Creating Food Product Quality Traits in the Crop Ontology for Roots, Tubers and Bananas

Internship Report

September 2020-February 2021

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Content

Objective of the internship

The 6-month internship took place from September 2020 to February 2021. The internship was supported by the CGIAR Roots Tubers and Bananas Research Programme, at the Alliance of Bioversity-CIAT, under the supervision of Elizabeth Arnaud and in collaboration with Pricilla Marimo. The objectives of the internship were:

- To compile existing protocols, surveys and gray literature from the RTBFoods research community.
- To test the use of the Crop Ontology Trait Dictionary Template (http://www.cropontology.org/TD_template_v5.xls) to extract quality traits by crop and testing a format for sensory traits on processed products, for hedonic scales and lexicons used by trained panels.
- To collaborate with the team at Boyce Thompson Institute, US, to test the format and data sets in the databases
- To compile the processing techniques per food product.

Introduction

The RTB Breeding Community of Practice of the CGIAR Roots, Tubers and Bananas Research Programme (RTB) develops crop breeding product profiles that must integrate traits preferred by diverse social groups or market segments with a gender parameter among others. As part of this community, the RTBFoods project 'Breeding Roots, Tubers and Banana products for end user preferences'[1], led by CIRAD, France, focuses on Africa (Figure 1) aims at providing data sets and information required by breeders to understand the preferences of end-users in each market segment for food product qualities and make them storable into the breeding databases called Breedbases. To this end, the connection of the breeding product profiles to the food product profiles per region is desirable. Therefore, ontologies that compile RTB food quality traits with their definitions, methods of measurements and scales, will ensure the harmonization of the assessments or measurements of products properties and support data interpretation across social

[1] https://rtbfoods.cirad.fr/fr

groups and provide interoperability in the Breedbases. By providing descriptions of agronomic, morphological, physiological, quality, and stress traits along with a standard for composing the variables, the Crop Ontology enables digital capture and aggregation of crop trait data (Shrestha et al., 2012). The Crop Ontology is integrated into the RTB Breedbases.

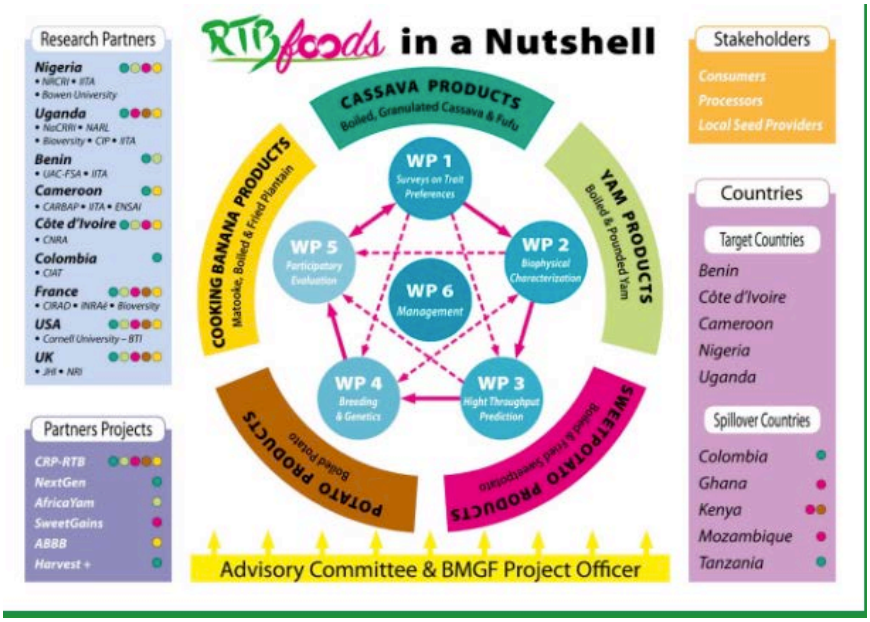

Figure 1: RTBFoods in a Nutshell (source RTBFoods web site, 2020)

The internship focused on the results of two workpackage activities under RTBFoods:

- Workpackage 1 that looks at socioeconomic aspects and identifies the criteria that determine whether a variety is adopted or rejected. Aspects linked to gender (role of women and children in decision-making) is closely looked at. Only Activity 4 reports about local processors preferences and processing techniques were used during the internship.
- Workpackage 2 that establishes the link between the above user's criteria and the biophysical properties of different varieties: how do people's preferences (texture, consistency, taste...) relate to biophysical data (starch and fiber content...)

RTBFoods research included several food products but only a few were focused on during the internship (Table 1) Food products that were not included did not have validated reports at the time of the internship

Food Products	Country	to be covered in 2021 & 2022	Existing but requiring validation	Developed by the first internship & validated
Boiled Cassava	Uganda			√
Boiled Plantain	Cameroon, Nigeria	√		
Boiled Potato	Uganda	√		
Boiled Sweet potato	Uganda		√	
Boiled Yam	Benin, Cote d'Ivoire, France		√	
Fried Sweet potato	Nigeria, Ghana, Cote d'Ivoire	√		
Fried Plantain	Cameroon	√		
Attieke (Cassava)	Cote d'Ivoire	√		
Eba	Nigeria,	√		
Cassava Fufu	Nigeria, Cameroon	√		
Gari	Nigeria	√		
Pounded Yam	Nigeria	√		
Matooke	Uganda	√		

Table 1: Food products under the RTBFoods research

A trait of a food product can be: (a) observed through surveys and free listing of preferences, (b) assessed through food tests using hedonic scales or (c) measured by trained sensory panels using a lexicon of defined attributes and categorical scales. The trait is observed, assessed or measured on an entity that. For agronomic traits, this will be a part of the plant whilst for sensory traits, this will be a part of the raw or processed food product. These elements must be properly captured to

describe data produced by food scientists. The properties or qualities of the processed products needs to be harmonized across studies using an ontology.

Figure 1 proposes a representation of the full research context to capture preferred traits for developing a breeding product profile and introduces the concept of 'observer' or 'informant' that is a person providing its preference on the traits of a variety or a food product or assessing the trait quality during a sensory trial. An ontology is needed that integrates the properties and of sensory lexicon aside the hedonic scales, as well as an ontology of the processing techniques with the variables. Therefore, it is necessary to develop an ontology for describing the person providing the information or measurement as the way the trait is expressed depends on the observer characteristics (e.g. geolocation, social segment, role in the value chain, etc.).

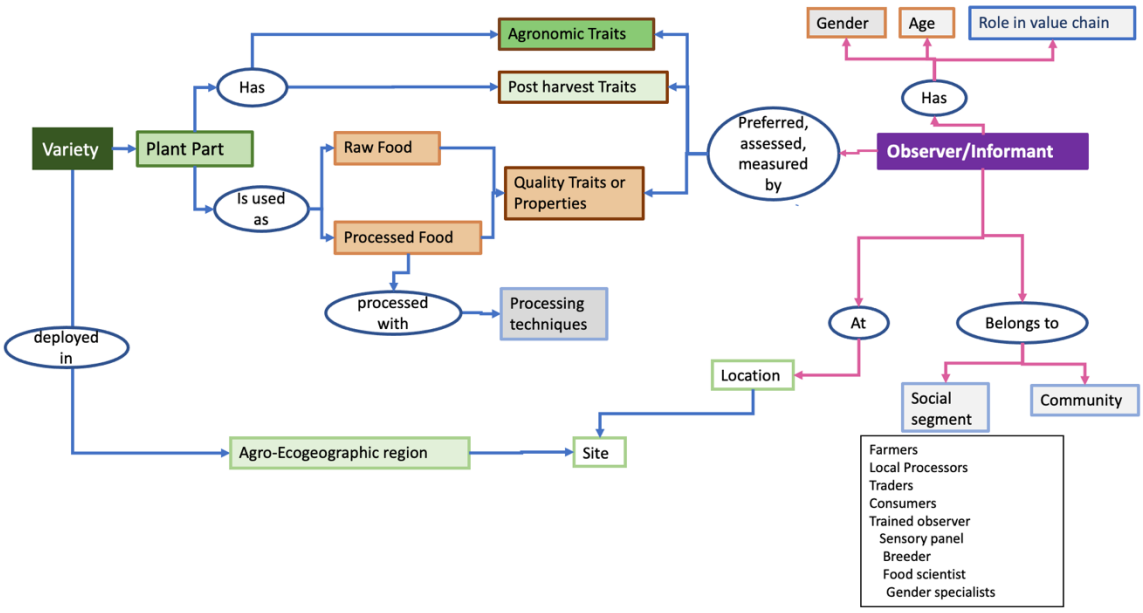

Figure 2: Organization of the elements needed to describe the trait preferences, assessment and measure on a variety and on food products by diverse social segments. Proposed by E. Arnaud.

Figure 3 provides an example of a data set collected by NARL during a sensory panel on matooke. The columns headers indicate the attributes that were observed but there is not information about the method and scale used, and the meaning of abbreviations. This prevents the full understanding

of the datasets once published and its reuse by breeders in Breedbase.

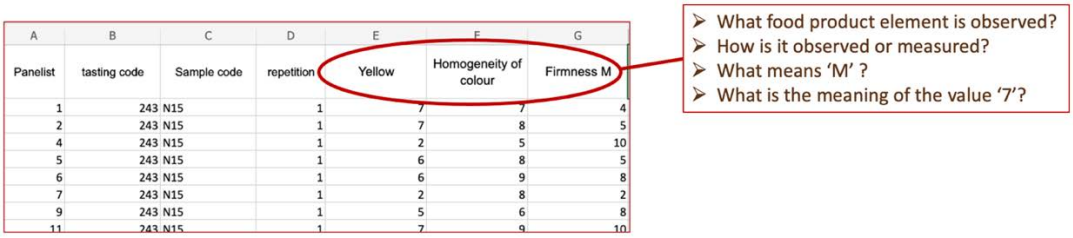

Figure 3: Type of data collected by NARL during a trained sensory panel on matooke, using the lexicon.

Methodology

Method used to extract quality traits and variables

For consistently extracting the elements composing the variable measured or observed on the food product, we used the Crop Ontology Trait Dictionaries Template, available in the Crop Ontology web site (www.cropontology.org), which provides a format for trait description and a nomenclature for variables.

User guidelines are provided in the web site to help with the use of the template and provide clear definitions of the traits and variables aside method types. Originally, this template was conceived with breeders to describe crop variety traits and variables for field measurement. Therefore, the template was modified and adapted to the measurements made on food products, raw or processed, and to those performed during processing.

A variable describes the actual measurement of the trait and its name is composed by a Trait, a Method and a Scale (Petraglia J. et al, 2020). In the Crop Ontology, one trait can be linked to several methods of measurement and scales thus enabling to store side by side the variables provided by different countries or projects, and by different social groups. This is important for storing sensory variables that can be different for the same food product because the method or the scale used in different countries.

Using the sensory lexicons in Standard Operating Procedures (SoPs) for trained sensory panels

The first activity was to extract sensory traits measured by trained panels to complement the Quality Trait class of the Crop Ontology with the objective of integrating it into Breedbase. The sensory traits, called properties and attributes, are compiled into a lexicon that is used as a standard by panel members. As defined by Suwonsuchon S. (2019), a lexicon is a set of standardized vocabularies developed by highly trained panelists for describing a wide array of sensory attributes present in a product.

We started with SoPs produced by Food scientists and validated by the QualiSud laboratory at CIRAD for matooke, boiled sweet potato, boiled cassava, boiled yam, fufu, eba and pounded yam. Each SoP includes a lexicon which is a table listing sensory traits to be measured along with their definitions, standard methods of measurement, and categorical scales of measurement (0-10). The lexicons were used to develop a sensory trait dictionary per food product. Sensory traits are qualities of a raw or processed food product.

Each element of the lexicon was mapped to the Trait Dictionary Template and columns were added or modified to include the food product as the main study object and accommodate the format of sensory traits (Figure 4).

The first food product template was developed for matooke, validated with Elizabeth Khakasa (NARL), and QualiSud. It was checked with a sample data set from NARL. We then applied the modified Trait Dictionary Template to the other validated SoPs: boiled cassava, boiled sweet potato, boiled yam, fufu, eba and pounded yam. The sweet potato lexicon was discussed with Mariam Nakitto (CIP), Jolien Swanckaert (CIP) and cassava with with Michael Kanaabi (NaCRRI).

Trait name (Attribute)	Trait class (Type)	Trait description
Matooke surface yellowness intensity	Appearence	Color of the surface of the sample from light yellow to bright yellow
Matooke homogeneity of surface colour	Appearence	Uniformity of color of the surface of the sample

Type	Attributes	Definition	How to measure?	Scale
Appearence	Yellow	Color of the surface of the sample from light yellow to bright yellow	When you receive the sample, observe the surface and evaluate the intensity of the color and its homogeneity	0: very light yellow 10:bright yellow
	Homogeneity of colour	Uniformity of color of the surface of the sample		0 : heterogeneous 10 : homogeneous

Method name (How to measure)	Method class	Method description	Formula
Appearance method	Sensory descriptive measurement	When you receive the sample, observe the surface and evaluate the intensity of the color	
Appearance method	Sensory descriptive measurement	When you receive the sample, observe the surface and evaluate the homogeneity	

Scale name	Scale class
yellowness scale 0-10	Ordinal
color homogeneity scale 0-10	Ordinal
firmness scale 0-10	Ordinal

Figure 4: Lexicon in the SoP that was used to make trait dictionary

Visit to NaCRRI Namulonge and NARL Kawanda research stations.

Amos Asiimwe visited the laboratories at Kawanda and Namulonge research stations for more interactions with food scientists, particularly with Elizabeth Khakasa (NARL) for matooke, Michael Kanaabi (NaCRRI) for cassava and Mariam Nakitto (CIP) for sweet potato. Discussions on how the SOPs were generated, explanations about the procedures for conducting trained panel sessions and clarification on some unclear traits and definitions were made. Also, during the visit to NARL, observations of trained panel sensory sessions were made. This provided in-depth understanding of the SOPs and eased the extraction of information for making the trait dictionaries.

Extracting concepts and variables for the food processing techniques

The qualities of a food product are linked not only to the variety used but also to the processing techniques. Currently, there is no ontology describing the processing techniques of the RTB food products, neither the types of variables measured which can hinder to the interpretation and comparability of the processing trials.

The Crop Ontology Trait Dictionary Template was again taken as a basis and modified to accommodate the description of the processing operating units and the format of the variables measured. We developed the dictionary starting with the first validated report of WP1-Activity 4

on boiled cassava in Uganda. The format of the template and the extraction of the variables were discussed with Alexandre Bouniol, CIRAD, work package 1 co-leader. This format was then used to compile TDs for the boiled sweet potato and boiled yam. It will be applied to the other food products once the reports are validated. Figure 5 shows an excerpt of the trait dictionary for the processing techniques of boiled cassava root.

Food product	Processing technique	Entity	Property	Definition	Method Type	Scale type	Scale /unit	Variable Label
Boiled cassava	Peeling	Raw cassava root	Total weight to peel	Total weight of the roots to be preocessed	Measurement		Kg/processor	Total raw roots weight in Kg
Boiled cassava	Peeling	Raw cassava root	Peeling time	Time taken to remove the skin (peel) of the cassava root	Measurement		min	Raw cassava peeling time in mn
Boiled cassava	Peeling	Raw cassava root	Peeling yield	Amount of the cassava root remaining after removal of the peel	Computation		% wet basis	Peeling yield
Boiled cassava	Peeling	Raw cassava root	Peeling Productivity	Quantity of raw cassava peeled by a processor per hour	Computation		kg/h/processor	Peeling productivity
Boiled cassava	Washing	Peeled cassava root	Washing time	Time taken to wash the peeled root	Measurement		min	Washing time
Boiled cassava	Washing	Peeled cassava root	Washing productivity	Quantity of peeled cassava washed by a processor per hour	Measurement		kg/h/processor	Peeled cassava washing time
Boiled cassava	Size reduction	Peeled cassava root	Trimming time	Time taken to slice a cassava root into chips	Measurement		min	Peeled cassava trimming time
Boiled cassava	Size reduction	Peeled cassava root	Slicing yield	Amount of the cassava root remaining after slicing of the peeled root				
Boiled cassava	Size reduction	Peeled cassava root	Slicing Productivity	Quantity of peeled root sliced by a processor per hour				
Boiled cassava		Peeled cassava root slice	Cooking ratio	Quantity of water introduced in the cook system for a quantity of peeled cassava slice				
Boiled cassava	Boiling	Peeled cassava root slice	Boiling time	Time for boiling cassava roots				
Boiled cassava	Boiling	Peeled cassava root slice	Boiling yield	Amount of the cassava root remaining after boiling of the root slices				
Boiled cassava	Boiling	Boiled cassava root slices	Boiling Productivity	Quantity of root slices boiled by a processor per hour				
Boiled cassava		Boiled sliced roots total weight	Weight of boiled slices	Quantity of boiled cassava slices after boiling				
Boiled cassava	Boiling	Boiled cassava root slices	Processing yield	Quantity of boiled cassava root slice obtained from a quantity of raw material				
Steamed cassava	Steaming	Steamed cassava root						
Steamed cassava	Steaming	Steamed cassava root						
Steamed cassava	Steaming	Steamed cassava root						

Figure 5: Trait dictionary for processing techniques of boiled cassava

Results

The Food Product Sensory Trait Dictionaries

The Trait Dictionaries for sensory traits of the following food products: matooke, boiled/steamed cassava, boiled sweet potato and boiled yam were generated and discussed with the Food scientists and the product lead persons. The systematic extraction of information into the Trait Dictionaries led to point out inconsistencies in the lexicons that were reported to the scientists. The copies of the trait dictionaries for all the food products mentioned above were uploaded on the CIRAD RTBFoods platform.

The original Trait Dictionary Template was modified so the column. ‘Growth Stage’ was replaced by ‘Food Product’ and a new context of use ‘Sensory panel’ was added (Figure 6). In the Trait

dictionary Template, the method must be allocated a 'Method type'[2]. Food scientists at QualiSud recommended to use the method type '*Measurement'* for results of a trained sensory panel and the class '*Estimation'* for hedonic sensory assessment.

We propose to name the new template the "Food product sensory Trait Dictionary".

F	G
Context of use	Product
Sensory panel	Matooke
Sensory panel	Matooke
Sensory panel	Matooke
Sensory panel	Matooke
Sensory panel	Matooke
Sensory panel	Matooke
Sensory panel	Matooke
Sensory panel	Matooke
Sensory panel	Matooke
Sensory panel	Matooke
Sensory panel	Matooke
Sensory panel	Matooke
Sensory panel	Matooke
Sensory panel	Matooke
Sensory panel	Matooke

Figure 6: Creation of the 'Product' column and the 'Sensory Panel' option on the context of use.

Matooke (Uganda) lexicon and Trait Dictionary

In the matooke lexicon, for the yellow colour of the surface and the homogeneity of the colour, there is only one 'how to measure' method description (see Figure 7). However, the two elements are separated attributes. Therefore, the method of measurement in the Trait Dictionary was separated to accommodate the two separate attributes better and then annotate precisely the measurement in the data file.

Lexicon

Type	Attributes	Definition	How to measure?	Scale
Appearence	Yellow	Color of the surface of the sample from light yellow to bright yellow	When you receive the sample, observe the surface and evaluate the intensity of the color and its homogeneity	0: very light yellow 10:bright yellow
	Homogeneity of colour	Uniformity of color of the surface of the sample		0 : heterogeneous 10 : homogeneous

Trait Dictionary

[2] List of Method types available in the Crop Ontology Guidelines

Attribute	Method description
Surface Yellowness intensity	When you receive the sample, observe the surface and evaluate the intensity of the color
Surface color homogeneity	When you receive the sample, observe the surface and evaluate the homogeneity

Figure 7: A single method combining two state of an attribute in the lexicon and its separation in the TD

The trait synonym column contains the abbreviation used in the data file of NARL (Figure 8)

Trait class (Type)	Trait synonyms
Appearence	Yellow V
Appearence	Homogeneity of colour V
Texture in mouth	Firmness M
Texture in mouth	Moisture M
Texture in mouth	Smoothness M

Figure 8: Trait synonyms are abbreviations used on the data file

In the end, we created the variable name following the nomenclature recommended by the Crop Ontology (Figure 9). This abbreviated variable name will be used to describe the column headers of the data file:

Variable name	Variable synonyms
Matooke yellowness measurement scale 0-10	MatYell_Meas_1to10
Matooke homogeneity of colour measurement scal	MatHomCol_Meas_1to10

Figure 9: Example of variable names and synonyms

Boiled sweet potato (Uganda) lexicon and Trait Dictionary

In the boiled sweet potato lexicon from Uganda, the method of measurement for smoothness and fibrousness was the same yet these are different characteristics. After discussions with Mariam Nakitto, this was rectified and different methods of measurement for the attributes were given. We noticed that the attributes of aroma and taste were duplicated in the lexicon table.

Boiled cassava (Uganda) lexicon and Trait Dictionary

In this lexicon, there was ambiguity in the way the aromas were presented for example ‘pumpkin’, ‘yam’, and ‘roasted cassava’ aromas. These were modified to read ‘pumpkin-like’, ‘yam-like’, and ‘roasted cassava-like’ aromas.

The attribute '*kiwuta*' in '*Texture in mouth*' type of the boiled cassava lexicon, scored using a presence / absence scale, appears to be a combination of several attributes of a different nature (see Figure 10). The best practice is that an attribute must be a single element with a clear definition and an 'how to measure method' that rely on a categorical scale so the panelist can measure it. Elizabeth Khakasa explained that '*kiwuta*' attribute is the consequence of pre-harvesting conditions, like too late harvesting, and is not directly due to the variety quality or to the processing, this attribute is not currently included in the dictionary.

Kiwuta	Characterised by any of the following: "*oozes upon squeezing*" "*crunchy like raw carrot*" "*remains raw after cooking*" "*glassy appearance*" "*tasteless*", "*sweeter than original*" and usually have off-flavour	Put a part of boiled sample into the mouth, chew it and after 5 chews, evaluate between tongue and palate the presence of the given characteristics	YES/NO

Figure 10: 'Kiwuta' attribute combined in fact several attributes and is linked to pre-harvest conditions.

Boiled yam (Benin) lexicon and Trait Dictionary

The boiled yam SoP produced by Université des Sciences d'Abomey Calvi (FSA-UAC), Bénin was validated by QualiSud. However, the trait dictionary was started on before the validation was done. Several issues were raised from the lexicon:

Type	Attributes	Definition	How to measure?	Scale (mm)
Colour / appearance	**White colour**	Both inner and outer colour can range from light yellowish (off-white) to white (pure white)	Observe the surface of product and evaluate the intensity of each type of the colour and its homogeneity	0 : Off-white 100: Pure White
	Brown colour	Brown colour of product after cooking		0 : No brown 100 : Brown
	Purple colour	A purple colour drawing on the pink		0 : No purple 100 : Purple

Figure 11: Excerpt of the boiled yam lexicon

- Scales for all attributes are 0-100 so we thought that this was an error as lexicons usually have scales 0-10. Explanation was sought from QualiSud and the scale 0-100 was validated.

- The attribute *'White colour'* indicates to look at both inner and outer colours but for the two other attributes in this type, there is no indication if the panelist should still look at both or only oner. Clarification would be needed here (Figure 11).
- The definition of the '*purple colour'* which is '*purple drawing on the pink'* it not clear and is not reflected in the scale. After clarification by the Food scientist, we decided to phrase the definition as follows: '*A purple colour tending to pink after cooking'*.
- The attribute '*Hard to break/cut*' is unclear. The use of the 2 terms separated by slash is confusing as we think that the definition of each term is different: '*break'* could mean broken by hands for example, while "*cut*" could be with a fork or a knife. However, scientists did not wish to change the definition.

Fufu (Nigeria) lexicon and Trait Dictionary

Validated Fufu SoP was used to construct a trait dictionary. Examples of some issues we found in the lexicon were: the method of measurement and definition for aroma was not indicated, and ambiguity in the scale for appearance (Figure 12). Audience with the lead person for the fufu SoP has been sought to clarify this issue and feedback is yet to be given.

Type	Attributes	Definition/Description	Measurement method	Scale
Visual aspect (Colour)	**White**	Colour of cooked fufu being As white as a flip chart paper	**Visually inspect sample surface**	1: white 2: Off-white 3: Grey 4: Light grey 5: light Cream 6: Light yellow
	Off-white	As off-white as soy milk colour		
	Grey	As grey as skin of sardine fish		
Aroma	**Fufu odour**			0: No fufu odour 5: Mild fufu odour 10:Strong fufuodur

Figure 12: Extract of the fufu lexicon

Eba (Nigeria) lexicon and Trait Dictionary

A trait dictionary for eba was constructed and several issues were cited in the lexicon for eba for example: the attribute 'Smoothness' in the lexicon falls under the property 'Taste'. This attribute

should have fallen under 'texture in mouth' (Figure 13). Audience with the lead person for eba SoP has been sought to clarify this issue and feedback is yet to be given.

Taste	Sweet	Basic taste produced by solutions of various substances such as sucrose	Take a small piece of sample, chew slowly and take a whiff to score the intensity of basic tastes you observe	0: slightly sweet 5 : sweet 10: very sweet
	Sourness	gustatory complex sensation, generally due to presence of organic acids	Put a part of the sample in the mouth and evaluate the intensity of the sourness	0: slightly sour 5: sour 10: very sour

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	Smoothness	Geometrical attribute associated with the overall degree of absence of particles within sample	After chewing feel sample between tongue and palate to assess the amount of string like particles present on sample	0: fine 5: moderately coarse 10: coarse

Figure 13: Extract of the eba lexicon

Pounded yam (Nigeria) lexicon and Trait Dictionary

A trait dictionary for pounded yam was constructed and several issues were cited in the lexicon for pounded yam for example: A combined scale for different colours and ambiguity in the description of colours (Figure 14). Audience with the lead person for eba SoP has been sought to clarify this issue and feedback is yet to be given.

Type	Attributes	Definition	How to measure?	Scale
Visual aspect	Colour white	The degree of whiteness of the pounded yam sample like a plain white paper or white flip chart/colour of boiled egg albumen.	Visually inspect sample surface	1: white 2 : Off- white 3 : Grey 4 : Light grey 5 : Cream 6 : Light yellow 7 : Yellow 8 : Light brown 9 : Brown
	Colour off-white	Colour of the pounded yam comparable to that of Soymilk or "Eba" from white "Gaari"	Visually inspect sample surface	
	Colour grey	Colour of Pounded yam comparable to that of greyness covering a boiled egg yolk	Visually inspect sample surface	
	Colour light grey	Colour of pounded yam	Visually inspect sample surface	
	Colour cream	Colour of Pounded yam comparable to that of evaporated liquid milk such as Peak milk	Visually inspect sample surface	
	Colour light yellow	Colour of pounded yam comparable to boiled egg yolk that is light in colour	Visually inspect sample surface	
	Colour yellow	Colour of Pounded yam comparable to deep colour of Yellow maize	Visually inspect sample surface	
	Colour light brown	Colour of Pounded yam comparable to the colour whole wheat meal	Visually inspect sample surface	
	Colour brown	Colour of Pounded yam comparable to the colour of carton paper	Visually inspect sample surface	

Figure 14: Extract of the pounded yam lexicon

Processing techniques of food products

The second part of the internship looked at processing techniques of different food products using validated reports from workpackage 1. The objective of developing the ontology is to harmonize the way data are collected and described in the database. The Trait Dictionary template was adapted to the Food processing techniques starting with boiled cassava in Uganda. The extraction was complicated as we had to start from the report and not from a lexicon. The reports are produced by food product and by country. Reports includes both boiled and steamed products according to

the region. Operating unit name simplified and listed as peeling, boiling, the data will be geolocated in the database as preferences and processes are different per region but not the operating units' names.

The template records the processing step name, the definition, the method used to measure or observe (e.g. time for boiling taken from when the pan is put on fire with cold water, or when the water starts boiling), and the measurement unit used (mns, hour, % etc)

In the report, the processors' preferences are classified by 'good qualities' and 'bad qualities' with their citation frequency. This information was extracted in a separate sheet of the Trait Dictionary, for future mapping with the ontology. The schema in the report showing the processing operating units and the summary tables were of great help (Figure 15).

Appendix 1. Summary table of quantitative data

Varieties/Location	Processing quantitative data								
	Peeling unit operation						Boiling unit operation		
	Peeling time (min)	Yield (%)	Productivity (kg/h/op)	Trimming time (min)	Yield (%)	Productivity (kg/h/op)	Boiling time (min)	Yield (%)	Productivity (kg/h/op)
APAC									
Bao	2.0	74.0	45.3	2.0	62.3	41.9	50.2	58.8	1.3
AlanyoDyer	2.5	67.6	35.2	2.5	53.6	25.5	48.2	48.9	1.2
NASE 14	2.3	76.2	50.8	2.3	66.9	45.5	50.2	64.0	1.5
NAROCASS 1	2.7	73.6	31.9	2.7	62.7	31.6	57.3	57.2	1.3
TME 14	1.2	70.7	65.8	1.2	58.3	73.2	58.4	53.6	1.1
LUWEERO									
Bwanjule	4.7	72.1	35.5	4.7	62.5	29.8	49.9	57.4	1.2
NASE 13	3.5	58.0	33.5	3.5	42.9	24.2	56.7	38.7	0.6
NASE 14	6.1	68.0	26.1	6.1	59.9	22.8	61.8	45.8	0.7
Nabwangu	3.4	67.1	51.3	3.4	51.1	36.2	49.6	51.3	1.0

Figure 15: Summary table of quantitative data in the report for boiled cassava food techniques in Uganda used for extracting the variables

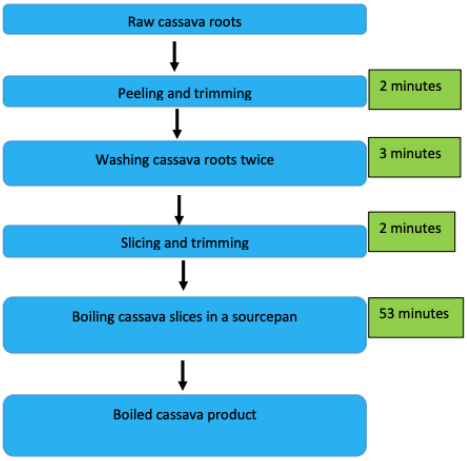


Figure 2. Schematic flow of preparing boiled cassava in Apac, northern Uganda

Figure 16: Schema about operating steps for boiled cassava in Uganda used to extract the processing techniques.

The first dictionary was produced testing a format (Figure 17) The column 'Food Product' was added like for the sensory traits' TD as well as a 'Processing techniques' column to store the processing units (e.g. peeling; washing, boiling, etc).

The 'Entity' is the piece of food product on which the processing unit is done for example, Entity is '*Raw root*' for the '*Peeling*' unit and Entity is '*Peeled raw root*' for the '*Slicing*' unit.

Food product	Processing technique	Entity	Property	Definition
Boiled cassava	Peeling	Raw root	Total weight to peel	Total weight of the roots to be preocessed
Boiled cassava	Peeling	Raw root	Peeling time	Time taken to remove the skin (peel) of the cassava root
Boiled cassava	Peeling	Raw root	Peeling yield	Amount of the cassava root remaining after removal of the peel

Method
Weight all the raw roots before peeling
Start timing with a stop clock as soon as the processor starts peeling
Weigh the raw root before and after peeling and calculate the yield as the percentage of the root remaining aft
results is expressed on the wet basis (doesn't take into account the dry matter content of the product)

Variable Label
Total raw roots weight in Kg
Raw cassava peeling time in mn
Peeling yield

Figure 17: Excerpt of the resulting Food Processing Techniques Dictionary

The format of the excel Template has been validated by Alexandre Bouniol and was applied to boiled yam (Benin) and boiled sweet potato (Uganda). We had an exchange about some of the variables. For example, 'Peeling time' which is the necessary time for the processor to peel all the raw roots. We proposed to add a new variable for 'raw roots total weight to be peeled' that will permit the calculation of the peeling productivity.

Trait Dictionaries attribution, documentation and availability

In the TD, each trait is attributed to a scientist (the lead food scientist for the SoP) with the affiliation. The SoP name and version is indicated in the "xref" column. This is important to (a) identify the author and the source document of the concepts and increase trust for reusing it in other projects, (b) to provide the geographical origin of the SoPs.

A 'Readme' file that explains the content of the Template's columns was added to each TD as well as a color code to differentiate the trait, the method, the scale and the variable, following the model of the Crop Ontology Template. The final versions of the TDs uploaded in the RTBFoods project platform which is in restricted access but will be open when it is validated.

Integration of the Food Products' Trait Dictionaries into Crop Ontology

A test of integrating the sensory traits under the 'Quality traits' class in the Crop Ontology for matooke was performed by Marie-Angélique Laporte (Figure 18) and discussed with the QualiSud Food scientists. The TD format adapted to sensory traits works rather well for the connection of the trait, method and scales, as well as for the definitions. Modifications should be done to better adjust to the scientists' feedback: for example, we were asked to provide an access by the Method: measurement (trained panel) or assessment (hedonic). RTBFoods scientists also should provide us with better names for the SoP files as well as a DOI or URL. We are concluding that a new section in Crop Ontology for Food Products is needed.

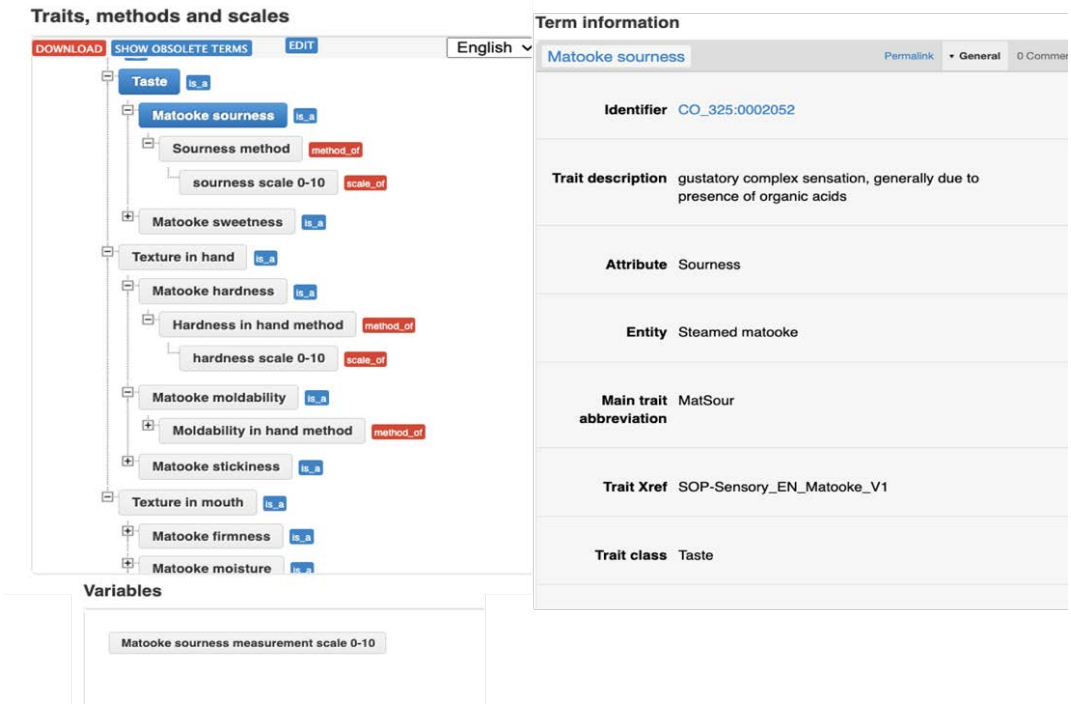


Figure 18: Display of the matooke sensory traits, method, scales and definitions for trained panel in the 'Quality Trait' class of the Crop Ontology for Banana

Feasibility of Integrating a Food Product Ontology and Data Sets in Breedbase

Two virtual meetings were held with the team at Boyce Thompson Institute to identify options to integrate the Food Product Ontology and Sensory Panels' data sets. A discussion with Afolabi Agbona, IITA and Cassavabase manager, allowed to clarify some of our questions about the database and possible linkages of the sensory data with the germplasm and the field trials.

RTBFoods project did not plan for a food scientist preparing a sensory panel with selected samples to directly use Breedbase to create the panel lab book. The primary objective is to make the data collected available to breeders for their germplasm in Breedbase. Breeders should be able to call for the sensory profile of a variety in a given country for example.

We have access to the test versions of Musabase and Cassavabase. There is an important learning curve for a newcomer, not being a breeder, to use Breedbase. First light tests to create a sensory panel using the Trial creation process showed that it is possible to link results of a sensory panel to field trials and to accessions but the process is currently not satisfactory: the forms to fill in do not correspond to the elements of a sensory panel data set. The lack of full users' rights to create

new list of accessions blocked the test at the early stages. After solving the problem, we resumed the tests late January 2021.

An Agreed Format of the Data sets is needed

To check the validity of the TD and the Crop Ontology format, we needed to assess how data are recorded i.e. the format, variable names, and values. We received from NARL, a data set for matooke and one for boiled cassava. The format and information provided in the two data sets are different so agreement about a valid format is needed. The matooke data set only provides the name of the germplasm tested while the cassava data set indicates also the field location of the material tested (Table 2).

Plot-name
Plot_ID
Accession Name
Plot-number
Block_Number
Rep_number

Table 2: Information recorded in the data set of a sensory panel for boiled cassava data set provided by Paula Iragaba, NaCRRI)

These fields will enable linking the results of the sensory panels to the plant in the field and therefore to the field trials in Breedbase. Figure 19 shows that the field trial named 'YUT_White_Namulonge' is recorded in Breedbase which mean that the varieties used for the boiled cassava sensory panel held in Uganda August 2020 are recorded and the sensory test data can potentially be attached. The file about Matooke should include similar information.

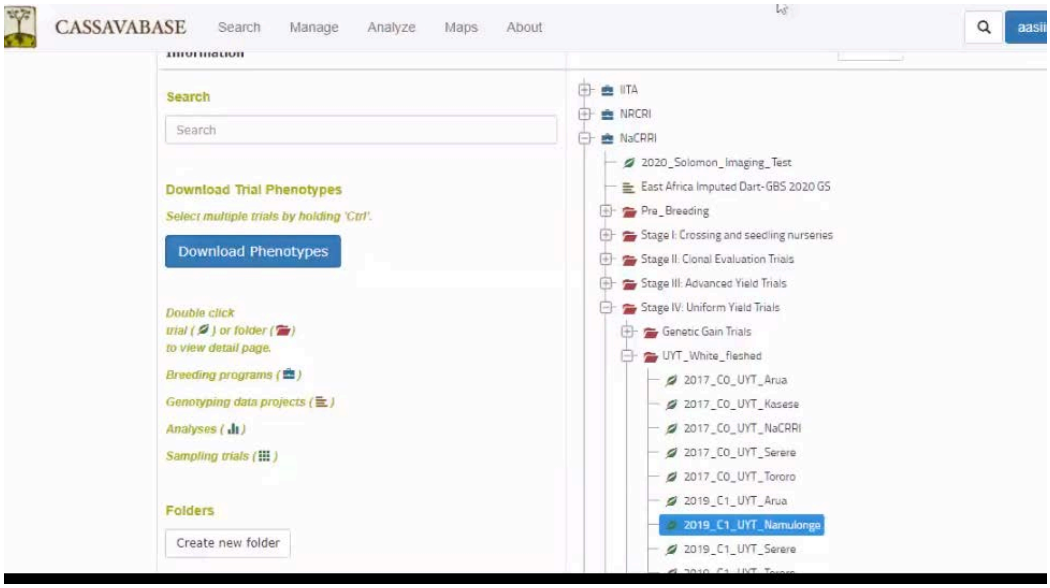
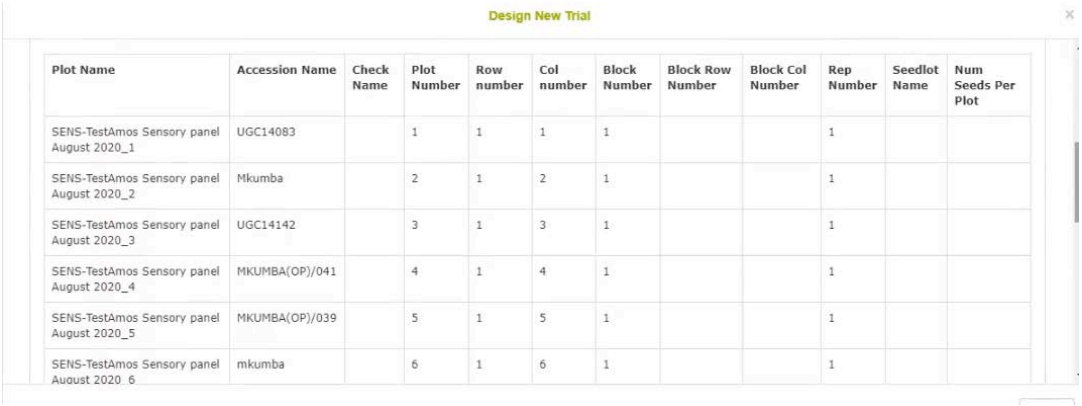


Figure 19: The field trial 'YUT_White_Namulonge' from which the cassava roots were selected for a sensory panel in August 2020 is recorded in Cassavabase



Plot Name	Accession Name	Check Name	Plot Number	Row number	Col number	Block Number	Block Row Number	Block Col Number	Rep Number	Seedlot Name	Num Seeds Per Plot
SENS-TestAmos Sensory panel August 2020_1	UGC14083		1	1	1	1			1		
SENS-TestAmos Sensory panel August 2020_2	Mkumba		2	1	2	1			1		
SENS-TestAmos Sensory panel August 2020_3	UGC14142		3	1	3	1			1		
SENS-TestAmos Sensory panel August 2020_4	MKUMBA(OP)/041		4	1	4	1			1		
SENS-TestAmos Sensory panel August 2020_5	MKUMBA(OP)/039		5	1	5	1			1		
SENS-TestAmos Sensory panel August 2020_6	mkumba		6	1	6	1			1		

Figure 20: Example of accessions from the selected for the field trial 'UYT_White_Namulonge' for the sensory panel on boiled cassava August 2020

We need to further test Breedbase but obviously the data entry forms (Figure 21) need to be adapted to the sensory panel data (e.g. panel size, members, randomization of samples, repetition, etc.) and the sensory variable should be made available.

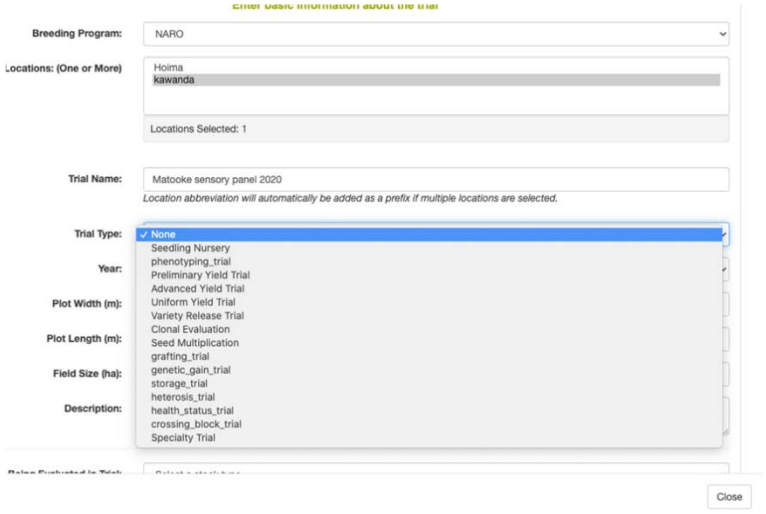


Figure 21: Example of an entry form for Field trials

Integrating the Ontology for Food Products and Data into Breedbase

The column headers of the data files for food product attributes can easily be annotated with the recently developed sensory trait ontology.

The Ontology team will have to define in 2021 with BTI how these pieces of ontologies can be added in the current ontology display in Breedbase (Figure 22). There is a 'TREAT' ontology for 'treatments 'that enables to indicate if the product was boiled, steamed or fried. However, a specific concept selection window will be needed to display the method, definition and scale.

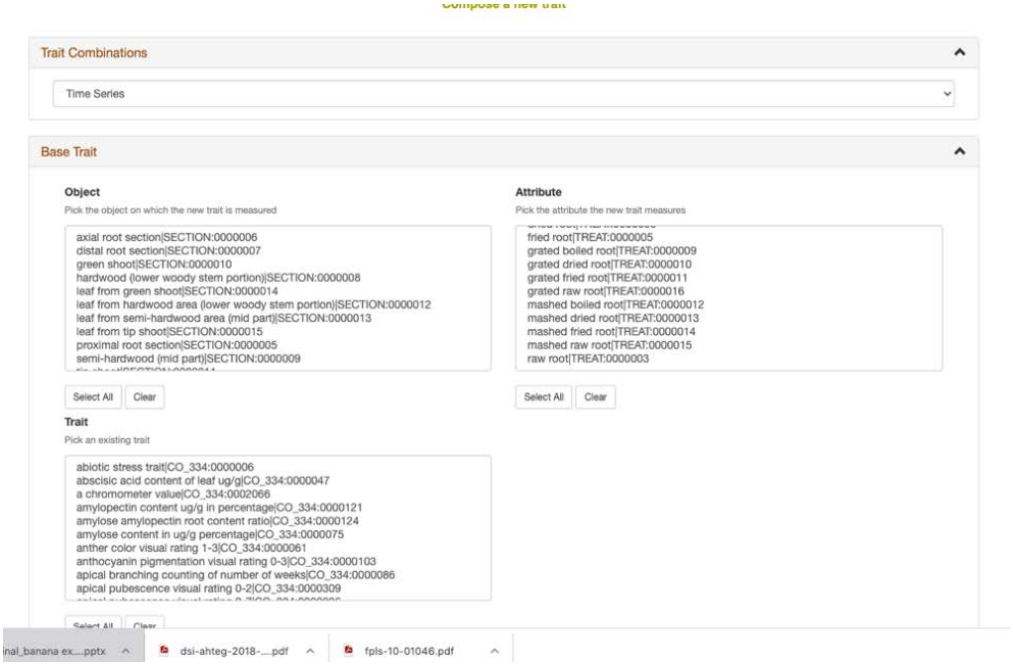


Figure 22: Currently ontology display in Breedbase for creating a variable

Creation of Crop and Food Products Ontology Expert Groups

Multidisciplinary expert groups are required in order to validate the TDs content and new addition, provide valid sources for getting the terms and their definitions.

Banana Ontology Expert Group

Pricilla Marimo, Alliance Bioversity-CIAT, invited following colleagues to join the Banana Ontology Expert Group:

- Kephas Nowakunda (NARL)
- Brigitte Uwimana (IITA)
- Kenneth Akankwasa (NARL)
- Samuel Edgar Tinyiro (NARL)
- Moses Matovu (NARL)
- Moreen Asasira (NARL)
- Nelson Willy Kisenyi (Alliance Bioversity-CIAT)
- Priver Bwesigye (NARL)
- Ivan Arinaitwe (NARL)

The banana 'expert group' is composed by breeders, social scientists, gender researchers and food scientists from Bioversity, NARL and IITA and will validate and curate banana specific traits that will be incorporated in the banana ontology. An inaugural meeting with the group took place in December 2020. The plan is for the group to continue meeting regularly. Part of work will focus on creating user defined and inclusive ontologies based on preferences from the different value chain actors – this will be co-financed by funds from the CG Gender Platform and CRP RTB.

Sweet Potato and Potato Ontology Expert Group

Hannele Lindqvist-Kreuze, CIP, nominated the following CIP colleagues

- Jolien Swanckaert for sweetpotato
- Thiago Mendes for potato.
- Moctar Kante for molecular markers related ontology.
- Bert de Boeck, lead statistician, and data management coordinator for CIP breeding,

Presentation of progress at an RTBFoods webinar

A presentation entitled '*Development of RTB Food Products' Quality Trait Dictionaries for storage in Breedbases'* was made on 12 Feb 2021 by Asiimwe Amos in RTBFoods webinar organised by Eglantine and attended by 30 participants. The recording of the presentation can be accessed on the link; https://www.youtube.com/watch?v=qeZtNYVzcgE

Future steps

Trait Dictionaries will be uploaded in the Crop Ontology and we will prospect the development of a specific Food Product section. Further discussions with BTI will occur to make sure that the new ontologies are harmonized in the databases, including ClimMob, and are useful for the breeders. The feasibility to insert sensory data into Breedbase will be studied.

A validated report for matooke processing techniques is not yet available. We are awaiting the reports and data on gender mapping of the different food products.

We will initiate the ontology for the description of the observer or informant of the traits or qualities (see Schema1): social segment, market segment, roles. This will most probably fall after Amos' internship is over.

We will continue engaging scientists in expert groups for cassava and yam.

Recommendations

1. The Template for Food Product Trait Dictionaries will have to be promoted for extending the Ontologies with Sensory traits and processing techniques
2. A Food Product section needs to be created in the Crop Ontology
3. All Trait Dictionaries developed will be uploaded into Crop Ontology
4. Expert group for cassava and yam needs to be created
5. Data sets produced from sensory panels must include the information on the material provenance (field trial, plant number, population, etc.) and the ontology will have to be used for the attributes' and variables' names.
6. Breedbase will have to be adapted for the entry of sensory panel results

Documents used to extract sensory attributes

SOP_Sensory_EN_Matooke_Final

SOP_Sensory_EN_Boiled Sweetpotato _Final

SOP_Sensory_Boiled Cassava_Final_June_2020

SOP_Boiled yam_Sensory_UAC-FSA_V2

WP2_SOP_Sensory Analysis_Eba_IITA V3

WP2_SOP_Sensory Analysis_Fufu_NRCRI V3

SOP_pounded yam Bowen_V4

Documents used to extract processing techniques

Boiled cassava_processing technics_WP1_4pdf

Activity 4 report - boiled sweetpotato - CIP UGANDA

Report_activity_4_Boiled_Yam_fsa_uac_Benin

Lessons learnt and knowledge gains from the internship

Other than the technical experience, the following have been learnt from the internship;

- I have improved my writing and communication skills,
- I have learnt to work under virtual supervision due to COVID-19 context
- I have enhanced my presentation skills from the experience gained after presenting at the webinar.

- I have learnt how to use virtual platforms like Zoom and Teams for conducting meetings
- My confidence to undertake new tasks has been enhanced.
- I got to understand processing techniques of different foods and their preferred or least preferred traits of the different foods from various countries.
- I obtained knowledge about electronic data management through the use of breedbases, crop ontologies, and trait dictionaries.
- I obtained knowledge on how trained sensory panels are organized after a visit to NARL

Bibliography

Pietragalla J., Valette L., Shrestha R., Laporte M.A., Hazekamp T., Arnaud E. (2020). Guidelines for creating crop-specific ontologies to annotate phenotypic data, version 2.0, Alliance Bioversity International-CIAT, December 2020

Shrestha, R., Matteis, L., Skofic, M., Portugal, A., McLaren, G., Hyman, G., Arnaud, E., (2012).Bridging the phenotypic and genetic data useful for integrated breeding through a data annotation using the Crop Ontology developed by the crop communities of practice. Frontiers in Plant Physiology v. 3 Article 326: doi: 10.3389/fphys.2012.00326, ISSN: 1664-042X

Suwonsichon S. The importance of sensory lexicons for research and development of food products (2019). *Foods*. 8(1):27. doi:10.3390/foods8010027