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## *Executive Summary*

### **Integrating End User Preferences in RTB Breeding Programs Workshop**

February 26-27, 2015  
Speke Resort, Munyonyo, Uganda

The workshop, jointly sponsored by the Bill and Melinda Gates Foundation (BMGF); NEXTGEN Cassava; and the CGIAR Research Program on Roots, Tubers and Bananas (RTB), brought together experts from diverse backgrounds to share knowledge and experience and to build a joint vision through a consensus roadmap. Bridging disciplines was essential to integrating end user preferences in breeding, with experts in agricultural economics, gender, food science, molecular biology and plant breeding all represented. The workshop was structured around a process model that provided the “conceptual glue” and guiding principle for the presentations, group exercises and discussions. The process model outlines the necessary steps to move from end user preferences to variety development on station, giving special emphasis to poorly understood quality traits in RTB crops. The proposed steps are: 1) End user (consumer) profiling; 2) Trait discovery; 3) Phenotyping method development for identified traits; 4) Marker discovery; 5) Population screening/selection. The process model is cyclical, recognizing that the material selected or released will once again need to be evaluated by end users.

The workshop was a mixture of practical exercises, group work and plenary presentations, structured in three parts: 1) Plant breeding: the importance and challenge of including end user preferences; 2) Understanding consumers: Organoleptic tests and biochemical properties of RTB-based foods; 3) Breeding for end users: Tools and approaches. In Part 1, variety adoption study results were highlighted to show the importance of market demand as a “pull factor,” while following presentations focused on defining who end users are through market segments and highlighted the importance of gender as a variable. In Part 2, sensory evaluation and preference studies in cassava and banana were presented, revealing different use categories and associated preference profiles. Additional talks focused on literature reviews of consumer preferences in RTB crops and potential genes that control key quality traits. In Part 3, QTL analysis and marker discovery for key flavor traits were presented, in addition to field tools for breeders to generate farmer typologies and capture trait information. Throughout the workshop, different food science aspects of end user preferences were highlighted, potentially linking ill-defined quality attributes to underlying physiochemical and organoleptic principles. Private-sector perspectives were highly motivational, outlining the importance of consumer profiling before a product is developed and testing products with the intended consumer (Nestle), as well as the importance of mechanization and standardization of quality analysis in high-throughput breeding programs (HZPC).

The workshop concluded with participants contributing to the process model, outlining what is already known or possible within each step, and laying out a roadmap of essential information that is needed to achieve the full process cycle. At the workshop close, participants were interested in remaining engaged and working across disciplines to fill in some of the gaps in knowledge and technical support that must be addressed to bring greater “end-user awareness” to public sector RTB breeding programs.

## A. Introduction

### A.1 WORKSHOP CONTEXT

The workshop was jointly sponsored by the Bill and Melinda Gates Foundation (BMGF); NEXTGEN Cassava; and the CGIAR Research Program on Roots, Tubers and Bananas (RTB), in collaboration with partners and research institutions (Cornell University, CIRAD-CIAT and IITA).

The CGIAR Research Program on RTB is a broad alliance including Bioversity International, CIAT, CIP, IITA and CIRAD, as well as a growing number of research and development partners beyond CGIAR. It brings together research on banana (and plantain), cassava, potato, sweet potato, yam and minor roots and tubers through a product portfolio of themes with respective team leaders.

The workshop brought together forty participants from the fields of agricultural economics and gender, food technology, molecular biology and breeding to share knowledge and experiences. Participants collaborated to build an interdisciplinary perspective essential to capture different end users' needs and preferences, with the aim of developing user-centered RTB breeding programs. The participant list is provided in Annex 2.

CGIAR programs and the BMGF are investing in crop improvement and promotion of new varieties by RTB farmers, processors and consumers. However, adoption of improved varieties has been slower than anticipated, as the underlying causes of non-adoption are influenced by socioeconomic, cultural and subjective factors and are therefore difficult to measure and equally difficult to understand.

### A.2 OBJECTIVES OF THE WORKSHOP

- Review current knowledge and discuss new approaches for end user profiling and testing for RTB crops
- Formulate tools to translate end user quality preferences (disaggregated by gender) into measurable selection criteria (traits)
- Propose scheme to use existing RTB breeding/genetic populations to map key end-user traits to feed molecular markers in genomic selection models
- Prepare a roadmap to develop these tools and integrate them into participatory and user-centered RTB breeding programs

### A.3 STRUCTURE OF THE WORKSHOP

The workshop was structured as a mixture of presentations, practical exercises, group work and plenaries.

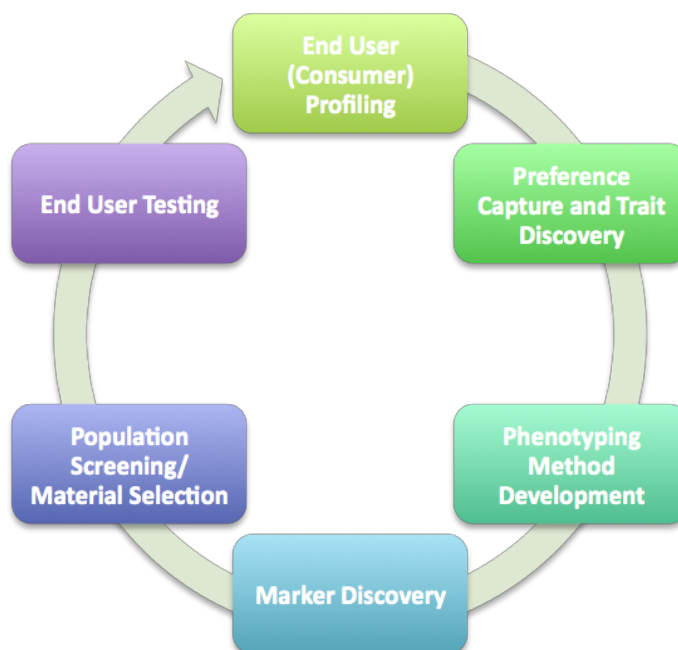
**Presentations** from different perspectives and disciplines covered key aspects such as:

- Part 1: Challenges and importance of including user preferences, by gender, in plant breeding programs: who are the end users? What are the factors that determine their preferences? What are their needs? What tools and methodologies are used to capture these preferences and translate them into verbal descriptors?
- Part 2: Translating users preferences (descriptors of organoleptic characteristics) into biochemical properties of RTB based foods
- Part 3: Tools and approaches used by Breeding programs to develop end-user centered varieties

**Each section of the workshop was introduced by a practical exercise to build mutual understanding across disciplines** and followed by presentations and open discussions.

The last part of the workshop was dedicated to the design of a road map presenting learning from the workshop, knowledge gaps and challenges and areas of collaboration and improvement for the future.

The following process model was used as a centerpiece to organize thoughts throughout the workshop and recap insights from presentations, discussions and group exercises, building up knowledge for the road map organizing the way forward.



# 1. Part 1: Plant Breeding: Importance and Challenges of Including User Preferences

## 1.1 GROUP EXERCISE: UNDERSTANDING END USERS' NEEDS AND PREFERENCES

The first introductory exercise focused on understanding users' needs and preferences from different perspectives and with different tools and approaches. Researchers were split into three disciplinary groups: social science, including gender and agricultural economics; food science, and plant breeding and molecular biology. All groups were given a scenario whereby they were part of a team of researchers who just received funding to develop a novel purple-fleshed yam variety through conventional breeding. The donors required that the variety meet specific demands of young women who earn a living making purple-pounded yam in Ghana. They had to answer the following guiding questions:

- How would you consult the end users to understand their preferences?
- Please specifically describe:
  - Who would you consult?
  - How?
  - How often?
  - What would you ask them? (Suggest 3 questions)

The results of the exercise are presented in Annex 3.

## 1.2 PRESENTATIONS

Presentation 1 Part 1: "[Varietal adoption in cassava and other RTB crops: understanding end user needs and preferences](#)" Arega Alene, Agricultural Economist, IITA

So far, yields have typically been the leading trait for breeding programs. Mismatches between preferences and proposed products can lead to non-adoption of new varieties.

A survey on adoption of improved cassava in Southwest Nigeria in 2009 showed methodological challenges of measuring adoption rates and lack of knowledge from end users of names of varieties.

### Who are the end users and what are their preferences?

- Farmers focus on how a variety fits into their system and are looking for both quality and meeting the market demand.
- Men/women can have different trait preferences.

### How do we collect information on end-user adoption?

- Important to establish a protocol for collecting information on adoption on a regular basis and to give feedback on adoption to end users
- Adoption studies should identify types of cultivars farmers prefer and why they prefer them.
- Experts gave estimates on adoption, which were compared with findings from household and field surveys. Household survey estimates were measured through area and the number of households that adopted.

- Adoption information can be collected through focus groups, farmer interviews, field observation and area measurement with GPS.
- Multidisciplinary teams must gather and analyze this information and give feedback.

### Concluding points and Q/A

- List of varieties to be assessed for variety adoption was generated by breeders
- Experts tended to overestimate adoption, especially for larger states.
- Farmers' interviews did not generate reliable variety-specific estimates, as farmers tend to use generic names and may call all varieties by the source name.
- One variety can have different names across communities.
- Farmers were able to distinguish between local and improved varieties, though they consider varieties from other areas improved.
- When asked to rank attributes in order of importance, farmers identified aggregated and early bulking as most important.
- Not much variation between male-headed and female-headed households, though approach may have been limited
- Main reason cited for not adopting new varieties was lack of planting materials
- Farmers prefer early maturing varieties (6-9 months) to get quick returns, otherwise they will plant other crops.
- Cost of production (included in yields) and soil nutrition could be also key criteria of preference.
- Market demand is an important (pull) factor: e.g., in one state, starch content was identified as main preference criteria by farmers who supply a large starch company.
- Methodology for gathering end users' reasons for non-adoption did not adequately address end user preferences. It will be addressed in a new adoption study in Nigeria.

### Presentation 2 Part 1: "[\*Gender responsive participatory plant breeding\*](#)"

Jacqueline Ashby, Senior Advisor, CGIAR Consortium

Gender is nested in a set of relationships between men and women, and preferences are shaped by end users' social characteristics.

### Who is the end user?

- Women are not a homogeneous group. In any social group, they can have different and competing interests.
- It is important to link preference traits and characteristics of users who express them.
- Varietal adoption decisions are the product of the interaction between the characteristics (traits) of the variety (V), characteristics of end users (U), and the characteristics of the socioeconomic environment (E).
- Characterization of end users is complex and fragmented; all opinions of actors along value chains should be considered.
- Private enterprise confronts this challenge of diverse fragmented demand by prioritizing markets. One way to gain precision is to develop typologies by classifying individuals into types of users (segments).
- Participatory varietal evaluation is a good way to do this, but we need to find ways to aggregate preferences across locations.

### **Trait prioritization has a gender dimension**

- Whatever the social class they belong to, women have immediate, practical needs as well as strategic interests (control over strategic resources).
- Increased yield can lead to loss of control of crops—men see the advantage of marketing the crop. Strategic needs of women aren't addressed if the only focus is on yield.
- One case is cassava and “the power of bitterness”: women highly valued the bitterness of the cassava because it was correlated with their ability to control the harvest. The more bitter the cassava, the less it was stolen.

### **Methods, tools and gaps**

- Approaches such as co-development with PPB (participatory plant breeding) and PVS (participatory varietal selection) help elicit information very quickly.
- A shortcoming of this approach is that it does not allow scientists to create a typology of users or target user groups before engaging with them (socioeconomic targeting: segmented markets and traits clusters).

### **Concluding points and Q/A**

- Stay close to the customer
- Need for more precise targeting of market segments
- Identify socioeconomic research tools to define market groups/segments
- Take into consideration typology of actors and poverty level while also looking at gender dynamics and disaggregation of data
- Think ahead to the future—don't just focus on breeding in the present. Combining hypothetical varieties and traits can help do this.
- Need to consider the size of the markets for new varieties: volume vs. efforts
- Need better coordination and exchanges between social scientists within CG to reflect on markets, needs, and who the users are

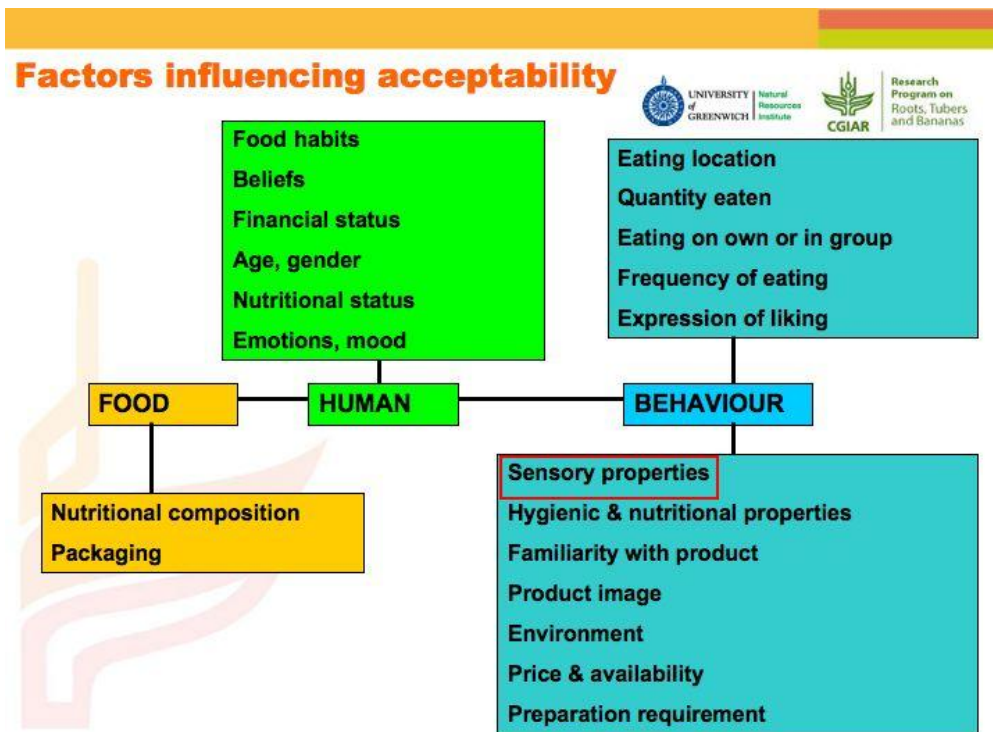
Presentation 3 Part 1: <a href="#"><u>“Understanding relationships between cassava traits and end-user preferences and gender responsiveness”</u></a> Aurelie Bechoff, Food Technologist, Natural Resources Institute
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End user acceptance is conditioned by a variety of factors, which include food, nutrition, and behavior. Products are varied and complex, ranging from directly consumed to fermented, fried, pounded, etc.

### **Who is the end user?**

- Consumers want a homogeneous product without extraneous matter.
- The major sensory characteristics are color, odor, taste and texture. Other characteristics are dryness and wetness. Elasticity is also important for processing.





### What are the preferences?

- From a nutritional point of view and for different uses (processing)
- Traits, sensory perception and consumer acceptability: biochemical traits and nutritional composition influence consumers' preferences. Below are the major preferred traits of cassava:

#### Nutritional composition

- Carbohydrates, primarily to provide energy
- Protein and lipids are very low
- Sugar content and taste
- Varieties with mineral content (zinc, iron)
- Carotenoids: high carotenoid content varieties could tackle nutritional deficiencies

#### Flavor and texture

- Generally, texture is the main attribute for consumer acceptance
- Starch, dry matter, and texture
- Starch is the main component (85%); the higher the starch, the higher the dry matter
- Starch and composition are important for texture
- Pectin is the main component in friability
- Yellow products (carotenoid high) weren't important for acceptance
- Slightly acidic products are appreciated by consumers
- With post-harvest physiological deterioration, there is production of hydroxycoumarins. This affects taste and appearance.

### Concluding points and questions

- A wide range of compounds and factors are responsible for preference. Some are directly related to cassava, and others are linked to processing. Traits in cassava are expressed through a variety of genes.

- There is a diverse range of cassava end-uses, and socioeconomic factors are also important – i.e., gender, age and frequency of consumption. The information about end user preferences and what influences them is sparse and incomplete.
- Reviewed current knowledge: What can we learn from the past? Can it help us predict the future? In the future, will we require different strategies for breeding selection?
- Which traits are the most important?
- Should we consider demand from competing starch products?
- Price? Quality of cassava imported from elsewhere?
- How important is promotion in influencing trait preference?
- How can breeding benefit those who are most food insecure?

#### Q/A

*Are there biochemical characteristics for friability and poundability? Should we evaluate pectin in roots to measure friability? How is friability defined? The quantity of oil needed to cook cassava?*

- It relates to texture: when you crush it, it breaks into powder
- Hardness and /softness depend on the structure of the membrane of the starch.

*Do iron levels really affect acceptance, since they're so low?*

- In beans, fortification did not have negative effects; hopefully it will be the same in cassava.

### 1.3 DISCUSSION AND RECAP OF PART 1

It is important to keep in mind the diversity of end users (market segmentation) and to have appropriate tools to capture their preferences.

#### **Breeding now and for the future: how can we take stock of what we know?**

*Will there be a database where information on different end users by gender can be compiled?*

*Is baseline data available to avoid having to gather data each time?*

- The CGIAR global comparative study on gender norms, aims to build a database.
- There are baselines, but each project uses different formats, etc.; there needs to be social science “big data” that can be compared, used and aggregated. There is a need for economists and social scientists involved to make their datasets more compatible.

#### **What are the quality traits preferred by women (farmers, processors, consumers)? Are these taken into consideration? Do the prioritized traits address women’s basic needs or their strategic interests?**

*By committing to high productivity (CGIAR goal), are we disadvantaging women by default?*

*To what extent are we trying to address the more strategic needs of women?*

*Are we more interested in focusing on practical needs (food security, nutrition)?*

*Are efforts to reduce poverty necessarily disruptive to gender? How do we address the economic (poverty) side as well as the food side?*

- These efforts can disrupt gender, but there have to be additional interventions put in place to create an enabling environment; you also have to do it at a large enough scale to really make a change.
- Impact of commercialization on gender relationships: focusing on yields and commercial crops with high and quick returns could be more interesting for men
- Some people offered the opinion that addressing the strategic needs of women isn’t the responsibility of CGIAR centers.

**How and who should prioritize traits for breeding? Can we develop niche breeding for segmented markets? According to what criteria? Can breeders influence release committees?**

*If there is a desire for niche breeding in segmented markets, will breeders be able to get these varieties past the release committees?*

*Yield often dominates. Have you had experience getting varieties with quality traits that can't match yield?*

- When there was an end-user preferred variety that didn't meet "classical" requirements, we had to have many conversations to argue for it.
- As a breeder, you know the release committees will try to find ways to cut down 5 varieties to 2-3; they expect breeders to know how you can cut them down.
- Within a country or a region, there are different preferences concerning sensory qualities and priorities for traits, depending on the way the product is processed and consumed; e.g., gari is classified as a fermented product, though most gari products are non-fermented. Also, for gari, sensory properties, especially swelling, are important in some countries, but in Benin, gari is eaten dry or diluted in water, so swelling is not the important sensory quality.

## 2. Part 2: Organoleptic Tests and Biochemical Properties of RTB-Based Foods

### 2.1 GROUP EXERCISE: TASTE TEST

The objectives of the taste test were to illustrate the subjectivity of consumer preferences and identify traits/criteria related to texture, flavor, color or odors that influence different users' preferences of different varieties of the same product. Participants were asked to taste boiled sweet potato pieces from 5 different varieties (A, B, C, D, E) and then to complete a form to score these 5 varieties and describe each with a single word.

Statistical analyses and graphing of preferences led to the following findings: among the 5 varieties tested, taste seemed to be the most important trait to determine the "most-liked" variety, and taste and texture were the most important traits for determining the "least-liked variety." Variety A was the most liked and variety E the least liked. The most liked for appearance was the orange, while the least liked for appearance was the white (C). There was no significant difference in scoring for smell between varieties. Data was also presented under consumer cluster graphs by age, discipline, gender and country of origin of the consumer.

Some of the limitations of the test were that it was carried out with a smaller than usual number of individuals (usually consumer testing is carried out with 120 individuals, but at least 60, while this test had around 40). Sweet potatoes provided were off-season and so were under certain stress. Additionally, for testing to be accurate the potatoes should be kept at a constant, warm temperature. This exercise revealed the complexity of setting up such a test and how difficult it is to capture relevant information on consumer acceptance. See Annex 5 for the full results of the taste test.

### 2.2 PRESENTATIONS

Dominique Dufour, Food Technologist and RTB post-harvest leader for CIRAD/CIAT, introduced part 2 of the workshop by stressing the importance of the perception of food and drink in relation to acceptance. Perception and acceptance depend on many different criteria from users along the value chain and also on cultural factors and eating habits from one region to another (e.g., gari from Cameroon and Benin or fufu in Cameroon with new IITA varieties). Processing is an important factor to consider for adoption and preference. These factors should be incorporated into the objectives of RTB breeding programs: better access to new markets, more nutritious products and improved livelihoods.

Presentation 1 Part 2: "[Sensory testing for African cassava and yam based foods in Benin](#)"  
Noel Akissoe, University lecturer

Benin is the 4<sup>th</sup> producer of yam and 8<sup>th</sup> producer of cassava in Africa. Yam is the 2<sup>nd</sup> food crop after cassava.

Results of surveys of end users in Nigeria, Benin and Ivory Coast:

- Varieties and key preferred traits were grouped into 3 classes: varieties for pounding, dried chips and boiling.
- There are many associated food dishes requiring these characteristics.

- This work focused on pounded yam and amala (sundried).
- The study looked for factors such as taste, texture and color through sensory tests. The most important factors were texture (translated by extensible, soft, adhesive, smooth) and taste (translated by light sweet, tasteless, sweet—no bitter taste included).

#### **Tools and methods used**

- Sensory evaluation was performed through sensory analysis in labs.
- Consumer testing in fields
- The general approach consisted of developing predictive models for sensory attributes using instrumental parameters—physicochemical parameters and consumer sensory test.

#### **Assessed varietal and storage effects of yam cultivars**

- Preferred cultivars are stored for short periods of time.
- Non-preferred varieties of pounded yam should be stored for a long time to increase acceptability.
- Storing tubers changes their ability to produce good pounded yam—light improvement of elasticity and sweetness
- Florido variety was least preferred, while Laboko was most preferred
- Found relationship between dry matter and extensibility
- Dried yam tuber used for amala
- Color, taste, texture all matter
- Kokoro is most preferred variety

#### **Cassava**

- Main products are gari, tapioca, boiled, dried, etc.
- Importance of sensory attributes of selected cassava-derived products
- Friable root has low pectin content
- Irrespective of age, improved cultivars showed low friability scores.

#### **Future work:**

- Sensory analysis on gari types

#### **Concluding points and Q/A**

*What is the correlation between sensory panels that use consumer-trained panelists vs. farmer trials?  
What's the composition of your panel?*

- For a recent project, they will correlate the perception of panelists and farmers. In the past study, they were positively correlated.
- It would also be interesting to correlate the results of sensory analysis with what farmers and consumers want.

Presentation 2 Part 2: [\*\*\*“Examining banana and user preferences”\*\*\*](#)

Beloved Mensah Dzomeku, Senior Research Scientist from CSIR – CROP Research Institute

- Focus on plantains, a major staple in Ghana and a source of energy and income
- There are different ways of consuming plantains: fufu, chips, fried with spices, mashed then fried with bean sauce, plantain cake, boiled in plantain leaves with spices, etc.
- Some of the challenges leading to development of new varieties are diseases (black sigatoka, viruses), pests (nematodes and weevils) and environmental conditions such as poor soil nutrition and prolonged drought.
- New varieties of cooking bananas are being introduced (FHIA material) from South America, central Africa, and Asia. When boiled, these varieties were not accepted, but in chip form they were.

#### **Testing/consumer surveys**

- Had different professions test the plantains: evaluation of hybrid plantains and cooking bananas
- 500 farmers evaluated; local vendors were given bananas to prepare dishes
- A hybrid dessert banana was given to a juice processor

#### **New technology dissemination assessment**

- 169 farmers in 12 communities were asked to evaluate agronomic, yield, cooking qualities, taste, and acceptability.
- Farmers were trained in how to generate planting materials and on good agronomic practices.
- Social networking played a role in technology dissemination.
- They saw materials given as far as 50km from where they were introduced, particularly during social events such as funerals, etc.
- There was a consumer preference of hybrids, which stayed green with more green leaves.
- Regarding fruit quality, many qualities were considered
- Short fingers were rejected; easily peeled bananas were preferred.
- FHIA 25: long duration, cooking banana, bad taste, outright rejected
- Tetraploids are mainly rejected; they're now testing the triploids.
- Challenging to combine all the different preferences

#### **Concluding points and Q/A**

*Were there differences between men and women trained on rapid multiplication?*

- 500 farmers were trained in the first year and 1,000 more in the 2<sup>nd</sup> year
- Women adopted the varieties most; women were more patient in learning the skills
- Men were often not patient enough to locate the meristem.
- They expected farmers to use the materials to go commercial to a larger scale than they did
- There were more men than women at the onset, but eventually more women sought the training.
- Plantain is put in as an intercrop between cacao and used for shade by men; women could use the family land for plantains.

Presentation 3 Part 2: ***“Product properties in relation with consumer preference: the private sector perspective”*** Yolande Codo, from Nestle R&D Center in Abidjan

- Understand consumers (life moments and habits), preferences; tailor products to meet consumer expectations
- More than 6,000 brands globally

#### **Consumer-centric approach**

- The end user is a key player.
- They don't buy what they don't value.
- You must understand what they value.
- When you forget the end user, you lose in the market.
- Identify habit patterns, significance of patterns, and assess cultural need: millet example

#### **Hot porridge habit**

- Understand why consumers behave how they do by using methodologies such as focus groups, individual interviews, ethnographic research
- Find cultural value of grains
- Take into account how people eat/store their food into our protocols
- Explore product territories that consumers prefer: preference mapping using samples covering the widest variety of attributes
- Segmentation, why preferences exist; what are the sizes of the groups?

- Find consumer cluster driven by texture and regionally repeated clusters
- Understand and discover commonalities in consumer preference drivers to shape nationally- or regionally-accepted products
- Fine tune understanding of consumer expectations
- Product tests, consumer insight knowledge, past studies
- Use R&D to match products with expectations and preferences for the best nutrition, price, and factory efficiency
- Try to match products attributes to consumer preferences
- To industrialize, you must make well-defined sensory specifications, based on consumer acceptability limits.
- Trained assessors to monitor sensory attributes
- Use consumer understanding for communication/marketing
- Once you know why they like it, use that to market it to your audiences.

#### **Success factors**

- Important to keep consumer knowledge and understanding from beginning to end
- Design and maintain preferred product properties; not always easy
- Master every step of product development: conception to production
- Always a cross-functional teamwork (food technologists, process technologists, nutritionists, statisticians, sensory specialists)

#### **Concluding points and Q/A**

*For those in the public sector whose end users are individuals processing their own foods, how much are the values of traditional foods changed when people move from rural areas to urban areas?*

- Sensory attributes don't vary much for traditional foods like fufu, from village to town, but it becomes more about prioritizing sensory against services, e.g. convenience (preparation time, etc.)

*What link do you have to breeders (producers of millet, etc.)?*

- R&D Abidjan has an agronomic department that works with breeders of national & international research centers to develop agronomic & nutritional characteristics of African staples crops. Thus, we are collaborating in the development of biofortified crops, including corn, for example. New crops varieties that were developed with research partners are received in Abidjan and tested in industrial applications. It's a two-way approach.

*How do you choose your consumers?*

- You have to be representative of your core consumers. For some product categories you may need to integrate both the primary consumer (purchaser) and the end-consumer.

*We are trying to address the importance of the consumer in poverty alleviation. Should we start adding to the complexity of this the nutrition and health issues?*

- Nestlé is a Nutrition Health and Wellness company. We believe it's our responsibility to address nutrition, but we recognize that sensory experience is often the first driver for food. Our challenging commitment is to always conciliate both.

*Is there a way to link what the social scientists and the breeders are doing? How do you give data across the division?*

- In Ivory Coast, there was a variety of cassava that was too large for farmers to bring to processing, so it failed. You need to consider organoleptic criteria and technology needs; different disciplines need to be involved.

*In product development, how do you define a new product? Do you have to start from scratch? How do you define the raw quality requirements in the private sector?*

- The private sector used to consider only companies' needs, now they also consider the consumers' preference to drive the quality requirements and up the raw material specifications.

- Small changes in a product are called “renovation”—nutritional additions, for example. Not all projects are breakthrough innovations; you can often leverage from existing products data and knowledge.

*For someone starting a new project, what advice do you have for the relative level of investment to make in the balance of the consumer understanding versus product development?*

- This could be based on opportunities size and the business objectives.

*How do you track progress along the product/development pipeline? How many make it through? Where do most drop out of the pipeline?*

- There is a specific system for this, with different gates from opportunity to industrialization.
- From concept to industrialization, there can be up to 50% dropout rate. It is important to screen winning ideas as early as possible.

Presentation 4 Part 2: [“Breeding for root, tuber and banana. Textural Traits: a Review of the Available Food Science and Consumer Preferences Literature”](#) Presented by Jim Lorenzen, Senior Program Officer, BMGF  
Evans School Policy Analysis & Research Group (EPAR), University of Washington

The review is of interest in terms of communication and terminology. It could provide language for breeders to interact with food scientists. The purpose was to review available literature on consumer preference studies and current food science of texture for RTB crops.

#### **How was the review organized?**

- Sources consulted were Scopus, Google Scholar, Science Direct, etc.
- Methods: consumer panels, surveys, interviews, consumer preference studies
- What are the best terms? What are the right definitions?
- Linking verbal description of traits with physiochemical and genetic drivers.

#### **Defining consumer preferences for each crop**

- Expert consultations with a number of scientists
- Defining texture
- Taste is often not about flavor or aroma, for non-trained consumers
- Research methods
  - Subjective and objective (instrumental) methods
- Classification of textural characteristics
- Drivers of textural characteristics
- Multiple measurable food product characteristics exist, which are driven by genetics
- Half the hits of all RTBs were for potato

#### **Sweet potato highlights**

- Pasting profiles of sweet potato starch vary widely
- Sweet potato changes during preparation, and much sweetening takes place during cooking

#### **Tropical yam: highlights**

- Elasticity, stickiness is important for yam products; amylose is important for texture

#### **Cassava: highlights**

- Not as much detail as for yam, even though it’s a much more important food crop
- Drivers of cassava texture
- Focus is on starch, but recognizing that pectins are very important
- Must ask what the uses for starch will be

#### **Banana/plantain**



- Very little found on cooking bananas
- There are a huge number of drivers (genotype X environment)
- Textural complexity
- What are the most relevant sensorial attributes (e.g. which one to choose out of 40 attributes that can be found in different varieties?)

### **Concluding points and Q/A**

- The complexity of consumer preference indicates there should be earlier interaction with farmers and others.
- Complexity can be overwhelming, but there's also knowledge to be gained from private industry, which creates typologies and targets specific consumers.
- There is a great opportunity for aggregating preference characteristics into traits that are more understandable. Now we need to summarize and translate this into breeding.
- For sweet potato, China, Philippines, and Asia have done a huge amount of work. The greatest barrier is language: BMGF could focus on translation to integrate this knowledge.
- We should look at two types of consumers: farmer/home consumption and consumers to reach after the whole market chain.

Presentation 5 Part 2: "**Potato breeding experiences**" Hans van Doorn, HZPC Holland BV

Development of objective (instrumental) protocols for evaluating traits: many tools exist; much big data analysis.

### **Potato sensorial profiling**

- Great detail in sensorial attributes
- Most sensing takes place with your nose
- Sensorial space for potato plots attributes to show how they differ between varieties

### **Consumer preference mapping**

- Asking panel participants about both sensorial profiles and liking leads to problems
- In US preference mapping study, there is clear variation about what consumers like
- Clustering potatoes into 3 clusters shows that there is not one perfect potato; there are many perfect potatoes, depending on the clusters and many other factors.
- There is no compromise variety

### **Instruments**

- Flavor of potato instrumentally measured by active headspace sampling
- For big data, it is most important that you have the right software and that it performs well
- Textural traits also have an aroma and flavor phenotype—in addition to texture analyzer data
- Measuring flavor traits: freshness and earthiness and others
- It is now possible to easily profile attributes in an instrumental way
- High-throughput texture analysis allows for 10,000 or 100,000 samples in a breeding season
- Through all sampling, 350 flavor components make or break the quality of the potato
- There is overlap, but also specificity of components
- Sugar is the most important piece for processing trait profiling
- Analysis tool exists to measure 10,000 samples a day for sugar

### **Dry matter**

- Not evenly distributed inside or between potatoes; some varieties have better distribution through genetic traits

- Many defects are related to poor distribution of dry matter and starch

#### **After-cooking darkening**

- There are ways to measure this ahead of time with photos

#### **Genetic modeling**

- Developing SNP markers for potatoes: about 20-25 SNP markers may explain 80% of variance
- Many traits are multigenic in nature.
- Can apply genotyping principles and genomic selection

#### **Conclusion**

- There's a wide variation in preferences related to traits
- Consumer preferences are segmented into distinct liking clusters
- Quality traits can be measured objectively
- Most quality traits have medium to high heritability and are multi/polygenic in nature
- Developed genetic maps and SNP polymorphisms allow breeding and selection for quality traits according to genomic principles
- Breeding and selection for quality profiles is at the proof of principle stage for single traits, but traits are linked, so we must be aware of this
- Look out for G, E, and GxE
- Prepare for big data sets

## **2.3 DISCUSSION AND RECAP OF PART 2**

Hale Tufan facilitated a discussion following the presentations.

#### **Opportunities identified**

- Work between food scientists and breeders
- High-throughput opportunities in the private sector to analyze traits
- Integrating evaluation and breeding

#### ***Engaging consumers: what do we do with consumer preferences information for breeding programs?***

- We depend on the consumer to select desirable traits.
- We should see the regional preferences from our group and other groups. Previous projects find very different levels of acceptability by region.
- A study in Uganda found that people who were all likers were those for whom the crop was a staple crop; those in urban areas were more dislikers.

#### ***At what stage should breeders be incorporating consumer acceptance?***

- The tendency is to wait until on-farm trials. One way to go is toward the idea of 3 or 4 market classes, presenting less variability with releases, but with a higher probability of adoption.
- Breeders choose a target group to taste prototype amongst others already on the market. Then ask how it could be improved, if they'd buy it, how much, etc. Requested changes are made and prototype retested
- Taste panel on 30-40 varieties of sweet potato to assess sensory preferences in Tanzania available in publication (Keith Tomlins).

#### ***The need for food scientists and breeders to work together***

- Are we creating a database of preferences data? Should we think about more targeted breeding by region, to save everyone's time and not reinvent the wheel?

- In regards to how to use this information, there's a step that's missing: once we know what consumers want, we need to come back, take a larger pool of varieties, link sensory evaluation with instrumental evaluation; breeders need more of the functional properties.
- Evaluation of traits today is often subjective; food technologists must translate their data for breeders to breed for different varieties.
- For wheat, there were ranges for different quality traits, and breeders started breeding according to those traits, but first identified the genetic control.

***High-throughput opportunities in the private sector to analyze traits***

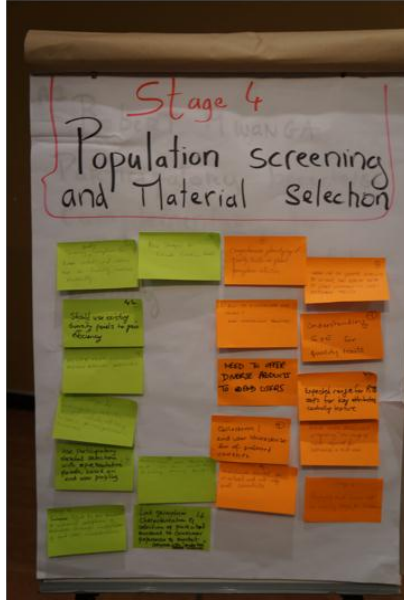
- There is incredible potential in high-throughput assays. We can start doing quality analyses on the genotypes available, make predictions about acceptability for different uses, and set a test panel. At the same time, the specialists in labs could start to look at candidate genes. With high-throughput, what's possible?
- What is the relationship between the varieties we provide and the processing technologies? How important are the characteristics of the input product, and how much can you do with good processing?
- As markets become more industrial/sophisticated, the tasks of food scientists almost disappear. Industrialization makes it far simpler because of processing capabilities.

***Integrating evaluation and breeding***

- Breeders and those who fund breeders have expectations of their return on investment. On average, we need to justify covering 10,000 hectares of coverage. End user preferences are fascinating, but we need to justify the inputs into developing.

### 3. Part 3: Breeding for End Users – Tools and Approaches

#### 3.1 RECAP OF PREVIOUS DAY WITH STEPS OF PROCESS MODEL



Hale Tufan presented the process model with the 6 stages. Titles of the 6 stages were written on 6 different flip charts. Participants had 10 minutes to write on different colored sticky notes key points and challenges they noted during the previous day. They then placed the sticky notes on the charts under each stage of the process map (stage 1 and 6 were combined as both deal with end users). This input was used to feed into the road map.

#### 3.2 PRESENTATIONS

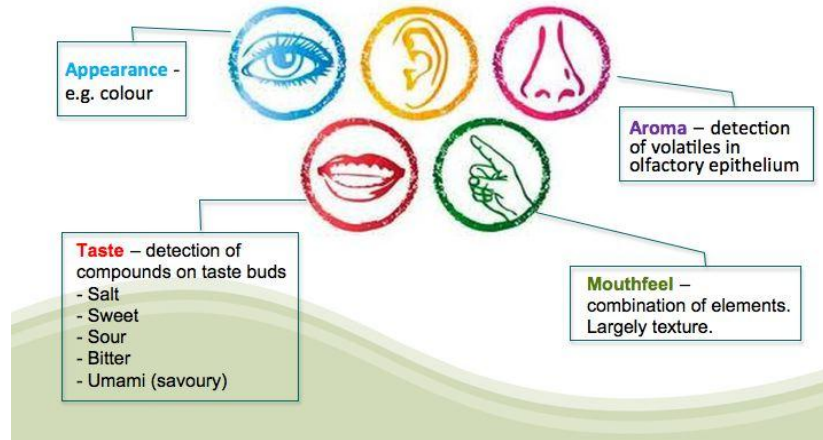
Presentation 1 Part 3: [“Findings on molecular dissection of flavor and texture traits of potato by comparing Phureja and Tuberosum”](#)

Laurence Ducreux, James Hutton Institute, Scotland

- The potato is the world’s third largest food crop in terms of fresh produce.
- High in vitamins, minerals, carbohydrates
- Necessary to understand molecular basis behind traits to improve germplasm
- Flavor: appearance, aroma, mouth feel and taste
- Solanum tuberosum group Phureja differs from Tuberosum
- Phureja germplasm tends to score higher for acceptability
- Strong correlation between flavor intensity and acceptability

## What is flavour?

Synaesthetic experience creating an overall sensory impression...



### Sensory data panels are useful tools

#### Umami/taste

- Non-volatile flavor compound: key determinant in potato flavor, gives creaminess and viscosity
- Glutamate and GMP are most important compounds for umami flavor: umami flavor foods eaten all over world
- 5'-ribonucleotides released on cooking: levels are higher in Phureja mature tubers
- Glutamate levels: significantly higher in Phureja mature tubers, no differences during development
- Equivalent umami concentration (EUC) higher in Phureja at maturity; no differences at development
- EUC/sensory score correlation: volatiles between two significantly differ between Phureja and Tuberosum

#### Microarray analysis

- Compared transcript profiles, results from two growing seasons
- Terpene synthase example: found 20 genes that were annotated for terpene synthase, through microarray; cloned this gene, expressed it

#### Texture

- Phureja much softer
- Pectin is important in texture
- Found 2 genes involved
- PME activity much lower in Phureja
- PME is probably a key gene in texture; could be possible marker for breeding

#### Genetic Analysis—QTL mapping

- Analyzing traits by phenotyping then linking trait to marker on map
- Expand range of variation by doing crosses
- Diploid Tuberosum crossed with Phureja
- 2 selected to be backcrossed with each of the parents
- Variations in size, shape, color, texture, flavor
- Correlation of 2-heptenal with earthy flavor

#### Concluding points

- Phureja/Tuberosum comparison is useful

- Correlations between volatiles and flavors
- QTLs identified for flavor, volatiles
- Transgenics can be useful for validating
- Future:
  - Expand analysis
  - Develop methods for consumer preferences
  - Accelerated breeding with cultivars

## Q/A

*What tests were used?*

- Texture test used mimics experience of biting; no tests of viscosity

*Did you dissect why people liked Phureja to understand which features?*

- Test was done by professional taste panel, so many criteria were considered
- Colleague did sensory analysis with heat map linking characteristics

Presentation 2 Part 3: [\*\*"Agronomy and processing considerations linked to varietal choice by cassava and sweet potato farmers linked with value chains in Nigeria"\*\*](#)

Dai Peters, Senior Technical Advisor, CRS

Most products derived from cassava and sweet potato are processed into:

Fufu

- Very specific product
- Mainly for city consumption, doesn't last as long
- Generates higher profits

Akpu,

- Fresh wet mass
- Can last 2-3 months
- Generates lower profits

## Post-harvest considerations

- Products derived, processing characteristics, end uses, transport, shelf life, types of farmers, market forces
- Market forces affect what farmers will grow.

## Four types of cassava value chain farmers typed by how they sell

*First: roots by weight only*

- Collectors don't differentiate by variety, they look for high fresh yield varieties
- Inefficient chain; make least profit, some negative

*Second: roots by weight and variety*

- Sell to collectors who demand specific varieties
- More local varieties, higher dry matter content
- Look for high price and high fresh yield

*Third: processed products*

- Gari processors:
  - Income from variety based on root/gari conversion rate
  - Only adopt varieties with high gari yields (high DMC) plus gari quality, reflected in prices
- Akpu processors:
  - Income from variety based on root/akpu conversion rate

- Only adopt varieties with high akpu yields, starch quality to allow storage for 2-3 months
- Akpu variety named for product; most popular—higher return, storage time
- Why akpu instead of gari?
  - Lower profit, but doesn't require any equipment (presser or roaster)
  - Much less investment and labor; better for poorer households
  - Lower demand on women's labor

*Fourth: roots for industries*

- Large farmers selling directly to factories that pay by starch content
- Income based on starch yield: % starch\*fresh yield
- High starch yield variety adoption
- Huge difference compared to imported wheat flour

**What varieties are adopted?**

- Each type of farmer is looking for different varieties
- 2: more money from high fresh yield
- 4: more money from starch content
- Market prices affect adoption and variety selection

**Fresh root market: Sweet potato in West Africa**

- Varieties must be able to last 2 weeks for transport, through transporters to cities
- Ability to be fried: all based on oil consumption; less oil required
- Only 2 varieties in any market that are acceptable in Nigeria
- Majority fried
- Three types of sweet potato farmers
  - 1 and 2 will accept varieties required by larger markets
  - 3 will accept varieties for nutritional needs, since they're mostly for home consumption

**Post-harvest perspective of Participatory Breeding**

- Incorporate trader/collector perspectives
- If they don't accept it, farmers won't grow it
- Consumer preferences are reflected in and constrained by market forces

**Concluding points and Q/A:**

*Interesting to see typology illustration to break out targets. How many among the 4 groups were female farmers?*

- Almost all of the processing was done by women; processing is related to female labor.
- Importance of markets as driving force

*Are there specific needs of the breeders within the typologies?*

- The farmers are always looking for new varieties. Consumers can only get what the market offers.
- One Nigerian participant commented that Akpu is a pre-form of fufu.

Presentation 3 Part 3: "[\*Capturing gendered cassava traits—developing tools for breeding programs\*](#)"  
Hale Ann Tufan, Project manager, Next Generation Cassava Breeding Project, Cornell University

**Why are end user preferences important?**

- Focus on key traits: most varieties are developed to improve yields and for disease resistance
- In focusing on more visible preferences, are we marginalizing women?

**Are there gendered traits?**

- There are differences, related to value chain
- Determined by gender roles/relationships and labor loads

### **Operationalizing in breeding programs**

- How do we capture preferences and bring them into breeding?
- How do we understand the traits?
- How do we prioritize the traits?
- How do we breed for these?
- Very long, disengaged spectrum of end users; how do we bring it together?

### **Case study: NEXTGEN cassava**

- Genomic selection to breed cassava
- Do we know where we want to go? Are we forgetting traits?
- Are we making the process worse by selecting negatively correlated (to end user preferences) traits

### **Do we need gender “omics”?**

- Can we use “omics” to accelerate development of appropriate varieties for smallholder women farmers? How?

### **Tool development and testing**

- Scoping studies: key informant interviews
- Pilot study
- Sex-disaggregated focus group discussions
- Sex-disaggregated individual semi-quantitative interviews

### **Nigeria pilot results**

- Differences between men/women preferences for different varieties
- Across, women have broader understanding of traits, not just weighing 1 or 2 traits

#### *Site 1*

- Nwageri: Women ranked 1—high yielding, fufu draws, produces many tubers
- Chigazu: Women ranked 2—not watery, swells. Men ranked 2 because early maturing

#### *Site 2*

- Dangaria (TME 419)
- Men and women ranked equally, 1<sup>st</sup>, but for different reasons
- Women: fast maturing, high yielding, leaves for soup, could be pounded like yam
- Men: swells, moldable, dewater fast

#### *IITA*

- Women: Ranked 4<sup>th</sup>, storability
- Men: ranked 2<sup>nd</sup>, forms canopy for their cacao, big roots

Complexity in end user preferences: varies greatly from local area, marital status and age

### **How do we codify local knowledge: how can we measure, benchmark knowledge/language?**

#### **A proposed process**

- Interviews
- Farmers/visit
- Stakes for planting material
- Processing observation interview: correlating different processing types with suitable varieties
- Product sampling
- On station
- Collected material
- Gari reference nursery
- Product sampling
- DNA sample for GBS
- Taxonomic description
- Screen/phenotype breeding material?
- GWAS/GS/marker discovery



- Select lines for farmers
- Farmer field tests

### Concluding points and Q/A

- Need to bring together different disciplines for common process
- Focused on women smallholders
- Capturing preferences can be done, but it's very diverse

*Can we generate markers linked to quality traits?*

- We hope so
- Collect all varieties grown by a farmer to contrast best/worst varieties for gari

*In the informant interviews, is there a process where women/men would sit together and negotiate/describe, or do we assume women are overpowered in these situations?*

- Generally, men's voices will be louder if they are together, and women are overshadowed.
- It depends on the cultural situation in each community; if men/women are allowed together
- In focus groups, you don't want to encourage negotiation; you want a group with common views, which explains relevance of separate focus groups for men and women.
- It seems that gender alone is not enough—social class is also important.
- That was an oversight: we classified the community as a whole, but what we didn't do was benchmark each individual interview—we will do this for phase 2. We need the self-reflection of wealth for phase 2.

*Did you distinguish whether these are characteristics they're interested in for home consumption or for selling?*

- When we collect varieties, we'll need descriptions for what they use each for

*Since we know cassava is a female crop, cacao is a male crop, how do you think of this?*

- We didn't want to assume that, so we first observed and asked what the situation was; we focused on areas where cassava was grown, both by men and women

*Is it true that varieties that store for longer periods of time are preferred by women?*

- We saw this in Nigeria; it doesn't come out very clearly, but in the pilot, women were saying cassava is a bank that can be left in the soil to pay school fees: early maturing and lasting in soil is desired

## 3.3 DISCUSSION AND RECAP OF PART 3

*How do we modify our approaches to be more responsive to different needs, especially how different disciplines collaborate with each other?*

- Storability and drought raise a key need: with roots that stay longer in the ground, it's hard to get a good product out of it in the end—it can lead to bad gari.
- There's good interaction between Dai Peter's diversity of value chain actors and Hale's end user preferences. If varieties don't meet the needs of actors along the chain, they lose. Even when radar charts of preferences look the same, there can be big differences in preferences and weighting. This is complex work.

*For sweet potatoes, at smallholder levels, we need to remember that farmers keep a mix of varieties—how do we capture this?*

- There are varieties that get farmers food fast, but also those that allow them to eat for the year. Only highly commercialized farmers restrict to 1-2 varieties. As we profile, we must remember that farmers rely on multiple varieties to get through the year.

*Would the food scientists like to translate the common terms to food science?*

- The best technology for drawing is stretching ability; not drawing is related to degradation of the starch. Dewatering has to do with the water binding capacity.

*Is there capability to measure all the phenotypes in 1,000 varieties in the space of one week?*

- We have sensory descriptions; as food scientists, we can measure that and translate it into instruments to measure these things.

*For the breeders, can we then translate the measurements into markers?*

- We don't know how to do this yet.

*Is there a way for us to take key words described to food scientists and ask what needs to be measured to test these descriptions? Is there a resource to link descriptions to instrumental measurements?*

- We can describe these properties, then in the lab we can test these.

*How do we connect the properties described in the field with measurements in the lab?*

- There needs to be a better connection between social scientists and food scientists.
- We need to set priorities for food scientists. They need to be part of the breeding team, to understand the importance of traits and then tell the breeders how they can incorporate alleles for genes that will define these properties.
- Terms like pounding, swelling, stretchability, are functional properties controlled by the composition of starch and other saccharides. You should think of measuring water/solvent retention capacity—these can be measured. Then find markers to define those functional properties.
- Properties like firmness, etc., are very complex; it's not just one trait that is responsible. If fufu softens when it's cold, this can be related to starch, amylase content, fiber, or cellular deconstruction. If you measure firmness, analyze characteristics; you can use regulation to explain the characteristics that explain the firmness. Working with molecular biologists, you can then identify the associated genes. It's not so complicated.

*What was the scale of the study that Hale reported?*

- The idea that villages are homogeneous units is incorrect. Variability between villages must have to do with typologies of actors along the value chain and social class. It will be very important to expand the scale before going to food scientists and prioritizing certain traits.
- We need to also genotype all varieties, provide ranges to each property—this leads to a huge study that can only be done at a smaller scale; so how do we get breadth, then?
- We need to differentiate villages and typologies. This will help us understand end user preferences and profiles. In addition, we have a survey of thousands of farmers to get a better idea of users—the challenge is to connect studies and surveys.

### 3.4 RECAP OF EXERCISE 3 – BUMBLEBEES AND BUTTERFLIES

The purpose of this session was to share experiences and learn from participants who did not make presentations in plenary and to collect additional insights to feed into the road map.

There were 2 rounds of 4 speakers presenting their experiences simultaneously in different corners of the room. Participants had to choose among the 4 presenters. They could either move from presenter to the others like bumblebees who cross-pollinate the workshop or stay in the same place, like butterflies who create quiet centers of non-action for stillness and creating knowledge and novelty. Participants were asked to write down on sticky notes of different colors i) ideas, key points and ii) knowledge gaps and place them on the flip chart under the 5 stages of the process map.

See Annex 3 for names of presenters and themes.

After the presentations, participants reconvened the plenary and drew the following conclusions:

- Better understanding is needed of what other disciplines and specialist are doing and the challenges they face
- Classify the different crops and food types and have sub-classifications of the processing methods
- Yam is a great example of how research was able to identify indicators of a complex trait by using different instruments. Are there plans to develop high-throughput methods to do similar things?
- To obtain sensory data, we will need very quick methods to analyze these attributes in a two-week time period.
- There is great diversity in end user needs, expectations and within the different value chains. There's an opportunity to see if 20% of factors can explain 80% of characteristics.

## 4. Part 4: Road Map for End Users Preference Integration in RTB Breeding Programs

In the final session of the workshop, participants organized in groups for each stage, drew on the sticky notes collected earlier for that stage, and produced a synthesis of: a) what we know, b) what we miss, c) critical linkages and d) next steps. This provides the basis for the roadmap going forward.

### What we know

#### Stage 1: End user profiling and testing

- Keep in mind the diversity of end users (market segmentation)
- Appropriate tools for gender sensitive end user profiling (village level, aggregate and link to gender)
- How to translate consumer profiling info into physical/chemical processes
- Multivariate analysis

#### Stage 2: Preference capture, trait discovery

- Knowledge of baseline traits, e.g., in-ground storage, marketing, resistance to remobilization of starch, dry matter, dietary fiber, cyanide (cassava)
- Texture and flavor are primary drivers of preferences
- Good methods for preference capture

#### Stage 3: Phenotyping method development

- Starch content and functional properties of starch
- NIRS for partial knowledge base
- Physical and chemical traits
- Information on deficiency and quality traits but not always why

#### Stage 4: Population screening

- Screening markers for some varieties
- Genetic variations in databases

#### Stage 5: Molecular markers

##### *Phenotyping perspective*

- For all crops, differentiation of cluster traits representing market chain actors: consumers, processors, producers, traders (pre-/post-harvest, processing, flavor/aroma, consumer preference, market needs, health/nutrition, transportation, especially bananas and plantains)
- Small part of these traits and genetic definition

##### *Genetic perspective*

- **Ploidy** level plays a role: lower ploidies have better chances
- Reference genomes for banana, cassava, potato; lack for sweet potato, yam
- Develop SNP polymorphisms for all crops; develop SNP arrays, like for potatoes

### What we miss

#### Stage 1: End user profiling and testing

- More complete socioeconomic analysis to verify core target groups (by gender) and define sample frame to collect baseline data (location specific)
- Links between products and target groups; customer and product profiles; sensory profiling
- Catalogue the traits of predominant varieties and their end user groups

#### Stage 2: Preference capture and trait discovery

- Data management and statistics capacity
- Better understand flavor
- Trained panels of 10-15 people for sensory evaluation
- Preference capture at different stages: parents, early, late products
- Translation of qualitative results into measurable parameters

**Stage 3: Phenotyping method development**

- Correlation between physicochemical and consumer preference traits
- High-throughput assays
- Throughput for nutritional traits (protein/amino, iron, zinc, fatty acids, starch quality)
- GxExM for all quality traits
- Information early in breeding cycle for breeders

**Stage 4: Population screening**

- Genetic markers prioritizing key traits
- Test with end user at early stage with probability bubble

**Stage 5: Molecular markers**

- Prioritize traits for every crop
- Phenotypic definition of traits
- Segregate populations for all traits (over 2,500 individuals per population)
- Proven heritability for traits
- Measure interaction between G and E traits

**Critical linkages**

**Stage 1: End user profiling and testing**

- Communicate findings on end users and products profiles to food technologists and breeders: joint planning and results sharing at critical points; iterative process
- Get benchmark traits and integrate them into phenotyping process
- Compare products from ongoing breeding programs to catalogued varieties in the baseline
- Validate varieties/qualities with end user groups
- Work closely between food scientists and breeders on all aspects of quality evaluation

**Stage 2: Preference capture, trait discovery**

- Multidisciplinary training among organizations, especially for surveys
- Networking among labs
- Coordination among national programs
- Scaling high-throughput phenotyping (NIRS)
- Internal quality control checks
- Validation steps for methods at different intervals
- Network on quality traits, similar to gender network; mentoring in quality analysis
- Accounting for ethnic, language differences in communication among different groups and market stakeholders (importance of local names and gender responsive ways of relating to things)

**Stage 3: Phenotyping, methods development**

- Link end users preferences to phenotypes, prioritize product specific traits
- Continual feedback on phenotyping methodology

**Stage 4: population screening**

- Testing of markers with end users at an early stage

**Stage 5: Molecular Markers**

- Develop biometric and bioinformatic capacity (discovery team)

- Multi-environment facilities, target heritability, markers for breeding and selection (breeding programs)
- Cost efficient platforms (discovery), breeding by design ((breeding programs), BLUP, link with genomic data

### **Next steps**

#### **Stage 1**

##### *Use existing opportunities*

- Existing program for phenotyping across crops: integrate quality traits
- Gender budget under RTB could integrate social science with resources
- Link to PIM (Policy Market group) research consortium
- Layer into the RTB Map effort by Glenn Hyman
- Link to the genomics side, NEXTGEN, etc.
- Fuller integration could be planned for upcoming round of consortium research projects in 2016

##### *Knowledge management*

- Establish innovation platforms along the chain to identify and prioritize EU preferences
- Build a conceptual framework based on existing case studies
- Use Masters and PhD students
- Contribute to knowledge portals

##### *Establish partnerships*

- Co-sharing on some of these investments
- Use current public/private partnership (committee on potato; CIAT cassava partnership with Thai starch) and build new ones
- Breeding/companies
- Approve linkages with NRI and CIRAD under RTB and national institutions and target countries

#### **Stage 2**

- Implement assessment process in programs to have indicators of end user involvement
- Control points to show progress
- Use this to demonstrate flexibility to change and needs
- Plans for better characterizations of parents and early breeding programs
- With databases, conditions for quality traits
- Proof of concept projects to demonstrate we can improve phenotypes for preferences
- Re-characterize land races
- Improve participatory selection designs of national coordinated trials
- Make more robust for sensory evaluations
- Make use of simple screening tools when they exist
- Engage food scientists to improve poundability tests

#### **Stage 3**

- Knowledge base on high-throughput phenotyping; identify and prioritize a limited number of key traits for key products

#### **Stage 4**

- Cross reference with high-throughput phenotyping to compare efficacy (H-T vs. screening)
- After validation, use markers to pre-screen before end user testing (avoid screening out varieties that may be good)
- Develop methods for genetic gain
- Evaluate global germplasm for markers
- Evaluate the data base for quality

## 5. Conclusion

Concluding remarks and acknowledgements by Jim Lorenzen from BMGF and Graham Thiele, Director of CGIAR Research Program on Roots, Tubers and Bananas

The workshop helped everyone have a better appreciation for interdisciplinary relationships among attendees and how these can help their programs in the future. RTB, CGIAR, BMGF are supporting breeding programs. The products of these breeding programs should do good, not harm, and impact end users, including women, positively. What should be done to improve responsiveness of products being developed by breeding programs and ensure adoption?

Participants were asked to prioritize actions for the future.

### ***What are the next steps? What can we plan with existing resources? What needs additional resources?***

- Consider end user feedback around gender when carrying out population screening and material selection
- Identify the traits (esp. friability, pectin, etc.) and select key ones, stepwise. Define them properly and communicate to the breeders
- High-throughput (1,000s)
- Identify the traits and know the linkage between the genetic and biophysical traits; combine and reduce the set of traits for breeding
- Challenge the user, the farmer, the consumer: expose them to certain technologies so they can think if what they are doing in the traditional way is still the way to go or if it is time to change their habits for their own benefit
- Appreciate limits of where traits are and the limits of the breeding populations gene pool (e.g., wheat and sorghum)

### ***What is impossible to achieve without an influx of new resources?***

- Multi-environment trial approach
- High-throughput methods
- User profiling at the scale it needs to be done: the tools, staff, implementation and collection/consolidation of information
- Phenotyping methods and tools
- Keep people of different disciplines connected and sustain the collaborative interest: maintain the silo-breaking between social scientists and economists, food technologists and breeders
- NEXTGEN is an opportunity to pool resources and bring people together
- Share cassava learning across the crops
- Better interaction between theme leaders
- Use the workshop report to write a white paper translating lessons and learning into concrete actions

Each participant wrote down a personal commitment on a sticky note to pursue work and collaboration initiated in this workshop (Annex 4)

## 6. ANNEXES

### ANNEX 1. WORKSHOP AGENDA

Day 1 – 26 <sup>th</sup> February 2015 – Regal Hall <sup>1</sup>		
Time	Activity	Responsible
8:00 - 8:30	Introduction and objectives of the workshop	Jim Lorenzen
8:30 - 9:00	Ice breaker and introduction of participants	Jacqueline Terrillon
<b>Part 1: Plant breeding: Importance and challenges of including user preferences</b>		
9:00 - 10:00	Group exercise: understanding end user needs and preferences	Hale Ann Tufan and Graham Thiele
10:00 - 10:20	Varietal adoption in cassava and other RTB crops: importance of end user preferences and gender responsiveness	Presentation- Arega Alene
<b>10:20 - 10:40 Coffee – Tea Break – Outside Regal Hall</b>		
10:40 - 11:00	Gender responsive participatory plant breeding	Presentation- Jacqui Ashby
11:00 - 11:20	Understanding relationships between cassava traits and end user preference: what are the cassava quality traits that drive end user acceptance and crop adoption?	Presentation- Aurelie Bechoff
11:20 - 11:50	Discussion – Recap of Part 1	Hale Ann Tufan
11:50 - 12:30	Group Exercise 2: Taste test	Sarah Mayanja and Genevieve Fliedel
<b>12:30 – 13:30 Lunch Break - Munyonyo</b>		
<b>Part 2: Understanding consumers: Organoleptic tests and biochemical properties of RTB based foods</b>		
13:30 - 14:00	Sharing results of taste test and introduction to Part 2	Introduction by Dominique Dufour and brief feedback on taste test

<sup>1</sup> Break-out room: Emerald Hall



# INTEGRATING END USER PREFERENCES IN RTB BREEDING PROGRAMS

14:00 - 14:20	Sensory testing for African cassava and yam based foods	Presentation - Noel Akissoe
14:20 - 14:40	Examining banana end user preferences	Presentation - Beloved Mensah Dzomeku
14:40 - 15:10	Product properties in relation with consumer preference: The private sector perspective	Presentation - Yolande Codo
15:10 – 15:30 Tea – Coffee Break – Outside Royal Hall		
15:30 - 15:40	Breeding for Root, Tuber, and Banana Textural Traits: A Review of the Available Food Science and Consumer Preferences Literature	Presentation - Jim Lorenzen
15:40 - 16:30	Discussion – Recap of Part 2	Dominique Dufour
16:30 - 17:00	Evaluation of Day 1	Jacqueline Terrillon
17:00 - End of Day 1		
18:00 - Reception and dinner – Marina Restaurant		

## Friday 13th June 2014

Day 2 – 27 <sup>th</sup> February 2015 – Royal Hall		
Time	Activity	Responsible
Part 3 - Breeding for end users: tools and approaches		
8:30 - 9:00	Plan for the day	Jacqueline Terrillon
9:00 - 9:20	Molecular dissection of flavor/texture traits	Presentation - Laurence Ducreux
9:20 - 9:40	Varietal choice by cassava and sweet potato farmers linked with value chains In Nigeria: agronomy and processing considerations	Presentation – Dai Peters
9:40 - 10:00	Capturing gendered cassava traits – developing tools for breeding programs	Presentation - Hale Ann Tufan

# INTEGRATING END USER PREFERENCES IN RTB BREEDING PROGRAMS

10:00 - 10:30	Discussion – Recap of Part 3	Peter Kulakow
10:30 - 11:00 Coffee – Tea Break – Outside Royal Hall		
11:00 - 12.30	Bumblebees and butterflies	Various Speakers – Graham Thiele and Jacqueline Terrillon to facilitate
12:30 - 13:30 Lunch Break - Munyonyo		
<b>Part 4:</b> Roadmap for end user preference integration in RTB breeding programs		
13:30 - 16:30	Building a roadmap for end user responsive breeding programs	Group Exercise- Jim Lorenzen and Graham Thiele
16:30 – 16:45	Evaluation of the workshop	Jacqueline Terrillon
16:45 - 17:00	Closing words	Jim Lorenzen
17:00 End of workshop		

## ANNEX 2. LIST OF PARTICIPANTS



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## ANNEX 3: GROUP EXERCISES

### GROUP EXERCISE 1: UNDERSTANDING END USERS NEEDS AND PREFERENCES

Social Scientists

Who to consult?	How?	How often?	How would you ask them?
<ul style="list-style-type: none"> <li>All stakeholders: farmers, processors, consumers</li> <li>Value chain audit (market led)</li> <li>End users</li> <li>Especially the young lady processors because they know the raw material and they are consumers and sellers</li> </ul>	<ul style="list-style-type: none"> <li>Visit them</li> <li>Hold focus groups</li> <li>Observe processes</li> <li>Conduct qualitative surveys all along the food chain</li> </ul>	<ul style="list-style-type: none"> <li>Season analysis</li> <li>Several times with open discussion, pre-surveys, focus groups</li> </ul>	<ul style="list-style-type: none"> <li>For you, what are the important characteristics of the yam to give a good pounded yam product?</li> <li>Are you able to say, by looking at a yam tuber, if it will give a good pounded yam product?</li> <li>During the processing, what are the crucial steps to give a good pounded yam product?</li> <li>As a consumer, what are the main sensory characteristics you are expecting so that you say: "Ah it's a good pounded yam product".</li> </ul>

#### Different steps:

- Conduct a survey with consumers/main buyers
- Observe traditional processing: criteria of quality
- Define product attributes
- Relate quality criteria to physicochemical properties
- Consult women groups (have prior knowledge)
- Farmers: quality criteria
- Analyze market: Price, product, place, promotion (based on purple flesh property, nutritional value), where is product sold? (Volumes? Competing products?)
- Are there niche needs?
- List stakeholders
- SWOT analysis

## INTEGRATING END USER PREFERENCES IN RTB BREEDING PROGRAMS

### Food Scientists

Who to consult?	How?	How often?	How would you ask them?
<ul style="list-style-type: none"> <li>Young women making products</li> <li>Gender specialist/social scientists</li> <li>All market aspects: consumers, sellers</li> <li>Producers</li> <li>Yam breeders/germplasm/agronomists/IPM</li> <li>Food technologists</li> <li>Funders (bank, financial advisor)</li> <li>Value chain specialist</li> <li>Processing equipment manufacturers</li> </ul>	<ul style="list-style-type: none"> <li>Focus groups</li> <li>Value chain diagnosis, promotion</li> <li>Define sampling strategy</li> <li>Prototype experimentation</li> <li>Niche opportunities</li> <li>Consumer panels</li> </ul>	<p>Iterative process</p> <p>Appropriate to the question being asked</p> <p>To get feedback, inform into research design</p> <p>Need to define critical steps</p> <p>Post project evaluation</p>	<p>What do you have now?</p> <p>What is the profile of what you wish to produce?</p> <p>What are your expectations for this product? Why?</p> <p>What is the market opportunity?</p>

### Breeders

Who to consult?	How?	How often?	How would you ask them?
<ul style="list-style-type: none"> <li>Acceptability from value chain actors perspective: <ul style="list-style-type: none"> <li>Producers</li> <li>Processors</li> <li>Traders</li> <li>Consumers</li> </ul> </li> <li>Where is the target group?</li> <li>Trade-off among traits: <ul style="list-style-type: none"> <li>Willingness to pay</li> <li>Productivity versus taste</li> <li>Time for maturing v. productivity or taste</li> </ul> </li> <li>How will the new variety benefit young women?</li> </ul>	<p>Diagnosis</p> <ul style="list-style-type: none"> <li>Rapid value chain assessment</li> <li>Social geography (market size) to analyze sector or territory</li> <li>Population of young women yam pounders</li> </ul> <p>Implementations</p> <ul style="list-style-type: none"> <li>Participatory trials and varietal evaluations</li> <li>Panels of consumers, taste testing</li> <li>Perishability</li> </ul>	<p>Initial diagnostic</p> <p>Baseline information</p> <p>Seasonal consultation with improved materials: value chain actors (producers, processors)</p>	<p>What is the product, what is the demand? Why purple? What is the market size?</p> <p>What purple varieties are being used and their constraints and characteristics?</p> <p>What are the socioeconomic characteristics of the value chain actors, especially the target group? Where are the young women along the value chain?</p>

## GROUP EXERCISE 2: TASTE TEST

### Consumer testing of different varieties of sweet potatoes

From left to right: E, D, C, B, A



Words used to describe **"Most Liked"** variety, sized by number of occurrences



Words used to describe **"Least Liked"** variety, sized by number of occurrences



Sweet Potatoe	Average Overall acceptability	Groups	
A	4,0	A	
D	3,7	A	B
B	3,6	A	B
C	3,4	A	B
E	3,3		B

Sweet Potatoe	Average Appearance	Groupes	
B	4,1	A	
E	3,6	A	B
A	3,6	A	B
D	3,4		B
C	3,1		B

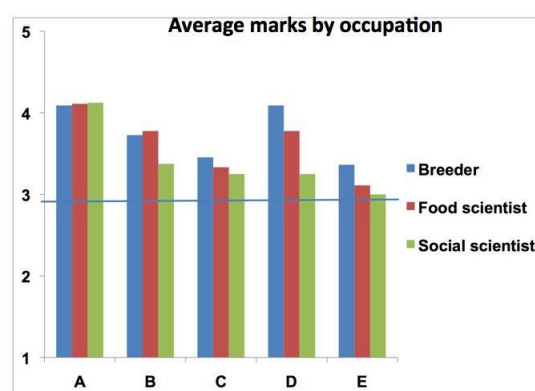
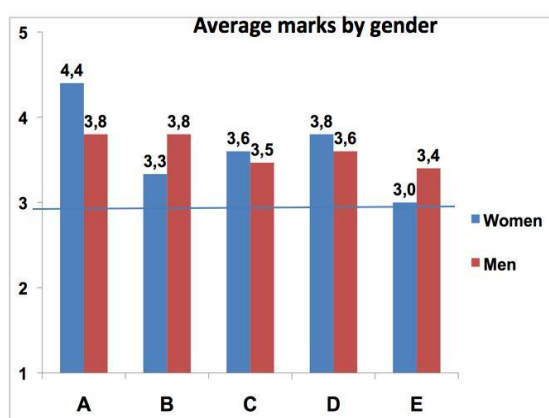
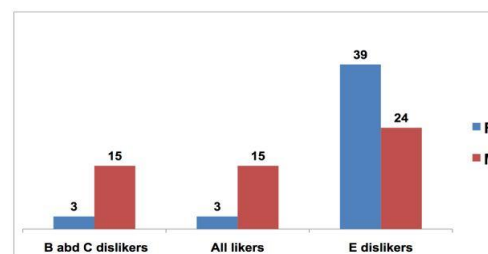
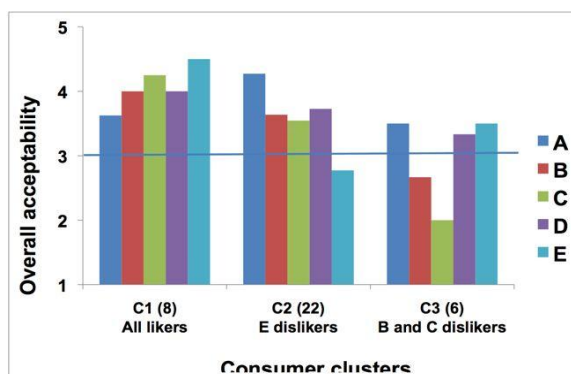


## INTEGRATING END USER PREFERENCES IN RTB BREEDING PROGRAMS

Sweet Potatoe	Average Smell	Groups
A	3,7	A
C	3,6	A
D	3,5	A
B	3,5	A
E	3,5	A

Sweet Potatoe	Average Taste	Groups
A	4,2	A
D	3,9	A
B	3,6	B
C	3,6	B
E	3,3	B

Sweet Potatoe	Average Texture	Groups
A	4,0	A
C	3,7	A
D	3,7	A
E	3,4	A
B	3,1	B



### GROUP EXERCISE 3: BUMBLEBEES AND BUTTERFLIES - PRESENTATIONS

Session	Presenter	Organization	Title
A1	Joyce Haleegoah	CRI Ghana	Changes in local foods, end users perspective
A2	Robert Mwanga	CIP - Uganda	Participatory breeding complementary to successful sweet potato breeding
A3	Chiedozie Egesi	NRCRI, Nigeria	End user perspective for cassava breeding
A4	Eva Weltzien	ICRISAT	What is yield? End users perspectives for sorghum in West Africa
B1	Bolanle Otegbayo	Bowen University, Nigeria	Food textural quality indicators in pounded yam
B2	Hans van Doorn	HZPC, Netherlands	Consumer preference trait definition in potato
B3	Luis Augusto Becerra	CIAT, Colombia	Sensory Analysis, Consumer Preferences and Genetic Evaluation can change RTB Crop improvement programs
B4	Thomas Zum Felde	CIP, Peru	High-throughput phenotyping of quality traits in sweet potato and potato; which traits could be added to address consumer preferences?

## ANNEX 4. LIST OF COMMITMENTS FROM PARTICIPANTS TO ACHIEVE END USER CENTERED BREEDING PROGRAMS

- Framework on how to make consumer preferences data ready to translate for use by breeders – Thierry Tran
- Integrate discussion on end user profiling quality traits into annual sweet potato breeders meeting in June 2015 – Jan Low
- Evaluation of Pectin diversity in cassava in relation with texture change during cooking – Dominique Dufour
- Workshop on gender responsive end user profiling: tools and methods for profiling and prioritization with NEXTGEN – Cassava – Jacqui Ashby – CGIAR gender network
- As Theme 2 leader, I will implement an end user priority testing of LAC with food technologist in CIRAD and NRI – Augusto Becerra
- I will be available to follow-up on the exchange of information for HT phenotyping – Hans Van Doorn
- Report on/share the identified opportunities and private sector engagement needs with management in project review and visit report – Yolande Codo
- Review relevance of RTB cassava processing project to broader consumer preferences research to target consumers, especially sensory analysis standard methods – Clair Hershey
- Contribute to design of cassava variety adoption study in Nigeria that improves gender responsive profiling – Peter Kulakow
- Identify consumer and processor traits (local knowledge) and have them translated to physical scientist terms and phenotyping – A (?)
- To request the breeding program in sweet potato in Ghana to include food technologists and nutritionists to help in selection of roots/leaves with desirable traits for end users – Francis Kweku Amagloh
- Collaborate with breeders on identification of quality indicators in specific food products – Olegbayo Bolanle
- A follow-up discussion on concrete way forward with the food scientist, social scientist and key players that I will need for breeding for end users – Elisabeth Parkes
- Share the knowledge on the importance of including end users in breeding programs to the Institute – CSIR – CRI – Joyce Haleegoah
- I am going to have a meeting with Meredith Bonierbale and Asral Amele working on potato breeding to discuss a collaboration focusing on gender and PVS in Ethiopia. We will adopt and adapt some methods suggested in this meeting for use in Ethiopia on end user profiling and adoption - Netsayi Mudege
- Literature research on user preference related to physiochemical phenotyping. Thinking about strategies to implement next generation phenotyping— Felde Genevieve
- Profile fufu consumer traits in the South-East of Nigeria – Ugo Chijioke
- Outline publication of sorghum grain quality preferences in West Africa – Eva Weltzien
- Share my experience with my colleagues – scientists are not always aware of end-users preferences and gender – Laurence Ducreux
- Think of few but critical quality phenotypic traits that breeders should be breeding for and what high throughput tool could be offered – Roberto Javier Pena
- Include a discussion on end user profiling on the sweet potato breeders annual meeting agenda in June 2015 – Roberto Mwanga
- Design end user preference assessment instruments jointly with breeders and food scientists – Alene Arega

- Stay involved in any follow-up to this workshop – Tahirou Abdoulaye
- Contribute to new gender awareness – enhanced of PVS protocol – Merideth Bonierbale
- Contribute to value chain perspective in understanding the breeding needs?
- Involve end users in the evaluation process using interactive approach
- In BMGF banana breeding project, link up social scientists for baseline studies and with food technologists for sensory evaluation
- I will share the learning I got here and I am committed to get more involved in NEXTGEN cassava in my expertise (Plant physiology)
- Interact more with other colleagues such as breeders, economists and gender specialists
- Need to develop inter-countries studies to highlight real and pertinent criteria for end users
- Case studies to understand the needs and preferences of men and women RTB value chain actors with regards to PH traits of crops
- Contribute to better capture the importance of end-users preferences for varietal development in the RTB flagship post-harvest