International Journal of Bio-resource and Stress Management

https://ojs.pphouse.org/index.php/IJBSM

Crossref

IJBSM September 2026, 17(9): 01-09

Article AR7224

Research Article

Natural Resource Management

DOI: HTTPS://DOI.ORG/10.23910/1.2026.7224

Participatory Cassava Clone Production to Food Recipe Demonstration in Food Insecure Areas of Wag-himra Zone, Ethiopia

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ABSTRACT

The study was conducted from May, 2022 to February, 2023 in Wirke-dibnu and Saka kebeles of the Abergelle district, Wag-himra zone, Ethiopia, aimed to evaluate two cassava varieties (AWC-2 and AWC-4) and demonstrate their potential for food diversification in food-insecure regions. The trial was executed in two phases. During the first phase, varietal performance was assessed across 20 farmers' fields, with each 100 m² plot serving as an independent replicate. Agronomic and preference data were analyzed using descriptive and inferential statistics. Results revealed that AWC-4 consistently outperformed AWC-2, and exhibited higher seedling survival (79.9%), root length (28.8 cm), root girth (4.9 cm), and total storage root yield (23.0 t ha^{-1}). Besides, the farmers showed a strong preference for AWC-4 due to its adaptability, vegetative vigor, and superior yield. The second phase concentrated on cassava-based food diversification. Four recipes viz., Enjera, Kitta, Bread, and Porridge were prepared using three cassava-wheat composite ratios (10:90, 20:80, and 30:70). Sensory evaluation by 60 local panelists employed a nine-point hedonic scale and ranking matrix. Panelists consistently ranked Enjera highest, followed by Kitta, Bread, and Porridge. The 10:90 composite ratio was most preferred, and underscoring cassava's potential to enhance dietary diversity without compromising taste or texture. Overall, the findings suggest that cassava, particularly AWC-4 variety can significantly contribute to food security and nutritional diversification in vulnerable communities. Extension efforts should prioritize raising farmer awareness, providing training, and promoting cassava cultivation. Further research is warranted to explore its socioeconomic and environmental impacts.

KEYWORDS: Cassava flour, food recipe, sensory evaluation, nutritional diversity, panel test

***Citation* (VANCOUVER):** Mihiretu and Assefa, Participatory Cassava Clone Production to Food Recipe Demonstration in Food Insecure Areas of Wag-himra Zone, Ethiopia. *International Journal of Bio-resource and Stress Management,* 2026; 17(9), 01-09. HTTPS://DOI.ORG/10.23910/1.2026.7224.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, author have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The author has declared that no conflict of interest exists.

RECEIVED on 27th May 2026 RECEIVED in revised form on 17th August 2026 ACCEPTED in final form on 02nd September 2026 PUBLISHED on 11th September 2026

1. INTRODUCTION

Cassava, scientifically known as *Manihot esculenta Crantz*, is a perennial shrub with an edible root that thrives in tropical and sub-tropical regions across the globe. It holds the distinction of being the fourth most important crop worldwide, following rice, wheat, and maize, and is a staple food for over 1 billion people globally (Owoeye, 2020). Despite its relatively low cost of cultivation, cassava ranks fourth in terms of calorie content, trailing behind rice, sugarcane, and maize. This versatile crop is highly valued in many tropical countries for its resilience in the face of extreme droughts and its ability to thrive in a variety of soil and climate conditions, particularly in marginal areas (Yin et al., 2019). Cassava is a vital subsistence crop in sub-Saharan Africa, cultivated primarily by small-scale farmers who frequently intercrop it with vegetables. Its adaptability and nutritional value make it a vital source of sustenance for many communities in the region (Mansoor et al., 2020). Cassava is cultivated in expansive regions throughout Ethiopia, with a particular concentration in the southern part of the country. It was introduced mainly to fill the food and nutritional gaps for subsistence farmers mainly during the crop failure as a result of drought (Barati et al., 2019). Although cassava was initially introduced to the southern regions of the country in the 1960s, this plant is presently being distributed nationwide as a solution to food insecurity (Leemud et al., 2019). Despite its ability to thrive in various environments and its versatility, cassava has not yet reached its full potential in tropical agriculture due to a lack of specific recommendations for early maturing, high yielding, and low hydrogen cyanide varieties (Manuel Villa et al., 2024). In Ethiopia, most of the cassava varieties grown by local farmers are low yielding, late maturing, bitter, and high in hydrogen cyanide. In order to tackle these challenges, variety development and adaptation trial has been carried out to recommend cassava varieties across various agro-ecological regions (Waje et al., 2025). Cassava has been introduced in Ethiopia through the release of two varieties, *Qulle* and *Chichu*, in 2005 (Eshbel et al., 2022). While these varieties demonstrated promising storage root yields, their performance across diverse agro-ecological zones remained insufficiently assessed (Tewodros et al., 2013). To address this gap, the Sekota Dry-land Agricultural Research Center, in collaboration with Jimma and Hawassa Agricultural Research Centers, conducted a two-year evaluation trial involving seven cassava clones. The study ultimately recommended two varieties, AWC-2 and AWC-4, for verification and production in the Wag-himra zone and other similar agro-ecologies of Northeast Ethiopia (Tesfaye et al., 2017). Smallholder farmers in tropical and subtropical regions, including Wag-himra, face limited and erratic rainfall, restricted livelihood opportunities, and poor dietary diversification. The zone is particularly vulnerable to recurrent drought, infertile soils, and narrow cropping systems. In such contexts, drought-tolerant root crops like cassava and sweet potato are increasingly advised, as they can withstand harsh climatic conditions and contribute to food security. Cassava's resilience to water stress and poor soils makes it a suitable option for subsistence farmers, while its potential for food diversification addresses nutritional gaps (Tesfaye et al., 2017). Against this backdrop, the present study was designed with two objectives: first, to compare and evaluate the performance of AWC-2 and AWC-4 under farmers' field conditions with active participation; and second, to demonstrate cassava-based food recipes and then assess their demand and consumer acceptance. By integrating agronomic evaluation with food utilization trials, the study aimed to highlight cassava's dual role in enhancing productivity and promoting dietary diversification in food-insecure communities of Northern Ethiopia.

2. MATERIALS AND METHODS

2.1. Study sites and trial context

The participatory trial was conducted between May, 2022 and February, 2023 in the Wirke-dibnu and Saka kebeles of the Abergelle district within the Wag-himra administrative zone (Figure 1). These adjacent sites shared nearly similar agro-ecological characteristics. At Wirke-dibnu, the mean annual temperature was 35.7°C with an average rainfall of 376.5 mm, situated at 1300 meters above sea level with coordinates of 39°38' E longitude and 13°40' N latitude (Tesfaye et al., 2017). In contrast, Saka recorded a slightly higher mean annual temperature of 37°C and rainfall of 374.5 mm, located at 1250 m above sea level with coordinates of 38°57' E longitude and 13°20' N latitude. The pedology of both areas was characterized by steep slopes and bare plains, coupled with erratic rainfall that contributed to high runoff, reduced groundwater retention, and significant soil erosion (Mihiretu et al., 2023). The soil

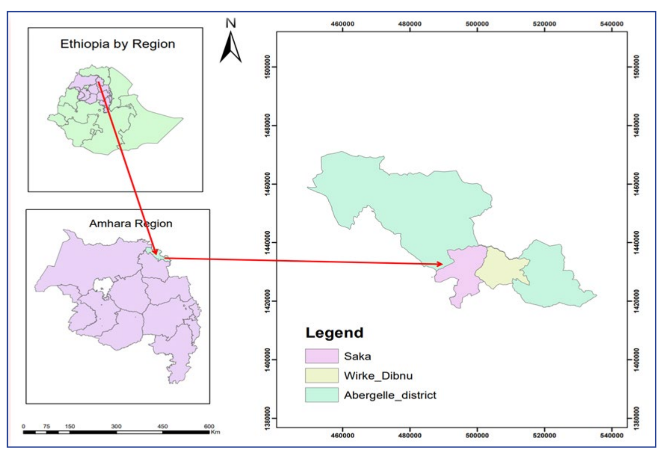

Figure 1: Location map of the study area

composition consisted of 55% brown porous soil, 30% red silt, and 15% sandy soil. Recurrent environmental shocks, particularly drought, progressively weakened farmers' resilience to climate variability, with impacts most severe during seasons of very low precipitation (Atnafua et al., 2021). Crop production was predominantly rain-fed and confined to relatively fertile and moist soils due to limited access to drought-resistant and adaptable crop varieties. The spatial and temporal variations in temperature and rainfall, combined with subsistence farming and restricted livelihood options, rendered these areas highly vulnerable to recurrent food insecurity (Mihiretu et al., 2021). Despite the availability of recommended adaptive crop types, there was a lack of sufficient participatory studies to provide policymakers with location-specific, fit-for-purpose intervention strategies.

2.2. *Sampling, experimental design and implementation*

Site selection was a collaborative effort with local extension workers, taking into account the irrigation potential for supplementation. The study units were farmers who owned land in the irrigation scheme in both study locations (Eshbel et al., 2022). These farmers were then organized into the Farmer Research and Extension Group (FREG), and both kebeles two FREG were formed consisting 60 farmers (Mihiretu et al., 2019). Subsequently, per kebele 10 farmers were purposefully selected based on their interest and willingness to participate in the trial, as well as their willingness to allocate land to host the trial. The demonstration trial was implemented in two phases using a participatory approach (Gezahegn et al., 2022). In the first phase, two cassava varieties (AWC-2 and AWC-4) were evaluated on the farmers' field from May, 2022 to December, 2023 under supplementary irrigation. The two treatments were laid out on two side by side simple plots, and then the replication was planted on 20 farmers' field, i.e. 10 in each site (Mihiretu et al., 2019). Per farmer, 100 cuttings of each cassava varieties were planted at 100 m^2 plots. Planting was made using 1, 1 and 2 m spacing between plants, rows and plots (Atnafua et al., 2021). Training and in-depth discussion with stakeholders (farmers and local experts) was held to bear awareness on the entire agronomic practices and management of cassava.

2.3. *Food recipe demonstration and acceptance*

After the field evaluation was completed, demonstration of different food recipe and utilization of cassava was followed as immediate phase using the best fit variety in terms of agronomic and farmer preference traits. Farmers in collaboration with researchers harvest the tubers of selected cassava variety in the demonstration plots and processed in to manageable cutting size. The tubers were peeled the day after harvesting, then washed and thinly sliced using a shredder. The shredded cassava was washed thoroughly with running water and soaked for 24 h to remove toxins (Sarah et al., 2023). Then cassava was spread thinly on a clean concrete surface and left in the sun for approximately 12 hours until it became brittle. Once brittle, the cassava was ground to a fine flour level and sifted to remove any fibers or larger particles (Samuel et al., 2024). The flour was then stored in plastic buckets (Figure 2). Additionally, cassava flour in ratios of 10%, 20%, and 30% by weight were blended with 90%, 80%, and 70% wheat flour, respectively, to create cassava-wheat composite flours in ratios of 10:90, 20:80, and 30:70. These composite flours were labeled and stored in airtight flour sacks in a dry condition for future food recipes and use (Parwada et al., 2021).

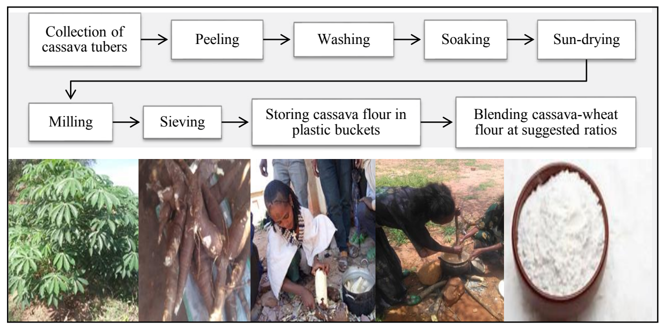

Figure 2: Cassava and cassava-wheat composite flour preparation procedure

2.4. *Panelist selection, sensory attributes and evaluation*

Given that cassava was a new root crop in the area, conducting cooking demonstrations with various food items was essential. A comprehensive sensory evaluation was thus required, with a clear methodological framework to ensure reliability and reproducibility. Ethiopian food recipe that are common to the area, viz., *Enjera, Kitta,* Bread and Porridge (Figure 3) were prepared using three levels of cassava-wheat flour blends for organoleptic test (Liben et al., 2025). A total of 60 individuals, 30 from each kebele, were selected based on their willingness to participate and their relative familiarity with the cassava plant, while ensuring they were not professionally biased. They were carefully selected from a pool of local farmers who possess strong literacy skills, as well as local experts and experienced farmers who have participated in various food tasting trials in the past. Demographic diversity was prioritized to represent different age, gender, and socioeconomic groups, thereby capturing a wide range of preferences. Individuals with taste or smell impairments were excluded to mitigate health risks (Wubet et al., 2022).

Panelists received orientation on cassava attributes, including texture, flavor, aroma, and appearance. Calibration exercises were conducted using reference samples to standardize

Enjera
It was a traditional Ethiopian flatbread made from *teff* flour, a gluten-free grain native to the Horn of Africa. But, it was still made from and other cereal flours with different composite levels (Waje et al., 2025).

Kitta
It was an unleavened flatbread made from basic ingredients like flour, water and salt. Unlike the more widely known Ethiopian bread and Enjera, Kitta was thicker, chewier, and often enjoyed as a breakfast item or a snack (Awel, 2020).

Dabo/Anbasha
(Ethiopian Bread)

Porridge/*Genfo*
It was African and Ethiopian cuisine mainly known as Ethiopian Porridge, *Genfo*, Porridge used mostly for breakfast (Mihiretu et al., 2023).

Figure 3: Food types prepared from different cassava-wheat flour composite

scoring, alongside scoring practice on a 9-point Likert or hedonic scale to ensure consistency (Visses et al., 2018). Various recipes using cassava-wheat flour composites at three levels were prepared into common local dishes under standardized conditions, maintaining consistent boiling time, temperature, and portion size. Cooked food samples were presented in random order to prevent bias, and evaluations were conducted in neutral rooms with minimal distractions.

The sensory attributes used in the assessment were identified by panelists to be water absorbing capacity, appearance, color, taste, texture, mouth feel, aroma and overall acceptance. In order to assess the sensory attributes, a nine-point hedonic scale was utilized to gauge the level of preference and liking of the samples with greater precision compared to other Likert scale variations. The nine-point hedonic scale represents varying degrees of preference or enjoyment. It ranges from 1, indicating extreme dislike, to 9, indicating extreme like. The scale includes levels such as 2, dislike very much, 3, dislike moderately, 4, dislike slightly, 5, neither like nor dislike, 6, like slightly, 7, like moderately, 8, like very much (Parwada et al., 2021).

To ensure accurate results, precautions were taken to eliminate any lingering flavors by having panelists rinse their mouths with water between tastings of different food types. The nine-point hedonic scale is a widely accepted method in sensory evaluation studies due to its ability to facilitate thoughtful and effective evaluation of samples (Waje et al., 2025).

2.5. Data collection and analytical methods

To evaluate the two cassava varieties, we followed a structured methodology that combines field measurements, statistical analysis, and farmer perception surveys. The quantitative data measures of seedling survival rate, earliness, number of roots per plant, storage root length and girth, and storage root yield were collected at the plot level (Mihiretu et al., 2019). Storage root yields were clustered into marketable and unmarketable yield, and total yield was the sum of both. The "marketable root yield" pertains to storage roots weighing between 100-500 grams that are free from disease and insect infestation, but "unmarketable root yield" refers to roots that do not meet these criteria (Gezahegn et al., 2022). To assess root crop performance under field conditions, several quantitative indicators were systematically recorded. The seedling survival rate was evaluated by counting the number of surviving seedlings after a specified establishment period and expressing this as a percentage of the total planted. Earliness was determined by recording the number of days from planting to the appearance of the first harvestable roots or other visible maturity indicators (Eshbel et al., 2022). Yield components were assessed by determining the number of roots per plant, achieved by harvesting representative sample plants and counting the storage roots produced per plant. Morphological traits were measured at harvest, with storage root length and girth recorded in centimeters using caliper (Tesfaye et al., 2017). Overall productivity was quantified as total storage root yield, calculated by weighing harvested roots per plot and extrapolating the results to tons per hectare.

Descriptive statistics such as means and standard deviation were used to analyze variance for each trait across replicates in the collected data. Inferential statistics (two-sample t-tests) using SPSS were used to compare means among the two varieties and to test significance of differences in the collected data. A two-sample t-test is ideal to compare the means of two independent groups to see if they are statistically different from each other. In the context of our cassava dataset, it's the right tool to evaluate whether AWC2 and AWC4 varieties differ significantly in their measurable traits like yield, survival, or root dimensions (Mihiretu et al., 2023). In addition, the varietal yield gap and index of the cassava varieties were assessed using the following formulas (Eq. 1 and 2).

$VG=Y_1-Y_2$ ....(1)

$VI=VG/Yp\times100$..(2)

Where, VG=Varietal gap, Y_1=yield of variety 1, Y_2=Yield of variety 2, VI=Varietal index, Yp=Potential yield

Moreover, the Principal Component Analysis (PCA) plot was made for cassava traits to show how the two varieties clustered based on their performance across yield and growth attributes. It was a multivariate statistical technique used to simplify complex datasets by reducing their dimensionality while retaining most of the variation present in the data (Wubet et al., 2022). This analysis was particularly insightful as it highlighted trait clustering, yield determinants, and variance explanation. Likewise, the Principal Components (PCs) were linear combinations of the original variables that captured the most variance. Farmers identified and rate traits of various attributes such as storage root yield, survival rate, root length, root girth, and number of roots plant^{-1} to compare and determine their preferences for different cassava varieties. This comparison and rating was conducted using a five-point Likert scale, with 1 representing strongly disagree and 5 representing strongly agree (Mihiretu et al., 2021).

Besides, to draw the panelists' sensory attributes and preference of food recipe of cassava-wheat flour composite, water absorbable capacity, appearance, color, taste, texture, mouth feel, aroma and overall acceptance were scored using nine-point hedonic scale, with scores collected anonymously to minimize peer influence (Leemud et al., 2019). The attribute scores were added and averaged in a simple ranking matrix for final scaling. Finally, cluster analysis was employed using graphs to illustrate differences among food items within similar composite levels. One-way analysis of variance was employed to analyze statistical mean variations among hedonic scale attributes of different food recipes of cassava-wheat composite using appropriate statistical package (Eq. 3).

$\sum(N/n)$..(3)

The value N, determined by the group of farmers for each treatment, was based on specific selection criteria. The variable n represented the total number of selection criteria utilized by the farmers.

3. RESULTS AND DISCUSSION

3.1. Yield and related parameters performance

This study investigated the factors influencing plant growth and yield, focusing on the survival rate of the plant (SRP), number of roots plant^{-1} (NRPP), root length (RL), root girth (RG), marketable storage root yield (MSRY), unmarketable storage root yield (UNSRY), and total storage root yield (TSRY). However, the potential yield (Yp) value provided, 25.34 t ha^{-1} was not a calculated value rather it was the attainable yield recommended during the adaptation trial (Liben et al., 2025). The AWC-4 cassava variety demonstrated a superior survival rate of 79.9% compared to 47.3% for the AWC-2 variety. Additionally, AWC-4 exhibited higher average root length (28.8 cm) and root girth (4.9 cm) than AWC-2 ($p\leq0.05$). The average total root yield of AWC-4 was 23.0 ton ha^{-1}, significantly surpassing the 18.3 t ha^{-1} yield of AWC-2 ($p\leq0.05$). As a result, AWC-4 outperforms AWC-2 in SRP, RL, RG, MSRY, and TSRY. In contrast, AWC-2 showed a higher NRPP and UNSRY, indicating a greater number of roots but less efficiency in marketable yield (Table 1).

There were significant differences among cassava varieties in terms of survival rate, root length, root girth, marketable and unmarketable storage root yield, and total storage root yield, except for the number of roots plant^{-1}. The higher survival rate of AWC-4 suggests that it was more adaptable to marginal areas compared to other varieties. The increased root length and girth of a variety were likely due to genetic

Table 1: Performance of yield and yield related attributes of tested cassava varieties

Yield related attributes	Cassava varieties (Mean±SD)		t-value	Significance levels
	AWC-2	AWC-4		
SRP (%)	47.3±2.1	79.9±3.5	32.4	0.001
NRPP	7.2±0.3	6.6±0.4	5.6	0.01
RL (cm)	23.1±0.9	28.8±0.5	27.8	0.001
RG (cm)	2.9±0.6	4.9±0.6	11.2	0.001
MSRY (t ha^{-1})	13.6±1.2	21.3±1.2	19.8	0.001
USRY (t ha^{-1})	4.2±0.5	1.6±0.4	20.3	0.001
TSRY (t ha^{-1})	18.3±0.7	23.0±1.2	17.5	0.001
VG (t ha^{-1})	4.7 (25.7%)			
VI (%)	18.6			

Where, VG: Varietal gap; VI: Varietal index; Yp: Potential yield; SD: Standard deviation; ***, ** are significant levels at p=0.01 and p=0.05; Source: Own evaluation, 2022/2023 factors, which were important for achieving a higher total storage root yield in cassava (Awel et al., 2020). The study also revealed that a varietal gap of 4.7 t ha^{-1}, indicating that using the improved AWC-4 cassava variety could increase farmers' productivity and income by 25.7% in the area. The lower varietal index of 18.6% further supported the feasibility of using the AWC-4 variety in the real context of farmers.

Comprehending these factors was crucial for optimizing plant growth and productivity, providing valuable insights for breeders to enhance plant yield and efficiency, and ultimately maximizing profitability.

Furthermore, the PCA plot was made to illustrate distinct clustering patterns (Figure 4). The AWC-2 points were thus grouped on the left, associated with moderate growth traits like root length and girth, whereas AWC-4 points clustered on the right, strongly linked to high-yield traits such as seedling survival, earliness, number of roots plant^{-1}, and total yield. This separation was evident across the primary cassava traits, with arrows indicating attributes driving this divergence. In this cassava dataset, PC_1 (≈58%) encapsulated yield-related traits such as seedling survival, earliness, and total root yield, while PC_2 (≈23%) encompasses secondary traits like root girth and length. These results corroborated the t-test results, which demonstrated that AWC-4 consistently exceled in traits valued by farmers, whereas AWC-2 exhibited moderate performance, overlapping only in girth. The PCA plot revealed that the AWC-2 cluster points were positioned on the left side, correlating with moderate root length and girth. In contrast, the AWC-4 cluster points were located on the right, demonstrating a strong association with seedling survival, earliness, number of roots plant^{-1}, and total yield. The PCA analysis confirms that AWC-4 was yield-driven and high-performing, whereas AWC-2 was moderate yet stable (Waje et al., 2025). Traits such as seedling survival and total root yield serve as the most significant discriminators between varieties. Additionally, PC_1 accounts for the majority of the variance (≈58%), indicating that yield-related traits predominantly influence the separation. This visualization aids in both breeding decisions and farmer adoption strategies by identifying the traits that most significantly impact performance differences (Manuel Villa et al., 2024).

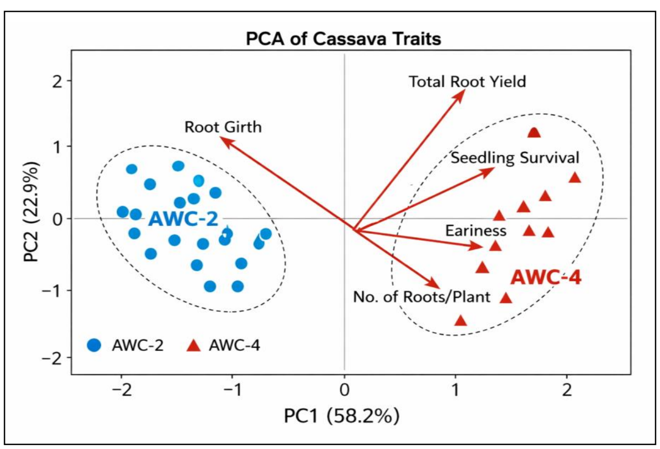

Figure 4: Principal component analysis of traits of the cassava varieties

3.2. Preference and demand of cassava varieties

The farmers set six preference criteria (viz., survival rate, earliness, roots plant^{-1}, root length, root girth and total root yield) to select a variety that best fits their real context using a five-point Likert scale agreement levels (1=Strongly disagree; 2=Disagree; 3=Neutral; 4=Agree; 5=Strongly agree). The farmers' perceptions and/or agreement levels were calculated (Table 2) in descriptive statistics to compare and evaluate the two cassava varieties by their sum and average scores (Wubet et al., 2022). As a result, AWC-4 outperformed AWC-2 in seedling survival, earliness, number of roots per plant, storage root length, and total yield ($p \leq 0.05$). The strongest differences were in number of roots plant^{-1} and total storage root yield, where AWC-4 was clearly superior.

At the end of the trial and/or harvesting stage, field day was held involving 90 (18 female) stakeholders (farmers, researchers and experts at zonal, district and kebele levels).

Table 2: The farmers' preference criteria and selection of best fit cassava variety

Selection criteria (Five-point Likert scale)	Cassava varieties (Mean ± SD)		t-value	Sig.
	AWC-2	AWC-4		
Seedling survival rate	2.25± 0.73	4.15± 0.52	-9.6	0.001***
Earliness	3.0± 0.58	4.35± 0.49	-8.1	0.001***
Number of roots per plant	2.15± 0.52	4.9± 0.31	-22.5	0.002***
Storage root length	4.45± 0.51	4.85± 0.36	-2.9	0.012**
Storage root girth	4.0± 0.58	4.2± 0.41	-1.2	0.102ns
Total storage root yield	2.25± 0.52	4.35± 0.49	-13.8	0.001***
Total score	18.1	26.8		
Average	3.0	4.5		
Rank	2	1		

Where, ns: Non-significant; Note: ***, ** were significant levels at p=0.01 and p=0.05; Source: Own evaluation, 2022/2023

The participants as a group evaluated both cassava varieties by their overall performance, and preferred AWC-4 variety for its vegetative performance, adaptable to harsh environment and better storage root yield. Farmers showed a preference for the AWC-4 cassava variety over AWC-2 due to its superior survival rate, higher number of roots plant^{-1}, and increased total root yield. About 76% of farmers who participated in the field day expressed interest in growing the AWC-4 variety in the upcoming irrigation seasons (Tesfaye et al., 2017).

3.3. Food recipe, sensory evaluation and rating

The panelists' overall sensory rating on food types prepared from different cassava-wheat flour composite levels was evaluated. In both cassava-wheat composite levels i.e. (10:90) and (20:80), the panelists preferred *'Enjera'*, *'Kitta'*, Bread and Porridge as their 1st, 2nd, 3rd and 4th food choices owing that a rates of like slightly to like extremely. Whereas, in the third composite cassava-wheat level (30:70), the panelists preferred *'Enjera'*, Bread, Porridge and *'Kitta'* as their 1st, 2nd, 3rd and 4th food choices at the rates of like slightly to like extremely (Table 3). The food types prepared from different cassava-wheat composite levels were well-liked by panelists, indicating that these compositions were acceptable and effective in the local context. The panelists had positive and negative feedback on the food recipes prepared from the various cassava-wheat composite levels (Awel, 2020). Overall, the sensory attributes of the food types, including water absorbing capacity, appearance, color, taste, texture, mouthfeel, aroma, and overall acceptance, were positively received by panelists across all cassava-wheat composite levels (Sarah et al., 2023).

The preparation of cassava flour has often been criticized for the perceived difficulty in removing toxins from the storage root. Additionally, the taste becomes bitter and the palatability of various food types decreased when the ratio of cassava flour exceeds 30% in the cassava-wheat composite flour.

Moreover, the food products made from the three cassava-wheat composite ratios (10:90, 20:80, and 30:70) were predominantly favored by the panelists, with ratings of 6 or higher on the hedonic scale (Figure 5). The summary statistics of liking in Table 4 indicated that food types from level-3 (30:70) cassava-wheat composite level had the lowest mean rating, but the highest rating was from level-1 (10:90). Food preferences with in similar composite levels, however had significant difference ($p \leq 0.05$) which indicated that the panelists had inconsistent taste preferences.

While the new cassava varieties have the potential to enhance yields and bolster food security, their adoption and applicability were hindered by socioeconomic barriers, including limited knowledge and processing challenges. The literature on the environmental impacts of cassava production presented mixed findings. Some researchers (Hasmadi et al., 2012; Atnafua et al., 2021; Eshbel et al., 2022) suggest that cassava cultivation could enhance resilience to climate change, whereas others (Tewodros et al., 2013; Samuel et al., 2024) expressed concerns regarding its effects on soil depletion and biodiversity. The positive impacts of cassava production were associated with climate resilience and carbon mitigation. Cassava's ability to tolerate drought and poor soils, along with its role in crop diversification, could reduce reliance on cereal crops and supported food security under climate stress (Awel, 2020).

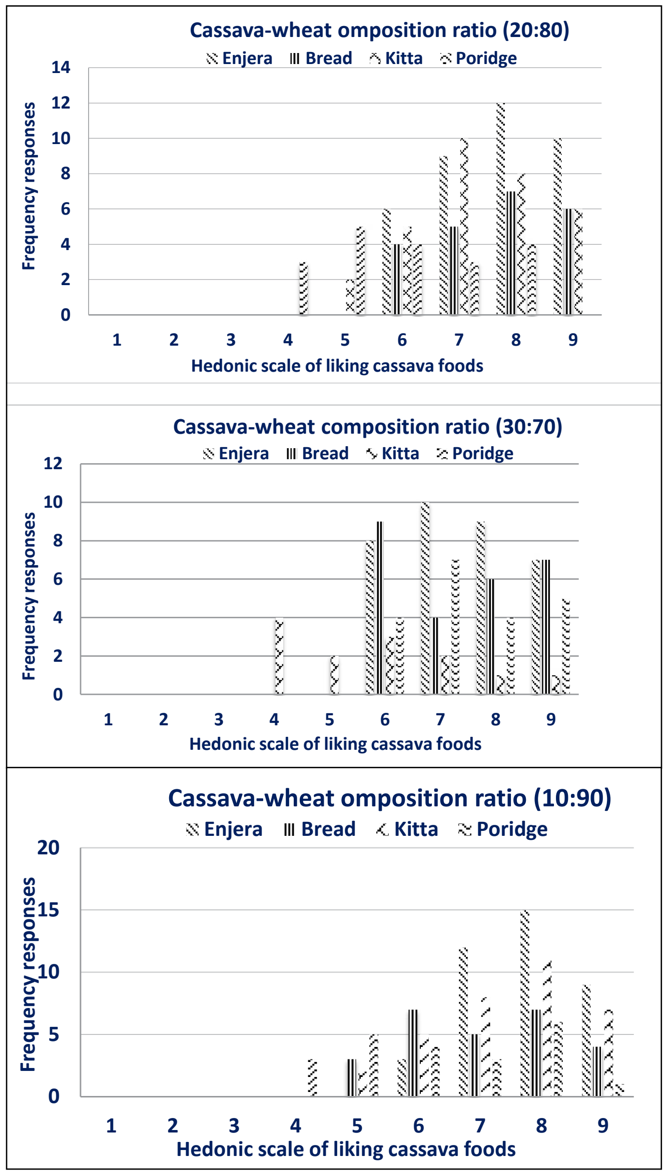

Figure 5: Overall sensory ratings were conducted on various food types made with different levels of cassava-wheat flour composites. The ratings were based on a nine point hedonic scale, with 1 indicating extreme dislike and 9 indicating extreme like (Parwada et al., 2021). Source: Own evaluation, 2022

Table 3: Sensory preference of food types at different cassava-wheat flour composite levels

Sensory attributes	Cassava-wheat flour composite levels											
	Level-1 (10:90)				Level-2 (20:80)				Level -3 (30:70)			
	E	B	K	P	E	B	K	P	E	B	K	P
Water absorbing	7.9	6.5	7.8	6.5	8.5	8.2	8.5	6.7	8.0	7.6	4.2	6.6
Appearance	8.2	6.4	7.6	5.2	8.4	6.5	8.5	5.4	7.5	6.4	6.0	6.4
Color/whiteness	7.8	7.4	7.6	7.4	8.2	8.0	8.4	8.0	9.0	9.0	7.9	9.0
Texture	7.8	6.2	7.4	5.6	7.5	6.5	7.8	5.5	7.2	7.0	6.3	6.1
Aroma	8.4	8.2	8.2	8.2	7.5	7.0	7.5	7.0	7.4	7.4	6.1	7.2
Mouth feel	8.6	6.5	7.4	6.4	8.6	6.2	7.4	6.5	7.7	7.2	5.2	6.4
Taste	8.4	7.2	7.9	6.7	8.8	6.3	7.6	6.4	7.5	7.1	6.0	7.4
Overall liking	8.0	7.4	7.8	6.2	8.5	7.5	8.2	6.0	8.6	8.2	6.3	7.1
Sum	65.1	55.8	61.7	52.2	66	56.2	63.9	51.5	62.9	59.9	48	56.2
Mean	8.2	7.0	7.7	6.5	8.3	7.1	8.0	6.4	7.9	7.5	6.0	7.0
F-value	0.586	0.479	0.474									
Sig.	0.001***				0.021**				0.013**			

Where, E: Enjera; B: Bread; K: Kitta; P: Porridge; CF: Cassava flour; WF: Wheat flour; Note: ***, ** were significant levels at p=0.01 and p=0.05; Source: Own evaluation, 2022/2023

Conversely, some scholars argued that continuous cassava cultivation could lead to soil nutrient depletion. Large-scale mono-cropping of cassava might reduce ecological diversity, and post-harvest processing could generate effluents that potentially polluted water sources (Liben et al., 2025).

4. CONCLUSION

The AWC-4 cassava was outperformed AWC-2 in survival rate, root traits, and yield, with farmers strongly preferring it. The food taste trial was also showed that the 10:90 cassava-wheat ratio best suited for recipes, especially *Enjera*. Expanding AWC-4 in drought-prone areas, coupled with farmer training, pest management, and improved post-harvest practices, was thus recommended. Future studies also should address cassava's soil nutrient depletion, agro-ecological impacts, processing constraints, and adoption barriers to ensure sustainable production and broader farmer benefits.

5. REFERENCES

Atnafua, B., Tesfaye, T., Asfaw, K., Tewodros, M., Getachew, E., 2021. The Elite Cassava Genotypes with High Yield and Stability in Diverse Environmental Conditions of Ethiopia. Current Topics in Agricultural Sciences 2, 81–89. DOI: https://doi.org/10.9734/bpi/ctas/v2/3241f.

Awel, M., 2020. Performance of cassava varieties at different Areas of South Omo, Southern Ethiopia. Journal of Plant Sciences 8(3), 67. DOI: https://doi.org/10.11648/j.jps.20200803.13.

Barati, Z., Latif, S., Müller, J., 2019. Enzymatic hydrolysis of cassava peels as potential pre-treatment for peeling of cassava tubers. Biocatalysis and Agricultural Biotechnology 20, 101247. DOI: https://doi.org/10.1016/j.bcab.2019.101247.

Eshbel, A., Muluneh, M., Awol, M., 2022. Evaluation of improved Cassava (*Manihot esculanta* Crantz) varieties in mid land area of South Omo Zone, Ethiopia. International Journal of Agricultural Research, Innovation and Technology 12(1), 101–104. DOI: https://doi.org/10.3329/ijarit.v12i1.61038.

Gezahegn, B., Tadesse, A., Tadesse, A., Kelifa, Z., 2022. Effect of cassava legumes intercropping on yield and yield components of compound crops in Jinka on station, Southern Ethiopia. International Journal of Agricultural Research, Innovation and Technology 12(1), 30–33. DOI: https://doi.org/10.3329/ijarit.v12i1.61028.

Hasmadi, M., Merlynda, M., Mansoor, A.H., Salwa, I., Zainol, M.K., Jahurul, M.H.A., 2021. Comparative studies of the physicochemical and functional properties of sweet potato (*Ipomoea batatas* L.) flour. Food Research 5(4), 145–152. Available from: https://www.myfoodresearch.com/uploads/8/4/8/5/84855864/_19__fr-2020-610_hasmadi_2.pdf.

Leemud, P., Karrila, S., Kaewmanee, T., Karrila, T., 2019. Functional and physicochemical properties of Durian seed flour blended with cassava starch. Journal of Food Measurement and Characterization 14(1), 388–400. DOI: https://doi.org/10.1007/s11694-019-00301-6.

Liben, L., Ejamo, M., Bergena, A., Chuntale, K., 2025. Cluster based large scale demonstration of cassava (*Manihot esculenta Crantz*) technology at low land Areas of Gofa Zone, Southern Ethiopia. Journal of Food and Nutrition 4(1). DOI: https://doi.org/10.58489/2836-2276/036.

Mansoor, A.H., Jahurul, M.H.A., Zainol, M.K., 2020. Physicochemical and functional properties of cassava flour grown in different locations in Sabah, Malaysia. Food Research 4(4), 991–999. DOI: https://doi.org/10.26656/fr.2017.4(4).405.

Manuel Villa, P., Jha, R., Zainuddin, I.M., Manuel Faneite Noguera, A., 2024. The cassava crop: cultivation, potential uses, and food security. https://doi.org/10.52305/cobz4221.

Mihiretu, A., Asefa, N., Wubet, A., 2019. Participatory evaluation of sorghum technologies in the marginal dryland zones of Wag-lasta, Ethiopia. Cogent Food & Agriculture 5(1), 1671114. DOI: https://doi.org/10.1080/23311932.2019.1671114.

Mihiretu, A., Assefa, N., Wubet, A., 2023. Pearl millet, the hope of food security in marginal arid tropics: implications for diversifying limited cropping systems. Journal of Agribusiness and Rural Development 1(67), 93–102. DOI: http://dx.doi.org/10.17306/J.JARD.2023.01670.

Mihiretu, A., Okoyo, N., Lemma, T., 2021. Causes, indicators, and impacts of climate change: understanding the public discourse in Goat based agro-pastoral livelihood zone, Ethiopia. Heliyon 7(1), e06529. DOI: https://doi.org/10.1016/j.heliyon.2021. e06529.

Owoeye, R., 2020. Comparing climate adaptation strategies on technical efficiency of cassava production in Southwest, Nigeria. Agricultural and Resource Economics: International Scientific E-Journal 6(1), 62–75. DOI: https://doi.org/10.51599/are.2020.06.01.05.

Parwada, C., Chigiya, V., Ngezimana, W., Chipomho, J., 2021. Effect of three organic fertilizer treatments on sensory evaluations of baby spinach (*Spinacia oleracea* L.). International Journal of Horticultural Science 27, 59–63. DOI: https://doi.org/10.31421/ijhs/27/2021/8670.

Samuel, S.W., Berhanu, K.S., Solomon, Z.W., 2024. Exploring key drivers affecting adoption decision and intensity of cassava technology: evidence from cassava growers in Southern Ethiopia. Cogent Food and Agriculture 10(1), 2428368. DOI: 10.1080/23311932.2024.2428368.

Sarah, O., Ainoa, Escrich, Ikechukwu, Achilonu, Molemi, R., Jordy, A.L., Jose, R.M., Leonardo, R., 2023. The future of cassava in the era of biotechnology in Southern Africa. Critical Reviews in Biotechnology 43(4), 594–612. DOI: https://doi.org/10.1080/07388551.2022.2048791.

Tesfaye, T., Atnafua, B., Engida, T., Getachew, W. M., Tewodros, M., Wubshet, B., Mesele, G., 2017. Performance of cassava (*Manihot esculanta. Cratz*) clones in potential and low moisture stressed areas of Ethiopia. African Journal of Agricultural Research 12(20), 1738–1746. DOI: https://doi.org/10.5897/ajar2016.11365.

Tewodros, M., Getachew, W., Tadesse, B., Tesfaye, W., 2013. Genetic diversity of cassava (*Manihot esculenta Crantz*) genotypes in Ethiopia. Greener Journal of Agricultural Sciences 3(9), 636–642. DOI: https://doi.org/10.15580/gjas.2013.3.061013658.

Visses, F.D.A., Sentelhas, P.C., Pereira, A.B., 2018. Yield gap of cassava crop as a measure of food security - an example for the main Brazilian producing regions. Food Security 10(5), 1191–1202. DOI: https://doi.org/10.1007/s12571-018-0831-2.

Waje, S.S., Shano, B.K., Walelign, S.Z., 2025. Unpacking cassava market dynamics: exploring the determinants affecting market participation and channel choices in South Ethiopia. Discover Sustainability 6(1). DOI: https://doi.org/10.1007/s43621-025-01108-w.

Wubet, A., Mihiretu, A., Assefa, N., Ayen, K., 2022. Pre-scaling up evaluation of Banana technology under irrigation conditions in Abergelle District, Wag-himra Zone, Ethiopia. International Journal of Horticultural Science 28, 39–44. DOI: https://doi.org/10.31421/ijhs/28/2022/10787.

Yin, Y., Ma, Z., Nong, G., Wang, S., 2019. Strategies of energy management in a cassava starch plant for increasing energy and economic efficiency. Journal of Cleaner Production 234, 1296–1305. DOI: https://doi.org/10.1016/j.jclepro.2019.06.309.