Post-harvest issues for tropical root and tuber crops in a changing world

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Post-harvest issues for root and tuber crops

- Value addition
- Implications of climate change and variability
- Implications of major pre-harvest diseases
- Positive impact on nutrition
- Creating benefits for women
- Responding to urbanisation and changing demands
- Reducing post-harvest losses and adding value to wastes in the value chain
C:AVA I and II strives to develop a vibrant and competitive HQCF industry based on market-led efficient production and processing, leading to a reduction in rural poverty.

Aims to increase incomes of > 100,000 smallholder households and processing employees by improving and developing HQCF value chains.

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**Intervention 1: Farmers**
- Work with community groups to build capacity on cassava production
- Introduce new high-yield cassava varieties
- Ensure constant root supply

**Intervention 2: Processors**
- Support communities on proper processing
- Introduce new processing technologies or improve existing ones
- Improve quantity and quality of HQCF produced

**Intervention 3: Markets**
- Identify potential markets for HQCF
- Provide business and technical support to make case for HQCF adoption
Cassava
  ↓
Peel/wash
  ↓
Grate
  ↓
Press
  ↓
Dry
  ↓
Mill and bag

Press
  ───>
Pressed cake

Cassava grits
  ───>
HQCF
Value chain

**Main inputs**
- Support farmer organisations
- Increase cassava productivity
- Support Village Processing Units
- Ensure quality

**Service providers capacity strengthening**
- Business development services
- Financial services
- Technical support in processing
- Ensure quality
- Technical support in adopting HQCF
- Financial services

**Intermediaries (private sector)**
- Semi-processed product
- Business opportunity
- Employment

**Bakeries – replacing wheat with HQCF**
- Food processing industry using HQCF

**Benefits**
- Rural areas:
  - Increased farmer/processor incomes
  - Employment
- Intermediaries:
  - Increased profitability
  - Business opportunity
  - Employment
- End-users:
  - Increased profitability
  - Lower consumer prices
  - Reduced imports

**Village Processing Units**
Impacts of climate change and variability on cassava food systems

- Climate change and agri-food systems – strengthening climate resilience & understanding greenhouse gas emissions.
- Little consideration of postharvest systems.
- Climate contexts diverse.
  - Mean annual temp, for Uganda, Tanzania, Malawi ~ 22 °C (1970-99), ~ 4°C lower than W. African countries (Ghana Nigeria);
  - C:AVA sites rainfall varies from ~1,000 – 2,000 mm
- Temperatures have increased:
  - Ghana (1.0°C), Nigeria (0.8°C), Uganda (1.3°C), Tanzania (1.0 °C ) and Malawi (0.9 °C ), and number of hot days, between 1960 and 2006.
- Projections – SSA hotter and weather more unpredictable and intense. Rain uncertain, E/W Africa wetter; S. Africa drier.
- Cassava climate resilient: high temp., drought tolerance, tolerance to erratic rains and +ve yield with increased CO₂.
- Climate resilience, alongside other drivers e.g. rising populations and increasing urbanization, will result greater importance in SSA.
- Cassava systems affected by CC and contribute to future CC.

(Source: from Lamboll and Stathers, forthcoming)
Impacts, vulnerability and resilience of cassava food/ post harvest systems

• **Diverse cassava postharvest systems** exist across SSA. Mostly food systems.

• **Climate**, alongside other biophysical (e.g. soils) and socio-economic (e.g. markets) factors, **shapes current cassava systems**. Almost all production in SSA is rain-fed, and this along with temperature, influences how the crop is managed and outcomes at harvest.

• **Environmental conditions influence** properties of harvested roots (including cyanogen content), timing of harvesting and postharvest activities such as drying and processing, incl. fermentation.

• **Impacts will differ** depending on the climate change trends which occur, the location and the specific characteristics of the postharvest system.

(Source: from Lamboll and Stathers, forthcoming)
Impacts, vulnerability and resilience of cassava food/ post harvest systems

• Although resilient in production, **cassava systems are relatively vulnerable in postharvest phase** (e.g. shelf-life reductions and food quality issues; processing stages heavily influenced by water and energy availability).

• **Transformation and storage increase the climate-resilience of cassava systems**, but dried products often damaged by storage pests and affected by humidity and temp.

• **Climate compatibility** of processing, storage, transport and marketing facilities and infrastructure will be another **determinant of the resilience** of cassava systems.

(Source: from Lamboll and Stathers, forthcoming)
Cassava food systems and responding to climate change

FOOD SECURITY and other DEVELOPMENT GOALS

Addressed through:
- Technologies
- Practices
- Policies
- Institutions, Infrastructure
- Capacity strengthening

Climate smart options minimize the trade-offs and maximise the synergies between development, adaptation and mitigation.

Offers opportunities to contribute to SDGs along more innovative, equitable & sustainable pathways.

Climate smart:
- Potential for private sector engagement
- Require capacity strengthening at individual, organisational and systems levels
Climate Smart cassava systems

**ADAPTATION**
- **Adaptation strategies** e.g. diversified pre and post harvest systems, improved and adaptive storage and processing
- **Climate resilient development** e.g. improved climate adapted varieties, improved storage methods, & processing, improved market information and access, weather forecasting

**FOOD SECURITY and other DEVELOPMENT GOALS**
- **Development strategies** e.g. improved storage, improved market information and access, *increased value addition*

**MITIGATION**
- **Low carbon development** e.g. improved no or low fossil fuel drying processes; more efficient grating and milling equipment
- **Mitigation strategies** e.g. reforestation, **Minimize transportation**. Reduce storage losses to improve food security.

**Climate smart development**: Cassava systems that benefit food security, improved livelihoods, adaptation and mitigation e.g. restoration of degraded land, improvement of soil-macro, and micro-nutrients. **Socio-ecologically resource efficient adaptive drying, processing, storage, marketing** and climate information systems

**Co-benefits** e.g. on-farm production and use of biofuels, improved pre and post harvest management and food security
Optimisation of processing technologies

• Artificial drying ~33% of the total production costs for HQCF
• Mechanical-dewatering prior to drying has no power or energy cost, efficiency of de-watering has a major impact on the cost of drying
• Since 2008, NRI worked with SME HQCF producers and Nigerian equipment fabricators to obtain objective data on de-watering and drying efficiency and to develop practical solutions to improve the economic viability of SME processing

- Assessed 7 types of SME FDs in Nigeria
- All highly energy inefficient
- Worst case = 14.20MJ/kg of HQCF
- Low outputs 90-150kg/hr
- High cost for drying worst case = US$374/tonne of HQCF
Development of Improved Flash Dryers for SMEs (2009-2016)

- Current 6 Cyclone flash dryer
- 2.92Mj/kg of HQCF
- Output ranging from 330-500kg/hr dependent on capacity of heat exchanger
- >90% reduction in costs for heat energy
- Developed solid-waste systems to replace diesel & kerosene
Mechanical de-watering SME jack press

- Most use 32t truck jacks
- Reduce moisture content from 65-70% to 42-50%
- Moisture reductions are highly variable due to combination of engineering and operational issues
- In collaboration with a Nigerian fabricator NRI has demonstrated improved press reduces to 36-38% moisture equates to a 19% saving on fuel during artificial drying
Postharvest Implications of pre-harvest pests and diseases

- Cassava brown streak disease (CBSD) and cassava mosaic disease (CMD) increasingly important
- Cassava brown streak disease recognized as an important disease of cassava in coastal East Africa and the shores of Lake Malawi and Mozambique in the South
- CBSD expanding towards central Africa in parts of Uganda, Kenya, Tanzania, Burundi, Rwanda and Congo

Seeking to establish:
(1) constraints arising from CBSD necrosis, such as the ability of farmers to meet market demand and quality specifications;
(2) management practices arising;
(3) economic implications to processors
Case study on CBSD in Uganda and Tanzania

• Study conducted with three villages per district and ten fields per village, and 37 processed cassava samples
• Cassava wide range of uses
• HQCF for bakery, brewery and confectionery sectors
• Substitutes expensive wheat or corn starch
• End users require a product with tight specifications (viscosity, fibre, colour, pH, starch content, etc.).
Results and conclusions

- Grades 2/3 acceptable for HQCF if diseased tissue removed
- Processors able to get sufficient roots below grade 3, but tissue losses between 10-58% gave economic implications
- Analysis of flour prepared from roots (starch, and carbohydrate content, viscosity, pasting temperature, colour and pH value showed significant differences between grades 1 and 2, and 3 to 5
- Strong correlation ($R^2=0.904$) between flour viscosity breakdown and pH value, and with peak viscosity and pH value ($R^2=0.737$)
- Loss in flour quality (at grades 3-5) would exclude use for applications such as high quality adhesives

CBSD negatively impacts:
- Value addition in terms of affordability of fresh roots, and
- Quality of processed cassava products
Positive impacts on nutrition: Carotenoids in biofortified root and tuber crops

Working with HarvestPlus, NRI has been determining retention of carotenoids in:

- orange-fleshed sweet potato after drying & storage and cooking of the flour
- yellow cassava during gari & fufu processing

Chapati made with 100% wheat flour: negligible vitamin A content
Chapati made with 30% OFSP flour & 70% wheat flour: 100% daily nutritional needs in vitamin A of a child

Source: Bechoff, A. 2010, Uganda
Source: Bechoff, A. 2012, Nigeria
Source: Bechoff, A. 2013, Nigeria
Source: Bechoff, A. 2007, Mozambique
OFSP & YC products could significantly contribute to nutrition (significant levels) whilst freshly prepared. However, storage of the dried products (i.e., dried sweet potato chips or gari) had drastic impact on carotenoid retention (70% loss after 3 months).
Contribution to women’s income and food security

In theory, new commercial R&T opportunities can benefit women and contribute to broader development goals.

Research in cassava markets shows that there are opportunities for benefit derived from women’s high participation in cassava value chains, building on their skills in production and processing to improve productivity and efficiency.

*In some contexts* women are able to take advantage of increasing market opportunities, which has benefited children’s education, diet diversity, and agricultural investment.
Lessons to ensure women’s continued benefit

- Women’s participation and benefit from R&T markets vary by the type of value chain and its structure - thorough gender analysis and gendered needs assessment are required.
- Factors determine gains include: breadth and depth of their social networks for access to key inputs, life stage, gender norms and intra household relations.
- All intervention points should consider gender – e.g. programs on varietal improvement need to address women’s lower access and exposure to new varieties and their requirements, and ensure varieties meet characteristics valued by women.
- Women’s local processing and marketing groups can ensure women's participation and benefit.
Lessons to ensure women’s continued benefit

• Greater emphasis on inclusion and leadership needed to encourage women’s participation in larger and more technical markets, e.g. employment opportunities, working with women’s groups, technical training

• Potential tension between increasing R&T commercialisation and household food security influenced household gender relations - research shows men increase their involvement with greater profit and tend to sell in bulk, so there is a potential risk of men selling without keeping some for food or not using the income for food.
Consumer preferences of root and tuber crops in Africa

Consumer preference is important in the value chain but often neglected regarding poor people. Information about preference and markets can increase the success of a new more nutritious varieties or safer products.

NRI has explored preferences and willingness to pay of biofortified sweetpotato and cassava. Language and education were initially a challenge.

For example: new vitamin A orange sweetpotato in Uganda was liked by 82% of consumers but 18% did not. Clear rural / urban differences.

Increasing demand to understand preference. Challenge is diverse varieties and products but lack of knowledge about markets and demand.
Reducing post-harvest losses and adding value to wastes in the value chain

EU FP7 project adopted a dual strategy of reducing losses and utilising waste.
• Physical losses of 30% often quoted. Probably lower at 3-12%.
• Economic losses in the cassava value chain higher than thought; US$0.5 billion in Ghana. Economic losses lower if processing is close to the farm (Vietnam, Thailand and Nigeria) but higher at the consumer end (Ghana).
• Gender - waste is often more valuable to women
Post-harvest loss of cassava to honeybees
Sarah Arnold/Richard Lamboll

Sun-dried cassava grits collected by honeybees in Tanzania

• Considerable post-harvest product loss (possibly 14% of grits)
• Disruption to processing activities
• Bees essential to local cashew industry and some honey producers
Reducing post-harvest losses

Yam (*Dioscorea* spp.) important staple crop in West Africa.

Losses of yams during on-farm storage can be as high as 50%, with both rotting and sprouting major forms of loss.

NRI is working with researchers in Ghana and Nigeria to reduce these losses.

- demonstrated a reduction in rotting by introducing a period of "curing" (= promoting natural healing of wounds) at the start of storage.
- identified effective sprout control strategies (see presentation by Hussein Etudaiye, NRCRI at this conference)
- Introducing low cost stores capable of reducing storage losses

CSIR-CRI & CSIR-FRI Ghana
NRCRI & FUNAAB Nigeria
IITA
Reduction in weight loss and rotting by introducing a period of **curing**

Curing by covering tubers of *Dioscorea rotundata* for 7 days with sacking slows down weight loss. The impact varies with variety. Laboratory studies at NRI show that this relates to differences in efficiency of wound-healing between varieties.

*Work carried out by Evelyn Adu-Kwarteng, CSIR-CRI, Ghana*
low cost stores capable of reducing storage losses

Low cost stores with improved storage environment can reduce tuber losses in terms of weight loss and rotting. Data shown is the average data over four sites in Ghana.

Work carried out by Shadrack Amponsah, CSIR-CRI Ghana
Gains from Losses – FP7 GRATITUDE

Food use based innovations from losses or new used estimated to benefit economies of Africa and Asia by up to Euro300million per annum. Examples:

- Environmentally efficient drying
- Mushrooms from cassava waste
- Recovery of starch from pulp using enzyme methods (Inc. 2 patents)
- HQCF for gluten free products.
## Potential for commercial adoption of best-bet innovations arising from 'Managing waste'

<table>
<thead>
<tr>
<th>Innovation/best bet</th>
<th>Benefits, uptake and viability assumptions</th>
<th>Estimated future annual benefit (Million €/annum)</th>
<th>Potential for commercial adoption (Low to High)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved HQCF drying</td>
<td>Flash dryer retrofit Nigeria – 43% energy reduction</td>
<td>2.7</td>
<td>Very High</td>
</tr>
<tr>
<td></td>
<td>Improved bin drying (50%) uptake in Ghana – 30% reduction in drying time</td>
<td>0.4</td>
<td>High</td>
</tr>
<tr>
<td>Cassava waste for mushroom cultivation</td>
<td>Viability not yet demonstrated commercially</td>
<td>-</td>
<td>Medium</td>
</tr>
<tr>
<td>HQCF for gluten free products</td>
<td>5% of current gluten free starch market possible</td>
<td>99.3</td>
<td>High</td>
</tr>
<tr>
<td>Recovery of starch from pulp</td>
<td>6.25% additional starch recovery in Thailand alone</td>
<td>173.0</td>
<td>Very high</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>275.4</strong></td>
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Conclusion

• Post-harvest is more than value addition.
• Climate change is a challenge – climate smart development (development, adaptation and mitigation)
• Efforts to improve nutrition has to take into account post-harvest
• Realisation of benefits for women are often post-harvest
• Urbanisation will mean changing food preferences that important to understand
• Post-harvest losses should not be neglected – economic and physical
• How can wastes in the value chain be best utilised?
Acknowledgements

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sprout control strategies

Treatment with gibberellic acid is an effective way to control sprouting in varieties of *Dioscorea rotundata* and *D. alata*. Efficacy varies with variety. Further studies are underway to determine the optimum concentration of gibberellic acid and to determine whether a sufficiently cheap supply of gibberellic acid can be identified for this to be an appropriate method of sprout control in Nigeria.

Work carried out by Hussein Etudaiye, NRCRI, Nigeria (see poster at this conference)