Post-harvest treatment of Cavendish Banana with Nitric Oxide Enhances Shelf-Life through the Regulation of Polyamines

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Background of the study

Banana is a fruit of high nutrition-staple fruit

Being climacteric fruit, shelf life is the challenge

Achieving the better shelf life is possible through delayed ripening

Chemical methods

Management through modified postharvest storage

Transgenic approach

Elicitation

Tackling simultaneous control of expressions of several ripening-specific genes by non-genetic approach
Ripening Physiology

Cell wall

Senescence

Ethylene pathway

Sugar

Receptors & TF’s

Manjunath et al., 2012

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The approach

Differential and preferential regulation of ripening genes

Cell wall
- Polygalacturonase
- Pectatelyase
- PME
- Expansins
- β-galactosidase

Ethylene
- ACC Synthase (ACS)
- ACC Oxidase (ACO)

Starch/sugar
- α-amylase
- β-amylase
- Suc-synthase
- SPS

Senescence
- Catalase
- Peroxidase
- PPO
- PAL

Polyamine
- SAMdc
- ODC
- Spd synthase
- Spm synthase

Ethylene receptors & TF's
- ERS-1, 2
- MADS- 1,2,4, 6
- EIL-1, 2, 3, 4

• Study of differential response of ripening-specific genes to exogenous treatments
• Regulation of SAM (substrate for ethylene pathway) via polyamine pathway

Possible out-come:
Eco-friendly formulation for preferential regulation of ripening genes
Expression of ethylene biosynthesis pathway genes

• ACS being the rate limiting enzyme, is strongly induced by ethylene
• MJ also hastened ripening
• Gibberellic acid, IAA, ABA, SNP significantly down-regulated ACS

• ACO is not much affected as that of ACS
• SNP, IAA, GA down-regulated ACO
Cell wall – related genes

**Polygalacturonase**

- GA and SA down-regulated/delayed PG, pectin metabolizing enzyme
- All the other phytohormones also decreased the level of expression

**β-galactosidase**

- All the phytohormones down-regulated the expression
• GA treated fruits showed the expression of PL only on the 20th day.

• SA, GA, IAA delayed the expression of PME

• Ethylene – down-regulated
Cell wall related genes were maximum down-regulated/delayed by Gibberellic acid followed by SA and IAA

- GA delayed the expression
- Kinetin – down-regulated even on 20th day
Starch/sugar-related genes

• GA, ABA and IAA prolonged the expression till 20\textsuperscript{th} day

• No significant delaying/down-regulation
• Not much affected by any of phytohormone/Signaling compound
Ethylene treated fruits showed maximum expression on the 5th day.

• GA, IAA showed maximum on 10th day.

• Considerable constitutive expression was found.

• MJ up-regulated on 10th day; ethylene was maximum on the 5th day.
Senescence-related genes

- IAA, ABA showed up-regulation throughout
- SNP up-regulated from 5th day to 20th day
• SNP up-regulated from 5\textsuperscript{th} day to 15\textsuperscript{th} day

• SA, MJ and SNP down-regulated the expression
• MJ, IAA and SNP up-regulated on 20\textsuperscript{th} day
IAA significantly affected on the 10th day after treatment
GA, Kinetin and ABA also increased
• IAA, ABA treated fruits showed expression throughout.
• MJ up-regulated on 20th day.

• IAA, ABA and kinetin treated fruits showed expression throughout.
Receptor - genes

ERS 2

ERS 3

Control
Ethrel
GA
IAA
ABA
Kinetin
SA
MJ
SNP

Control
Ethrel
GA
IAA
ABA
Kinetin
SA
MJ
SNP

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Transcription factors

MADS 1

Number of days after treatment

Relative expression

MADS 2

Number of days after treatment

Relative expression

0,0 0,5 1,0 1,5 2,0 2,5

0 5 10 15 20

Control

Ethrel

GA

IAA

ABA

Kinetin

SA

MJ

SNP

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MADS 6

Relative expression vs. Number of days after treatment
- Ethrel
- GA
- IAA
- ABA
- ABA
- Kinetin
- SA
- MJ
- SNP

MADS 4

Relative expression vs. Number of days after treatment
- Ethrel
- GA
- IAA
- ABA
- Kinetin
- SA
- MJ
- SNP
Ethylene suppression by diverting the precursor

Genes studied:
- ACC synthase
- ACC oxidase
- SAM decarboxylase
- Spermine synthase
- Spermidine synthase
- Arginase
- Arginine decarboxylase
- Ornithine decarboxylase
Putrescine (nmol/g FW)

Number of days

Putrescine (nmol/g FW)

Number of days

Putrescine (nmol/g FW)

Number of days

SNP treated and control fruit showing pulp quality – 20th day

SNP treated and control fruit showing pulp quality – 20th day

HPLC chromatogram of standard mixture (Putrescine, spermine and spermidine)
Expression studies of polyamine pathway genes

ACO

ACS

ODC

Arginase

ADC

SPDSYN

SPMSYN

SAMdC
NO effect on other amines (Serotonin and melatonin)
Gibberellic acid: down-regulated cell wall softening related genes

Auxins: down-regulated the ethylene biosynthesis gene, particularly the ACO

SNP and SA: Delayed senescence-related genes

No single compound had comprehensive effect on ripening

Individual treatments differentially regulated various classes of ripening-related genes

Tackling simultaneous control of expressions of several ripening-specific genes by non-genetic approach

Synergetic effects?? → Formulations??

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THE APPROACH

Selection of bio-compounds that impart desirable effects and use them at judicious levels and combinations

Phytohormones

Signaling compounds

- Different concentrations
- Different combinations
- Different time periods

Formulations
Thank you