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# A gendered assessment of crop traits to improve breeding product design and uptake: the case of potato in Kenya

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The study assesses the gender implications of a target product profile for table potato in Kenya. Breeding programs mostly emphasize farmers' trait requirements and rarely pay attention to other value chain actors' preferences. This partially contributes to the low uptake of improved varieties. Therefore, efforts are required to assess the gender implications of crop product profile proposals during development, testing, and dissemination. In this paper, we assess the gender implications of traits targeted by a potato breeding program in Kenya using the G+ tools. The study applies the G+ product profile tool to examine the instances the selected traits may exacerbate gender disparity along four domains: unpaid labor, access to employment opportunities, requiring extra inputs and control over benefits. We use mixed methods including a review by social scientists, key informant interviews and a multistakeholder workshop to gather insights from female and male farmers, breeders, and other stakeholders. Findings show that pest, disease resistance, and shelf-life traits benefit women and men in the target customer segments. On the other hand, earliness, dry matter, and yield could increase drudgery for women. The traits increase demand for women's unpaid labor during harvesting, sorting and food preparation time while also displacing women from profitable nodes. We recommend that gender-responsive strategies accompany the release of the target variety to mitigate inequities and enhance adoption.

## KEYWORDS

gender-responsive, breeding, potato, target product profile, G+ tools, traits preferences, Kenya

## 1 Introduction

A senior breeder recently said at a multistakeholder meeting convened to map trait preferences of different breeding customers: "We breed for all people, not women." Many breeders share this sentiment. That is, there is little recognition that breeding customers extend beyond the farm and are a heterogeneous group of actors along the value chain actors with different interests. The disconnect between breeders' and customers' preferences arises from a lack of interest in each other's perspectives (Haverkort et al., 2022). Participatory Plant

Breeding (PPB) and Participatory Variety Selection (PVS) were introduced to address the divide and dominance of breeders' priorities in designing new varietal traits and accelerate the adoption of customer preferred traits. Nonetheless, despite considerable gains in breeding programs, the input of men and women across crop value chains in the traits they would like to see in improved varieties is uneven. There has been slow progress in the incorporation of gender preferences in breeding processes, even with the recognition that this could help increase adoption. The failure to consider the varietal and trait preferences of heterogeneous customers is linked to the low adoption of improved varieties developed by the Consultative Group for International Agricultural Research and National Research Institutions (McEwan et al., 2021; Thiele et al., 2021). Consumption traits that are hardly considered have a significant role in impeding adoption (Walker and Alwang, 2015). While improved disease resistance motivates adoption, "entrenched consumption preferences are major constraints to adoption."

The PPB and PVS processes were to get information from all customers (consumers, traders and the industry) besides the farmers for poorly understood varietal traits (Walker, 2006). Conversely, plant breeders have used these approaches mainly to get feedback from farmers albeit late in the breeding process. The feedback has also tended to focus on the elite clones developed on-station (Almekinders et al., 2006). Failure to consider the trait preferences of the broader group of breeding customers along the entire value chain leads to the promotion of unsuitable varieties, resulting in low adoption rates among important actors (Muhinyuza et al., 2016). For example, Kisakye et al. (2020) found that in Uganda, the desired characteristics of raw potatoes differ among stakeholders in the potato industry. Producers, traders, and consumers prefer potatoes with red skin color, yellow flesh color, smooth skin, and big size tubers. On the other hand, processors favor potatoes with white/cream flesh color, medium to large size, shallow eye depth, smooth skin, and high dry matter content.

Gendered trait preference of value chain actors predisposes women to lower adoption of certain improved varieties (Mudege et al., 2021). New crop varieties might possess traits that inadvertently disadvantage women, leading to an increase in their workload or necessitating additional inputs that women have limited access to compared to men (Kramer and Galiè, 2020). Women usually prioritize culinary traits in relation to their caregiving roles, while men opt for market-preferred traits (Mudege et al., 2021). Differences in trait preference are related to the varying actors' roles in the crop value chains (Okonya et al., 2019). Banana, cassava, and potato studies show that the preference for traits varies with the sociocultural context, gendered labor, and access to markets. Rather than conforming to rigid, binary models where women and men have distinctly different preferences, there exists an overlap (McDougall et al., 2022). Female cassava processors prioritize culinary traits that are given low priority in breeding profiles (Teeken et al., 2018). Male processors tend to focus on agronomic traits with preferences depending on geography and religion. Male and female banana growers' trait preferences differ and align with gender-specific roles. Female farmers are involved in cooking and male farmers in the manufacture of beer (Marimo et al., 2020). While men and women have common preferences in traits such as drought tolerance and pest resistance, there are gender variations for attributes such as seed coat color (Jinbaani et al., 2023).

Breeding programs have to understand their clientele and take into account their varying roles, choices, and the implications of

varietal traits on the different gender categories. There is a consensus on the significance of breeding programs being more gender-responsive but treading unfamiliar territory. A primary obstacle is the absence of data on gendered preferences and the incomplete knowledge/expertise of how to incorporate this information into the different phases of breeding profile building. In this paper, therefore, we apply the G+ tools (Ashby and Polar, 2021a) to interrogate, with a gender lens, a target product profile (TPP) for table potato in Kenya with the *Shangi* variety as the benchmark. The paper specifically examines the use of the G+ tools under three settings, namely: (1) review by social scientists based on their expertise with support from existing literature; (2) subjecting the G+ tools to opinions of key informants drawn from across potato value chain; and (3) administering the G+ tools to participants in a multistakeholder workshop involving breeders, agronomists, social scientists and customers representing key roles or functions in the potato value chain. The specific objectives of this paper are:

- i Assess the gender implications of each trait in the table potato target product profile using the G+ tools.
- ii Compare the outcome of G+ tools in assessing varieties of traits under different methods.

## 2 Study context

Potato is a major crop in tropical highlands of sub-Saharan Africa (SSA). With approximately 800,000 farmers in potato cultivation, potatoes have emerged as Kenya's second most important food crop, gaining popularity in 15 counties, particularly in the Rift Valley and Western regions (CIP, 2019). Due to its productivity per unit area and time, potato cultivation holds significant promise in ensuring food security (Muthoni et al., 2013). It reduces poverty by serving as a livelihood source for farmers and individuals involved in the value chain (Gikundi et al., 2023). According to the National Potato Council of Kenya, consumption projection by 2022 was 2.3 million Metric Tons, with an average consumption per person of 5 kilograms per year. A 40% increase in the number of farmers growing potatoes could lead to a 0.3% boost in Kenya's GDP (National Potato Council of Kenya, 2023). The varieties grown include Unica, Dutch Robijn, Asante, Tigoni, Desiree, Kenya Karibu, Kenya Sifa, Sherehekea and Shangi. Shangi is incredibly popular and currently commands an estimated 80% market share (National Potato Council of Kenya, 2023). Shangi's popularity can be attributed to its appropriateness for boiling, shorter cooking time, early maturation, large tubers, and high yields (Sinelle, 2018).

For decades, breeders have strived to introduce new potato varieties in SSA to improve production and productivity. While these efforts have led to the release of new varieties, only a few are utilized by farmers (Mumia et al., 2018). The study emphasizes the limited attention breeding programs paid to quality traits, which consumers, especially women, prioritize when selecting table potatoes. Further, it notes that potato breeding has focused on disease and climate change resilience, ignoring marketability and cooking quality traits which are central to end users' preferences. Insufficient attention paid to consumer-preferred traits has led to low adoption of roots, tuber and banana modern varieties but there is a paucity of ample evidence to determine whether the neglect

of gender differences among users contributed to low adoption (Thiele et al., 2021). The gender dimension of low adoption of improved varieties has been explored recently, and findings indicate a paucity of research on gender-specific potato trait preferences (Mudege et al., 2021).

Gender roles determine access to knowledge, resources (including plant genetic resources), decision-making, labor allocation and control over benefits and employment, all of which have a role in varietal adoption decisions (Tufan et al., 2018). The actor's role in the value chain, individual and household characteristics, and cultural factors influenced end-users' prioritization of traits (Weltzien et al., 2019; Marimo et al., 2020). Gender-specific preferences and intrinsic cooking quality characteristics such as color, flavor, and text were critical to adopting new hybrid banana varieties (Nasirumbi Sanya et al., 2017). Understanding gendered trait preferences as an expression of underlying structural gender inequalities in assets, resources and opportunities for growing and processing a crop can help breeders assess demand for new varieties that address gender-specific objectives for food, nutrition or economic security (Polar et al., 2022). Weltzien et al. (2019) portray the adoption of new crop varieties as a coping strategy in the face of changes in agroecological and social conditions that are major transformative factors of farm and food systems. Production goals (subsistence versus commercial), understood as coping strategies, can often differ by gender and may play a significant role in the varietal preferences of women and men. Women often prioritize production for home consumption and usage traits, and men favor market traits, reflecting their unequal access to markets and commercial opportunities (Elango and Kawarazuka, 2019).

In Uganda, Mudege et al. (2021), while developing a gendered product profile for boiled potatoes, concluded that in addition to agronomic traits, breeders need to consider how gender roles and social norms condition market relationships and feed into trait preferences which influence the selection of new varieties by farmers. Household members are employed, among others, as producers, hired farm labor providers, and pesticide applicators, and they provide significant unpaid family labor. Women mostly engage in seed conservation, establishment, weeding, roguing, harvesting and packaging. These activities are not mechanized, are backbreaking, and are offered as unpaid family labor. Men are involved in initial land preparation, pesticide application, transportation and selling to urban markets (Okello et al., 2020).

In contrast to activities done by women, men-led activities are mechanized and geared towards commercialization. For example, land preparation is done using oxen ploughs. With the commercialization of potatoes, men can hire labor in joint activities like pest and disease control; women fetch the water for mixing chemicals while men operate the spray pumps (Okello et al., 2020). Further, even when it comes to participation in profitable activities such as seed production, it is estimated that 78% are men (Sebatta et al., 2014). Potato contributes 22% of the income for male farmers transitioning from subsistence farming to commercial compared to 17% for women (Mugisha et al., 2017). Men are the main price negotiators in commercial potato production (Kyomugisha et al., 2017). Commercial potato seed production is a male niche because women lack productive resources. At the household level, gender disparities exist concerning access to products and services offered by upstream (such as seed traders and extension workers) and downstream actors (such as traders/marketers, transporters, processors and consumers). For instance, women have limited access to agricultural extension services, improved seeds, fertilizer and pesticides mainly due

to low mobility and purchasing power (Kisakye et al., 2020; Mudege et al., 2020; Puskur et al., 2021). This is compounded by their limited access to and control over benefits from the potato enterprise. The above findings call for gender mainstreaming across the breeding pipeline, i.e., from setting breeding objectives to varietal release and dissemination. Specifically, there is a need to assess the effects breeding for specific traits can have on men and women.

## 3 Materials and methods

### 3.1 The G+ tools

The G+ tools are a suite of three tools which assess the gender-responsiveness of target or actual breeding product profiles at the variety design stage and other stages of varietal development. The tools include (i) the G+ Customer Profile tool (Orr et al., 2021), (ii) the G+ Product Profile Query tool (Ashby and Polar, 2021a) and (iii) the G+ Standard Operating Procedure tool (Ashby and Polar, 2021b). The G+ Customer Profile organizes the evidence from gender analysis, including information on how men and women value important plant traits, to decide which customer segments to prioritize using a socially inclusive and gender perspective (Orr et al., 2021). For a specific customer, the G+ Product Profile Query (G+ PP) appraises each trait proposed for inclusion in the design of a variety, i.e., Product Profile (Ashby and Polar, 2021a). Together, they provide a framework for multidisciplinary research teams to incorporate the results of gender analysis into two decisions that public-sector plant breeders routinely make for variety development. These are (i) the intended customers of the plant breeding products, that is, varieties and (ii) the important features of the breeding product intended for this customer. The tools have been piloted in sweetpotato (Uganda), beans (Kenya), cassava (Nigeria), bananas (Uganda) and lentils (Morocco) value chains (Polar et al., 2022).

In this study, we applied the G+ PP tool. This tool organizes and synthesizes the evidence from gender analysis so that the breeding team makes evidence-based judgments to evaluate each trait's positive and negative features from a gender perspective. Specifically, the G+ PP tool assigns two "gender impact" scores to each trait in a product profile: (i) a negative or neutral score based on a "do no harm" analysis and (ii) a positive or neutral score based on a gendered analysis of the benefits of each trait. Scoring is similar to the nominal index breeders use to assign a value for disease tolerance of a variety. The tool requires the breeding team to make the final choice or trade-off, between the positive and negative gender aspects of each trait analyzed by providing a traffic light warning system: (i) Stop- there's a risk of overlooking an important gender inequality (ii) Take care- there are ambiguous gender inequality outcomes or (iii) Go- a gender-neutral or beneficial outcome is possible.

Lastly, the G+ PP tool evaluates individual traits included or proposed in a breeder's target product profile<sup>1</sup> (TPP). As illustrated in Figure 1, for each trait, the tool generates a gender impact score for "Do No Harm" ranging from -2 (reject) to 0 (gender neutral) and another gender impact score for "Positive Benefit" ranging from 0 to +3 (required). Two scores are generated because breeders

<sup>1</sup> A target product profile simply refers to a description of traits that are embodied in a variety.

often weigh trade-offs between the downside and upside of a given trait to decide whether to include the trait in the final TPP. In the “Do no harm” scale, -2 implies an increase in the gender inequality dimensions with serious harm to women and men or households’ wealth and welfare for more than 50% of the target customer segment. A score of -1 shows moderate harm for the majority, and variety release should be accompanied by interventions to remove identified gender inequalities. A score of zero implies that the trait is gender neutral for the “Do no harm” and “Positive benefit” assessments. For the “Positive benefits” scale, a score of +3 is rated as a ‘must have’ trait with benefits with anticipated major improvements for all women and men or household wealth and welfare in a target customer segment. A score of +2 implies significant improvement for the more than 50% of the women. Such a trait is rated to be ‘important’. A score of +1 implies a moderate benefit for most women in the target customer segment and is rated as ‘nice to have’ (Figure 1).

### 3.2 The PASTTA project

We applied the G+ PP tool to assess the table potato TPP developed under the Partnership for Seed Technology Transfer in Africa (PASTTA) project. The PASTTA project is a Global Development Alliance (GDA) between the United States Agency for International Development (USAID) Feed the Future initiative and the Syngenta Foundation for Sustainable Agriculture (SFSA). Its main objective was to assist African smallholder farmers in Mali, Senegal, Kenya, Malawi, and Uganda in accessing quality seeds of improved crop varieties to increase their productivity and profit/income. The project targeted seven staple food and cash crops: sorghum, maize, pearl millet, beans, groundnut, soybean, and Irish potato (herein referred to as potato).

CIP provided gender expertise, which, among others, entailed a gendered analysis of the table potato TPP focus traits using the G+ PP. The profile targeted six traits (Table 1): disease and pest

resistance, tuber yield, Earliness, dry matter content and shelf-life. The TPP aligns with the findings of Okello et al. (2019), which indicate that the primary factors driving potato farmers’ decision to invest in quality seed potatoes are “high yield,” “good taste,” “early maturity,” “disease resistance,” and “long shelf-life.” The first version of the TPP was created in 2019, coinciding with the launch of Seeds to Business Project’s new strategy. The version was based on a demand-led breeding TPP template and tailored to fit the context of the Syngenta Foundation’s activities. Ideally, conducting a market study would be necessary before writing the TPP. However, the extensive list of segments made conducting a market study impractical. To overcome this challenge, the team developing the TPP relied on various sources of information, leveraging internal expertise through local utilizing internal and external protocol examples sources and conducting extensive bibliographic research.

The TPP is benchmarked on Shangi, which has existed in Kenya for less than one decade. Shangi “escaped” from the breeding station/program during trials/evaluation and went into spontaneous production, multiplication and dissemination by farmers before its official release in 2015. Shangi is one of the dominant potato varieties in Kenya. Among the things that have made it very popular with farmers is its short dormancy. It also has good taste and high demand. This is usually a testimony to a variety of highly desirable end-user traits. The TPP creates preference groups from Syngenta’s client/customer base. These preference groups are determined by identifying distinct needs and preferences of different segments. Among these groups are women (W), whose preferences are highly sought after and catered to in Syngenta’s variety’s design.

Similarly, men (M) have specific preferences addressed through intentional design considerations. Additionally, the younger demographic, encompassing both men and women under 30 (Y), is recognized by targeting to incorporate traits that align with their preferences. Lastly, a category denoted as W + M + Y (All) indicates that the traits associated with this group suit users across different genders and age groups.

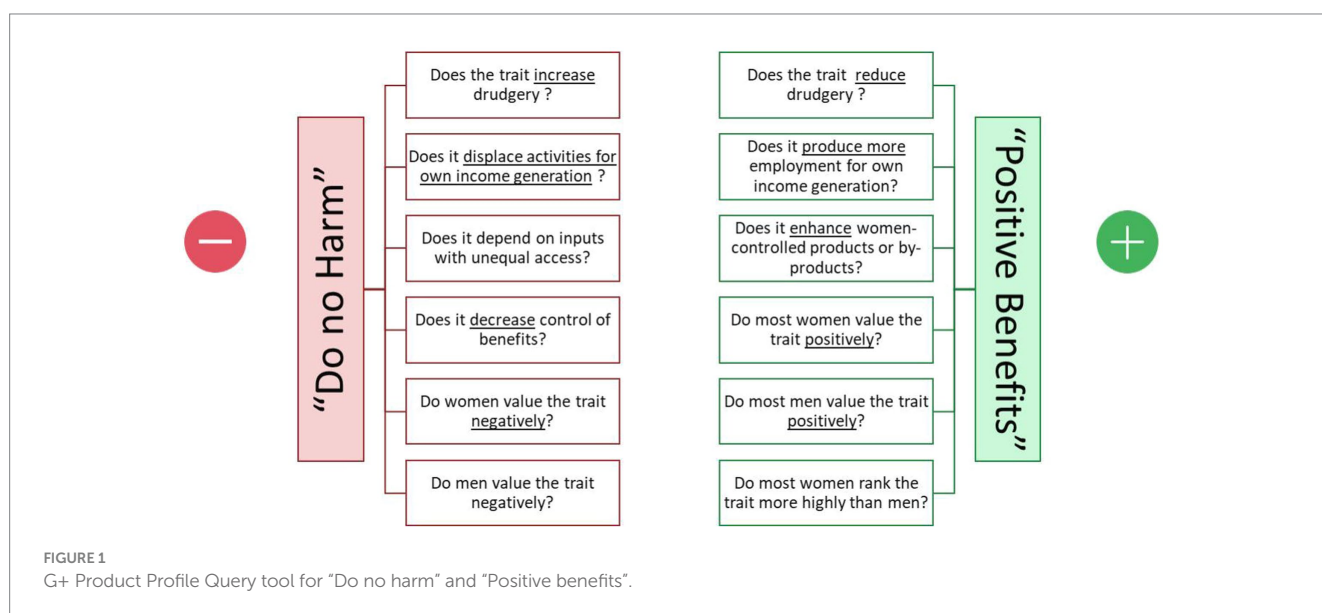


TABLE 1 Target product profile developed by PASTTA project for table potato in Kenya.

Client/customer	Driver	Trait category	Preference group: Women (W); Men (M); Youth (Y); All (W + M + Y)	Trait demand classification: 1 = Essential/"must-have"; 2 = Niche opportunity; 3 = Added value; 4 = Winning trait	Target traits	Trait description (Quantitatively measures)	Name of benchmark variety	Performance required compared to benchmark variety, etc.
Consumer	Satisfaction		All		Dry matter content (%)		Shangi	$\leq$
Farmer	Crop management and harvesting	Plant architecture	All	3	Earliness (days), normalized by Planting date	Maturity date – planting date	Shangi	$\leq$
	Productivity	Yield components	All	3	Tuber Yield (t/ha), normalized by Plot area (m <sup>2</sup> )		Shangi	$\geq$
		Biotic stress resistances	All	3	Pest resistance	Percentage of plot infected	Shangi	$\geq$
		Biotic stress resistances	All	3	Disease resistance	Percentage of plot infected	Shangi	$\geq$
Retailer	Sales and profit	retailer shelf-life	All		Shelf life	Number of days after sprouting	Asante, Shangi	$\geq$

### 3.3 Data collection

One objective of this paper is to compare three methods to evaluate individual plant traits listed in [Table 2](#): desk based social scientists review (SSR), interviews with key informants (KIIs) drawn from key roles and functions in the value chain, a multistakeholder workshop (MSP) in which the tool was applied to generate consensual judgments using evidence from gender analysis. The three methods were undertaken in a stepwise fashion. The need to trial different methods arose from the paucity of available evidence in applying the G + PP tool, which involves scoring each plant trait in the Product Profile using the G + PP gender gap questionnaire ([Ashby and Polar, 2021a](#)). This questionnaire is designed to help the breeding team select and organize the results of available gender analyses of the target customer population relevant to each plant trait under consideration. The social scientists' review identified gaps in the evidence needed to complete the G + PP gender gap questionnaire.

Therefore, we collected primary qualitative data from key informant interviews (KIIs) and a multistakeholder workshop to address the lack of suitable evidence.

#### 3.3.1 Step 1: social scientists' review

In April 2021, 4 CIP social scientists (3 agricultural economists and 1 gender scientist) reviewed the TPP to engender it. To support their analyses of gender impact scores, they relied on a scoping literature review of published and unpublished sources. The scoping review sought to gather information related to drudgery, as well as the roles and responsibilities of men and women farmers in the potato value chain in Kenya. Due to the limited availability of gender-specific studies and the lack of explicit coverage of the issues in most relevant research, a systematic review was not feasible. The primary objective of the search was to address the 12 questions outlined in the gender gap questionnaire ([Ashby and Polar, 2021a](#)). Google Scholar and CG Space databases were utilized to search, using keywords such as gender, Kenya, potato, men, women, female, male, unpaid labor, control, employment, benefits, equity, traits, farmer, and preferences.

#### 3.3.2 Step 2: key informants' interviews

Key informants' interviews were conducted with 13 (7 male and 6 female) selected from the different nodes of the potato value chain to represent the major actors. The participants included breeders (1 male and 2 female), seed producers/trader (1 female and 1 male), agricultural extension worker (1 female), commodity marketer (1 male), farmers (2 female and 1 male), food scientist (1 male), social scientist (working with the breeding program) (1 male) and social scientist (national potato council) (1 male). They were interviewed by phone using a checklist of questions adapted from the G + PP tool to probe their assessment of the effects each trait was likely to have on women and men using the parameters shown in [Figure 1](#). The traits assessed during the interviews were limited to traits prioritized by the PASTTA project for the target potato TPP. A trained research assistant conducted the interviews between August and September 2021.

#### 3.3.3 Step 3: multistakeholder workshop

In the third stage we conducted a workshop with participants from different nodes of the potato value chain selected using the EiB guide ([Mashonganyika, 2018](#)). The participants included breeders (2

male and 1 female), seed producers/trader (1 female), agricultural extension worker (1 female), commodity marketer/trader (1 male), farmers (2 females and 1 male), food scientist (1 male), social scientists (2 male and 1 female) and gender specialist (1 female). All the actors were also potato consumers; hence, we did not include separate representatives for the consumer node due to limitations on the size of face-to-face meetings imposed by the COVID-19 restrictions.

The one-day workshop was designed so that participants would discuss the gender implications of the table potato TPP ([Table 1](#)), and generate consensus scores on the gender impacts. The workshop was organized into four sessions: the first session introduced the participants to the purpose of the meeting. It exposed them to gender principles and how culture and social norms entrench gender inequalities in agriculture. To summarize the session, participants watched a video illustrating how culture and social norms influence gender in sweetpotato production. The second session explained the gender assessment process and discussed the questions used in generating the scores to ensure that all participants understood the questions and scoring process.

In the third session, participants were paired and asked to score the traits in the CSPro program using the tablets to ease data entry, collation, and analysis. This exercise allowed familiarization with the gender assessment explained in the second session. Finally, in session four, the results of the scores were presented to the whole group. The groups whose scores differed from those of others were asked to explain their scores and the whole group discussed the responses in the plenary. Explanations were offered, and key points from the discussion were recorded. Based on the results and ensuing discussion, the participants were asked to agree on a consensual gender impact score for each trait.

## 4 Results

This section presents, first, the assessment of five traits with the G + PP tool using the findings from the three methods used to generate the judgments required for scoring. Next, the comparison of the methods is presented.

### 4.1 Gender analysis of the table potato TPP traits

The findings of the assessment of five traits using three methods: desk-based social scientists review (SSR), individual interviews (KIIs) and assessment by the multistakeholder workshop participants (MSP), are presented in [Figure 2](#) and [Table 2](#).

#### 4.1.1 Dry matter

The results indicate SSR associates high dry matter reduced drudgery for female farmers and consumers a positive benefit ([Figure 2A](#)). According to the reviewers, the trait improves the acceptability of boiled potatoes for all household members, regardless of age. An increase in mealiness enhances the taste and reduces cooking time, reducing women's unpaid domestic labor. The KIIs discussed trade-offs associated with dry matter, other traits and the implications. A food scientist pointed out the link between high dry matter content and small tubers, which could increase peeling time

TABLE 2 Engendered product profile – with the overall gender impact scores<sup>1</sup> for each trait.

Client/ customer	Driver	Trait category	Preference group: Women (W); Men (M); Youth (Y); All (W + M + Y)	Target traits	Trait description (Quantitative measures)	Name of benchmark variety	Performance required compared to benchmark variety	Social Scientists (SS)		Individual Interviews (KIs)		Multistakeholder workshop participants (MSP)	
								"Do No Harm"	Positive Benefit	"Do No Harm"	Positive Benefit	Consensus scores <sup>2</sup>	
												"Do No Harm"	Positive Benefit
Consumer	Satisfaction	Consumer	All	Dry matter content (%)		Shangi	≤	0	3	0	3	-1	3
Farmer	Crop management and harvesting	Plant architecture	All	Earliness (days), normalized by Planting date	Maturity date less planting date	Shangi	≤	-1	2	0	3	0	3
	Biotic stress resistances	All	Pest resistance	Percentage of plot infected.	Shangi	≥	0	3	0	3	0	3	
				All	Disease resistance	Percentage of plot infected	Shangi	≥	0	3	0	3	0
Retailer	Sales and profit	retailer	All	Shelf life	Number of days after sprouting	Asante, Shangi	≥	0	3	0	3	0	3

<sup>1</sup> -1 = Amend; 0 = neutral; 1 = nice to have 2 = important; 3 required. <sup>2</sup>The consensual score was agreed upon based on the plenary session discussions.

and thus increase women's unpaid labor. Further, high dry matter content does not necessarily equate to reducing cooking time, which depends on the preparation method. Per the KIIs agribusiness officer, dry matter alone will not guarantee a reduction in cooking time. The officer gave the example of Dutch Robijn, a potato variety with high dry matter which takes long to cook and has an unpleasant taste rendering it unsuitable as a table potato.

MSP highlighted the trade-off between high dry matter and early maturity. Participants reflected on a low-dormancy and early maturity variety, Sherehekea to evaluate the trade-off. Sherehekea has lower dry matter content and a longer maturity period than Dutch Robijn. This trade-off holds implications that farmers prioritizing early maturity may need to make concessions in achieving the desired dry matter content. This compromise could influence the quality characteristics of the harvested potatoes.

Further, contrary to SSR and KIIs, MSP associated dry matter with the likelihood of displacing women from income-generating activities. They argued if the trait implied a heavier tuber, it would generate more income, hence the likelihood of potato farming becoming a male-dominated enterprise. Secondly, though high dry matter was perceived as attractive to chips processors and consumers, the MSP concluded that women processors using such varieties risked losing control over their income to their spouses as the business became more profitable. Thus, while the trait benefits consumers, female farmers and processors will likely face negative income benefits.

#### 4.1.2 Earliness

SSR results in Figure 2A shows that early maturing potatoes could increase drudgery, displace women from their income generation activities and lose control over income. If the trait attracts male farmers to engage more in commercial potato production, women may have less control over the income generated from the crop.

The SSR noted that early maturing potato varieties may lead to increased drudgery for farmers due to intensified labor requirements. Farmers may need to invest more time and effort into planting, tending, and harvesting early varieties than traditional ones if the planting cycle is doubled. This shift in labor requirements may favor male farmers if specialized knowledge, physical strength or mechanization are prerequisites for this engagement. The KIIs and MSP assessments, considered earliness to be positively valued and beneficial to women farmers. Most farmer KII respondents associated earliness with alleviating labor constraints in production, such as minimizing planting, weeding and spraying needs and reducing the labor required for monitoring thefts. Male farmers observed that earliness increases farmers' returns to land and capital. It enables a farmer to grow the crop thrice a year and increases profits because early potatoes are sold at a higher price when there is no glut.

However, a breeder in the KIIs had a different perspective, noting that the effect of earliness farmers' labor requirements would remain the same, hence no influence on unpaid time. Even if farmers adopt early planting practices, it would not affect unpaid time because essential farming activities, such as land preparation, planting, weeding, and harvesting, depend on the crop's maturity time. The breeder stressed that early maturity would allow farmers to harvest and sell their crops earlier in the season leading to higher profits or better market prices. The benefit would outweigh any perceived increase in labor requirements, as it provides improved opportunities for farmers to generate income.

According to the MSP, earliness decreases drudgery and enhances women-controlled products, and most women rank the trait higher than men (Figure 2C). They were also aligned with the SSR regarding the narrative that once men got attracted by the high prices associated with earliness, they would take control of the sales, edging out the women. After evaluating the trade-offs between positive and negative gender equity implications of earliness, the MSP decided that earliness is associated with multiple benefits for women, such as reduced cost of production, food security, reduced costs of crop protection products, and minimized tuber rotting incidences. Other positive effects mentioned were adaptation to climate change, reduced disease pressure, reduced labor costs, higher prices in the market, and enabling farmers to plant more than twice a year. Women also benefit from food being available earlier in the season, thus bridging the hunger gap and boosting household food security. Male farmers value increased income opportunities, while women value food security (Okello et al., 2020). The MSP results (Figure 2C) indicate that women rank 'earliness' higher than men, which is divergent from the views of the KIIs and SSR.

#### 4.1.3 Tuber yield

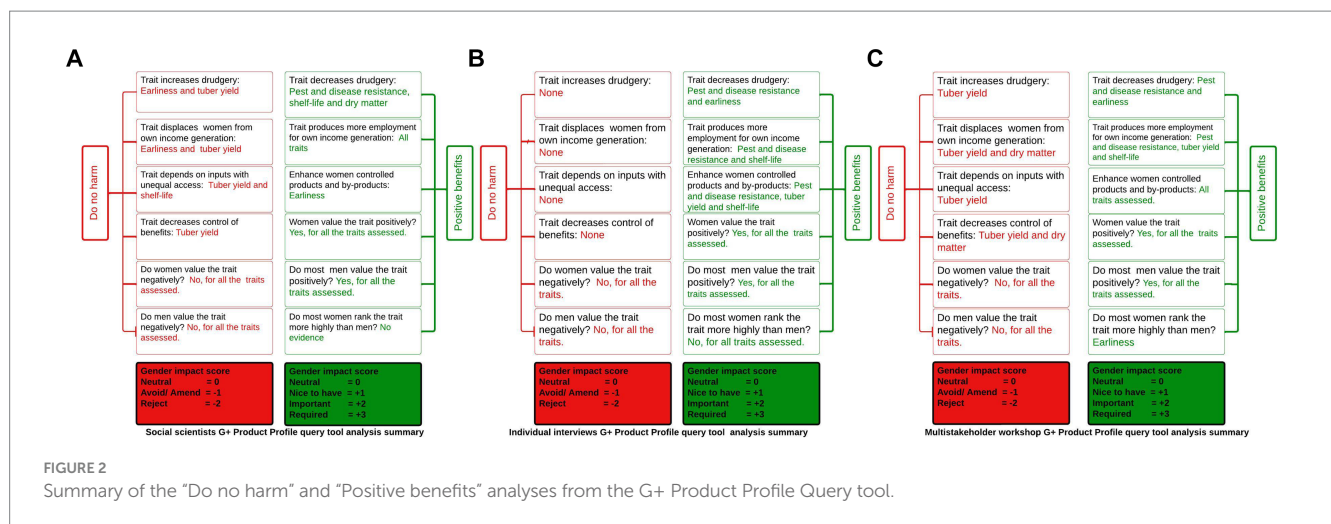
SSR results indicate tuber yield could increase drudgery, displace women from income-generation activities, require inputs with unequal access, and reduce benefits control (Figure 2A). Farmers in the KIIs did not associate increased yield with negative effects for the four dimensions. However, other actors, the agriculture extension officer, seed multipliers and agronomists, observed that increased yields could increase women's workload during harvesting, transporting (from the field to sales or storage points), grading/sorting, packaging and storage. For example, the female seed agronomist noted, "If you have high tuber yields, it means you will need more labor for harvesting, grading, transporting, sorting, packaging and storage..... women mostly do these activities."

Regarding the anticipated effect of tuber yield on income control, the KIIs also had different opinions from the SSR. One breeder mentioned that women's control over income from increased yields could increase, arguing that: "I do not see this trait impacting this [i.e., control of income] since it is more of social arrangement; maybe the women will make more money and might cause some change on the social arrangement. It is about meeting a particular criterion required by the processor." Women farmer participants in MSP mentioned the danger of being displaced by men with the advent of a high-yielding variety in alignment with SSR, which is something that breeders should note.

#### 4.1.4 Pests and diseases resistance

Pests and disease-resistant varieties reduce unpaid family labor use based on the SSR. Biotic stress resistance traits benefit married women participating in labor-intensive pest and disease management practices such as rouging and fetching water for spraying against crop protection products. Further, they associate the traits with increased production, food security, and incomes, which benefit both women and men farmers. From the KIIs, reducing drudgery for women was mainly associated with lower labor costs for female farmers who have to pay the male sprayers. Men benefit because they provide financial resources for purchasing agrochemicals. Pest and disease-tolerant varieties will also minimize pesticide exposure, implying improved health for farmers and consumers. The KIIs associate the trait with





increased employment opportunities and enhanced control of benefits because of higher yields for all the farmers. Workshop discussions highlighted that reducing the usage of crop protection products would reduce drudgery for women because they would not have to fetch water for mixing the pesticides nor purchase water for spraying, thus saving money and reducing time poverty.

#### 4.1.5 Shelf life

The SSR observed that this long shelf life is beneficial; while the TPP targets this trait to retailers, it is important to female farmers. Most female potato farmers who use quality seed rank long-shelf life highly because it enables early entry into the markets, and they are not forced to sell at low prices during the glut (Okello et al., 2019). The SSR assessment shows that shelf-life positively benefits women and inputs and information access are dimensions of inequality that require mitigation. Women retailers could be disadvantaged if they lack access to storage facilities like their male counterparts. Shelf life was associated with increased employment opportunities and enhanced control of inputs, which respondents in the KIIs and MSP considered beneficial. During the workshop, plenary discussions revealed that longer shelf life was associated with reduced post-harvest losses and better prices. The KIIs respondents mentioned reduced fumigation treatments to prevent rotting and cold storage-related costs, while farmers could benefit from price hedging.

#### 4.1.6 Gendered product profile

Table 2 presents an engendered product profile with scores from the three methods. The SSR results revealed that dry matter content was a positively valued trait with potential benefits to women consumers. Its “Do no harm” gender impact was rated 0, and “Positive benefits” scored 3, qualifying this trait as required. The KIIs’ gender impact scores for dry matter were positive, aligning with the SSR assessment. The MSP scored dry matter a – 1 for the “Do no harm,” a result divergent from the SS and KIIs. The MSP elected to retain high dry matter as a priority trait but recommended a mitigation strategy to counter the negative effects of reduced employment opportunities and women’s control over potato income.

The SSR analysis shows that earliness can have both negative and positive effects on gender equality during potato production (Table 2),

depicted by a “Do no harm” gender impact score of –1 and a “Positive benefits” score of 2. “Positive benefits” were associated with better control of products and by-products by women. Potatoes with a maturity period of less than 4 months benefit women because they ensure a stable food supply and income (Mudege et al., 2021). In this study, women mentioned that early sales enabled them to cover basic household expenses like school fees, clothing and hospital bills.

SSR suggested an ‘amend’ for the “Do no harm” assessment of tuber yield. This necessitates developing strategies that foster joint household planning and equitable allocation of benefits to go hand-in-hand with disseminating high-yielding varieties. The strategies will ensure that ‘high yield’ does not further amplify the gender inequalities associated with the allocation of household labor and access to and control over resources and benefits from potatoes. The overall gender impact score generated from the KIIs showed that ‘increased yield’ is required by most women farmers. The informants argued that even if they (women) were disadvantaged in some instances, e.g., the loss of control of the resources, high yield increases food security, which is very important to them. Female farmer interviewees also argued that increased yields could offset the additional labor requirements by selling higher harvest volumes and using part of the proceeds to pay for hired labor.

The MSP final ‘Do no harm’ gender impact score for tuber yield is –1, which aligns with the results of the SSR (Table 2). After the plenary discussions on the likely impacts of the trait, the MSP changed their “Do no harm” score from 0 (Neutral) to amend (–1). This score implies that the trait could induce increased gender disparities related to unpaid labor and control over benefits (Figure 1). Notably, the switch from neutral in the individual and group scoring to amend in the multistakeholder workshop was mostly influenced by contributions from the farmers and extension agents. They argued that, while the potato was mainly a women’s crop in Limuru (located in the highlands of the central region of Kenya), the higher the yield, the more likely men would also start growing it, displacing women from remunerable nodes of the potato chain. This result suggests the need for a gender-responsive strategy to accompany the promotion of high-yielding varieties to mitigate the potential gender disparities.

Results from all three methods indicate that disease and pest resistance are positively beneficial and associated with a major decrease in drudgery for male and female farmers. Thus, they are key

traits given that they were associated with no 'Do no harm' across scoring in all three methods. Following consensus in the workshop plenary session, the "Positive benefits" gender score for pest and disease traits was a 3, implying the trait is required, and participants agreed that "Do no harm" was neutral (Table 2).

Shelf life was the other key trait with a neutral score for 'Do no harm' across the analysis. The SS analysis shows that the trait would benefit most women retailers positively, with the "Do no harm" and "Positive benefits" scores of 0 and 3, respectively. For retailers, reducing value-addition practices to improve shelf-life, such as repackaging to minimize spoilage, could reduce unpaid labor. In addition, a longer shelf-life would reduce losses and costs associated with preservation.

## 4.2 Comparison of methods for generating evidence and engendering the product profile

The methods we used to engender the TPP have different strengths and weaknesses (Table 3). The SSR engaged with the tool more intensively, which helped guide the other methods and identify difficulties early in the G+ tools application. As the reviewers interacted with the literature to support their analysis, they obtained and provided base evidence on the four gender aspects analyzed using the G+ PP query tool. Then, the SSR process is quick and has in-house expertise, which can help identify research gaps to be addressed in future surveys and tool applications. Nonetheless, the approach can be constrained by individual assumptions and beliefs in the assessment process, including evidence gaps concerning gender-disaggregated data and reliance on context-specific studies, lack of a multidisciplinary team and biases of the individual team members.

KIIs provided an opportunity to include up-to-date information unavailable from published literature into the analysis. Additionally, it offered the opportunity to probe and gain an in-depth understanding of the local context and identify gender-specific issues necessary to apply the G+ tools. In this study, the interviews facilitated an understanding of the challenges faced by women. KIIs enabled an understanding of the socio-economic perspective of potato production in Limuru that was contrary and divergent from views held by subject matter specialists and existing literature. Furthermore, KIIs provided an opportunity to gather tacit knowledge from female farmers, who shared valuable insights from their lived experiences, particularly regarding income and benefits control issues. Meanwhile, the breeders expressed their opinions on topics they may not typically be vocal about.

However, the subjectivity of participants is a weakness of the approach and requires keenness to identify respondents that can capture the views of target customers. Onwuegbuzie and Leech (2007) highlighted the potential for bias in interview responses and the difficulty of generalizing findings due to the small sample size. Additionally, as Bergen and Labonté (2020) argued, power dynamics and social desirability bias may affect the accuracy of the information obtained. Also, some interviewees hesitated to discuss issues, especially those related to monetary benefits, perhaps due to societal expectations and power imbalances.

Multistakeholder workshops involving a plenary for consensus building have several strengths that can contribute to their

effectiveness in engendering crop product profiles. The collaborative process enabled stakeholders with diverse values and objectives to develop a shared opinion, understanding and a well-balanced perspective in engendering the TPP. In the workshop, participants could identify trade-offs and deliberate on blindspots not adequately addressed in the other methods. As a result, the method led to robust and gender impact scores that were acceptable to a wide audience. By building consensus on the gender impact scores, multistakeholder workshops strengthen the reliability of the engendered TPP. On the other hand, dynamics within plenary can result in unequal participation and dominance of certain individuals or groups. This can lead to quiet members taking a passive position and affirming consensus that does not adequately represent their perspectives.

## 5 Discussion

### 5.1 Gender-responsive product profiling

While breeders have traditionally considered 'yield' beneficial for all end-users, the analyses showed that the trait could have a potential 'harm' associated with increased drudgery and displacement of women from income-generating activities. Increased income from crop commercialization can displace women from remunerative nodes in the value chain (Mudege and Heck, 2019). Thus, while the recommendation would not be to 'reject' the trait, breeders need to be aware of the potential negative consequences of high-yielding varieties for gender equity. An innovation resulting in income loss could perpetuate dependency and loss of agency (Wigboldus et al., 2016). The fact that women potato farmer participants in MSP mentioned the danger of being displaced by men with the advent of a high-yielding variety raises a red flag that breeders should acknowledge. The findings corroborate those of Beuchelt and Badstue (2013), who found that high-yielding technologies often lead to increased drudgery, especially for women, creating a livelihood trade-off and low uptake of new technologies. Higher yields are associated with higher labor demand, which women may not attain due to the limited mechanization of most activities in smallholder settings in Kenya (Doss, 2018; Kahan et al., 2018). Household labor allocation follows social hierarchies' where men's plots take precedence (Pierotti et al., 2022). Increased yield is associated with complementary inputs such as fertilizer, for which women have unequal access and control (Doss et al., 2011). Even when women have the financial means and cultural support to hire labor, they may encounter difficulties in effectively managing male laborers (Zambrano et al., 2012).

Then, the SSR indicates that a high yield reduces control of the benefits. Mudege et al. (2021) observed that male farmers collaborated with this sentiment. However, while female farmers undertook most of the production activities, men had the upper hand in controlling potato income, aligning with the social-cultural context and gendered division of roles and responsibilities. While tuber yield is an important trait for women, they rarely score it first (Mudege et al., 2021). Thus, the implication is that the new table potato variety distribution should consider social disparities that could emerge in the target areas and how these could affect men and women.

Accompanying tuber yield with complementary technology to reduce drudgery (e.g., simple planters and harvesters) and improve

TABLE 3 Comparison of the strengths and weaknesses of the three approaches to implementing G + PP analysis.

Methods	Strengths	Weaknesses
Social scientists review	<ul style="list-style-type: none"> <li>Provides a research evidence base and support for evaluations on the four aspects under consideration in the G+ PP</li> <li>Allows easy access to a narrative about gender roles, responsibilities, and power relationships in crops</li> <li>Allows sufficient time for interaction with the G+ tools suite for reference and guiding other methods that may be used to generate evidence or scoring</li> <li>Quick methods, when limited with time and resources</li> </ul>	<ul style="list-style-type: none"> <li>They are constrained by a lack of gender-disaggregated data on breeding to inform processes of implementing the G+ tools</li> <li>The main references are context-specific studies; hence, generalizing findings and scores from one context need caution</li> <li>Requires a multi-disciplinary team of specialists to be on the same level of understanding of the application of the tool and deciphering the scale</li> <li>The positionalities of the team and reliance on individual perspectives and experiences can introduce subjectivity and bias into the application of the G+ tools</li> </ul>
Key informant interviews	<ul style="list-style-type: none"> <li>Sets a framework for participants to interact with the tool before the multistakeholder workshop is held</li> <li>It provides an opportunity to probe the complex issues in the G+ PP. Offer a holistic space for stakeholders to share their experiences, perspectives, and knowledge. Gender scientists can gather information not only on technical aspects of crop production but also on broader issues such as traditional knowledge, local practices, and market dynamics</li> <li>Informants possess tacit knowledge gained through experience. This knowledge may not be available through published sources or grey literature</li> <li>Up-to-date and current information about the crop, the latest trends, innovations, or challenges in crop production, ensuring that the crop profile is accurate and reflects the current state of the industry</li> </ul>	<ul style="list-style-type: none"> <li>It is time-consuming, especially where interviews are virtual. Identifying and engaging with suitable informants, arranging interviews, and analysis may require significant effort. Limited time and resources limit the depth and breadth of the interviews or the number of interviews conducted</li> <li>The tool may feel repetitive during the assessment as each trait is assessed independently</li> <li>The positions of the informants may influence the responses. For instance, some model farmers may feel pressured to provide socially desirable answers or may hesitate to express dissenting opinions, particularly when discussing sensitive topics related to gender dynamics or traditional norms</li> <li>Informants may not have exhaustive knowledge of all aspects of the crop or its market. They may have specific expertise in certain areas while lacking insights into others</li> </ul>
Multi stakeholder workshop	<ul style="list-style-type: none"> <li>Up to date, the representative opinion of the participants carefully selected to represent different nodes in the value chain. An ideal mechanism for establishing familiarity among key decision-makers about the product profile</li> <li>Discussion aids in highlighting trade-offs that would otherwise be left in the dark</li> <li>Creates a 'buy-in', especially amongst natural scientists, on the importance of gender in breeding</li> <li>Simplify the cognitive tasks for participants, especially those without prior exposure to the repeated independent gendered assessment of each trait</li> <li>It reveals grey areas and articulates new perspectives to the existing interpretation and adaption of the G+ PP questionnaire</li> <li>Supports the process of validating gender impact scores and improves the reliability of the engendered product profile through negotiation and consensus building</li> </ul>	<ul style="list-style-type: none"> <li>Some participants may be passive depending on the power relations and language used</li> <li>With the multistakeholder team, less confident participants' contributions may be influenced/adversely affected by those of dominant speakers</li> </ul>

access to complimentary inputs could result in a win-win situation. Such technology packages should be easily accessible to women, given their premier role in production and limited ability to purchase improved seeds and fertilizer. For example, packaging fertilizer in smaller packs and promoting decentralized agro-input dealers could increase women's access and use. Consequently, this changes the status quo where women farmers generate lower yields than men because they operate smaller farms with less use of these complementary purchased inputs (Puskur et al., 2021). With regards to the earliness trait, early crop maturity allows farmers to shorten the production cycle, harvest and sell their crops sooner, and perhaps plant twice a

year. This results in increased income from crop commercialization as they can generate revenue more frequently within a given period. Okello et al. (2019) found that only male farmers prioritized 'early maturity' because it fosters early market entry and, thus, better prices.

The final gender score for pest and disease resistance was positive, indicating that these are key traits. The focus on this trait by Syngenta Foundation, which has a more commercial outlook, is timely. According to Gildemacher and ter Steeg (2023), addressing late blight and virus resistance concerns have not received high priority from commercial breeders. The authors note this objective is not aligned with the interests of commercial breeding companies and there has

been a lack of development in varieties with stable resistance to bacterial wilt. Yet, most potato cultivation in the East African region is rainfed, and the control measures implemented by farmers to combat late blight are typically mediocre. Dissemination of pest and disease-resistant varieties should still be accompanied by information on proper use and management. Past evidence indicates farmers use ineffective practices due to limited awareness of recommended pest and disease management practices (Okello et al., 2020). Additionally, women have limited access to new technologies, such as new varieties, given their limited access to extension services, training and limited mobility (Mudege et al., 2020). This calls for gendered integrated pest and disease management training and field advice to accompany the release of biotic-resistant varieties. Just scheduling farmer training (and extension services) does not necessarily help women; rather, the training must intentionally target women (Mudege et al., 2017). For example, training schedules (e.g., time and season), location, methods, and length should be designed with women's needs and abilities in mind. Institutional biases within extensibility reproduce gender inequality. At dissemination, the seed system design should foster equity in availability and access to seed, for example, packaging in smaller units, demonstrations at accessible points, dissemination leaflets with easy-to-decipher graphics and integration of farmer-managed seed systems.

About 27% of potato farmers lose their stocks because of sprouting and greening (Musita et al., 2019). According to Kaguongo (2014), most post-harvest losses occur at the open market level, estimated at 24.4%. Therefore, SSR deemed the trait key and was supported by results from the other methods. These losses result from wastage due to greening, rotting, and sprouting, amounting to 815,000 tons annually, with an approximate value of KES 12.9 billion. However, From the scoping review, SSR found female farmers may be disadvantaged if they lose control over benefits from stored potatoes (Mudege et al., 2016). Men retailers, on the other hand, are disadvantaged due to their limited knowledge of food handling and storage (Musita et al., 2019).

Additionally, breeding for longer shelf life will negatively correlate with short dormancy, a trait women farmers prefer because they can plant their own saved seed from last-season harvest and obtain good yields (Thiele et al., 2021). A short dormancy in bi-modal production regions of Sub-Saharan Africa is advantageous as it allows farmers to replant their farm-saved seeds quickly. Still, its negative effect on seeds' storability causes breeders to hesitate to prioritize it (Gildemacher and ter Steeg, 2023).

The finding relating to short shelf life implies that farmers and male retailers must be given comprehensive post-harvest training to reduce losses and waste. This trait should be closely monitored because of its contrasting implications on gender equality. Longer shelf life may thus harm women who lack equity capital (i.e., savings) to buy externally sourced seeds during planting. Additionally, unlike men, women may not have access to storage facilities and can be marginalized by a variety with a longer shelf life. Poor storage leads to greening and sprouting, and the production of glycoalkaloids associated with a bitter taste in potato tubers harms consumers (Wamuyu, 2019). Thus, producing a variety with short dormancy should be accompanied by a training program targeting these challenges, with special emphasis on male retailers in the case of greening. Since shelf life was the other key trait, breeders should consider these important trade-offs between various value chain

actors, i.e., to remain attractive to women farmers and not negative to traders.

Dry matter was found to decrease drudgery. The results align with Jansky et al. (2010) and Kisakye et al. (2020), who link dry matter to mealiness, a texture most boiled potato consumers prefer. Tubers with high dry matter ( $\geq 20\%$ ) absorb less oil during cooking, making them an excellent choice for health-conscious consumers who seek low-fat food options (Ooko, 2008). The evidence from applying the G+ PP query analysis on dry matter through the different methods should draw the breeder's attention to the highlighted trade-offs, particularly concerning cooking time, tuber size, ease of peeling, and taste. Recent studies, such as Okello et al. (2019) and Mudege et al. (2021), provide support for the preference and benefits associated with the combination of these traits, especially among women when making decisions regarding the use of quality potato seed and in the preparation of boiled potatoes. All these are consumption traits that women prefer but are not in the current TPP. Striking a balance among these traits when adjusting dry matter level is essential to ensure that the resulting varieties meet the desired standards and fulfill the expectations of all farmers and consumers.

Overall, potato breeding programs should expand the focus and development of their product profiles to encompass gender dynamics and preferences. Further, the implication of target traits concerning the use of unpaid labor, access to internal and external inputs, and control over benefits should be considered. Incorporating gender dynamics in decision-making processes and acknowledging women's specific needs and preferences can empower them in agriculture, leading to increased participation.

## 5.2 Strengths and limitations of the three approaches to implementing G+ PP analysis

Tarjem (2022) assesses but does not apply the G+ tools for three uses: (i) communication and marketing, (ii) management and (iii) diagnostic and screening tools. Our assessment complements the diagnostic and screening component. Using the G+ tools at the three levels led to a rich and deeper analysis of the gender implications of the bundle of traits identified. For social scientists, using an evidence base was crucial as it enabled an impartial analysis. Through their expertise, social scientists help inform evaluations of the four aspects of the G+ PP that can be applied to other research areas in an organization. Additionally, they allow for quick analysis while having sufficient time for interaction with the G+ tools suite, enabling a deeper understanding of the subject matter. However, this was challenged by the lack of data and information, especially where existing studies did not provide a gender lens.

Individual interviews were equally rich, with respondents carefully selected to represent a wealth of knowledge in the potato sub-sector. Key informant interviews were an important method to introduce participants to the G+ PP tool and its complexities before engaging in a multistakeholder workshop. Their perceptions augmented the findings of the first stage of the multistakeholder workshop, where participants analyzed pairs. The consensus building in the multistakeholder workshop added a rich layer of confirmatory analysis; hence, it is a significant component of the G+ PP process.

Carefully selected participants representing diverse perspectives and nodes in the value chain are brought together to discuss and evaluate the product profile. The workshop serves multiple purposes, including familiarizing key decision-makers with engendering the product profile, facilitating discussions to address trade-offs that may not have been apparent previously, and uncovering new perspectives. It also aims to create “buy-in,” especially among natural scientists, regarding the importance of considering gender in breeding decisions.

Furthermore, the workshop simplifies cognitive tasks for participants who may not have prior exposure to the G+ PP tool, ensuring their engagement and understanding of its application. Through participatory negotiation, the workshop supports validating gender impact scores and enhances the reliability of the engendered product profile. From the workshop, breeders perceived the resultant analysis positively, some of whom had previously stood on the fence with a minimal appreciation of the gender analysis. As noted by one of the lead breeders: “This has changed my perception a lot: *“I always perceived that we breed for human beings, but now I see the importance of the social perspective to breeding.”* For complementarity and rich gender analysis, the three approaches are recommended for future users. However, should there be a constraint of resources, the breeding program can conduct a cost–benefit analysis to select between the key informant interviews and multistakeholder workshops approaches as the social scientist analysis is given.

## 6 Conclusion

Results from the three approaches identified pest, disease resistance, and shelf life as key traits in the target TPP. The multistakeholder approach findings show yield and dry matter will need accompanying strategies to address the anticipated gender disparities that could arise. Consequently, it shows the importance of gender integration at the various breeding stage gates if we attain varieties that meet end users’ needs.

An important finding from the key informant interviews and multistakeholder workshop is the need to go beyond individual trait assessment, as the interaction between traits has trade-offs. Trade-offs amongst stakeholder requirements for some traits could be better analyzed and inferred if factored during study design. This could be done using the G+ Customer Profile tool to enable better framing and assessing traits to include in breeding profile plans. Additionally, a cross-functional team constituted as recommended by Mashonganyika (2018) engagement in design and product testing to ensure the delivery of a more socially acceptable innovation that benefits all gender categories is recommended.

We also recommend trait dissection (especially for quality traits like dry matter taste and cooking time, which are important for women) to understand the biochemical and biophysical characteristics underpinning these traits. Drawing from Dufour et al. (2021), this would help breeders develop improved selection tools to measure and include or account for quality traits in the product profile, thus enhancing the adoption of modern varieties. To achieve this, the breeding program should constitute an interdisciplinary team comprising breeders, food scientists, gender researchers and agricultural economists. These would allow for a holistic approach to determining and including end-user-preferred traits in TPPs.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Author contributions

JM: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. SM: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. JN: Conceptualization, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. SS: Conceptualization, Funding acquisition, Project administration, Resources, Writing – original draft, Writing – review & editing. CR: Conceptualization, Funding acquisition, Project administration, Resources, Writing – review & editing. CO: Conceptualization, Funding acquisition, Project administration, Resources, Writing – review & editing. GH: Funding acquisition, Project administration, Resources, Supervision, Writing – review & editing. VP: Conceptualization, Funding acquisition, Methodology, Resources, Writing – review & editing. JA: Conceptualization, Formal analysis, Methodology, Writing – review & editing. JO: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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