



Perceived Knowledge of Cassava Value Chain Actors on Varietal Preferences for Various End Uses

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ABSTRACT

This study assessed end users' perceptions about preferred traits for various end uses, constraints, and varietal preferences using Participatory Rural Appraisal (PRA). A purposive sampling procedure was used to identify value chain actors. A total of 360 questionnaires were administered to 120 producers, 72 processors, 72 consumers and 96 traders. The study revealed that, 89.2% of the respondents grow cassava only whilst 82.5% grow and process in the three study districts. Farmers commonly select cassava varieties with focus on high yield, root size, root taste, early maturity period and inner color. Mean rank of studied traits were significantly ($p \leq 0.0001$) differed among cassava producers and processors. In Bo district, high root yield (1st), root size (2nd), dry matter content (3rd) and starch content (4th), were the most important traits. In Bombali district, high root yield (1st), root taste (2st), dry matter content (3rd) and poundability (4th) were the most desired. In Kenema district, high root yield (1st), root taste (2st), maturity period (3rd), and poundability (4th), were the most desired. The overall ranking based on producers' selection criteria revealed that starch content, dry matter content, root size and ease of peeling as the top key traits considered for cassava processing. Results suggest that participatory variety selection and participatory plant breeding techniques should be explored to promote collaborations between stakeholders and breeders for development of new cassava varieties with desired traits including high dry matter content, high root yield, high starch content and other desired key quality traits.

Keywords: Value chain actors, Selection criteria, SWOT analysis, Desired traits, Cassava.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a root crop cultivated by more than 800 million people in the tropics [1]. Cassava is the third most important source of calories in the tropics after rice and maize [2] and is currently a food source for more than 800 million people in Africa, Asia and Latin America [3,4]. The crop possesses useful agronomic attributes such as tolerance to minimal inputs under marginal soil conditions and can also thrive in regions prone to drought [4]. Cassava is mainly cultivated for its starchy roots and nutrient-dense cassava leaves that are

consumed as vegetables in many regions of Africa [5]. Starch constitutes the main component of the cassava root [6] and thus plays an important role in the use of cassava as a food and industrial crop. The economic value for cassava products for end users emanates from the dry matter content and starch content. The performance of cassava starch and dry matter in food, feed and other industrial applications varies according to variety from which the product was obtained [7,8].

In Sierra Leone, cassava is one of the most important food crops widely consumed by a large number of the population as a staple food especially during the rainy season [9]. Several cultivars are grown and most of the cassava produced are consumed in various forms such as boiled, roasted, and are mainly processed into gari, fufu and tho. According to Okogbenin and Fregene [10], dry matter content and starch are important requirements for the transition of cassava from a traditional to an industrial crop. End-use quality significantly affects the acceptance of cassava varieties by farmers and consumers [9]. The success of newly developed varieties is contingent upon the agronomic attributes and acceptability by end users including consumers in terms of sensory and utilization characteristics [11]. Cassava storage roots have diverse uses due to wide variability in storage roots traits, organoleptic, culinary and nutritional properties, making some varieties more appropriate for certain types of food preparation than others.

Participatory Rural Appraisal (PRA) tools have been used to determine end users' preferences in many crop varieties. Manu-Aduening et al. [12] used the PRA technique to describe the characteristics needed for cassava varieties in Ghana and reported that farmers preferred cassava varieties that have early growth and vigor to suppress weeds, early maturing, high yield, good cooking quality for making fufu and suitability for intercropping. Participatory plant breeding approaches such as surveys and focus group discussions have been deemed necessary to elicit such vital information on what is needed by farmers [9,13, 16,15]. With the increase in commercialization of cassava and cassava products, the demand for higher quality varieties with high dry matter and starch contents that meet various needs will become the next obvious challenge.

However, there is dearth of information in Sierra Leone on preferences of cassava farmers, processors, traders and consumers; selection criteria for cassava cultivars, and information on the strengths, weaknesses, opportunities and threats for cassava farmers and processors. This makes a study in this area very necessary because every successful breeding program should be based on distinct identification of constraints and preferences of end users. Farmers are mostly reluctant to accept technologies which are not in line with their preference and consumer expectation [16]. Cassava cultivars that are selected for the market, should, therefore, meet most of these qualities if farmers and processors have to stay competitive in the market and increase income from cassava. The combination of desired traits that meet their culinary, agronomic and other needs are based on local knowledge which is translated into their everyday cultivar selection strategies and practices. Participatory Rural Appraisal (PRA) permits the inclusion of farmers, processors and other relevant value chain actors in research decision making, in planning the generation of new technologies, and also serves as a non-formal approach for detailed data collection [17]. The incorporation of vital information

obtained from the PRA in cassava breeding programmes would contribute to increased adoption of newly developed and improved cassava genotypes.

The research questions that prompted this study included the following: (i) What are the variations among cassava farmers, processors, traders and consumers' preferences for dry matter and starch contents? (ii) What are the variations among cassava farmers and processors' selection criteria for elite cassava genotypes? and (iii) What are the strengths, weaknesses, opportunities and threats that exist for cassava farmers and processors? Thus, the objectives of this study were to (i) assess the preferences of cassava farmers, processors, traders and consumers; and (ii) determine farmers' cassava selection criteria for cassava cultivars; and (iii) determine SWOT analysis for cassava farmers and processors.

METHODOLOGY

Study Area

The Participatory Rural Appraisal (PRA) study was conducted in the Northern, Eastern and Southern regions located in the coastal belt agroecological zones of Sierra Leone (Fig 1). The climate is tropical, hot all year round, with a dry season and a rainy season, due to the African monsoon, which runs from May to November in the north, from April to November in the east, and May to October in the south. The annual rainfall varies from 2,000 to 3,000 mm, with a maximum rainfall in the coastal area.

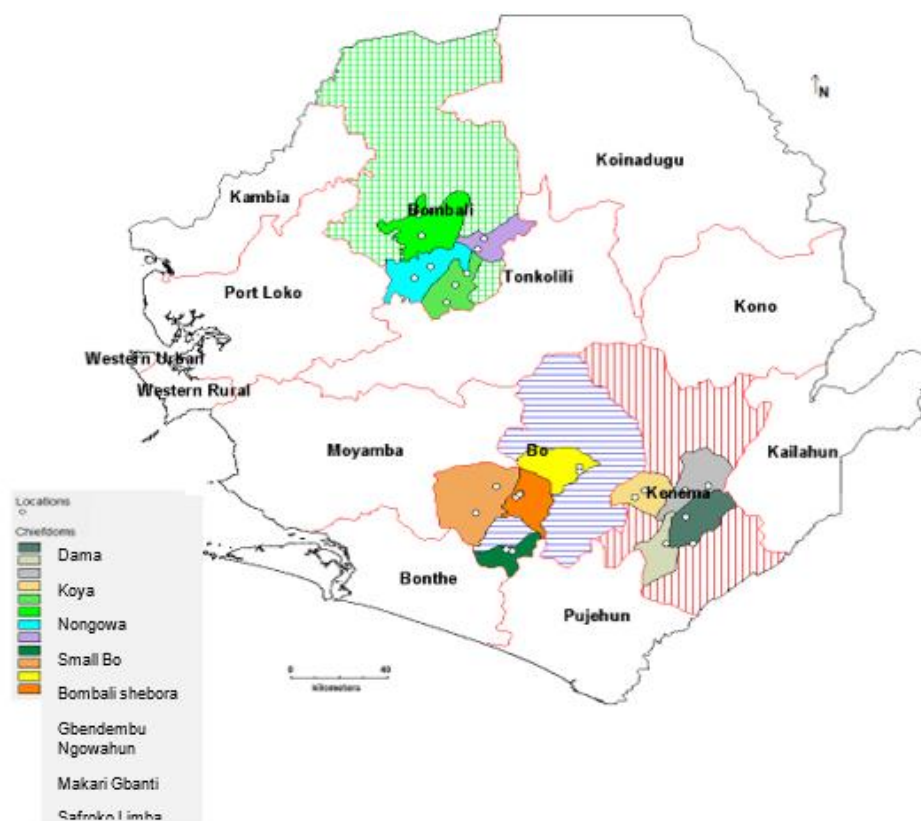


Figure 1. Map of Sierra Leone showing the three study districts: Bombali, Kambia and Bo
Source: <https://www.mapsofworld.com/sierra-leone/>

Sampling Procedure and Research Design

A purposive sampling procedure was used to identify region, villages, farmers, processors, traders and consumers. Three regions, Northern, Eastern and Southern, were selected for this study. The regions were selected based on their potential for cassava production. Farmers, processors, traders and consumers that were involved in the formal and informal interviews were randomly selected from the village with the help of village hamlet leaders and Agricultural Extension Officers. Four chiefdoms were selected from each district. Four research designs were selected for the study:

- a. A mixed-method research design that combines qualitative and quantitative approaches was applied.
- b. Qualitative Approach: Focus group discussion (FGD).
- c. Quantitative Approach: Individual interviews with structured questionnaires
- d. A multistage sampling was used to arrive at 360 sampling units that were then distributed among producers, processors, traders and consumers.

Cochran [18] sampling method was adopted to determine the sample size as following:

$$n = \frac{z^2 pq}{d^2} \quad (1)$$

Where: n= sample size; Z = 1.96; P = population (0.5 proportion); q = is a weighting variable computed as 1 – p; d = margin of error.

One (1) community per chiefdom was randomly selected for the focus group discussion. The summary of sample procedure and research design in the study areas is presented in Supplementary 1.

Data Collection

Data collection was based on focus group discussion and questionnaires administration. In each village, a focus group discussion was conducted with groups of 12 representatives. A checklist was prepared to guide the discussion. Ranking technique was employed to complement semi-structured interviews. A total of 360 questionnaires were administered to 120 producers, 72 processors, 72 consumers and 96 traders. The questionnaires were first pre-tested to validate the importance of the variables and the possible responses in addressing the objectives.

Data Analysis

The qualitative and quantitative data were analysed using Statistical Package for Social Scientists (SPSS), 16th version [19]. The results were presented using descriptive statistics such as frequencies and percentages. Data on ranking of constraints of fish farmers was analysed using Kendall Concordance analysis [20]. The Kendall's Coefficient of Concordance statistical procedure was used to identify and rank a given set of constraints and farmer preference, from the most to the least influential, as well as measure the degree of agreement or concordance among the respondents on the ranking of constraints and preferences. The identified preferences were ranked from the most preferred to the least preferred using numerals, (1, 2, 3, 4... N), called a Likert. The mean rank score for each preferred character or

constraint was computed and the factor with the least score was ranked as the most preferred or the highest constraint, whilst the highest score was ranked as the least preferred. The total rank score computed was then used to calculate the coefficient of concordance (W), which measures the degree of agreement among the respondents in the rankings [21]. The coefficient of concordance was estimated using the relation:

$$W = \frac{12[\sum T^2 - \frac{(\sum T)^2}{n}]}{nm^2(n^2-1)} \quad (\text{Kendall and Smith [20]}) \quad (2)$$

Where T = Sum of rank of factors being ranked; m = number of respondents (farmers); n = number of factors being ranked; W = coefficient of concordance. The W was tested for significance in terms of the F distribution.

The F -ratio is given by

$$F = \frac{(m-n) \times (1-W)}{(1-W)} \quad (\text{Kendall and Smith [20]}) \quad (3)$$

with numerator and denominator degrees of freedom being $(n-1) - (\frac{2}{m})$ and $m-1[(n-1) - (\frac{2}{m})]$, respectively. The null and alternative hypotheses of this study were stated as; H_0 : There was no agreement between the respondents on the ranking of the factors; H_1 : There is agreement between the respondents on the ranking of the factors.

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Cassava Farmers

The socio-economic characteristics of cassava farmers are shown in Supplementary 2. Three age groups were identified for each of the three districts with the adult group having the highest average percentage of 59.5% of the respondents followed by the youths (31.1%). Findings indicate that agricultural knowledge could be transferred from the older generation to the younger generation. The gender structure of the respondents shows that the male had the highest percentage respondents with an average percentage of 93.2%. Most of the respondents exhibited no formal education (with 34.7% having none and 20.3% of them Koranic), while 18.0%, 19.1%, 5.2% and 2.6% of respondents only had primary, junior secondary school, senior secondary school and tertiary education, respectively. The marital status of the respondents in the three districts shows that, the married group had the highest average percentage of 86.9%. It was also established that majority of the respondents (86.9%) were married, while 9.7% and 0.9% were single and widow or widower, respectively.

Cassava Production Systems

The study revealed that, in the Bo district 89.19% of farmers grow only cassava, while 10.81% grow and process cassava. In the Bombali district, 51.28% of farmers grow only cassava, while 48.72% grow and process cassava. In the Kenema district 82.50% farmers grow cassava only, while 17.5% grow and process cassava (Fig 2).

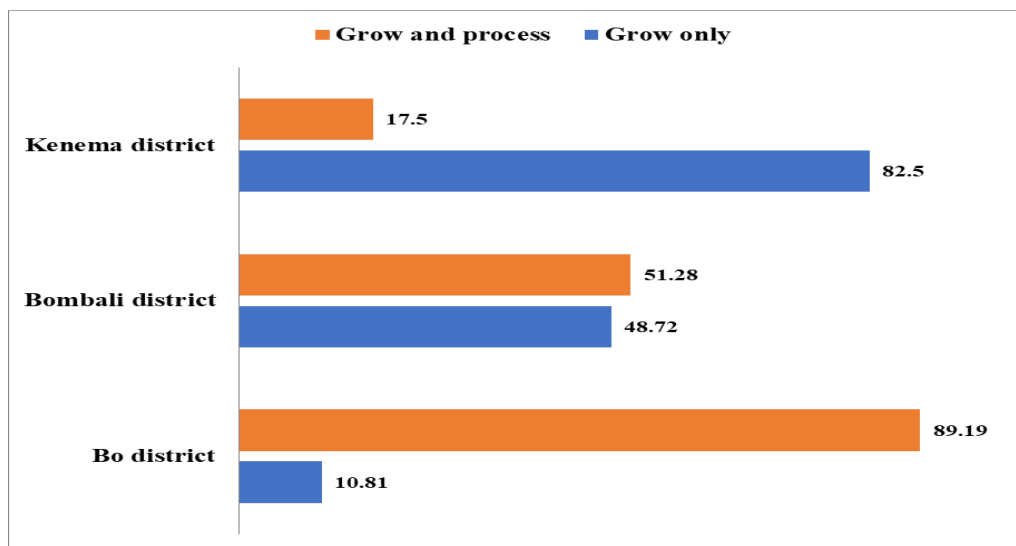


Fig 2: Percentage distribution of type cassava growers in the three study districts

The percentage distribution of type of cassava growers and processors across the three study districts revealed that, in the Bo district, 10.81% farmers cultivated only cassava, while 89.19% cultivated and processed. In Bombali district, 48.72% cultivated only cassava, 51.28% cultivated and processed and in Kenema district, 82.50% farmers cultivated cassava while, 17.5% cultivated and processed (Fig 3).

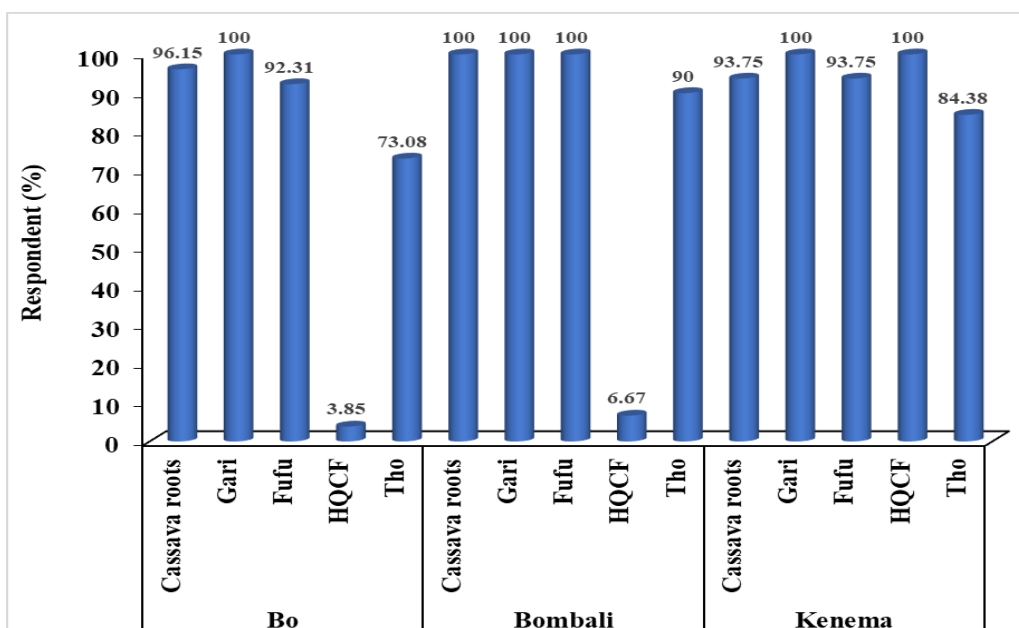


Fig 3: Percentage distribution of respondents to Cassava products consumer across the three-study district

Farmers' Preference for Dry Matter and Starch Contents in Cassava

Percentage distribution of farmers' preference for dry matter content in cassava across the three study districts revealed that 80.7% of the respondents in the Bo district considered high

dry matter content in cassava; 79.9% in Bombali district while 67.6% in the Kenema district also considered high dry matter content in cassava. Determining the level of dry matter content in cassava roots shows that, in Bo district 80.7% of the respondents determined the level of dry matter content required in varieties grown, 74.4% in Bombali districts and 97.3% in Kenema district, respectively. Farmers that grow cassava varieties with high dry matter content shows that, 83.8% of the respondents in Bo district cultivated cassava with high dry matter content, 95.0% in the Bombali district and 92.5% in Kenema District. However, 91.6% said they did not have easy access to cuttings of cassava varieties with high dry matter content in the three-study area. In the Bo district, 95.5% of the respondent said they were willing to pay high price for cassava cuttings of varieties with high dry matter content, 96.4% in Bombali district with 96.6% in Kenema district, respectively (Table 1)

Table 1: Percentage distribution of farmers' preferences for dry matter in cassava

Farmers' preference	Response	District (%)			
		Bo	Bombali	Kenema	Mean
1. Consider dry matter content for selecting cassava varieties for cultivation	Yes	80.7	79.5	67.6	75.9
	No	19.4	20.5	32.4	24.1
2. Level of dry matter content preferred in cassava roots	High	80.7	74.4	97.3	84.1
	Moderate	19.4	25.6	2.7	15.9
	Low	0.0	0.0	0.0	0.0
3. Grow cassava varieties with high dry matter content	Yes	83.8	95.0	92.5	90.4
	No	16.2	5.0	7.5	9.6
4. Have easy access to cuttings of cassava varieties with dry content	Yes	5.0	5.1	15.0	8.4
	No	95.0	94.9	85.0	91.6
5. Willing to pay high price for cassava roots with high dry matter content	Yes	95.5	96.4	90.8	94.2
	No	4.5	3.6	9.2	15.8

The percentage distribution of farmers' preference for starch content in cassava across the three study districts is presented in Table 2. In the Bo district, 80.7% considered starch content in selecting cassava varieties for cultivation while 19.4% did not consider starch content in selecting cassava varieties for cultivation. In Bombali district, 79.5% considered starch content in selecting cassava varieties while 20.5% did not consider starch in selecting cassava varieties. In Kenema district, 67.6% considered starch in selecting cassava varieties and 24.1% did not consider starch content in selection of cassava varieties. A total of 80.7% of the respondents preferred high starch content in the cassava varieties used for cultivation in Bo district while 19.4% preferred moderate starch in the cassava varieties used for cultivation. In Bombali district, 74.4% preferred high starch content in the cassava varieties used for cultivation while in Kenema district, 97.3% preferred high starch content in the cassava varieties used for cultivation. In the Bo district, 83.8% had cultivated cassava varieties with high starch content, 95.0% in the Bombali district and 92.5% in Kenema district cultivated cassava varieties with high starch content. 13.4% of the farmers in the three districts said they had easy access to cutting of cassava varieties with high starch content. Over 80.0% within the three districts (Bo, Kenema and Bombali) said they are willing to pay high price for cassava roots with high starch content.

Processors' Preference for Dry matter and Starch Content in Cassava

Analysis of processors' preference in cassava starch in the three districts indicated that 94.7% of respondents have access to process cassava roots with high starch content in Bo district, 95.0% and 94.0% have access to process cassava roots with high starch content in Bombali and Kenema districts, respectively (Table 3). About 94.4% of respondents in Bo district, 75.0% in Bombali district and 83.3% in Kenema district have easy access to cassava roots with high starch content. Processors who consider starch content in selecting cassava roots used for processing showed 83.3% in Bo district, 90.0% in Bombali district and 83.3% in Kenema district. In the Bo district, 44.4% of the respondents prefer high starch content in the cassava roots used for processing, 80.0% in Bombali and 58.3% in Kenema districts. For the dry matter content, 89.5% of the processors in Bo, 92.0% in Bombali and 91.7% in Kenema districts said they have access to process cassava roots with high dry matter content. About 94.1%, 90.0% and 90.9% of the respondents have easy access to cassava roots with high dry matter content in Bo, Bombali and Kenema districts, respectively. Processors who consider dry matter content in selecting cassava roots used for processing showed 94.1% in Bo district, 90.0% in Bombali district and 90.9% in Kenema district. Processors who prefer high dry matter content in the cassava roots used for processing showed 47.1% in Bo district, 80.0% in Bombali and 81.8% in Kenema district.

Table 2: Percentage distribution of farmers' preferences for starch content in cassava

Farmer's preferences		District (%)			
		Bo	Bombali	Kenema	Mean
1. 1.Consider starch content for selecting cassava varieties for cultivation	Yes	80.7	79.5	67.6	75.9
	No	19.4	20.5	32.4	24.1
2. 2. Level of starch content preferred in cassava roots	High	80.7	74.4	97.3	84.1
	Moderate	19.4	25.6	2.7	15.9
	Low	0.0	0.0	0.0	0.0
3. 3. Grow cassava varieties with high starch content	Yes	83.8	100.0	92.5	92.1
	No	16.2	0.0	7.5	7.9
4. 4. Have easy access to cuttings of cassava varieties with high starch content	Yes	15.0	5.1	20.0	13.4
	No	85.0	94.9	80.0	86.6
5. 5. Willing to pay high price for cassava roots with high starch content	Yes	89.5	92.4	80.8	87.7
	No	10.5	7.6	19.2	12.3

Table 3: Percentage distribution of cassava processors' preference for cassava roots with starch content and dry matter content

Trait	Response	Bo (%)	Bombali (%)	Kenema (%)
Starch content	i. Have access to process cassava roots with high starch content	94.7	95.0	94.0
	ii. Have easy access to cassava roots with high starch content	94.4	75.0	83.3
	iii. Consider starch content in selecting the cassava roots used for processing	83.3	90.0	83.3
	iv. Prefer high starch content in the cassava roots used for processing	44.4	80.0	58.3
Dry matter content	i. Have access to process cassava roots with high dry matter content	89.5	92.0	91.7
	ii. Have easy access to cassava roots with high dry matter content	94.1	75.0	81.8
	iii. Consider dry matter content in selecting the cassava roots used for processing	94.1	90.0	90.9
	iv. Prefer high dry matter content in the cassava roots used for processing	47.1	80.0	81.8

Traders' Preferences for Starch and Dry Matter Content in Cassava Products

Study of traders' preference in cassava starch in the three districts indicated that 88.9% of respondents sold cassava products with high starch content in Bo district, whereas for Bombali and Keema districts, 100.0% and 81.8% of the respondents sold cassava products with high starch content, respectively. About 87.5% of respondents have easy access to cassava products with high starch content in Bo district, 100.0% in Bombali district and 100.0% in Kenema district. Traders who consider starch content in selecting cassava products sold showed 81.3% in Bo district, 95.8% in Bombali district and 100.0% in Kenema district. In the Bo district 43.8% of the respondents prefers high starch content in the cassava products sold, 29.2% in Bombali and 22.2% in Kenema districts. However, 61.1% of the traders in Bo district said they have sold cassava products with high dry matter content, while 87.5% in the Bombali district and 95.5% in Kenema district have sold cassava products with high dry matter content. All traders in the Bo and Bombali districts have easy access to cassava product with high dry matter content and consider dry matter content in selecting the cassava products sold, whereas 95.2% of respondents in Kenema district opined to these suggestions (Table 4).

Table 4: Percentage distribution of traders' preferences for starch and dry matter in cassava products in the three study districts

Trait	Response	Bo (%)	Bombali (%)	Kenema (%)
Starch content	i. Have sold cassava products with high starch content	88.9	100.0	81.8
	ii. Have easy access to cassava products with high starch content	87.5	100.0	100.0
	iii. Consider starch content in selecting the cassava products sold	81.3	95.8	100.0
	iv. Prefer high starch content in the cassava products sold	43.8	29.2	22.2
Dry matter content	i. Have sold cassava products with high dry matter content	61.1	87.5	95.5
	ii. Have easy access to cassava products with high dry matter content	100.0	100.0	95.2
	iii. Consider dry matter content in selecting the cassava products sold	100.0	100.0	95.2

Consumers' Preferences for Cassava Starch and Dry Matter Contents in Cassava

The study revealed that, in the Bo district 88.5% of the respondents had eaten cassava products with high starch content as compared to 100.0% in Bombali district and 84.4% in Kenema district. 100.0% had easy access to cassava products with high starch content in the Bo district, 83.3% in Bombali district and 96.3% in Kenema district. 87.0% considered starch content in selecting the cassava products eaten in Bo district while in Bombali and Kenema districts, 86.7% and 96.3% consider starch content, respectively. In Bo district, 52.2% of the respondents preferred high starch content in the cassava products eaten, 10.0% in Bombali district and 25.9% in the Kenema district.

The study also showed that, 96.2% of the respondents in Bo district had eaten cassava products with high dry matter content, 100.0% in Bombali and Kenema district. About 92.0% had easy access to cassava products with high dry matter content in the Bo district, 86.7% in Bombali district and 96.9% in Kenema district. About 100.0% consider dry matter content in selecting cassava products eaten in Bo and Kenema districts and 80.0% in the Bombali district. In Bo district, 84.0% preferred high dry matter content in the cassava products they eat, 93.3% in Bombali district and 93.8% in Kenema district (Table 5).

Table 5: Percentage distribution of consumers' preferences for starch and dry matter in cassava products across the three study districts

Trait	Response	Bo (%)	Bombali (%)	Kenema (%)
Starch content	1. i. Have eaten cassava products with high starch content	88.5	100.0	84.4
	2. ii. Have easy access to cassava products with high starch content	100.0	83.3	96.3
	3. iii. Consider starch content in selecting the cassava products eaten	87.0	86.7	96.3
	4. iv. Prefer high starch content in the cassava products eaten	52.2	10.0	25.9
Dry matter content	5. i. Have eaten cassava products with high dry matter content	96.2	100.0	100.0
	6. ii. Have easy access to cassava products with high dry matter content	92.0	86.7	96.9
	7. iii. Consider dry matter content in selecting the cassava products eaten	100.0	80.0	100.0
	8. iv. Prefer high dry matter content in the cassava products eaten	84.0	93.3	93.8

Cassava Products and Selection Criteria for Cassava Cultivars

The study showed that gari, fufu, cassava roots and tho were highly consumed in the three study districts at 100%. On the other hand, cassava flour was only consumed in Kenema district with a high average percentage of 100%, while in Bo and Bombali districts, consumption rates ranged between 3.85% and 6.67 %, respectively (Fig 4).

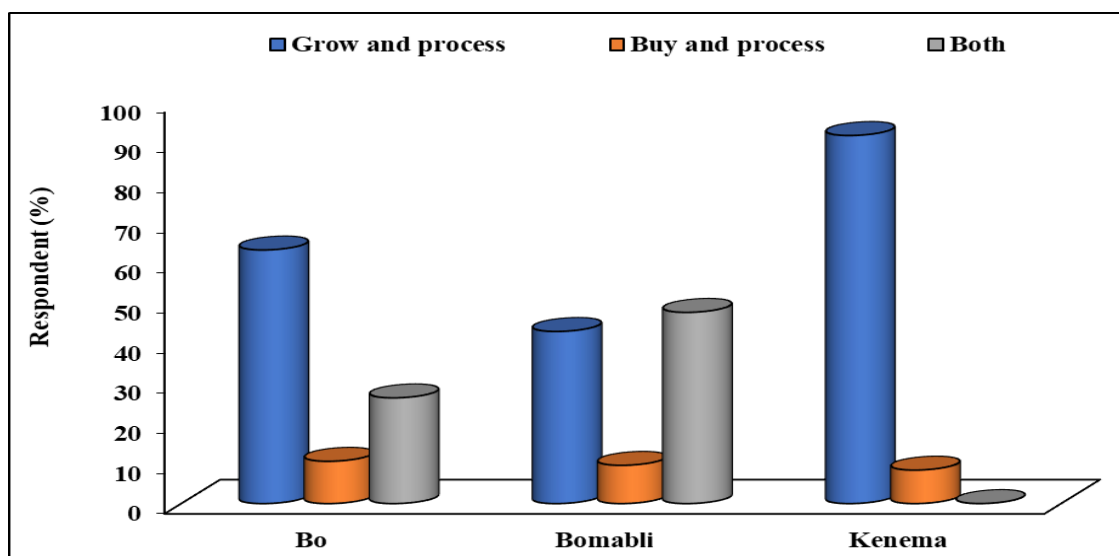


Fig 4: Percentage distribution of type of cassava growers and processors across the three study districts

The mean rank of preferred traits ranked by farmers across the three study districts is presented in Table 6. The preferred traits significantly ($p \leq 0.0001$) differed among farmers with medium Kendall's coefficient value of 0.433. The overall means ranged from 2.8 for high root yield to 8.5 for resistance to disease. This indicates that high root yield is the most desirable trait farmers want to be incorporated into cassava breeding programs followed by root size and root taste. However, in each district, the ranking of desirable traits to be incorporated in cassava breeding program varied. In the Bo district, high yield (1st), root size (2nd), dry matter content (3rd) and starch content (4th), were the most important traits. In the Bombali district, high root yield (1st), root taste (2st), dry matter content (3rd) and poundability (4th) were the most desired. In the Kenema district, high root yield (1st), root taste (2st), maturity period (3rd), and poundability (4th), were the most desired traits.

Table 6: Mean rank of cassava traits by farmers across the three study districts in Sierra Leone

	Bo		Bombali		Kenema		Overall	
Trait	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
High root yield	2.4	1	3.7	1	2.3	1	2.8	1
Outer skin colour	5.9	7	6.2	8	7.7	8	6.6	8
Root size	3.4	2	4.7	4	4.4	5	4.2	2
Starch content	5.1	4	5.0	6	6.1	6	5.4	6
Dry matter content	4.9	3	4.3	3	6.5	7	5.2	5
Root taste	5.6	5	4.3	2	3.0	2	4.3	3
Resistance to pests	7.1	8	8.1	9	8.7	9	8.0	9
Resistance to disease	7.5	9	8.9	10	9.1	10	8.5	10
Poundability	7.7	10	4.7	4	4.1	4	5.5	7
Maturity period	5.6	5	5.1	7	3.2	3	4.6	4
P value	<0.0001		<0.0001		<0.0001		<0.0001	
Kendall's W	0.321		0.322		0.655		0.433	

Kendall's W: Kendall's coefficient of concordance

The preferred traits significantly ($p \leq 0.0001$) differed among processors with medium Kendall's coefficient value of 0.331. The overall means ranged from 2.7 for starch and dry matter contents to 5.8 for fibre content. This indicates that high starch and dry matter contents are the most desirable traits processors want to be incorporated into cassava breeding programs followed by root size, ease of peeling and inner flesh color. However, in each districts the ranking of desirable traits to be incorporated in cassava breeding programme varied: In Bo the district: dry matter (1st), starch content (2nd), root size (3rd) and inner flesh color (4st), were the most important. In the Bombali districts: starch content (1st), dry matter content (2nd), root size (3rd) and PPD (4th) were the most desired. In the Kenema districts: starch content (1st), dry matter content (2nd), and root size (3rd) and ease of peeling (4th) were preferred (Table 7).

Table 7: Cassava traits ranking by processors across the study districts

Trait	Bo		Bombali		Kenema		Overall	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Root size	3.8	3	3.8	3	3.7	3	3.8	3
Starch content	3.1	2	1.8	1	3.3	1	2.7	1
Dry matter content	2.4	1	2.2	2	3.5	2	2.7	2
Ease of peeling	5.1	5	5.2	5	4.0	4	4.8	4
Postharvest physiological deterioration	5.6	7	4.8	4	5.6	6	5.3	6
Fibre content	5.4	6	6.3	7	5.8	7	5.8	8
Age of tuber	6.3	8	6.5	8	4.5	5	5.7	7
Inner flesh color	4.4	4	5.5	6	5.8	7	5.2	5
P value	<0.0001		<0.0001		0.029		<0.0001	
Kendall's W	0.296		0.512		0.186		0.331	

Kendall's W: Kendall's coefficient of concordance

Preferred Varieties for Different Cassava Products and SWOT Analysis of Farmers and Processors

The most preferred cassava varieties for different cassava products in the three study districts are shown in Supplementary 3. SLICASS 4 and 3 MONTH were preferred for processing gari, SLICASS 4, ROCASS and 8 MONTHS for starch processing, CARE, ROCASS and KABBAY for fufu, SLICASS 6 and WARIMA for cassava flour and CARE, WARIMA and BUTTER for processing tho. The SWOT analysis for cassava farmers across the three study areas revealed that, farmers strength ranged from 2.6% -100.0%, weakness 2.6% - 94.6%, opportunities 2.5% - 94.9% and threats ranging from 2.6% -95.0% (Table 8). The study showed that across the study areas, the processors strengths ranged from 8.3% - 95.0%, weaknesses from 25.0%-33.3%, opportunities 10.5% - 95.0% and threats ranged from 8.3%-94.7%, respectively (Table 9).

Table 8: SWOT analysis for cassava farmers in the three study districts

SWOT Analysis	Bo (%)	Bombali (%)	Kenema (%)
Strength			
i. Agricultural land	97.3	100.0	100.0
ii. Improve planting materials	83.8	87.2	95.0
iii. Family labour	62.2	97.4	90.0
iv. Finance	35.1	0.0	15.0
v. Membership in FBO	18.9	2.6	0.0
vi. Process cassava products	21.6	12.8	0.0
Weakness			
i. Lack of finance	94.6	92.3	85.0
ii. Lack of improve varieties	40.5	59.0	27.5
iii. Lack of labour	35.1	20.5	22.5
iv. Lack of training on improved agricultural practice	56.8	5.1	97.5

v. Lack of agro chemicals	64.9	94.9	67.5
vi. Difficult access to land	8.1	2.6	0.0
Opportunities			
i. Development of improved cassava varieties	67.6	89.7	82.5
ii. Support from MAFFS	21.6	10.3	7.5
iii. Availability of markets	70.3	94.9	90.0
iv. Availability of processing centers	48.7	2.6	90.0
v. Microfinance	13.5	35.9	22.5
vi. Support from NGOs	40.5	35.9	5.0
vii. Strong link with research institutions	37.8	30.8	2.5
Threats			
i. Thieves	24.3	17.9	12.5
ii. Grasshoppers	83.8	89.8	92.5
iii. Vertebrate pests	78.4	87.2	95.0
iv. High transportation cost	81.1	48.7	92.5
v. Strong market competition	2.7	2.6	7.5
vi. Fire outbreak	2.7	15.4	0.0
vii. Land tenure	16.2	38.5	0.0

Table 9: SWOT analysis for cassava processors in the three study districts

SWOT Analysis	Bo (%)	Bombali (%)	Kenema (%)
Strengths			
i. Strong knowledge and experience in cassava processing	94.7	95.0	91.7
ii. Have access to labour for processing activities	94.7	75.0	91.7
iii. Have access to credit and finance	26.3	0.0	8.3
iv. Have access to Market and storage facilities for products	21.1	30.0	25.0
v. Strong linkages with farmers for tubers	26.3	80.0	50.0
vi. Have access to processing equipment	36.8	20.0	33.3
Weakness			
i. Have limited access to market	52.6	60.0	66.7
ii. Have limited access finance and credit facilities	89.5	100.0	58.3
iii. Use of local processing equipment	73.7	70.0	75.0
iv. Lack of training on quality gari production	36.8	25.0	33.3
v. Inability to pay high transport fare for raw materials	47.4	45.0	66.7
Opportunities			
i. Availability of improved cassava varieties	89.5	95.0	100.0
ii. Strong linkages with value chain actors	42.1	85.0	66.7
iii. High demand for gari in local markets	84.2	85.0	75.0
iv. Provision of training by NGO's	15.8	10.0	25.0
v. Availability of processing centers with modern equipment facilities	10.5	25.0	33.3

vi. Increase in labour costs for gari activities	94.7	75.0	91.7
vii. High cost for accessing improved processing equipment and inputs	84.2	65.0	91.7
viii. Inadequate supply of raw materials	10.5	45.0	25.0
ix. Theft	5.3	15.0	8.3
x. High interest rates on loans	47.4	40.0	16.7
xi. Market diversity and competition with other food items	57.9	60.0	66.7

This study established stakeholders' preference for starch content and dry matter content for different cassava varieties. The study shows high proportions of illiteracy and married people amongst the respondents. Bala *et al.* [22] opined that illiteracy is a key hindrance to institutional support towards agriculture, while Nyagaka *et al.* [23] revealed that education had positive relationship with agricultural efficiency and production. Findings are also in concurrence with the suggestion that education influences agricultural efficiency and production [23, 24]. The study also reveals that majority of the farmers are male and are dominated by married people in the three study districts. This could be due to the fact that majority of the rural people are challenged with the responsibility of early marriage to increase in household size labor. The high marriage proportion of the respondents obtained in this study indicates that majority of the respondents are stable and could command societal respect. Being married could mean that the respondents are responsible. In a farming household, all members of the household assist each other with farming activities and other household chores. This is more the reason why marriage is paramount among the farming communities, because most farmers depend on their families as primary source of labor. About 89.2% of the respondents grow cassava only whilst 82.5% grow and process the crop in the three study districts. This could be attributed to high level of cassava consumption in the districts as it serves as an important staple food crop which can be processed into various cassava-based products including boiled storage roots, gari, starch and cassava bread (very thin, small, and flat, round pieces) traded mainly in Sierra Leone [25]. Farmers commonly select cassava varieties with focus on high yield, root size, root taste, early maturity period and inner color. These selection criteria reflected the importance of farmers' needs, priorities, as well as the type of farming systems they practice. High yield, root taste and inner color were selected because farmers believed that high yield cultivars generate income. Similar results were reported by Ntumngia [26] indicating that marketable roots, root size shape and color of the skin, which determine the demand and price for different cassava cultivars in the market. Farmers, however, preferred varieties that are resistance to pest and disease as a way of ensuring food security for their households.

However, processors' selection criteria are based on starch content and dry matter content. This selection criteria indicates that, cultivars with high dry matter and starch content are good in making cultivars quality cassava-based products (fufu, gari, tho and flour) and are more marketable. Cassava cultivars that are selected for the market, should, therefore, meet most of these qualities if farmers and processors have to stay competitive in the market and increase income from cassava. The combination of desired traits that meet their culinary, agronomic and other needs are based on local knowledge which is translated into their everyday cultivar selection strategies and practices.

Preference for the different cassava products in the study districts is high for all the different products (cassava roots, gari, fufu, and tho) except for cassava flour that is low in the Bo and Bombali districts due to lack of market facilities in the districts. Several cassava cultivars were grown by farmers, with more than three cultivars identified in each of the surveyed districts. Each cultivar was selected for its special attributes preferred by processors. Strength, weakness, opportunity and threats faced by the farmers and processors were cross-cutting. These major cross-cutting issues identified by farmers as strength include agricultural land, improved planting materials and family labor. The weaknesses identified are: lack of finance, lack of training on improved agricultural practices and lack of agro-chemical. The opportunities catalogued include development and availability of improved cassava varieties and markets. The threats are grasshopper attack, high transportation cost and vertebrate pest.

The strengths identified by the processors include: knowledge and experience in cassava processing, easy access to labor for processing and strong linkages with the farmers for storage root. Their identified weaknesses covered limited access to market, limited access to finance and credit facilities and use of local equipment. The opportunities are: availability of improved cassava varieties, high demand for cassava products in local market and strong linkages with value chain actors. Finally, the threats identified are: increase in labor cost for gari producing activities, high cost for improved processing equipment and inputs).

In countries with improved cassava value chains, various end users utilize improved technologies for production, processing, drying and storage of cassava roots for value addition and prevention or minimization of deterioration of storage roots [27]. Processing equipment such as mechanical peelers, cassava graters and chippers, motorised sieves, flash dryers, solar dryers, hydraulic pressers, and hammer mills are utilized in well-developed cassava value chains [27-29]. Improved storage boxes lined with moist sawdust, polypropylene bags (plastic film wraps), use of waxy coatings and refrigeration have been noted to improve shelf life of cassava products [27,29,30]. These technologies could be exploited for adaptation in Sierra Leone to boost the transformative drive of the cassava value chain from small-scale production to large-scale production, market-driven and product-oriented productivity sector.

CONCLUSION

The findings of the PRA conducted in Sierra Leone showed that farmers generally rank high yielding cassava varieties as the highest priority in selecting cassava varieties followed by, root size, root taste and maturity period. Processors rank starch content as the highest selection criteria followed by dry matter content, root size and ease of peeling. Several factors limiting cassava production and processing in the surveyed districts were also identified, key of which were cassava mosaic disease, grasshopper, lack of finance, and high transportation cost. Their criteria for cassava-based products were also identified. To, therefore, bridge the gap between stakeholders and breeders, participatory variety selection and participatory plant breeding should be conducted to promote collaborations between stakeholders and breeders for development of new cassava varieties with desired key traits for production, processing, marketing and consumption.

This study established the strengths, weaknesses, opportunities and threats as well as end users' varietal preferences for key traits considered in a market-driven and product-oriented cassava sub-sector. Based on the findings, the following are recommended:

1. Provision of training and awareness campaigns targeted at mitigating threats and weaknesses faced by end users to increase cassava productivity and value addition based on market-driven and product-oriented paradigm.
2. Inclusion of introduced improved low-cost technologies to improve production and processing of cassava roots based on market-driven and product-oriented paradigm targeted at improving the livelihoods and improving the income levels of the various end-users.
3. Application of modern breeding tools to exploit existing variability in local and introduced cassava genotypes for development of elite genotypes with desired end-user traits.

Acknowledgements

The authors are grateful to the cassava breeding teams at the Sierra Leone Agricultural Research Institute (SLARI), International Institute of Tropical Agricultural (IITA) for their technical support during the course of this study.

Declarations

Authors' Contributions

The authors were involved in experimentation, data collection, management and writing of the paper as well as reading and approval of the manuscript prior to its submission.

Competing Interests

Both authors declare that they have no competing interests.

Availability of Data and Material

Data available on request.

Funding

This research was funded by the International Development Research Centre (IDRC) under the IDRC/CORAF-WECARD/IITA sub-grant agreement for developing capacity for Agricultural Research in Sub-Saharan Africa (PJ-2126) to pursue PhD in Plant Breeding at the West African Centre for Crop Improvement (WACCI), University of Ghana; and the West Africa Agricultural Productivity Program Sierra Leone (WAAPP 1C SL) Grant Number: IDA Grant H654-SL and Japan PHRD TF099510-SL.

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SUPPLEMENTARY MATERIALS**Supplementary 1: Sampling procedure and research design**

Stage	Category	Sampling method	Sample size
1	3 regions (east, north and south)	Purposive	360 actors
2	3 districts (Bo, Bombali and Kenema)	Simple random	120 actors per district
3	12 chiefdoms	Simple random	30 actors per chiefdom
4	12 chiefdoms		
	Producers	Systematic	10 producers per chiefdom
	Consumers	Systematic	6 consumers per chiefdom
	Traders	Simple random	8 traders per chiefdom
	Processors	Simple random	6 processors per chiefdom

Supplementary 2: Percentage distributions of cassava farmers across the three-study district

Socioeconomic characteristics	Districts (%)			
	Bo	Bombali	Kenema	Mean
Age group				
Youth (18 – 35 years)	35.1	30.8	27.5	31.1
Adult (35 – 60 years)	62.2	56.4	60.0	59.5
Aged (above 60 years)	2.7	12.8	12.5	9.3
Gender				
Female	2.7	7.7	10.0	6.8
Male	97.3	92.3	90.0	93.2
Educational level				
None	37.8	51.3	15.0	34.7
Koranic	10.8	5.1	45.0	20.3
Primary	16.2	12.8	25.0	18.0
Junior Secondary School	24.3	23.1	10.0	19.1
Senior Secondary School	8.1	2.6	5.0	5.2
Tertiary	2.7	5.1	0.0	2.6
Marital status				
Single	16.2	12.8	0.0	9.7
Married	81.1	79.5	100.0	86.9
Divorced	0.0	0.0	0.0	0.0
Widow / widower	0.0	2.6	0.0	0.9

Supplementary 3: Preferred cassava varieties for different cassava products in the three study districts

	Bo		Bombali		Kenema	
Product	Variety	%	Variety	%	Variety	%
Gari	SLICASS 4	64.7	3 MONTH	30.0	SLICASS 4	40.0
Fufu	CARE	50.0	ROCASS	35.7	KABBAY	30.0
Starch	SLICASS 4	100.0	ROCASS	50.0	8 MONTH	100.0
HQCF	SLICASS 6	100.0	WARIMA	50.0		
Tho	CARE	66.7	WARIMA	20.0	BUTTER	50.0

HQCF=high quality cassava flour