Managing chilli (*Capsicum* spp.) quality attributes: the importance of pre-harvest and postharvest factors

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Abstract

Demand for chillies and peppers continues to increase in many parts of the world as chillies (*Capsicum spp.*) are a good source of beneficial compounds. Optimising postharvest storage of chilli fruit is not enough to gain highest quality products in the market place if there is a significant variation in the quality such as size, colour and phytochemical compounds at the time of harvest, which may be a result of pre-harvest factors. The objectives of this research were to understand effects of pre-harvest and postharvest factors on chilli quality in order to produce consistent quality chilli fruit.

Storing of Habanero and Jalapeño at 8 °C can maintain low respiration rates and delay loss of firmness without the development of chilling injury symptoms for 4 - 5 weeks, while Paprika requires warmer storage temperatures as loss of firmness was found during storage at 8 °C, although overall appearance was still marketable. Chillies were very susceptible to shrivel when stored above 8 °C. In Jalapeño, water loss occurred approximately equally through fruit skin and through the calyx and pedicel area until cracking appeared on Jalapeño fruit which stimulated a significant increase in skin water loss. A model was developed to predict the shelf life (using 5 % water loss as time to shrivel development) of Jalapeño during storage by conducting a sensitive analysis on the potential factors (such as fruit weight, water vapour permeance (P'_{H_2O}), temperature and RH); RH was the most important factor on the impact on rate of water loss and time to shrivel. Application of wax on fruit skin or the whole fruit is recommended as waxing on calyx and pedicel of Jalapeño increased shelf-life by 10 % compared to control fruit.

Pre-harvest factors such as time of planting, position on plant, maturity at harvest and crop load significantly influence Jalapeño quality (i.e. fruit size, colour and phytochemical composition). Fruit weight, colour and ascorbic acid varied with time of planting and time of fruit set during the season demonstrating that growing conditions affected plant and fruit growth. Fruit from plants planted late in the season (October) were small and contained low ascorbic acid concentration. Position on plant also affected fruit size and ascorbic concentration despite fruit being of the same maturity stage. Different fruit size may be explained by the competition between plant

and fruit growth and also the distance from nutrients and water supply rather than fruit to fruit competition as there was no influence of crop load on fruit size. However, ascorbic acid accumulation in fruit was stimulated by competition between fruit on the plant as fruit from high crop load plants showed higher ascorbic acid concentration than fruit from low crop load plants. In addition, it may be influenced by plant age or time of fruit set during season, as late season or upper node fruit produce low ascorbic acid concentration. Maturity had a major effect on colour at harvest, but colour change was influenced by position on plant and growing conditions. Colour development of fruit at lower nodes which were set at cooler temperatures was slower than fruit at higher nodes which were set at warmer temperature. Capsaicinoid concentration seemed to be consistent along the plant. However, the observed results showed that measurement of total capsaicinoid concentration can be affected by the sub-sampling error from the proportion of each individual tissue (i.e. pericarp, placenta and seed) contained in the sample due to large differences in capsaicinoid concentration among tissues. Similar to capsaicinoids, antioxidant activity (AOX) and total phenolic concentration (TPC) seemed to be consistent along the plant. A weak correlation was found between AOX and TPC or AOX and ascorbic acid indicating that ascorbic acid or TPC was not a major contributor of the AOX in Jalapeño. Further work in this area is required, but needs to start with harmonisation of extraction solvents.

In conclusion, this research generates an overall understanding on the effects of pre-harvest and postharvest factors on chilli quality which will assist chilli growers in controlling sources of variation and help to produce more uniform chillies. Based on these results, to produce larger Jalapeño fruit with high concentrations of health beneficial compounds such as ascorbic acid, Jalapeño plants should be pruned not to higher than 12 nodes. Thinning leaders during production is essential for decreasing the risk from plant collapse due to weight but does not influence fruit size. As this research was focused on plants with two leaders and a single first flush fruit per node at high crop load, investigating the role of more leaders, a higher number of fruit per node and the second flush of fruit production should be investigated in future work.

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Abbreviations

A	pre-exponential factor
AOX	antioxidant activity
a*	CIE Lab 'a' value measured by colorimeter
a_w	water activity
b*	CIE Lab 'b' value measured by colorimeter
C.A.N.	calcium ammonium nitrate
C_a	chlorophyll a
$CaCO_3$	calcium carbonate
C_b	chlorophyll b
CO_2	carbon dioxide
C_{x+c}	carotenoids
d	day
ρ	density of fruit
dpi	dots per inch
DW	dry weight
E_a	activation energy
Eq.	equation
FAA	formalin alcohol acetic acid
$FeSO_4.7H_2O$	ferric sulfate
FRAP	ferric reducing antioxidant power
FW	fresh weight
H	high crop load
HPLC	high performance liquid chromatography
J	joule
K	potassium
KOAc	potassium acetate
kPa	Kilopascal
L*	CIE Lab 'L' value measured by colorimeter
L	low crop load
LDPE	low density polyethylene
LSD	least significant difference

M	fruit mass during time of storage
M_0	fruit mass at the beginning of the experiment
N	nitrogen
Na_2CO_3	sodium carbonate
$P_{CO_2}^{initial}$	CO_2 concentration immediately after closing container (%)
$P_{CO_2}^{final}$	CO_2 concentration after certain period (%)
P^{total}	total air pressure
P'_{H_2O}	water vapour permeance
Δp_{H_2O}	the difference in partial pressure of water vapour between the environment and fruit
$p_{H_2O}^{f}$	the partial pressure of water vapour in fruit
$p_{H_2O}^{e}$	the partial pressure of water vapour in the environment
$p_{H_2O}^{sat}(T)$	saturated partial pressure of water vapour at temperature
Pa	Pascal
PGU	Plant Growth Unit
γ	psychrometric constant
R	ideal gas constant
R_c	predicted respiration rate
RH	Relative humidity
r'_{H_2O}	rate of water loss
r_{CO_2}	respiration rate
SA	surface area
SE	standard error
t	storage time
T	temperature
T_e	temperature of environment
T_f	temperature of fruit skin
T_w	wet bulb temperature
TPC	total phenolic concentration
TPTZ	2,4,6 tripyridyl-s-triazine
UV	ultra violet radiation
Vf	fruit volume
Vjar	volume of jar

W	width
WAF	weeks after flowering
WAFS	weeks after fruit set