Ripening behaviour of capsicum
(Capsicum annuum L.) fruit

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Abstract

Fruit of *Capsicum annuum* L. (capsicum or pepper) are one of the major sources of red food colourant and pungency for spice production. In the spice production industry, fruit are mechanically harvested at different ripeness stages and fruit colour needs to be synchronised before being processed. However, even though capsicum ripens normally on the plant it often fails to ripen fully and turn red once harvested at the green stage. Attempts to promote ripening of harvested fruits have had limited success and the reason for this has been unclear. This project, therefore, investigated ripening behaviour on and off the plant of capsicum fruit grown in Australia and examined effects of pre- and postharvest applications on ripening of green harvested fruit.

To examine ripening behaviour on and off the plant, capsicum fruit from three different cultivars (a mild paprika type *cv.* “Papri Queen”, a cayenne chilli *cv.* “Caysan”, and a sweet type bell pepper *cv.* “Aries”) were either allowed to ripen naturally on the plant or harvested at three different maturity stages: light green, deep green and breaker. Harvested fruit were stored individually at room temperature and several ripening characteristics including internal ethylene (C$_2$H$_4$) and carbon dioxide (CO$_2$) concentration, extractable colour, 1-aminocyclopropane-1-carboxylic acid (ACC) synthase and oxidase activity, and total soluble solid content (TSSC) were studied during storage.

There was very limited involvement of C$_2$H$_4$ during ripening of capsicum and the change in ACC synthase and ACC oxidase (two enzymes in C$_2$H$_4$ biosynthesis pathway) activity was not closely related to that of C$_2$H$_4$. However, it appeared that colour development in *cv.* “Papri Queen” was closely associated with what C$_2$H$_4$ production did occur while a climacteric-like peak of C$_2$H$_4$ could be observed in all fruit from *cv.* “Caysan”.

For all three cultivars, the level of internal CO$_2$ concentration, extractable colour and TSSC were greater in fruit ripened on the plant followed by fruit harvested at the breaker, deep green and light green stage, respectively. Fruit harvested at the light
green stage failed to change colour properly and had very low levels of internal CO₂ concentration and TSSC while fruit harvested from the breaker stage onwards ripened normally and developed sufficient colour for spice processing. This may suggest a role of external carbon-supply during ripening.

To study the effect of the external-carbon supply during ripening, the stem of fruit were cinctured when fruit reached the light green stage and fruit were left to ripen on the plant. Cincturing delayed colour development of fruit by approximately five days but cinctured fruit were still able to turn red and develop extractable colour higher than the acceptable level of 140 ASTA units. Cincturing did not significantly alter other ripening behaviour such as CO₂ concentration or TSSC. The lack of external carbon-supply is, therefore, unlikely to play a major role in the failure of green harvested fruit to ripen.

To study the effect of application of plant growth regulators (both pre- and postharvest), an effective method of solution application utilising cincturing was firstly developed. Different plant growth regulator solutions including ethephon, naphthalene acetic acid, abscisic acid, jasmonic acid, sucrose, and different combinations of these were applied to fruit at the light green stage to study preharvest effects on ripening parameters during storage. Only treatment with high concentrations of ethephon increased the extractable colour higher than the acceptable level of 140 ASTA units and induced the complete degradation of chlorophyll. To study effects of postharvest application, 10 µL of various plant growth regulators was dropped into the hole created on the stem of harvested fruit for ten consecutive days. Treatment with ethephon significantly increased extractable colour and degraded chlorophyll content of fruit. Pre- and postharvest ethephon treatment strongly up-regulated Capsanthin-capsorubin synthase (Ccs) gene expression in a manner similar to the up-regulation of Ccs observed in fruit ripened on the plant. This explains the effect of C₂H₄ on colour development and also indicates the possible reason for the failure of green harvested fruit to ripen. However, the Ccs gene expression and chlorophyll degradation induced by ethephon was not visible until 14 days after harvest which indicated it may not be a direct effect and other signal transduction factors may be involved. When fruit are ripened on the plant, colour development may, therefore, be induced by ripening-related
factors (other than $\text{C}_2\text{H}_4$) which is possibly inhibited or inactivated when fruit are harvested at the green stage. $\text{C}_2\text{H}_4$ application to fruit at this stage may help to reactivate or recover these factors which in turn induce colour development. Thus, although capsicum fruit show typical non-climacteric behaviour, $\text{C}_2\text{H}_4$ appears to be involved in some aspects of the ripening process.
Statement

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

To the best of my knowledge and belief, this thesis contains no material previously published or written by any other person except where due reference is made in the text.

I consent to this thesis being made available for photocopying and loan.

Pham Thi Ngoc Thang
05/06/2007
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List of Abbreviations

A      absorbance
ABA    abscisic acid
ACC    1-aminocyclopropane-1-carboxylic acid
AOAC   Association of Official Analytical Chemist
ASTA   American Spice Trade Association
B      breaker
BR     breaker red
°C     Degree Celsius
Ccs    capsanthin-capsorubin synthase
CH₃COONa sodium acetate
C₂H₄    ethylene
CO₂    carbon dioxide
cm     centimetre
DAA    days after anthesis
DAH    days after harvest
DG     deep green
DNA    deoxyribonucleic acid
DR     deep red
DR & D deep red and partially dried
DW     dry weight
EDTA   ethylenediaminetetraacetic acid
ethephon 2-chloroethylphosphonic acid
FW     fresh weight
g      gram
Hepes  4-(2-hydroxyethyl)-1-piperazine-ethanesulfonic acid
h      hour
HgCl₂  mercury chloride
i.d.   internal diameter
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<tr>
<td>JA</td>
<td>jasmonic acid</td>
</tr>
<tr>
<td>KOH</td>
<td>potassium hydroxide</td>
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<tr>
<td>Lcy</td>
<td>lycopene-β-cyclase</td>
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<td>LG</td>
<td>light green</td>
</tr>
<tr>
<td>LR</td>
<td>light red</td>
</tr>
<tr>
<td>LSD</td>
<td>least significant difference</td>
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</tr>
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<td>sds</td>
<td>sodium dodecyl sulphate</td>
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<td>SE</td>
<td>standard error of the mean</td>
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<tr>
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<td>sucrose</td>
</tr>
<tr>
<td>Tris</td>
<td>tris (hydroxymethyl) aminomethane</td>
</tr>
<tr>
<td>TSSC</td>
<td>total soluble solid content</td>
</tr>
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