Original article

Assessment of end user traits and physicochemical qualities of cassava flour: a case of Zombo district, Uganda

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Summary Cassava breeding programmes in Uganda do not currently select materials based on flour making quality, explaining in part the low adoption rates of many released varieties. In this study, we describe end user trait preferences, processing qualities and physicochemical properties of cassava flour. We found that higher proportion of women than men showed preference for most attributes of cassava flour quality evaluated in this study. Preference for colour was 66% and 52% among women and men, respectively, while that for stickiness of Kwon was 26% (women) and 15% (men). Ease of peeling and stickiness of Kwon were key processing traits. Heap fermented flour had higher pasting temperatures, but lower viscosities than sun-dried flour, and had lower amylose content compared to fresh root starch. The results demonstrate the importance of gender sensitive participatory evaluation of breeding materials, in tandem with physicochemical evaluation during selection of best possible candidate breeding lines.

Keywords Cassava, fermentation, men, physicochemical properties, women.

Introduction Cassava (Manihot esculenta Crantz) is a major root crop grown and consumed in the tropical and subtropical regions of the world (Burns et al., 2010). Cassava is mainly cultivated for its starchy roots (Sánchez et al., 2009), although its leaves are also eaten as a vegetable (Aduni et al., 2005). Cassava roots are bulky and highly perishable, and therefore need to be processed into longer lasting forms such as flour (Bradbury & Denton, 2010; Akama, 2013). Processing also reduces levels of hydrogen cyanide (HCN) (Guédé et al., 2013), thus rendering roots of cultivars with high levels of HCN safe for human consumption (Cardoso et al., 2005; Lambri et al., 2013). In sub-Saharan Africa, traditional cassava processing methods are highly variable and differentiated geographically. Submerged root fermentation is common practice in Nigeria to produce cassava products such as gari, fufu and papuru (Egwim et al., 2016), while heap fermentation is common in Uganda and Mozambique (Alexander et al., 1995; Tivana et al., 2007).

Cassava breeding efforts have led to identification and deployment of varieties with low HCN content, which are safe for fresh consumption. In Uganda, varietal selection is largely based on defensive and selected agronomic root traits (Kawuki et al., 2016). Ideally, roots of such varieties can be processed into flour without undergoing fermentation. However, some communities typically consume cassava products arising from flour processed through fermentation (Cardoso et al., 2005; Lambri et al., 2013). This narration highlights a major drawback in current cassava breeding operations that are implemented with limited and/or poor understanding of traits that define quality of processed root products.

This challenge is aggravated by commonly used outreach approaches like participatory variety selection that only engage men and women towards the end of variety development process, at which point variability for product quality traits may have been significantly lost or reduced. Consequently, these factors singly and/or in combination have created a situation where genetic gains in cassava for disease resistance, yield and adaptability are high, and on the contrary no and
or minimal gains for product traits (Teeken et al., 2018).

Essentially, cassava breeding should generate technologies that meet aspirations of men, women, boys and girls; these technologies should also be mindful of their different needs, constraints, roles and responsibilities (Farnworth & Jiggins, 2003). Women perform a bulk of the roles involved in cassava production, processing and marketing (Esuma et al., 2019) and thus should be actively involved in technology development, verification and/or dissemination.

For example, Linley et al. (2002) found that women continue to grow bitter cassava landraces and not elite varieties owing to the quality superiority of their end products; this has persistent despite the yield and disease susceptibility penalties the landraces experience (Ribeiro et al., 2012). It is thus imperative that cassava breeding programmes refocus their breeding strategies to ensure that varieties to be released combine both disease resistance and desirable product quality traits defined by men and women.

Ideally, selection for such traits requires their translation into objectively measurable parameters. Root profiling to quantify starch functional and biophysical properties has been proposed as a suitable strategy to quantify traits of cassava roots (Nuwamanya et al., 2010). Indeed, related studies have established that root quality can be assessed by evaluating starch properties and correlating them to amylose content (Nuwamanya et al., 2010; Osungbaro et al., 2012). Therefore, it is logical to propose that once measurable traits associated with product quality are identified, they can then be used routinely to guide selection. Accordingly, this study was aimed at (i) identifying flour qualities preferred by men and women consumers, (ii) conducting participatory cassava root processing and (iii) evaluating physicochemical properties of elite genotypes and landraces related to cassava flour quality.

**Materials and methods**

**Location**

This research was conducted in Zombo district, North Western Uganda between 2°30’48”N and 30°54’32”E. Zombo district was chosen because of the unique processing method specific to this area, where cassava roots are initially heap fermented and thereafter processed into flour. In addition, Zombo is a highland area and the cassava breeding programme was targeting to develop varieties suited for such environments.

**Men and women preference of cassava root quality traits**

Eight focus group discussions (FGDs) led by a facilitator and guided by preset questions were used to collect qualitative data. Moreover, questionnaires (n = 128) were used to collect quantitative data from Sixty-two men and Sixty-six women engaged in cassava production. Purposive sampling ensured respondents were from a range of ages, as well as balancing the number of women and men consulted.

**Sources and genotypes of cassava used**

The genetic materials used for processing evaluation comprised of 20 elite cassava genotypes sourced from an advanced yield trial and 16 landraces locally grown by men and women in Zombo. The elite genotypes were selected from a highland trial previously conducted in Zombo district in 2016. All agronomic data associated with the highland trial can be accessed at www.cassavabase.org/breeders/trials. An experimental trial was laid in a randomised complete block design with two replicates. Each clone was represented by ten plants per row at a spacing of 1 m × 1 m.

**Processing of cassava roots**

Eighteen women from the community were each supplied with cassava roots harvested from four genotypes, to process flour at their homes using the traditional heap fermentation practice with nine women processing roots from one replicate. In each woman’s home, cassava roots were peeled and spread on tarpaulin under the sun. Cassava roots were left under the sun for four to six hours to reduce the moisture content of the roots without complete drying of the roots. Thereafter, whole partially dry roots were heaped in a corner inside the house and covered with polythene sacs. The roots were placed on bare ground in heaps to ferment. Fermentation ended within two to three days, when roots were soft and covered with black moulds. The fermented roots were cleaned with knives to remove black moulds. Clean roots were broken into small pieces by pounding them in a local motor with a local pounding pestle called Konyu. Cassava flakes were spread on tarpaulin under the sun until they dried. Dry cassava flakes were pounded with in a local motor with Konyu into fine flour. A sieve was used to separate large flakes from fine flour for further pounding. The cassava product Kwon was prepared using cassava flour generated following heap fermentation. Briefly, 100 g of cassava flour was mixed with 250 mL of boiling water until a thick paste (referred to as Kwon) was formed.

**Evaluation of the processing quality of cassava genotypes**

The eighteen women who processed cassava roots evaluated genotypes on attributes related to processing of heap fermented flour and the product Kwon (thick
paste processed from heap fermented cassava flour). Consequently, a structured questionnaire with questions rated by a scale customised to the Likert scale (Likert, 1932) was used to assess cassava genotypes. Focus was given to attributes, namely (i) ease of peeling assessed by how easily the peel detached from the cortex during peeling; (ii) days to fermentation assessed by the number of days a genotype took to complete the fermentation process; (iii) texture after fermentation assessed by the softness or hardness of the roots after fermentation; (iv) ease of mixing flour with water assessed by how easily the stick moved during mixing cassava flour with boiling water; and (v) quality of cassava Kwon evaluated by ability of flour to make a paste that sticks together even when it is left to cool for ten minutes.

Table 1 Cassava varieties commonly processed into flour by men and women

| Variety      | Percentage of men and women who process the variety | Type of variety |
|--------------|-----------------------------------------------------|----------------|
|              | % men (n = 62) | % women (n = 66) |                  |
| Longe        | 11.3        | 8.7             | Sweet           |
| Nyacharitas  | 16.3        | 12.7            | Sweet           |
| Nyamatia     | 11.8        | 9.2             | Bitter          |
| Nyapalei     | 13.5        | 10.5            | Bitter          |
| Nyapamitu    | 56.2        | 43.4            | Bitter          |
| Nyapopoga    | 15.0        | 12.7            | Bitter          |
| Nyaronega    | 30.4        | 23.6            | Bitter          |
| Nyarudota    | 48.5        | 51.5            | Bitter          |

Chi-square ($x^2 = 9.71, P = 0.78, df = 14$).

Physical chemical evaluation

Remnant flour from processing evaluation of selected cassava genotypes was used for physicochemical evaluation. Selection of genotypes for physicochemical analyses was based on quality of cassava fermentation (days to fermentation and texture after fermentation) and stickiness of cassava Kwon. Quality of fermentation was considered because it is a step in production of cassava flour that influences the characteristics of flour (González & Johnson, 2009). Quality of Kwon was considered because the study to determine trait preferences of men and women showed that it was a quality attribute of flour. Therefore, flour from six elite cassava genotypes and six landraces was stored in well labelled air tight containers prior to being subjected to physicochemical evaluation.

Physicochemical analyses were done for heap fermented, sun-dried and fresh root starch samples. Fresh root starch was prepared following a method described by (Nuwamanya et al., 2010). To generate sun-dried flour, cassava roots were peeled, grated, sun-dried and pounded with a local motor and pestle. Fresh root starch and sun-dried samples were packaged in well labelled air tight containers. The samples were evaluated for amylase content, pasting properties, swelling power and solubility. Amylose content of the heap fermented cassava flour and fresh root starch was measured using the method described by (Afoakwa, 2011). Pasting properties of sun-dried and heap fermented samples were evaluated for using the rapid visco analyser (RVA) profiling procedure described by (Sánchez et al., 2010). Swelling power and solubility were determined for fresh root starch using a method described by (Ceballos et al., 2007).

Figure 1 Preferred flour quality attributes of men and women in Zombo district. SCP/B = sweet cassava paste/ flour, GWHC = good water holding capacity, HDM = high dry matter, LQF = large quantities of flour, GSC = good swelling capacity. % is a symbol for percentage. [Colour figure can be viewed at wileyonlinelibrary.com]
Data analysis

Content analysis described by Elo & Kyngäs (2008) was used to analyse data from FGDs. Briefly, data were examined to generate themes which were used to define cassava product traits. Meanwhile, descriptive statistics were generated from quantitative data using the statistical package for social sciences (SPSS) version 21.0 (2013 release, IBM Corp., Armonk, NY, USA). Summary statistics from evaluation for traits related to processing and the product were obtained using R software version 3.41 (R Core Team, 2020). Similarly, summary statistics from evaluation of physicochemical properties were generated using the same software.

Results and discussion

Preference profiles for cassava flour among men and women

This study sought to understand attributes that define the quality of cassava flour processed through heap fermentation, and how preference for such qualities varies among men, women in Zombo district, a highland community in North Western Uganda.

The study showed that most popular cassava landraces processed by both men and women in Zombo are Nyapamitu, Nyarodota and Nyaronega, all of which are bitter (Table 1). Fermentation of cassava roots is not uncommon in communities that cultivate bitter cassava landraces (Linley et al., 2015). Due to the inherent toxicity caused by high levels HCN, bitter varieties are often processed to make the resultant product safe and agreeable for consumption (Tivana et al., 2007). This means that preference for bitter varieties by men and women in the study may be linked to other attributes such as quality of flour, and not necessarily bitterness. Indeed, the chi-square test ($\chi^2 = 9.71$, $P = 0.78$, df = 14) indicated that gender and variety processed were independent implying that selection of a variety was largely influenced by its inherent attributes.

Cassava roots are commonly processed into flour following a stepwise procedure. In Zombo, the procedure of processing roots into flour was by heap fermentation. Apart from reducing levels of HCN, heap fermentation was purported to improve organoleptic attributes of cassava flour.

...fermenting removes bitterness, it gives cassava flour a nice smell and the ability to make sticky food... (Woman, Zeu sub-county FGD)
According to Putri et al. (2011), heap fermentation improves the odour and taste of cassava flour. A range of attributes were mentioned by men and women in describing their perception of high quality cassava flour (Fig. 1). Considering a cut-off of 20%, some attributes were preferred more by women than by men. Notable of these were white flour (66% women versus 52% men), fine texture (22% women versus 16% men), ease of mixing (22% women versus 16% men), good water holding capacity (24% women versus 16% men) and sticky Kwon (26% women versus 15% men), respectively. Despite this, heavy flour and high dry matter content were preferred by more men than women, although they did not meet the cut-off point. These flour quality attributes preferred by women and men are linked to cassava Kwon. This finding highlights both the importance of Kwon to the Zombo community and need for participatory product-based evaluation and selection.

Processing and physicochemical properties of elite cassava genotypes and landraces

Cassava genotypes used in this study were evaluated for major aspects of the processing procedure. We noted significant genotypic differences ($P < 0.05$) for ease of peeling and stickiness of Kwon (Table 2). Elite genotypes had an average of 3.1 for ease of peeling while land races had 3.9 clearly illustrating that landraces scored highly for ease of peeling (Table 3). According to Gonzalez & Johnson (2009), ease of peeling was one of the quality attributes that consumers considered when selecting cassava roots to purchase.

Furthermore, sticky Kwon ranged from 2.0 up to 5.0 (Table 3). It suffices to note that landraces had a slightly higher (4.3) average for sticky Kwon than elite genotypes (4.2). The ability of cassava flour to form a ‘thick paste’ referred to as ‘stickiness’ is a critical...
starch pasting property whose differences are reported to be genotype dependant (Asaoka et al., 1992). These differences in starch pasting properties provide breeders an opportunity to make selections (Nuwamanya et al., 2010). Starch pasting properties which occur during heating are well illustrated through RVA profiling (Osungbaro et al., 2012). Accordingly, we obtained RVA profiles for heap fermented and sun-dried cassava flour samples (Fig. 2).

Heap fermented flour samples had lower values for peak, final and breakdown viscosities than the sun-dried flour samples. On the other hand, heap fermented flour samples had higher pasting temperatures and trough viscosity as compared to the sun-dried flour samples. While sun-dried flour samples had a characteristic pasting profile with a visible break down, most heap fermented flour samples had unique profiles with no visible break down (Fig. 2). Indeed Gomes et al. (2005) found similar observations on fermented cassava starch which was modified by annealing. The authors attributed reduced peak viscosity to decreased amylose leaching.

Annealing is a process that modifies starch by rearranging starch granules without destroying their structure (Alcázar-Alay & Meireles, 2015). According to Corke (2007), such modifications result into starch following the type C pasting profile (has no visible pasting peak and breakdown) as were observed from RVA profiles of heap fermented samples in this study. Having no visible breakdown on the pasting profile indicates low extent of breakdown of the paste and thus paste stability at high temperatures (Eriksson, 2013). This attribute has positive implications on the ability of cassava flour to form Kwon at high temperature since the paste will remain viscous even at high temperature.

Nyacharitas had the highest peak, trough and end viscosities for sun-dried flour (Fig. 2b). In addition, Nyacharitast had the highest peak, trough and end viscosities for heap fermented flour (Fig. 2a). It suffices to note that, Nyacharitas had high ability to make sticky cassava Kwon (4.5) (Table 3). This finding suggest that high peak viscosities are associated to stickiness, a pre-condition that has to be examined further with more diverse cassava genotypes. Nyamukalasa (85.35 °C) and UGH150094 (85.35 °C) had the highest pasting temperature for heap fermented flour, while UGH150094 (78.95 °C) had the highest for sun-dried flour (Table 4). It is likely that high pasting temperature could be due to high amylose content (Ekwu et al., 2011).

Results for amylose content are presented in Table 5. Genotype UGH150121 had the highest amylose content (30.76%) among the fresh starch samples, while UGH150105 had the least amylose (22.1%). With regard to the heap fermented flour samples, Nyamukalasa had the highest amount amylose (22.5%), while Nyacharitas had the lowest (17.0%). Amylose content was higher in fresh root starch samples (with average 25.38) compared to heap fermented

### Table 4 Mean genotype performance for pasting temperature

| Genotype            | PT (°C)      |
|---------------------|-------------|
| Fermented UGH150059 | 82.55 ± 0.60|
| Sun-dried UGH150059 | 65.65 ± 0.00|
| Fermented UGH150067 | 84.15 ± 0.03|
| Sun-dried UGH150067 | 67.70 ± 0.00|
| Fermented UGH150094 | 85.35 ± 0.00|
| Sun-dried UGH150094 | 78.95 ± 1.13|
| Fermented UGH150105 | 67.3 ± 0.21  |
| Sun-dried UGH150105 | 65.83 ± 0.24 |
| Fermented UGH150121 | 78.45 ± 1.94 |
| Sun-dried UGH150121 | 66.05 ± 0.07 |
| Fermented Nyacharitas | 78.95 ± 0.03 |
| Sun-dried Nyacharitas | 64.76 ± 0.11 |
| Fermented Nyamateo | 80.95 ± 0.56 |
| Sun-dried Nyamateo | 66.03 ± 0.11 |
| Fermented Nyamukalasa | 85.35 ± 0.00 |
| Sun-dried Nyamukalasa | 65.28 ± 1.09 |
| Fermented Nyapaleyi | 83.8 ± 0.28  |
| Sun-dried Nyapaleyi | 64.02 ± 0.04 |
| Fermented Telengule | 68.45 ± 0.03 |
| Sun-dried Telengule | 68.05 ± 0.07 |
| LSD fermented       | 11.55       |
| LSD sun-dried       | 2.26        |

### Table 5 Amylose content of fresh root starch and heap fermented flour

| Genotype            | Amylose content (%) |
|---------------------|---------------------|
| Fresh roots starch  | Heap fermented flour |
| UGH150121           | 30.76 ± 2.51        | 21.72 ± 0.82  |
| UGH150059           | 26.94 ± 0.48        | 20.53 ± 0.46  |
| UGH150067           | 22.35 ± 0.67        | 21.12 ± 4.23  |
| UGH150089           | 25.49 ± 2.47        | 19.32 ± 2.06  |
| UGH150105           | 22.05 ± 5.18        | 20.63 ± 1.17  |
| UGH150094           | 28.70 ± 0.71        | 21.96 ± 0.30  |
| Nyapamitu           | 23.01 ± 0.89        | 24.32 ± 0.66  |
| Telengule           | 23.32 ± 0.08        | 21.18 ± 1.54  |
| Nyamukalasa         | 26.01 ± 4.92        | 22.54 ± 2.17  |
| Nyapaleyi           | 23.31 ± 3.36        | 22.25 ± 1.89  |
| Nyacharitas         | 23.45 ± 0.61        | 17.02 ± 5.09  |
| Nyamateo            | 29.14 ± 2.88        | 18.91 ± 0.93  |
| Mean                | 25.38               | 20.95         |
| LSD at 9%           | 24.66               | 12.10         |
| CV (%)              | 5.07                | 4.57          |

CV, coefficient of variation; LSD, least significant difference.

Note: Letters show grouping of clones after mean separation using Fisher’s protected least significant difference (LSD) test at 5%. Alphabetical letters show grouping of clones after mean separation using Fisher’s protected least significant difference (LSD) test at 5%.
flour (with average 20.95). Such differences could be due to amylose degradation by lactic acid bacteria (Lactobacillus fermentum) which is a key organism involved in fermentation (Tivana et al., 2007). Indeed, amylose content could have implications on pasting properties because it is a non-branched polymer of starch that is not easily hydrolysed (BeMiller & Whistler, 2009). Consequently, when exposed to heat, cassava flour from Nyamukalasa would require higher temperature to gelatinise and form a thick paste (Kwon) than that from Nyacharitas. The relationship between amylose content, pasting properties and stickiness of cassava Kwon, if further investigated, could be key in evaluating genotypes for the important attribute – stickiness of cassava Kwon.

Meanwhile, swelling power of cassava starch ranged from 30 to 40 g of water/g of starch. Nyapamitu had the highest ability to swell (40.66 g of water/g of starch) while Nyacharitas had the lowest swellability of 30.20 g of water/g of starch (Fig. 3). Solubility of fresh root cassava starch ranged from 10 to 18%. Telengule (18.48%) had the highest solubility while UGH150105 (10.3%) had the lowest solubility. According to Nuwamanya et al. (2010), swelling ability is inversely related to its amylose content. Indeed, UGH150105 which had the lowest amylose content (22.05%) (Table 5) had high ability to swell (39.25 g of water/g of starch, Fig. 3). Performance of UGH150105 for swelling power and solubility corroborated the findings by Ceballos et al. (2007) on mutant cassava. According to the authors, the mutant genotype had lower solubility but higher swelling ability and they related it to its low amylose content.

**Conclusion**

Data sets presented in this study highlight three major findings. First, men and women differ in their cassava flour preferences, strengthening the argument for considering gender related traits during selection, and including women and men to participate in the variety development process. Second, landraces possessed better processing qualities compared to elite genotypes. Thus, landraces with superior processing qualities can be used as progenitors and/or checks when undertaking root quality assessment. Third, physicochemical properties notably paste properties exhibited strong association with Kwon product thickness, a key quality attribute. This information could guide development of protocols for making selections for quality cassava flour. We postulate that this will contribute to development of improved varieties that exhibit critical quality traits preferred by men and women, for increasing adoption of released varieties.

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Conflict of interest
The authors declare that they have no conflict of interests.

Author contribution
Ritah Ann Nanyonjo: Conceptualization (supporting); Data curation (lead); Formal analysis (lead); Investigation (lead); Methodology (equal); Writing-original draft (lead); Writing-review & editing (equal). 
Enoch Wembabazi: Data curation (equal); Formal analysis (supporting); Investigation (supporting); Methodology (equal); Project administration (lead); Resources (supporting); Supervision (lead); Writing-review & editing (equal).

Data availability statement
Data that support the findings of this study are available from the corresponding author upon reasonable request.

References
Afoakwa, O.E. (2011). Application of multivariate techniques for characterizing composition of starches and sugars in six high yielding CMD resistant cassava (Manihot esculenta Crantz) varieties. Journal of Nutrition & Food Sciences, 1, 1–5.
Aduni, A., Olufumnike, A., Mpoko, B. & Busie, M. (2005). The use of cassava leaves as food in Africa. Ecology of Food and Nutrition, 44, 423–435.
Akama, O. (2013). Physicochemical properties of dried cassava flour from balls and chunks. International Journal of Scientific & Technology Research, 2, 63–70.
Alcázar-Alay, S.C. & Meireles, M.A.A. (2015). Physicochemical properties, modifications and applications of starches from different botanical sources. Food Science and Technology (Campinas), 35, 215–236.
Alexander, E., Cyprian, E., Remco, V. der G. & Otim-Nape, W. (1995). Reducing cassava toxicity by heap-fermentation in Uganda.pdf. International Journal of Food Science and Nutrition, 46, 125–136.
Asgarkhan, M., Blanshard, J. & Rickard, E. (1992). No title effect of cultivar and growth season on the gelatinization properties of cassava (Manihot esculenta) starch. Journal of the Science of Food and Agriculture, 59, 53–58.
BeMiller, J. & Whistler, R. (2009). Starch Chemistry and Technology. 3rd Edition, The Effects of Brief Mindfulness Intervention on Acute Pain Experience: An Examination of Individual Difference. United Kingdom: Elsevier. https://doi.org/10.1017/CBO9781107415324.004
Bradbury, J.H. & Denton, I.C. (2010). Rapid wetting method to reduce cyanogen content of cassava flour. Food Chemistry, 121, 591–594.
Burns, A., Gleadow, R., Cliff, J., Zacarias, A. & Cavagnaro, T. (2010). Cassava: The drought, war and famine crop in a changing world. Sustainability, 2, 3572–3607.
Cardoso, A.P., Mirione, E., Ernesto, M. et al. (2005). Processing of cassava roots to remove cyanogens. Journal of Food Composition and Analysis, 18, 451–460.
Ceballos, H. et al. (2007). Discovery of an amylose-free starch mutant in cassava (Manihot esculenta Crantz), Journal of Agricultural and Food Chemistry, 55, 7460–7476.
Corke, H. (2007). Specialty cereal and noncereal starches. In: The RVA Handbook (edited by G.B. Crosbie & A.S. Ross). Pp. 49–62. St. Paul: AACC international.
Egwim, E., Musa, A., Abubakar, Y. & Mainuna, B. et al. (2016). Nigerian Indigenous Fermented Foods: Processes and Prospects. In Mycotoxin and Food Safety in Developing Countries. INTECH. https://doi.org/10.5772/711.
Ekwu, F., Ngoddy, O. & Uwere, O. (2011). Functional and rheological properties of cassava flour processed by. JOURNALAR, 6, 17–30.
Elo, S. & Kyngäs, H. (2008). The qualitative content analysis process. Journal of Advanced Nursing, 62, 107–115.
Eriksson, E. (2013). Flour from three local varieties of Cassava (Manihot esculenta Crantz ): Physico- chemical properties, bread making quality and sensory evaluation. Swedish University of Agricultural Sciences, 371, 1–41.
Esufi, W., Nanyonjo, A.R., Miroy, R., Angudubo, S. & Kawuki, R.S. (2019). Men and women’s perception of yellow - root cassava among rural farmers in eastern Uganda. Agriculture and Food Security, 8, 1–9.
Farnworth, C.R. & Jiggins, J. (2003). Participatory Plant Breeding and Gender Analysis. CA: CIAT. Available at https://cgspase.cgiar.org.
Gomes, A.M.M., Mendes Da Silva, C.E. & Ricardo, N.M.P.S. (2005). Effects of annealing on the physicochemical properties of fermented cassava starch (polvilho azedo). *Carbohydrate Polymers*, **60**, 1–6.

González, C. & Johnson, N. (2009) Consumer preferences for table cassava characteristics in pernambuco, brazil. *Revista de Economia e Agronegócios*, **7**, 363–384.

Guédé, S.S., Traoré, S. & Brou, K. (2013). Assessment of cyanide content in cassava (*Manihot esculenta* Crantz) varieties and derived products from Senegal. *International Journal of Nutrition and Food Sciences*, **2**, 225–231.

Kawuki, R.S., Kaweesi, T., Esuma, W. et al. (2016). Eleven years of breeding efforts to combat cassava brown streak disease. *Breeding Science*, **66**, 560–571.

Lambri, M., Fumi, M.D., Arianna, R. & Dante Marco, D.F. (2013). Improved processing methods to reduce the total cyanide content of cassava roots from Burundi. *African Journal of Biotechnology*, **12**, 2685–2691.

Likert, R. (1932). Technique for the measurement of attitudes. *Archives of Psychology*, **140**, 5–55.

Linley, C.-K. et al. (2002). Bitter cassava and women: an intriguing response to food security. *LEISA Magazine*, **18**, 13–15.

Linley, C. et al. (2015). Farmer preference, utilization, and biochemical composition of improved Cassava (*Manihot esculenta* Crantz) varieties in Southeastern Africa 1. *Economic Botany*, **69**, 42–56.

Nuwamanya, E., Baguma, Y., Naushad, E., John, T. & Rubaihayo, P. (2010). Physicochemical and functional characteristics of cassava starch in Ugandan varieties and their progenies. *Journal of Plant Breeding and Crop Science*, **2**, 1–11.

Osungbaro, T.O., Jimoh, D. & Osundeyi, E. (2012). Functional and pasting properties of composite Cassava-Sorgum flour meals. *Agriculture and Biology Journal of North America*, **1**, 715–720.

Putri, W.D.R., Haryadi, D.W., Marseno & Cahyanto, M.N. (2011). Effect of biodegradation by Lactic Acid Bacteria on physical properties of cassava starch. *International Food Research Journal*, **18**, 1149–1154.

R Core Team. (2020). *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing. https://www.R-project.org/

Ribeiro, P.F., Akromah, R. & Manu-Aduening, J. (2012). Using marker assisted selection to hasten screening of cassava cultivars developed through introgression of cassava mosaic disease (CMD) resistance into cassava landraces in Ghana. *Journal of Agricultural Science and Technology*, **2**, 74–80.

Sánchez, T., Dufour, D., Moreno, I.X. & Ceballos, H. (2010). Comparison of pasting and gel stabilities of waxy and normal starches from potato, maize, and rice with those of a novel waxy cassava starch under thermal, chemical, and mechanical stress. *Journal of Agricultural and Food Chemistry*, **58**, 5093–5099.

Sánchez, T., Salcedo, E., Ceballos, H. et al. (2009). Screening of starch quality traits in cassava (*Manihot esculenta* Crantz). *Starch - Stärke*, **61**, 12–19.

Teeken, B., Olaosebikan, O., Halegoah, J. et al. (2018). Cassava trait preferences of men and women farmers in Nigeria: implications for breeding. *Economic Botany*, **72**, 263–277.

Tivana, L.D., Bvochora, J. M., Mutukumira, A.N. & Owens, J.D (2007). A study of heap fermentation process of cassava roots in Nampula Province, Mozambique. *Journal of Root Crops*, **33**, 119–128.