGAN KECEDERAAN DINGIN KEATAS PISANG BERANGAN SEMASA PENYIMPANAN SUHU RENDAH

Oleh

MUHAMMAD TAUFIQ RATULE

Oktober 2006

Pengerusi: Profesor Madya Azizah Osman, PhD

Fakulti: Sains dan Teknologi Makanan

Pisang Berangan adalah merupakan komoditi yang sangat mudah rosak dan memerlukan penyimpanan pada suhu rendah sebelum dijual atau dimakan. Walaubagaimanapun, pisang Berangan akan menunjukkan simtom kecederaan dingin apabila didedahkan pada suhu yang sangat rendah. Celupan air panas telah dikenalpasti dapat mengurangkan simtom kecederaan dingin. Pengurangan sensitiviti terhadap kecederaan dingin adalah disebabkan oleh kewujudan protein kejutan panas dan poliamina. Penurunan kecederaan dingin oleh protein kejutan panas dan poliamina boleh dihubungkait dengan ketahanan lipid membran daripada pemperoksidaan. Kajian ini bertujuan untuk mencirikan simtom kecederaan dingin pada pisang Berangan. Pisang Berangan kemudiannya diberikan rawatan celupan air panas untuk mengurangkan kesan kecederaan dingin. Protein kejutan panas dan kandungan poliamina dikenalpasti untuk menentukan faktor penyebab yang berhubungkait dengan pengurangan kecederaan dingin pada pisang yang dirawat dengan celupan air panas.

Pemperoksidaan lipid membran yang dihubungkait dengan pengurangan kesan kecederaan dingin pada pisang yang dirawat dengan celupan air panas juga di kaji.

Keputusan dari kajian ini menunjukkan warna kulit (L*, C* dan h^o) menurun dengan signifikan ($P \leq 0.01$) manakala kekerasan kulit, kehilangan berat, tahap keperangan, kebocoran elektrolit kulit dan kandungan pepejal terlarut meningkat dengan signifikan ($P \leq 0.01$) apabila pisang Berangan didedahkan pada suhu 5 ^oC. Walaubagaimanapun, apabila pisang Berangan di dedahkan pada suhu 10 ^oC, pengurangan dengan signifikan ($P \leq 0.01$) hanya didapati pada warna kulit (L*, C* dan h^o), dan peningkatan yang signifikan ($P \leq 0.01$) pula hanya pada tahap keperangan dan kandungan pepejal terlarut.

Buah yang telah dirawat dengan celupan air panas pada suhu 48 ^oC selama 8 minit menunjukkan nilai warna kulit (L*, C* dan h^o) dan tahap keperangan yang lebih rendah apabila dibandingkan dengan buah tanpa rawatan (buah kawalan). Walaubagaimanapun, kaedah celupan air panas tiada memberi kesan yang signifikan ($P \leq 0.05$) terhadap kandungan pepejal terlarut. Keputusan kajian ini menunjukkan bahawa celupan air panas pada suhu 48 ^oC selama 8 minit boleh digunakan sebagai kaedah kombinasi yang optimum bagi mengurangkan peningkatan kecederaan dingin ke atas pisang Berangan. Namun, celupan air panas pada 48 ^oC selama 8 minit tidak dapat menghalang sepenuhnya pembentukan kecederaan dingin pada pisang Berangan yang disimpan pada suhu 10 ^oC selama 16 hari.

Oleh kerana tidak terdapat sintesis protein pada pisang yang diberi rawatan celupan air panas, pengurangan kecederaan dingin bukanlah disebabkan oleh protein kejutan panas. Walaubagaimanapun, pengurangan kecederaan dingin diikuti dengan peningkatan kandungan poliamina yang signifikan ($P \leq 0.05$) terutamanya putresin dan spermidin selepas penyimpanan pada 10 ^{o}C selama 8 hari. Ini menunjukkan bahawa putresin dan spermidin terlibat di dalam penurunan kecederaan dingin pada pisang Berangan. Peningkatan putresin dan spermidin dalam kajian ini kemungkinan berhubungkait dengan pengurangan pemperoksidaan di dalam lipid membran.

Seperti yang didapati daripada hasil rawatan celupan air panas, tidak terdapat pengurangan yang signifikan pada komposisi asid lemak terutama asid linolenik dan asid arakidonik jika dibandingkan dengan buah kawalan. Didapati juga tiada penambahan enzim lipoksigenase yang signifikan. Enzim lipoksigenase dilaporkan bertanggungjawab terhadap pengurangan asid lemak. Keputusan ini berkemungkinan menyumbang kepada kestabilan nisbah asid lemak tidak tepu : asid lemak tepu yang terdapat pada pisang yang diberi rawatan celupan air panas. Keputusan kajian juga menunjukkan terdapatnya peningkatan signifikan ($P \leq 0.05$) kandungan malonaldehid pada kedua-dua pisang yang diberi rawatan celupan air panas dan kawalan. Walaubagaimanapun, peningkatan yang lebih signifikan ($P \leq 0.05$) terdapat pada pisang kawalan. Penurunan signifikan ($P \leq 0.05$) asid lemak (linolenik dan arakidonik) dan peningkatan signifikan ($P \leq 0.05$) bagi kedua-dua aktiviti lipoksigenase dan kandungan malonaldehid pada pisang

kawalan mencadangkan pemperoksidaan lipid yang signifikan ($P \leq 0.05$) jika dibandingkan dengan buah yang dirawat dengan kaedah celupan air panas. Keputusan kajian ini menunjukkan bahawa pengurangan kecederaan dingin yang dihasilkan oleh rawatan celupan air panas berkemungkinan berkaitan dengan peningkatan kandungan putresin dan spermidin didalam buah pisang, yang menyumbang kepada penurunan paras pemperoksidaan lipid. Kesimpulannya, rawatan celupan air panas berupaya mengurangkan kejadian kecederaan dingin pada pisang Berangan melalui pengurangan pemperoksidaan lipid yang disebabkan oleh peningkatan kandungan putresin dan spermidin.

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I certify that an Examination Committee has met on 13th October 2006 to conduct the final examination of Muhammad Taufiq Ratule on his Doctor of Philosophy thesis entitled "Application of Hot Water Dip in Reducing Chilling Injury of Banana cv. Berangan During Low Temperature Storage" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis 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 are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously on concurrently submitted for any other degree at UPM or other institutions.

MUHAMMAD TAUFIQ RATULE

Date:

TABLE OF CONTENTS