Cassava Post-harvest Deterioration: Towards Strategies for Solutions

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Overview

• What is post-harvest physiological deterioration (PPD)?
• Economic & social impacts of PPD
• Existing & potential strategies for control
• Strategies for solutions
What is post-harvest physiological deterioration (PPD)?

- Physiological / biochemical changes in the root (not due to micro-organisms)
- Becomes unpalatable and unmarketable within 24 - 72 hours of harvest
- Therefore, prompt consumption or processing necessary
- PPD is a major constraint to cassava production, processing and consumption
- Impacts on sustainable livelihoods of resource-poor farmers
Current understanding of PPD

- Active process involving changes in gene expression, enzyme activity & biosynthesis of low molecular weight compounds
- Parallels to:
  - Wound responses - except healing inadequate
  - Oxidative stress responses – activity of enzymes & compounds that modulate reactive oxygen species
  - Senescence responses – senescence-associated gene homologues expressed
Economic & social effects of PPD

• Significant wastage
  – e.g. 5-25 %, which ends up as animal feed
• Price reduction on deteriorated cassava:
  – e.g. 70-90% discounting on 3 day old cassava in Tanzania
• High mark-up on fresh roots, especially in urban markets
  – up to 60 % of final price
  – urban consumers choose other starchy foods
• Non-uniform input to processing & industry
  – reduces quality & competitiveness of cassava products
Therefore, controlling PPD would:

- Benefit small & large-scale cassava farmers
- Benefit urban consumers of cassava
- Benefit small & large-scale processors of cassava
- Reduce LDC imports of carbohydrate alternatives
- Make cassava products more competitive
Current & potential strategies for control

- Mechanical
- Breeding
- Biotechnological
Mechanical strategies

• Keep roots in field until required
• Pruning before harvest
  – But alters starch quality
• Processing into traditional & industrial products
  – Not all people consume processed cassava
  – Quality problems with large-scale processing
• Oxygen exclusion
  – Plastic bags – not adopted
  – Waxing – high cost
• Freezing
  – High cost
Breeding strategies

• Tried & tested means of crop improvement
  – Has worked well for some traits (e.g. yield) in cassava
• But:
  – Cassava’s high heterozygosity complicates breeding
  – PPD is a complex polygenic trait
  – PPD correlated with high dry matter
  – Environmental factors complicate scoring for minor PPD differences
• However, quantitative trait loci (QTLs) & marker assisted selection (MAS) could help breeding
Biotechnological strategies

• Advantages:
  – Potential to introduce genetic constructs into any cultivar
  – Specific manipulation of genes of interest
  – Success in some major crops & model plants

• Disadvantages:
  – Largely untried in cassava
  – Cassava transformation is complex & so far limited to model cultivars
Relevant successful examples

- Anti-sense polyphenol oxidase reduces browning in wounded potato & apple (Coetzer et al., 2001; Murata et al., 2000, 2001)
- Cytokinin biosynthesis gene driven by senescence-associated promoter inhibits leaf senescence in tobacco (Gan & Amasino, 1995)
- Anti-sense polygalaturonase gene alters ripening in tomato (Gray et al., 1994)
Strategies for solutions

• Tools required:
  – Genes
  – Promoters
  – Transformation
  – Field testing
  – Collaborating laboratories
  – Legislation
Tools required: genes

• Evaluation of cassava germplasm, including exotic, can help in selection of material
• Identification & characterisation of all genes involved in PPD – e.g. via cDNA microarrays
  – Potential spin offs:
    • markers for genomics
    • identification of QTLs
    • input into breeding via MAS
    • synergistic interaction with breeding/genetics
Tools required: promoters

- Organ, tissue & PPD specificity important
- Timing of activity may be critical
- Required to drive sense &/or anti-sense constructs

840 bp cassava PAL2 promoter driving GUS in transgenic cassava

TS of cassava root 24h after harvest

Stained for GUS activity
Tools required: transformation

• Efficient model system for testing candidate constructs in transgenic cassava
  – Current systems are complex, time consuming & cultivar dependant
  – Room for improvement
  – Dissemination of expertise

• System must be extended to farmers’ preferred & elite cultivars

• Availability of appropriate vectors - biosafety
Tools required: field testing

• Experimental candidate constructs will need evaluation in greenhouse & in field
• Transgenics for potential release will require full field testing in appropriate agro-ecologies
Tools required: collaborating laboratories

• Links & collaborations already exist:
  – Bath – PPD molecular biology & biochemistry
  – CIAT – germplasm, genomics, genetics, mapping, transformation, field testing
  – IITA – germplasm, genetics, mapping, field testing
  – ILTAB - transformation
  – Others?
Tools required: legislation

- Appropriate biosafety legislation required in target countries
- Influence & assist legislation process
- Approval of transgenic cassava varieties
Alfred Dixon:

• “Controlling PPD would turn cassava into a modern crop, unlocking its full potential for Africa and the world”

• Our challenge is to make Alfred’s words a reality

• Thanks