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Gendered sweetpotato trait preferences and implications for improved variety acceptance in Uganda

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Abstract

The principal selection objective in crop breeding has for a long time been driven by agronomic gains like yield maximization and climate resilience. Nevertheless, the continued low adoption of new varieties and documented gender technology adoption gap has triggered re-thinking of this strategy, with end-user acceptability of released varieties a key strategy in breeding objectives. Using a mixed-methods approach with a survey of 122 producers and focus group discussions with 200 male and female producers in two major sweetpotato [*Ipomoea batatas* (L.) Lam] producing districts in Uganda, this study set out to understand gender-disaggregated traits that drive acceptance for improved sweetpotato varieties as a guide to development of new varieties in the region. A generalized structural equation model approach is used to analyze how interrelated trait preferences shape acceptance for improved varieties, while in-depth insights from a qualitative approach are used to further ground observed results. Traits such as high root yields, drought tolerance, and vitamin A are shown to be key drivers to acceptance of improved varieties, while good taste and dry matter content dampen acceptance of improved varieties in favor of landraces. Male farmers are also shown to mainly prefer agronomic traits such as high yields and stress tolerance, while women mostly prefer quality traits such as good taste, vitamin A, and high dry matter content. To achieve higher acceptability and adoption of improved varieties across the gender divide, new varieties need to not only consider agronomic gains, but also quality-related traits such as taste and dry matter content.

Abbreviations: AT, agronomic trait; BMGF, Bill and Melinda Gates Foundation; CIP, International Potato Center; FCA, four-cell analysis; FGD, focus group discussions; GSEM, generalized structural equation model; IVA, improved variety acceptance; NT, nutrition traits; OFSP, orange-fleshed sweetpotato; OT, organoleptic traits; SIM, simultaneous equation model; SSA, Sub-Saharan Africa; SweetGAINS, Sweetpotato Genetic Advances and Innovative Seed Systems; VT, visual traits.

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1 | INTRODUCTION

The principal selection criteria in crop breeding have for a long time been driven by agronomic gains like yield maximization and agro-climatic suitability objectives (Defoer et al., 1997). Increasing demand of healthy and safe diets, changing sociocultural conditions, and the inherent global change challenges like climate change have all necessitated rethinking of this strategy (Dwivedi et al., 2017; Heck et al., 2020). More than ever, new crop varieties now need to be resilient to environmental stressors, provide nutritious diets to combat hidden hunger, and meet dynamic preferences for different groups of end users in target populations. The latter is becoming more prominent in the technology adoption literature, with demand-driven crop variety development gaining tract as a key driver to improved variety acceptance (IVA) and adoption (Campos, 2021; Ceccarelli & Grando, 2007; Ragot et al., 2018).

An emerging strand of literature shows that heterogeneous preferences for variety traits across gender could be a major determinant of the observed gender technology adoption gap, as well as overall observed technology adoption in Sub-Saharan Africa (SSA) (Ragot et al., 2018; Weltzien et al., 2019). Understanding such trait preferences is critical in ensuring that crop breeding programs are gender responsive for overall acceptability of new varieties and inclusive positive impacts through technology adoption by various segments of targeted population (Orr et al., 2018). While literature on demand- and gender-responsive breeding is still nascent across the agricultural development circles, much of this center around cereal and legume crops (for a review, see Weltzien et al., 2019). Yet, vegetatively propagated crops like roots and tubers are a key source of food and incomes for millions of households in the developing world, especially in the era of a changing climate, given their resilience to climate-related stressors (Acevedo et al., 2020; Manners et al., 2021; Thiele et al., 2017). Preferences for roots and tubers are also likely to be quite divergent from those of other crops such as cereals and legumes with cooking traits such as easiness of cooking and processing, visual traits (VTs) such as root shape, color, and size, and sensory traits such as taste and dry matter content, being more pertinent for the former compared to the latter.

This study adds to the growing literature on demand-responsive breeding by using a mixed-methods approach to understand various sweetpotato [*Ipomoea batatas* (L.) Lam] traits preferable to both men and women, in key sweetpotato growing areas in Uganda. The quantitative approach used allows for the assessment of how trait preference drives the acceptance for improved varieties, a novel addition in the technology adoption literature, to our knowledge. Understanding how preferences for certain traits shape the preference for either improved or local varieties is important in the agricultural technology literature, with implications on how breeding systems could better align new varieties with end-user demand for enhanced technology uptake. The qualitative approach, on the other hand, allows for the grounding of observed results from the quantitative approach, while decoupling preferences that are preferable to both men and women producers and consumers for a gender-responsive elicitation of trait preferences.

Core Ideas

- End-user acceptability is critical in crop breeding for adoption at scale of new released varieties.
- Quality traits are important for variety acceptance and need to be prioritized in variety breeding.
- For inclusive impacts, breeding programs need to consider gender implications of new varieties.

2 | LITERATURE REVIEW

The agricultural development literature identifies various technical, institutional, and policy challenges that result in a low rate of technological change in the region (for a review see Ruzzante et al., 2021). Similarly, a large body of literature is also dedicated to behavioral deterrents to technology uptake, and strategies for overcoming these for enhanced uptake of agricultural technology (Bridle et al., 2020; Duflo et al., 2013; Suri, 2011; Visser et al., 2020). Yet further nascent literature point to the importance of acceptance-driven innovations in agricultural technology development as critical to agricultural technology acceptance and adoption (Campos, 2021; Ceccarelli & Grando, 2007). Understanding who the targeted clients in technology development are and their needs is an important first step in ensuring widescale and inclusive adoption of new technologies (Yao et al., 2017).

Much of the focus of breeding programs has been on genetic gains leaning toward agronomic crop performance like higher yields, pest and disease resistance, climate resilience, and more recently on biofortification (Luo et al., 2019; Maranna et al., 2021; Mwanga et al., 2021). These gains in crop variety development are critical for sustainable food systems in an era of global challenges such as climate change, accelerated urbanization, and increasing malnutrition. For such programs to achieve the intended goals of reducing food insecurity and poverty, developed technologies need to rapidly achieve widescale acceptance and adoption by populations targeted in these interventions. Emerging literature shows complex decision-making by end users that may dampen adoption of important new technology, the mentioned

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technical, institutional, and policy challenges notwithstanding. For instance, in addition to agronomic traits (ATs), farmers may prefer varieties that are more nutritious, have good VTs, are more marketable, are better tasting, and induce less drudgery both in cultivation and meal preparation (Bocher et al., 2021; Kassie et al., 2017; Moyo et al., 2021; Shikuku et al., 2019). While these traits may seem trivial to prioritize in complex breeding systems, failure to account for them may lead to low acceptance of new technology, critically impeding intended intervention outcomes of mitigating food and nutritional insecurity and reducing returns of investment on plant breeding efforts.

Incidentally, similar to agricultural technology adoption, variety trait preferences have also been shown to be heterogeneous across gender. For instance, women have been shown to prefer varieties that appeal most to organoleptic qualities such as taste, aroma, and dry matter content, in the case of sweetpotato (Moyo et al., 2021; Ssali et al., 2021). Similarly, women have also been shown to prefer quality traits such as nutrition, which is positively linked to preference of biofortified crops such as orange-fleshed sweetpotato (OFSP), while men are more inclined toward preference for variety with market-related traits (Okello et al., 2022). Gender roles within the household are also important in determining which traits are more preferred by women. Varieties with drudgery-inducing traits, whether in cultivation and harvesting of the crop or in meal preparation, are also less likely to be preferred by women (Tegbaru et al., 2020). For inclusive impacts of intervention programs, designing breeding programs to be gender responsive is therefore imperative, not only to ensure widescale and inclusive acceptability, but also to guard against further entrenching gender inequality in targeted populations.

The reviewed literature on variety trait preference indicates a potential explanation to the low technology adoption puzzle in SSA, other identified confounders notwithstanding. However, much of this literature is dedicated to the identification of the (gendered) trait preferences, with an aim of guiding acceptance-driven and gender-responsive crop variety breeding, with only a few linking this to technology acceptance (see Adekambi et al., 2020). Our study contributes to the literature by identifying gendered preferences for sweetpotato variety traits in Uganda but also by further linking such preferences to the acceptance for improved varieties. Rather than focusing on adoption of improved varieties, our study focuses on intermediate individual-specific preference for either improved or local varieties, as an indicator of acceptance for either of these variety types. This is informed by the fact that there are many confounders to improved technology adoption (e.g. access to information, liquidity, and policy issues, among others) and a plethora of literature on these already exists (for a review see Ruzzante et al., 2021). Our focus in this study, in addition to eliciting gendered variety trait preferences, is to explicitly model and analyze how such preferences shape acceptance for either local or improved technology.

3 | CONTEXT AND DATA

3.1 | Background to project

Data for this study comes from the Sweetpotato Genetic Advances and Innovative Seed Systems (SweetGAINS) project, an investment of the Bill and Melinda Gates Foundation (BMGF) on the International Potato Center (CIP) and several National Agricultural Research Systems based in SSA. This undertaking aims at modernizing Africa's current sweetpotato breeding and seed systems by building on earlier approaches made at CIP, for example, efforts to combine high pro-vitamin A levels with tolerance to key biotic and abiotic constraints to produce OFSP (Mahmud et al., 2021). The SweetGAINS project adopts a strong end user-driven approach through the conduction of market intelligence studies and including insights from these studies into breeding objectives for the development of technologies that are aligned with end-user preferences. Inherent in this end user-driven approach is a strong gender theme achieved through a participatory effort to include the needs of women, men, and youth in the development of new varieties, for demand and gender-responsive breeding systems (Ragot et al., 2018; Tegbaru et al., 2020).

3.2 | Sampling and data

A mixed-methods approach was utilized in the study, where rapid assessments using gender-disaggregated focus group discussions (FGDs) were combined with a small-sample household survey, to understand gendered trait preferences and how these affect acceptance for improved varieties. Though traditionally used in health-related studies, rapid assessments are gaining tract in economic studies where time and resource constraints are binding for detailed surveys, especially in the context of Coronavirus pandemic (Gatto & Islam, 2021; Sharma et al., 2020). The sampling procedure involved a mix of purposive, random, and snowball sampling techniques. First, two districts in Uganda, that is, Iganga and Kamuli, were purposively selected based on sweetpotato production, consumption, and marketing potential (Kpaka et al., 2013). Similarly, two subcounties from each of the two districts, that is, Bulamagi and Nambale in Iganga and Bugulumbya and Nabwigulu in Kamuli were selected based on the same criteria. Next, random sampling was utilized to select two parishes from each of the selected subcounties and one village from each of the selected parishes for inclusion in the study. To get urban consumer perspective on trait preferences, four urban centers in each of the selected subcounties were also included in the sample (see Table 1).

Village leaders in the selected villages then assisted the survey teams in identifying a list of sweetpotato growers in the village, who were then randomly selected to

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TABLE 1 Description of focus group participants.

Variable	Iganga district		Kamuli district	
Sweetpotato producers	Male ($n = 50$)	Female ($n = 48$)	Male ($n = 52$)	Female ($n = 34$)
Average age of participants (years)	41	41	38	40
Education level (years)	8.9	7.0	8.1	6.0
Area under sweetpotato (acres)	0.9	0.8	1.2	1.7
Experience in sweetpotato production (years)	15	19	9	17
Sweetpotato consumers	Male ($n = 24$)	Female ($n = 23$)	Male ($n = 24$)	Female ($n = 23$)
Average age of participants	28	31	41	38
Education level (years)	10.1	8.0	8.9	7.6

participate in the FGDs. To select participants for the consumer FGDs, two approaches were utilized; first, contacts of regular sweetpotato customers were obtained from retailers and food vendors in the identified markets while the second approach involved strategic placement of facilitators at boiled and raw sweetpotato root selling points, where potential respondents were identified. A master list from both approaches was then generated and screened to get a balanced mix of male and female respondents to allow for an unbiased gendered elicitation of trait preference, then identified respondents were requested to participate in the FGDs slated for a later date. A total of 16 and 8 FGDs were conducted with sweetpotato producers and consumers across the two districts, respectively, with a total of 184 and 94 producers and consumers participating, respectively.

To identify respondents for the household survey, preliminary findings from the ongoing FGDs were used to trace the main sources of major market-preferred varieties. Using a snowball approach, identified producing households for these varieties were then used to further identify other producing households, whether market oriented or not. Random proportionate sampling was finally used to select 122 households from the identified villages above for inclusion in the survey. The key household member involved in agricultural activities, including decisions on crops and varieties to plant in a particular season, was then selected to be the primary respondent to the survey, with 69 % of these being women (see Table 2).

To construct the outcome variable, that is, IVA, respondents were asked to state their highest ranked variety in terms of preference. This variety was then determined whether it is an improved variety or landrace, with the involvement of local experts where local names may have been used to refer to released variety. The resultant-dependent variable is therefore a dummy variable, that is, IVA = 1 if the most preferred variety is improved and 0 if the most preferred variety is a landrace. The rationale for the focus on variety acceptance rather than adoption in this study is that even before effective acceptance of improved varieties comes into play, variety has to first be desirable to the end user. In addition, effective acceptance of an improved variety is confounded by many factors, such as those explored in much of the extant literature on barriers to technology adoption (see Ruzzante et al., 2021). Focusing on acceptance allows for the direct elicitation of the unconfounded impact of preference for certain variety traits on variety acceptance, as a first step in variety acceptance and adoption. The predictor variables on the other hand include agronomic, nutrition, organoleptic/sensory, and VT preferences. In the study, preference for ATs refers to respondent-elicited preference for traits such as drought tolerance and yields, while nutrition-related traits refer to preference for vitamin A. Similarly, preference for organoleptic traits (OTs) refers to the preference for traits such as dry matter content and taste of sweetpotato roots, while preference for VTs refers to preferences for traits such as root flesh color, shape, and size, and skin color and texture.

From the study sample, preliminary descriptive results show that most of the respondents (56%) preferring nutrition-related traits preferred improved varieties compared to landraces (5%), while those with high preference for OTs preferred landraces more (84%) (Table 2). Preference for ATs was relatively similar between landrace and improved variety preference. In terms of gender, the results show that a higher proportion of the female respondents preferred OTs compared to male ones, with preference for nutrition and VTs being fairly similar across the two groups. A notably higher proportion of male respondents however preferred ATs compared to female ones.

4 | CONCEPTUAL FRAMEWORK AND ANALYTICAL STRATEGY

4.1 | Modeling interrelated trait preferences and variety acceptance

We model the effect of trait preferences on the type of varieties that are acceptable to farmers, whether improved or local landraces. Trait preferences determine the type of varieties that are preferred and eventually adopted and utilized by end users, including farmers and consumers. These traits could either be

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TABLE 2 Description of surveyed sweetpotato producers.

Variable	Improved variety acceptance		Respondent is female	
	Yes ($n = 41$)	No ($n = 81$)	Yes ($n = 84$)	No ($n = 37$)
Traits preference (proportion preferring trait, %)				
Agronomic	78.0	72.0	72.6	75.7
Nutrition	56.1	4.9	22.6	21.6
Organoleptic	68.3	84.0	81.0	73.0
Visual	22.0	14.8	16.7	18.9
Respondent characteristics				
Female (%)	68.3	70.0	–	–
Age (years)	43 (9.8)	42 (10.1)	42.3 (9.3)	42.6 (9.3)
Education (years of schooling)	8.1 (3.4)	6.7 (3.1)	6.7 (3.4)	8.3 (2.7)

Note: Standard deviations are in parentheses.

agronomic (e.g., yield and drought tolerance), sensory/OTs (e.g., taste and dry matter content), or quality-related traits (e.g., vitamin A). Varieties rarely have all the suite of traits that are preferable to heterogeneous groups of end users. For instance, released new varieties may have high yield potential but lack visual qualities such as good shape, smooth skin, and undesirable flesh and skin color (Jogo et al., 2021). Similarly, flesh color may also be correlated with perceptions on nutrition potential of sweetpotato, given the decade-long promotion of the vitamin A-rich OFSP in the study counties. Such varieties, though rich in nutrients, have also been shown to be less acceptable to consumers due to low scores on main sensory traits like taste and dry matter content (Adekambi et al., 2020; Mashisia et al., 2019).

The described complex relationships among the various trait preferences presents a challenge in the estimation of their role in shaping acceptance for improved varieties. Few of the described traits are truly exogenous in determining the acceptance for improved varieties, as interrelations among these mediate the overall direct effect of each on the outcome variable. This calls for a multi-equation model that explicitly models the endogeneity among the explanatory variables in quantifying effect on IVA. The simultaneous equation model (SIM) approach has been used extensively in the literature to model a system of equations where endogeneity is hypothesized, given self-selection or omitted variable issues (Chege et al., 2015; Gitonga et al., 2020; Liebenehm & Waibel, 2014; Mulwa & Visser, 2020; Mulwa et al., 2021). The closely related structural equation model (SEM), popular in social and behavioral sciences, is also used to model complex multi-equations and control for endogeneity, especially in cases where latent unobserved variables are included in the models (Bollen & Noble, 2011).

While a SIM need not be a SEM and vice versa, Drukker (2011) demonstrates convergence in results obtained from using both approaches, in cases where all variables are observable in the data. In this study, we observe all the dependent and explanatory variables, that is, acceptance for IVA, elicited as preferences for varieties that are either improved or local landraces, and the producer preferences for sweetpotato variety traits. This would ideally call for the application of the SIM. However, the endogeneity problem in our econometric estimation falls more into a multicollinearity problem, given the interdependence among the various trait preferences, as shown in the pathway analysis in Figure 1, and less of a simultaneity problem with interrelated systems of equations, as presented in Wooldridge (2002).

Thus, while we observe all the variables in our models, we utilize the SEM, rather than the SIM, to understand the interrelationships among the correlated trait preferences, and their conditional effects on variety acceptance. The aim of this part of the analytical approach is twofold; first to investigate the causality between interrelated trait preferences and IVA, consistent with the main objective of the quantitative part of the study, and second to analyze how these trait preferences trade off against each, in informing IVA. The latter does not aim to examine causation among the various trait preferences, only the nature of the relationship among these, and therefore the choice of the dependent variable among these in the estimation process (discussed hereafter) is therefore arbitrary (Wooldridge, 2002).

4.2 | Empirical estimation

Based on the hypothesized impact pathways in Figure 2, we model a system of equations to test out these hypotheses as follows:

$$\text{IVA} = \text{NT} + \text{OT} + \text{VT} + \text{AT} + \mathbf{X} + \varepsilon, \quad (1)$$

$$\text{NT} = \text{OT} + \text{VT} + \varepsilon, \quad (2)$$

$$\text{VT} = \text{OT} + \text{AT} + \varepsilon, \quad (3)$$

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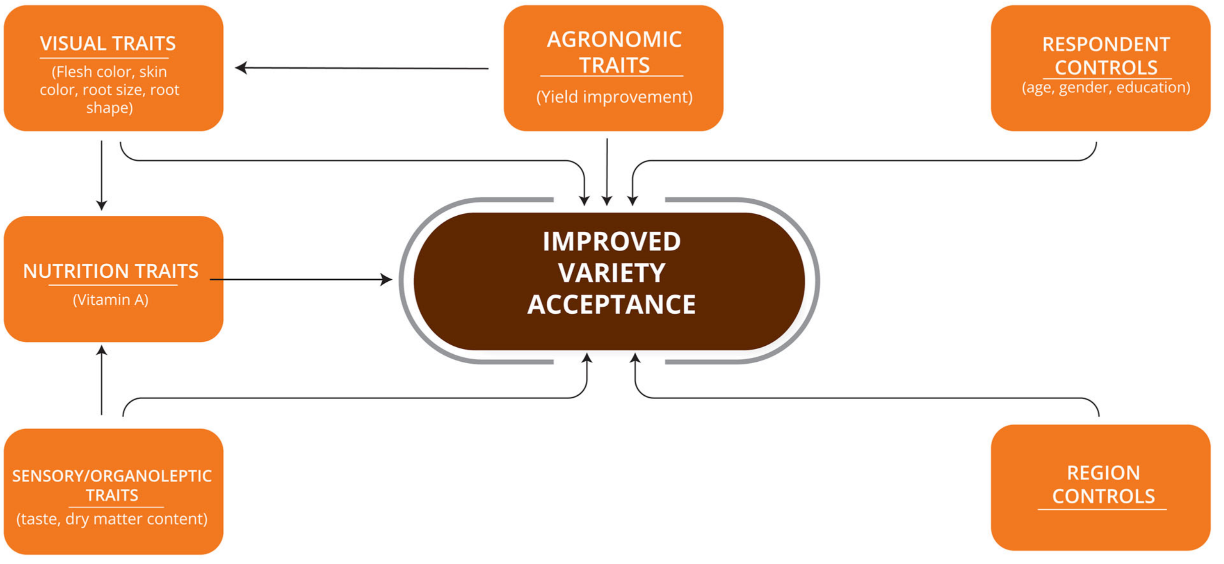

FIGURE 1 Conceptualization of trait preference and variety acceptance impact pathways.

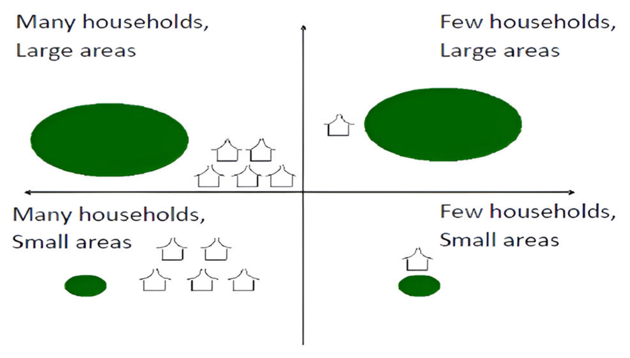

FIGURE 2 Example of the four-cell analysis approach. *Source*: Sthapit et al. (2014).

where IVA is improved variety acceptance; NT, OT, VT, and AT are preferences for nutrition, organoleptic, visual, and agronomic sweetpotato traits, respectively; **X** is a vector of control variables including respondent, household and location characteristics, and ε are the error terms. As indicated before, the choice of the dependent variable in Equations (2) and (3) is arbitrary, as the aim of this part of the analysis is to infer on the type of relationship among the various trait preferences, and not claim causality. The analysis is run in STATA version 17 using the generalized structural equation model (*gsem*) command, following Bartus (2017).

4.3 | Gendered qualitative insights

The analytical strategy described above is important in establishing causal relationship between trait preferences and variety acceptance, as well as the interrelationships among the trait preferences. However, for an in-depth understanding of observed results, qualitative insights are pertinent. This is more important given the gendered nature of variety trait preferences, which is difficult to deduce from the quantitative approach, first because the elicitation is at household level, and second because narratives on observed phenomena are difficult to capture with semi-structured questionnaires. Similarly, observed direction of relationships between trait preferences will be difficult to explain, without qualitative insights. Thus, to further ground the hypotheses used in the conceptualized impact pathways in above section, and explain observed results, we also conducted FGDs with both sweetpotato producers and consumers in the study areas. These FGDs were conducted with women and men separately to capture gendered heterogeneity in trait preferences. The aim of the FGDs was to elicit preferred sweetpotato varieties, whether improved or local landraces, and the traits that made these varieties preferable. It is worthwhile to note that while heterogeneity in trait preferences was considered for only men and women in this study, such heterogeneity could be more nuanced depending on social status within the society, income levels, spatial considerations, etc. For instance, there could be differences in trait preferences between women depending on their social status in the society, which may not be captured by the higher level heterogeneity considered in this study. This could be an area for future research on this topic.

Stepwise procedures were utilized in the FGDs to elicit variety and variety trait preferences; in the producer FGDs, the four-cell analysis (FCA) was used as a first step to establish the key reference varieties in terms of their abundance and distribution, based on the number of households (many vs. few) in a community growing a particular variety, and the area allocated to the variety by growing households (large vs. small) (see Figure 2).

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TABLE 3 Trait preferences and effect on improved variety acceptance.

Variables	Sample		
	Overall	Women	Men
***Dep var* (improved variety acceptance)**			
Vitamin A trait	2.447***	2.470***	7.600
	(0.500)	(0.741)	(563.6)
Organoleptic-related traits	0.266	0.442	0.159
	(0.444)	(0.701)	(0.941)
Visual-related traits	0.602	0.321	1.739**
	(0.391)	(0.505)	(0.870)
Agronomic-related traits	0.850**	1.225**	0.0523
	(0.399)	(0.609)	(0.802)
***Dep var* (vitamin A trait)**			
Organoleptic-related traits	−1.157***	−1.447***	−0.908*
	(0.297)	(0.386)	(0.542)
Visual-related traits	−0.422	0.0606	−5.416
	(0.409)	(0.468)	(736.7)
***Dep var* (agronomic traits)**			
Visual-related traits	0.0861	−0.0396	0.429
	(0.309)	(0.363)	(0.614)
Respondent controls	Yes	Yes	Yes
Region controls	Yes	Yes	Yes

Note: Standard errors are in parentheses. *Dep var*, dependent variable.
***$p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Next, pairwise ranking of these varieties was conducted to establish the most preferred varieties by the community, then all the preferred (and non-preferred) traits of the top three preferred varieties as elicited from the pairwise ranking were listed. Finally, these traits were also ranked to determine the top three traits preferred in each of the preferred variety. Similarly, the non-preferred traits in the least preferred varieties were also elicited, together with any traits recommended for inclusion in these preferred varieties. The procedure for the elicitation of consumer trait preferences followed a similar pattern, except for the first step where FGDs participants were only asked to list all the varieties that were consumed in the community, unlike in the producer FGDs where these were elicited using the FCA approach.

5 | RESULTS AND DISCUSSIONS

This section presents results from the quantitative and qualitative analytical strategies described before. First, results from the SEM on how interrelated sweetpotato trait preferences shape acceptance for improved varieties are discussed. Next insights from the qualitative assessment of preferred varieties and the traits that make these varieties preferable, by both men and women, are presented. The results from the quantitative analyses are then discussed within the context of the insights from the qualitative assessments.

5.1 | Trait preference and improved sweetpotato variety acceptance

Using the *gsem*, we run three estimations to test out the study hypotheses: after running the model with the full sample (Table 3, first column), we split the sample into female (second column) and male (third column) subsamples and re-run the estimations separately to test what trait preferences drove IVA among men and women.

In the first part of Table 3, all the variables (trait preferences) hypothesized to drive IVA are presented for the three sample estimations, with IVA as the dependent variable following Equation (1). Next, results on analysis of the relationship between organoleptic, VTs, and nutrition traits (NT) are presented, with NT as dependent variable following Equation 2. Lastly, results on the analysis of the relationship between ATs and VTs are presented, with ATs as dependent variable following Equation 3. Correlations tests performed in the analyzes reveal significant correlations across the various traits, which justifies the use of the SEM as the analytical method in the study. The results show that preference for

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FIGURE 3 Overall structural effect of organoleptic trait preferences on acceptance for improved sweetpotato varieties.

nutrition-related traits, specifically preference for varieties that are rich in vitamin A, is a key driver in the acceptance for improved varieties. This result is however primarily driven by women (see second column result), implying that women are more likely to adopt improved varieties that are rich in vitamin A, perhaps driven by the need to provide nutrition-dense food to families (Bayiyana et al., 2021; Mulwa et al., 2022).

In line with previous findings, AT preferences are shown to be another key driver for the acceptance of improved varieties (Okello et al., 2022). Further disaggregation by gender shows that contrary to findings elsewhere (see Teeken et al., 2018), this result is driven by the women subsample indicating that women producers are more likely to adopt varieties that have higher agronomic gains compared to men. Given that traits used in this composite variable include early maturing, drought tolerance, and high yields, the result is unsurprising as women have been shown to value traits that guarantee food security to the household. On the other hand, VTs (i.e., root shape and size, skin texture and color) are shown to be a key driver to variety acceptance among men but not women, perhaps due to market consideration with roots with such traits being more marketable. While there seems to be no impact of OTs (i.e., good taste and high dry matter content) preference on IVA, the results in the second part of Table 3 show a negative correlation between these traits and preference for vitamin A. This could be explained by the low sensory attributes associated with vitamin A-rich sweetpotato varieties in the region (Adekambi et al., 2020; Jogo et al., 2021; Okello et al., 2022).

Using *gsem* methods described before, we can further analyze the impact pathway of OTs on variety acceptance, first from how they affect vitamin A preferences (or vice versa), otherwise known as the indirect effect, to how they affect IVA directly (main effect), with a summation of the two being the total effect of OTs on variety acceptance. Since we find no evidence of mediating effects of any other trait relationships as hypothesized, we only conduct this further analysis for the organoleptic and vitamin A trait preferences for the full sample (Figure 3).

Both the indirect and total effects of preferences for OTs on IVA reveal a dampening effect on the latter. Producers who prefer roots with a good taste and high dry matter content are less likely to prefer vitamin A-rich varieties. Given that vitamin A trait preference has a positive effect on IVA, this positive effect is dampened by preference for OTs, perhaps explaining why OFSP varieties have been reported to have a lower acceptance among end users (Okello et al., 2022), even when such end users have high preferences for vitamin A. Conversely, farmers who prefer varieties that have good taste and are high in dry matter content are more likely to adopt local varieties than improved varieties.

5.2 | Qualitative insights on variety trait preferences

To further ground and triangulate results from the quantitative analysis above, we also present results from the four-cell qualitative assessment tool as discussed before. Similar to results from the quantitative analyses discussed, the results from the qualitative study show that both men and women rank local varieties higher than improved ones, with all three most preferred varieties for women being landraces while men second and third most preferred varieties were improved (Table 4).

Agronomic traits that make local landraces most preferrable include drought tolerance and early maturity, while these varieties were also mentioned to have good tasting roots with high dry matter content. This is in line with results observed from the quantitative analyses, where agronomic

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TABLE 4 Qualitative assessment of sweetpotato variety and trait preferences.

	Variety		Preferred trait in variety				
FGD type	Name	Rank	Agronomic	Visual	Sensory	Processing/Cooking	Nutrition
Women	Kasagaati[a]	1	Early maturing High root yield Drought tolerance	Big and long roots Thin smooth skin	Good taste High dry matter content	Easy to peel	–
	Muwulu aduduma[a]	2	High root yield Early maturing Drought tolerance	Big and long roots	Good taste Not fibrous High dry matter content	Short cooking time Long storage life	
	Bunduguza omukaire[a]	3	Early maturing High root yield		High dry matter	Long shelf life	
Men	Bunduguza omukaire[a]	1	Early maturing Drought tolerance High root yield	Big roots	High dry matter content Good taste Soft when cooked	Short cooking time Long storage life	
	NASPOT (8 and 13 O)[b]	2	Early maturing High root yield Drought tolerance	Big and long roots	-		vitamin A
	Ejumula[b]	3	Drought tolerance High root yield	Big roots	Mealy	Does well in poor soils	vitamin A

Abbreviation: FGDs, focus group discussions.
[a]Landrace.
[b]Improved variety.

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TABLE 5 Variety trait rankings by FGD (focus group discussion) type.

Men			Women		
Variety	Trait	Rank	Variety	Trait	Rank
Bunduguza omukaire	Early maturing	1	Kasagaati	Early maturing	1
	High dry matter content	2		High root yield	2
	Drought tolerant	3		Drought tolerant	3
	High root yield	4		Sweet taste	4
NASPOT 8	Early maturing	1	Muwulu Aduduma	High root yield	1
	vitamin A	2		Big and long roots	2
	High root	3		Sweet taste	3
	Big roots	4			
Ejumula	Early maturing	1	Bunduguza omukaire	Early maturing	1
	Drought tolerant	2		High root yield	2
	High root	3		High dry matter	3
				Long shelf life	4

and OTs were key traits in driving variety acceptance among women. Preference for VTs (i.e., big and long roots, and smooth skin) was also a key trait in preferred varieties, similar to results observed in the quantitative assessment before especially for the men subsample. A significant departure from earlier observed results regards vitamin A trait preference, which was shown to play a major role in shaping variety acceptance among women in the quantitative study, but now only observed as a key trait in the second and third most preferred varieties (both OFSP) among men. One possible explanation for this could be that men had more information on improved varieties that were close substitutes to the landraces, and therefore ranked these high as preferred varieties, given their nutritional value. The qualitative study also reveals other preferences missing from the quantitative assessment, especially around traits with implications on gender roles. Varieties that were easy to process and cooked easily were highly preferred among women, with all three women-preferred landraces said to have these traits. Such traits are therefore critical for the acceptance and adoption of improved varieties by women and have gender implications of reducing drudgery for female end users. This result amplifies the importance of a mixed-methods approach in understanding variety trait preferences for a comprehensive elicitation.

Finally, pairwise ranking of the trait preferences in the qualitative assessment revealed that ATs are consistently ranked high among men and women, indicating their importance to farmers (Table 5).

This is especially so for early maturing trait, which is seen as the most preferred trait across the preferred varieties by men and women producers. Sweet taste and dry matter content are the most preferred quality traits among men and women.

6 | CONCLUSIONS

Using a gendered approach, the study utilizes rapid assessment mixed-method approaches to understand preferences for sweetpotato variety traits that drive acceptance for improved and local varieties. Results from the quantitative analyses show that preferences for vitamin A and high yields are key to acceptance of improved varieties. Additional insights from the qualitative assessment confirm these findings, with ATs such as high yields, early maturity, and drought tolerance being key preferred traits by both men and women, while vitamin A is the main trait of preference in improved varieties of the OFSP family. Consistent with findings from the quantitative assessment, sensory traits, such as good taste and dry matter content, are key drivers to the preference for local varieties, with the improved varieties mentioned (belonging to the OFSP family) said to be missing these traits. The qualitative assessment also reveals that VTs, such as smooth skin and big and long root, are also key preferred traits found mostly in the local varieties, and therefore making these more preferable compared to the improved varieties. These preferences are also heterogeneous across genders, with women more inclined toward preference for sensory and VTs, while men are more inclined toward the preference for mentioned ATs. Similarly, women also that have less drudgery-inducing traits such as easy to process and cook.

These results have profound implications for the design of sweetpotato breeding programs aiming at achieving accelerated adoption rates of its varieties. Key traits that are preferable across genders, like early maturity, drought resistance, and high yielding, represent must-have traits in terms of breeding objectives. Similarly, good taste and high dry matter content are critical traits for the acceptance of improved varieties, especially among women. Enhancing taste and dry

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matter in varieties that have agronomic and nutrition gains has the potential of increasing acceptance for improved varieties in general and reducing the gender technology adoption gap in particular. Other important traits for women such as smooth skin, big and long-shaped roots, and short cooking time also have the potential to enhance acceptability of improved varieties and should be considered in breeding objectives. More research is however warranted to identify acceptability thresholds of these traits, especially sensory traits, since too high levels of these may have negative implications for other important gains such as processability and vitamin A content.

AUTHOR CONTRIBUTIONS

Chalmers Kyalo Mulwa: Conceptualization; data curation; formal analysis; methodology; writing—original draft; writing—review and editing. **Hugo Campos**: Funding acquisition; project administration; writing—review and editing. **Irene Bayiyana**: Formal analysis; writing—review and editing. **Srinivasulu Rajendran**: Writing—review and editing. **Reuben Ssali Tendo**: Writing—review and editing. **Margaret McEwan**: Writing—review and editing. **Simon Heck**: Writing—review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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