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EDITED BY
Claire Helen Quinn,
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Dolapo Adelabu,
University of the Free State, South Africa

*CORRESPONDENCE
Thobani Cele
✉ Thobanivpa@gmail.com

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Multifaceted determinants influencing South African smallholder farmers' choices to access and utilize underutilized crops

Thobani Cele* and Xolile Mkhize

Department of Community Extension, Faculty of Natural Sciences, Mangosuthu University of Technology, Durban, South Africa

Underutilized crops (UCs), referred to as neglected or orphan crops, play a crucial role in addressing food security, nutrition, and rural development. However, despite their nutritional, economic, and environmental benefits, their consumption remains low among smallholder farmers. This study investigates the socio-economic and perceptual factors influencing smallholder farmers' decisions to consume UCs, focusing on taro roots (*Colocasia esculenta*) and sweet potatoes (*Ipomoea batatas*) in KwaZulu-Natal, South Africa. Using data from 300 smallholder farmers, the study applies Factor Analysis (FA) and a binary logistic regression model to identify key determinants of UC consumption. The FA revealed four main perception factors influencing farmers' decisions: perception of production, taste, awareness, and availability of UCs. The binary logistic regression results showed that household size ($p < 0.05$), marital status ($p < 0.01$), and gender ($p < 0.05$) significantly influenced UC consumption. Notably, farmers' positive perception of taste ($p < 0.1$) increased the likelihood of consumption, whereas a lack of awareness ($p < 0.1$) had a negative impact. However, contrary to initial expectations, receiving a government grant ($p < 0.05$) and off-farm income ($p < 0.05$) were negatively associated with UC consumption, indicating that financial stability does not necessarily translate into increased adoption. These findings suggest that raising awareness, addressing market constraints, and fostering positive perceptions of UCs are crucial for increasing their consumption. The study highlights the need for targeted interventions to improve UC accessibility and appeal, thereby supporting sustainable food security strategies in South Africa and other regions with similar demographics.

KEYWORDS

consumption, underutilized crops, binary logistic analysis, factor analysis, KwaZulu-Natal, sweet potato (*Ipomoea batatas* (L.) Lam.), taro (*Colocasia esculenta*)

1 Introduction

The Green Revolution prioritized enhancing the yields of staple crops (such as maize, rice, and wheat) while neglecting other underutilized crops (Sobratee et al., 2022). Underutilized crops (UCs), also referred to as neglected or orphan crops, include plant species that have been historically important in local food systems but have received limited attention in formal research, commercial production, and global trade (Mabhaudhi et al., 2022). While some UCs, such as taro roots, remain largely neglected, others, like sweet potatoes are globally recognized as an important cash crop and are widely commercialized (Otálora et al., 2024). However, within certain smallholder farming communities in South Africa, particularly in

KwaZulu-Natal, they exhibit characteristics of an underutilized crop due to limited market access, production constraints, and shifting dietary preferences away from traditional staples (Kunene et al., 2022). Unlike truly neglected or orphan crops, which receive minimal commercial attention worldwide, sweet potatoes have significant economic importance globally but remain underutilized in specific regional contexts where smallholder farmers face socio-economic and market-related barriers (Bayiyana et al., 2024). According to Otálora et al. (2024) sweet potato is one of the root crops with economic and nutritional relevance in poor regions of developing countries in Asia, Africa, America, and the Caribbean. This crop contributes to the food security of these regions and is widely used in food preparations and pharmaceutical recipes, competing with other important root crops such as cassava, potatoes, and yams (Otálora et al., 2024). This study, therefore, classifies sweet potatoes as underutilized within the study region, acknowledging their broader commercial significance while highlighting localized challenges that limit their production and consumption.

Economically, households in low- and middle-income regions face significant constraints that limit their choice of food items (Raneri et al., 2019). These households opt for UCs as low-cost solutions, which are not only affordable but also adapted to local agronomic conditions (Raneri et al., 2019). This economic necessity drives the consumption of UCs, yet this aspect was previously under-discussed. Furthermore, market integration challenges for UCs mean that these crops do not reach mainstream markets, limiting their commercial exposure and economic viability (Sobratee et al., 2022; Mudau et al., 2022). Improved market access and integration can, therefore, not only boost the economic incentives for cultivating UCs but also enhance their consumption among wider populations (Ndlovu et al., 2024; Ali and Bhattacharjee, 2023). UCs like taro roots (*Colocasia esculenta*) and sweet potatoes (*Ipomoea sweet potatoes*) hold significant importance for their nutritional value and cultural relevance. These crops have been staples in the diets of rural communities, traditionally grown for household consumption and local markets (Mabhaudhi et al., 2016; Mabhaudhi et al., 2022).

The African Orphan Crops Consortium is working to enhance the genetic resilience and quality of underutilized crops (UCs) in response to climate change, aiming to diversify agricultural production and consumption (Akpojotor et al., 2025; Ismail et al., 2023). However, compared to staple crops, breeding efforts for UCs have historically received limited investment, contributing to their continued marginalization in agricultural systems (Chandra et al., 2020). Various factors, such as the dominance of multinational food corporations, government subsidy patterns, and the relatively low prioritization of UCs in crop improvement programs, have driven a shift toward the consumption of major staple crops (Revoredo-Giha et al., 2022; Li et al., 2020; Ali and Bhattacharjee, 2023). While interventions in production are essential, addressing demand challenges through promoting the consumption of UCs and products derived from them remains crucial.

Enhanced demand for underutilized crops (UCs) can generate better economic returns for smallholder farmers by creating stable markets and increasing the value of these crops, ultimately serving as a strategy to combat poverty (Ndlovu et al., 2024). Studies have shown that the commercialization of indigenous crops, such as African leafy vegetables and drought-resistant legumes, has improved farmers' incomes and livelihoods, particularly in rural areas with limited access to mainstream agricultural markets (Zondi et al., 2022a; Bokelmann et al., 2022; Mabhaudhi et al., 2022; Mabhaudhi et al., 2016; Ndlovu et al., 2024). Furthermore, UCs contribute to dietary diversity by offering essential micronutrients lacking in staple-dominated diets. For example, orange-fleshed sweet potatoes, rich in vitamin A, have been successfully promoted to address vitamin A deficiency in African countries (Mchiza et al., 2024; Beal and Ortenzi, 2022). Increasing consumption of UCs also presents a viable strategy to counter the growing reliance on highly processed, nutrient-poor foods, which have been linked to rising rates of obesity, diabetes, and non-communicable diseases (Li et al., 2020). Thus, promoting UCs through awareness campaigns and improved market access can simultaneously enhance farmer livelihoods and public health outcomes (Shembe et al., 2023).

Mainstream agriculture marginalizes UCs, which hold significant importance for smallholder farmers in developing countries where they can serve as a source of high-nutritional-value food and income (Sobratee et al., 2022; Zulu et al., 2022). Taro roots (*Colocasia esculenta*) and sweet potatoes (*Ipomoea batatas*) are among the underutilized tubers in KwaZulu-Natal (KZN) (Mabhaudhi et al., 2017), and they hold significant importance for both their nutritional value and cultural relevance (Mabhaudhi et al., 2017). These crops have long been staples in the diets of rural communities, traditionally grown for household consumption and local markets (Kunz et al., 2024). Taro roots are rich in carbohydrates, fiber, and essential micronutrients such as potassium and vitamin C, contributing to improved food security and nutrition in these communities (Mabhaudhi et al., 2022; Mabhaudhi et al., 2016; Mudau et al., 2022). Sweet potatoes, similarly, offer a high yield of vitamins A and C, making them an important crop in combating malnutrition (Low et al., 2020). Moreover, these tubers are well-suited to the climatic conditions of KZN, as they are drought-tolerant and thrive with minimal agricultural inputs, making them a sustainable choice for smallholder farmers (Gouveia et al., 2020). Underutilized crops (UCs) play a crucial role in enhancing human nutrition, generating income for smallholder farmers, and preserving cultural food diversity (Nkwonta et al., 2023). Despite these benefits, underutilized crops have been largely overlooked in favor of staple crops such as rice, wheat, and maize, which dominate global agricultural systems due to higher investments in research, commercialization, and policy support (Li et al., 2020; Odeku et al., 2024). This neglect has led to a limited focus on the cultivation, nutritional profiling, and genetic improvement of UCs, restricting their potential contribution to food security and rural development (Odeku et al., 2024).

While several studies have examined the nutritional and health benefits of UCs, research on the socio-cultural and economic factors influencing their consumption remains limited, particularly in KZN, South Africa (Mbosso et al., 2020; Omotayo and Aremu, 2020; Ali and Bhattacharjee, 2023). In KZN, a region where smallholder farming plays a critical role in rural livelihoods, UCs such as taro roots (*Colocasia esculenta*) and sweet potatoes (*Ipomoea batatas* (L.) Lam.) have historically been part of traditional diets (Mabhaudhi et al., 2016; Ndlovu et al., 2024). However, their consumption has declined due to factors such as market constraints, shifting dietary preferences, and inadequate policy support (Chivenge et al., 2015). Despite their agronomic adaptability, there is insufficient research on the socio-cultural and economic drivers affecting UC consumption in KZN. Understanding these factors is essential for designing policies that promote the sustainable production and integration of UCs into local food systems (Omotayo and Aremu, 2020). Therefore, this study primarily investigates the consumption of underutilized crops (UCs) among smallholder farmers in KZN. While other smallholder farmers cultivate their own food, this study does not assume that all consumers grow these species themselves. Instead, it considers both home-grown and purchased sources, acknowledging that various socio-economic and market-related factors influence UC consumption patterns. By analyzing these factors, this study provides insights into how consumption choices are shaped by availability, accessibility, and perception, whether the crops are self-cultivated or obtained through external means.

2 Analytical framework

The study used a random utility theory (RUT). At the household level, the decision to consume UCs is based on random utility theory (McFadden, 2012). The RUT assumes that a farmer, as a utility maximizer, would consume UCs if the expected utility from their consumption (U_i M) is greater than when they do not consume (Ui N). That is, a farmer chooses to consume UCs if the net utility, U_i*, i.e., (U_i M− U_i N) is greater than zero. The unobserved net utility can be expressed as a function of observable elements in the following latent variable model as shown in Equation 1:

$$U_i^* = \alpha X_i + \varepsilon_i, U_i = 1 \text{ if } U_i^* > 0 \quad (1)$$

Where U_i is a dummy variable that equals 1 for smallholder farmer i in case of consumption and 0; otherwise, α is a vector of parameters to be estimated, X_i is a vector of household and farmer characteristics, and ε_i is an error term.

3 Research methodology

3.1 Study area

Figure 1 illustrates the study area, which includes two rural communities: Swayimane, located in the uMgungundlovu Municipality, and Umbumbulu, situated in the eThekwini Municipality. These two municipalities are among the largest in KwaZulu-Natal Province. We selected these areas due to their socio-economic and demographic characteristics. Umbumbulu lies southwest of Durban, approximately 19 km from the Indian Ocean, while Swayimane is about 45.5 km from Pietermaritzburg, a central town between Durban and the Drakensberg Mountain range (Cele and Mudhara, 2024). Proximity to major towns plays a critical role in shaping food accessibility and economic opportunities, particularly in rural communities (Berkhout et al., 2023). This study primarily focuses on Swayimane, which receives annual rainfall ranging from 600 to 1,100 mm (Cele and Mudhara, 2024) and is part of the humid midlands within the mist belt. Temperatures range between 11.8 and 24.0°C, with dry winters and warm, wet summers (Cele and Mudhara, 2024). The dominant soil type in this region is clay loam, known for its high productivity, making it suitable for various agricultural activities (Cele and Mudhara, 2024).

Umbumbulu's 956 millimeters of annual precipitation falls between November and March, making it an abundant amount for agriculture (Ngcobo, 2019; Hlatshwayo, 2018). Farmers in our study areas typically begin their planting season in September or October,

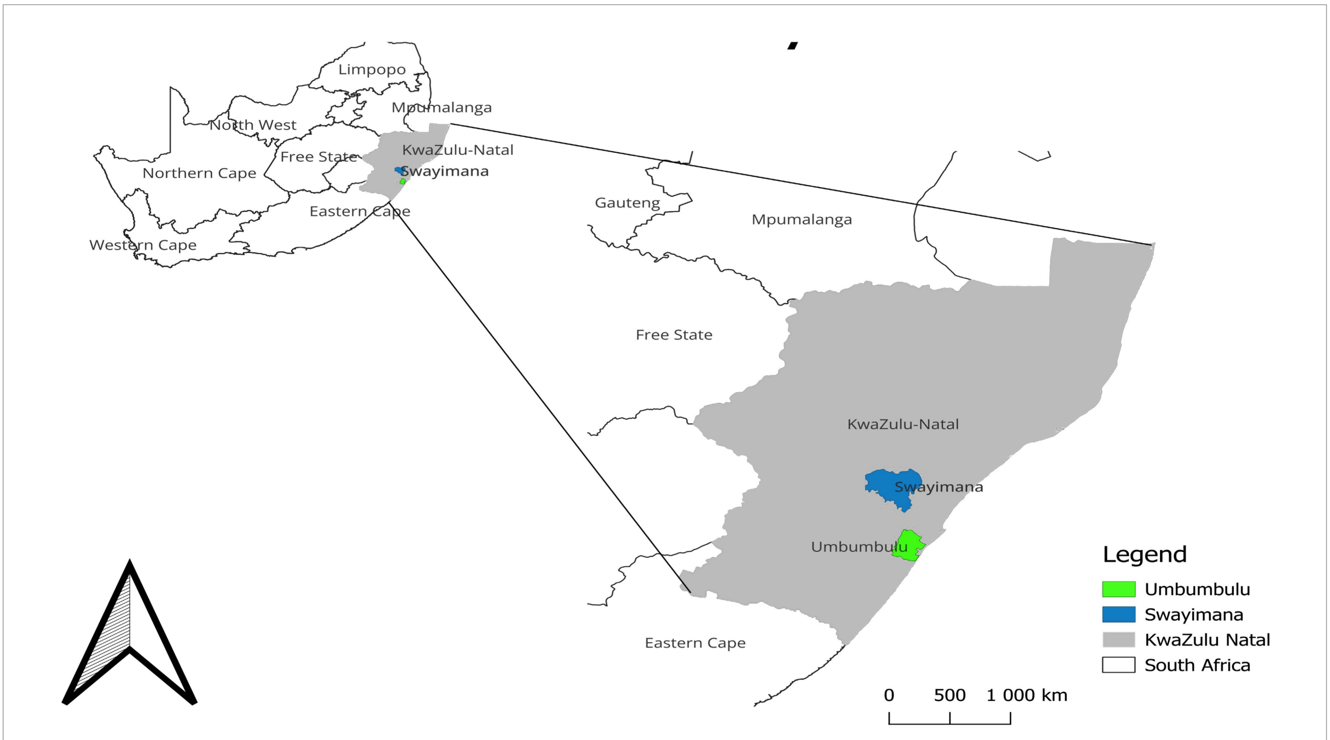

FIGURE 1
Location of study sites in KwaZulu-Natal (Cele and Mudhara, 2024).

just before the expected start of the rainy season. However, due to recent delays in rainfall likely caused by climate change, farmers have adapted by postponing their planting until the rains arrive (Olabanji et al., 2020). This adjustment ensures that planting coincides with optimal soil moisture conditions, which is crucial for crop growth and yield (Olabanji et al., 2020). According to Cele and Mudhara (2024), Umbumbulu experiences a maximum temperature of 24.0°C and a minimum of 13.4°C, creating favorable conditions for agriculture. Approximately 15% of the land in Umbumbulu is highly suitable for year-round farming, while an additional 9% is fertile but less ideal for intensive agriculture. Cele and Mudhara (2024) further emphasize that Umbumbulu's climate is well-suited for the cultivation of diverse crops, including taro and sweet potatoes, with dryland farming being feasible throughout the year.

3.2 Data collection and sampling

This study employed a structured questionnaire to collect data on socio-economic, behavioral, and perceptual factors influencing underutilized crop (UC) consumption among smallholder farmers. The questionnaire was divided into four key sections: demographic and household characteristics, economic and institutional factors, market and behavioral factors, and perception variables. Each variable was measured using categorical, continuous, or factor score-based scales, ensuring compatibility with statistical analysis (Boateng et al., 2018).

To ensure accuracy and reliability, the study used a combination of structured questionnaires, face-to-face interviews, and tablet-assisted data collection. The structured questionnaire was selected to ensure consistency across respondents and facilitate statistical analysis. It contained closed-ended and Likert-scale questions, which allowed for quantifiable responses, reducing interviewer bias (Karunarathna et al., 2024). Structured questionnaires are widely used in agricultural research as they enhance data comparability and standardization across large sample sizes (Harkness et al., 2010). Face-to-face interviews were conducted to enhance comprehension and accuracy in responses, particularly in rural areas where literacy levels may vary. Trained enumerators fluent in isiZulu conducted the interviews, ensuring respondents fully understood the questions. This method also helped to clarify ambiguous responses and reduce misinterpretation. Digital data collection using tablets was incorporated to minimize transcription errors, improve efficiency, and allow real-time data validation (Kalibbala et al., 2022). Given the large sample size (300 households), tablet-based data collection reduced data entry delays and improved data accuracy by eliminating the need for manual transcription.

A sampling frame of 1,365 farming households cultivating UCs was obtained from the Provincial Department of Agriculture, Land Reform and Rural Development (DALRRD) in KwaZulu-Natal. The sample size was determined using Raosoft's sample size calculator, with a 95% confidence level and a 5% margin of error, which resulted in a final sample of 300 households. To ensure representative and unbiased data collection, the study employed a stratified random sampling technique, followed by simple random sampling within each stratum. The two study areas, Swayimane and Umbumbulu, were considered separate strata, ensuring representation from both regions. Stratification helps to account for differences in geographic, economic, and agricultural characteristics between the two areas, improving the validity of comparisons (Stehman, 2014). Within each stratum, simple random sampling was used to select individual households, ensuring equal probability of selection and minimizing selection bias (Lohr, 2021). The sample was evenly distributed, with 150 households surveyed in each area to facilitate comparative analysis. An equal split was chosen rather than a strictly proportional allocation to allow balanced statistical comparisons.

Within each selected household, the primary decision-maker regarding food and agricultural production was interviewed. Typically, this was the household head or another key farming member responsible for crop cultivation and consumption decisions. Interviewing primary decision-makers ensured that responses accurately reflected household farming and dietary behaviors, which is critical for understanding UC adoption (Knight et al., 2022). To enhance the accuracy and reliability of the collected data, several measures were implemented, such as enumerators undergoing rigorous training on data collection protocols, ethical considerations, and question clarification techniques. The questionnaire was pretested with 30 farmers to refine question clarity, language appropriateness, and survey structure.

3.3 Statistical analyses

Tables 1, 2 show the descriptive statistics of continuous and categorical variables used in the study, respectively. To assess multicollinearity among the independent variables, the study computed the Variance Inflation Factor (VIF). The VIF test is commonly used to detect correlation between independent variables in regression models, as high multicollinearity can distort parameter estimates (Streukens and Leroi-Werelds, 2023). A VIF value above 10 is typically considered problematic, indicating severe multicollinearity (Lavery et al., 2019). In this study, all VIF values were below 10, confirming the absence of multicollinearity and ensuring the robustness of the regression results. A *T*-test was done for the continuous variables, and a chi-square test was done for the categorical variables. The two tests were used to determine whether the consumers and non-consumers of UCs are statistically different.

3.4 Factor analysis

The first research question explored the influence of farmers' attitudes and perceptions toward underutilized crops on their willingness to consume these crops. To address this, 24 attitude and perception-related questions were presented to farmers. To simplify the dataset and identify patterns in responses, the study employed Factor Analysis (FA). This statistical method reduces the number of correlated variables by grouping them into orthogonal (independent) factors (Kline, 2014). Before conducting FA, the suitability of the dataset was tested using the Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity. The KMO value was 0.766 (76.6%), indicating that the sample was adequate for FA (Qadar and Nawab, 2022). Bartlett's Test of Sphericity was significant at 1% (p-value = 0.000; χ^2 = 2672.72), confirming that the data had sufficient correlations to proceed with FA.

TABLE 1 Chi-square test of categorical variables.

Variables	Categories	Non-consumers	Consumers	*P*-value
		%		
Marital status	0 = not married (*n* = 183)	3.83	96.17	***
	1 = Married (*n* = 117)	22.22	77.78	
Education	1 = No school (*n* = 137)	8.76	91.24	n.s
	2 = Primary (*n* = 62)	8.06	91.94	
	3 = Secondary (*n* = 83)	13.25	86.75	
	4 = Tertiary (*n* = 18)	27.78	72.22	
Access to credit	0 = No (*n* = 249)	10.84	89.16	n.s
	1 = Yes (*n* = 51)	11.76	88.24	
Government Grant	0 = No (*n* = 82)	7.32	92.68	n.s
	1 = Yes (*n* = 218)	12.39	87.61	
Gender	0 = Female (*n* = 185)	14.78	85.22	*
	1 = Male (*n* = 115)	8.65	91.35	
Willingness To buy	0 = No (*n* = 150)	20	80	***
	1 = Yes (*n* = 150)	2	98	
Extension office visit	0 = No (*n* = 119)	12.61	87.39	n.s
	1 = Yes (*n* = 181)	9.94	90.06	
Training	0 = No (*n* = 145)	10.34	89.66	n.s
	1 = Yes (*n* = 155)	11.61	88.39	
Farmers group membership	0 = No (*n* = 231)	12.99	87.01	**
	1 = Yes (*n* = 69)	4.35	95.65	

*, **, ***, means the coefficient is statistically significant at 10, 5 and 1% levels, n.s means not significant.

TABLE 2 *T*-test results for continuous variables among non-consumers and consumers.

Variables	Non-consumers (*n* = 33) 11%		Consumers (*n* = 267) 89%		*T*-test
	Mean	±Std. dev	Mean	±Std. dev	
Household size	7.419	4.213	9.091	3.827	**
Off-farm income (ZAR) per month	2095	1443.952	3056.127	7097.813	n.s

**Means the coefficient is statistically significant at 5%, and n.s. means not statistically significant.

To ensure validity and reliability, the study used Cronbach's Alpha Coefficient, which measures internal consistency among items within each factor. An alpha coefficient greater than or equal to 0.6 was considered acceptable (Nawi et al., 2020). Eigenvalues were computed to determine convergent validity, following Kaiser's Criterion, where only factors with eigenvalues greater than 1 were retained for further analysis (Shrestha, 2021).

The FA identified four key perceptual dimensions influencing UC consumption (Table 3):

- Consumer Perception on Production (12 variables, eigenvalue = 5.4407, variance explained = 22.67%).
- Consumer Perception on Taste (6 variables, eigenvalue = 3.0475, variance explained = 12.70%).
- Consumer Perception on Awareness (4 variables, eigenvalue = 1.8061, variance explained = 7.53%).
- Consumer Perception on Availability (3 variables, eigenvalue =1.4732, variance explained = 6.14%).

The factor scores generated from these retained factors were incorporated into the Binary Logistic Regression Model as independent variables to analyze their influence on farmers' willingness to consume UCs.

3.5 Empirical model: binary logistic regression model

To analyze the determinants of underutilized crop (UC) consumption, a binary logistic regression model was estimated, followed by the computation of marginal effects. Marginal effects measure the change in the probability of consuming UCs given a one-unit change in an independent variable, holding all other factors constant (Greene et al., 2023). This approach provides a more intuitive interpretation of the impact of each independent variable compared to raw logistic regression coefficients. The binary model is motivated by the fact that when faced with a decision regarding consumption, a farmer either consumes or does not consume. The logistic regression model was chosen because the literature shows

TABLE 3 Factor analysis of attitudes and perception of underutilized crops.

Variable	Perception on production	Perception on taste	Perception on awareness	Perception on availability
Tartness (sourness)	−0.0664	0.0906	−0.2885	−0.0372
Flavor intensity	0.2641	**0.5666**	0.0875	−0.0781
Sweetness	0.3808	**0.7147**	0.1443	−0.0738
Texture	0.257	**0.6868**	0.1934	0.0883
Aroma	0.3202	**0.7946**	0.1862	0.0169
Nutritional value	0.2531	**0.5306**	0.0349	0.2849
Understanding of cultivation	0.2307	−0.0556	0.2657	0.0046
Familiarity with preparation	0.1985	**0.5998**	0.0058	0.0025
Quality of the product	**0.5828**	−0.2364	0.2419	−0.2886
Market demand	0.3342	0.1466	−0.1778	−0.0318
Reliability of the production process	**0.6483**	−0.2141	0.0603	0.0700
Responsiveness to customer needs	**0.6249**	−0.0950	−0.0902	0.0784
Transparency in production methods	**0.6815**	−0.1786	−0.1188	0.1818
Safety and hygiene standards during production	**0.5816**	−0.0924	**0.4343**	0.1629
Value for money in relation to the product's price	**0.6579**	−0.0926	**0.4149**	0.1772
Distribution channel	**0.6140**	0.0251	−0.3836	0.2262
Ethical practices in the production	**0.6538**	−0.1343	−0.2527	0.0868
Access to storage	**0.5314**	−0.0112	−0.1508	−0.1125
Access to transportation	**0.5991**	−0.1341	0.1329	**0.4754**
Environmental sustainability practices	**0.5984**	−0.1624	0.1868	**0.0.4868**
Availability in Season	0.2189	−0.2460	0.3678	**0.6591**
Availability of Information	0.359	−0.2637	**0.5682**	0.3134
Price stability	0.3028	−0.2587	**0.5438**	0.1634
Ease of accessibility	**0.5712**	−0.1364	0.1833	−0.3016
Eigenvalue	5.4407	3.04751	1.80611	1.47324
Proportion	22.67%	12.70%	7.53%	6.14%
Cumulative	22.67%	35.37%	42.89%	49.03%
KMO	0.766			
Alpha	0.8294			

Barlett's test of sphericity: Chi-square = 2672.72, degree of freedom = 276, *p*-value = 0.001. The bold numbers means that the eigen value is 0.5.

that it can analyze farmer consumption decisions (Mutwedu et al., 2022; Omotayo and Aremu, 2020). The dependent variable for this study was the farmer being a consumer or non-consumer of UCs, with a value of 1 (if the farmer consumed UCs) and 0 (otherwise). The likelihood of the farmer consuming UCs is predicted odds $(Y = 1)$, that is, the ratio of the probability that $(Y = 1)$ to the probability that $Y \neq 1$ as it is specified in Equation 2:

$$\text{Odd } Y = \frac{P(Y = 1)}{(1 - P(Y = 1))} \tag{2}$$

The binary logistic regression model is specified in Equation 3. The natural log of Odds gives the logit (Y).

$$\text{In}\left(\frac{P(Y = 1)}{(1 - P(Y = 1))}\right) = \log \text{Odds} = \text{Logit}(Y) \tag{3}$$

This can be expanded as the Equation 4 below:

$$\text{Logit}(Y) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon_i \tag{4}$$

where Y = dependent variable (consumption) with 1 = consumer and 0 = otherwise; α = intercept, βi = coefficients of the independent variables, X_n = the independent variables; P = the probability of farmer consuming underutilized crops; 1 − P = probability that a farmer does not consume underutilized crops; and ln = natural log.

3.6 Marginal effects calculation

While logistic regression estimates log odds, the marginal effects provide a more intuitive interpretation by measuring the change in the probability of UC consumption for a one-unit increase in an independent variable, holding all other factors constant (Greene et al., 2023). The marginal effect for each independent variable X_k is calculated as Equation 5:

$$ME_K = \frac{\partial P(Y=1)}{\partial X_K} = \beta_K P(Y=1)\left(1 - P(Y=1)\right) \quad (5)$$

This equation shows that marginal effects depend on both the coefficient β_K and the predicted probability of UC consumption $\left(P(Y=1)\right)$, making them more interpretable than raw logit coefficients. In this study, marginal effects were computed after estimating the logistic regression model, allowing for a direct assessment of how changes in independent variables influence the likelihood of UC consumption. This approach provides clearer insights into policy implications by quantifying the effect of each variable in probability terms rather than log odds.

3.7 Justification for inclusion of hypothesized independent variables

The independent variables included in the binary logistic regression model were carefully selected based on a review of relevant literature, with each variable hypothesized to influence smallholder farmers' decisions to consume underutilized crops (UCs) (Zulu et al., 2022), specifically taro roots and sweet potatoes as shown in Table 4.

4 Results and discussion

4.1 Socio-demographic characteristics

The socio-demographic characteristics of the sampled farmers ($n = 300$) were analyzed to distinguish between UC consumers (89%) and non-consumers (11%). Table 2 presents the T-test results for continuous variables, and Table 1 provides chi-square test results for categorical variables.

The results of the T-test in Table 2 support the hypothesis of a significant association between household size and the decision to consume UCs at ($p < 0.05$) significant level. On average, UC consumers had larger households (mean of 9 members) compared to non-consumers (mean of 7 members). This supports the hypothesis that larger households require more diverse food sources, leading to a greater likelihood of consuming UCs to meet dietary needs.

The chi-square test showed a significant association between marital status and UC consumption decision ($p < 0.01$), as shown in Table 1. Unmarried individuals were more likely to consume UCs (96.17%) compared to married individuals (77.78%). Unmarried individuals have more autonomy over their dietary choices compared to married individuals, who may need to consider the preferences and dietary requirements of other family members, including spouses and children. This autonomy can lead unmarried individuals to explore a wider variety of foods, including UCs, which might be less conventional or familiar (Neergheen-Bhujun et al., 2020). The results also indicated a significant relationship between gender and UC consumption ($p < 0.10$). Female farmers were more likely to consume UCs (91.35%) than male farmers (85.22%). Women have a higher awareness of the nutritional benefits associated with UCs (Chivenge et al., 2015). Due to their role in nurturing and providing for families, female farmers are more proactive in choosing food options that promote health and wellness, which can include the inclusion of UCs known for their health-promoting properties (Chivenge et al., 2015).

The analysis identified a significant relationship between the willingness to buy UCs and the decision to consume them ($p < 0.001$). Among those who were unwilling to purchase UCs, 20% did not consume them, whereas 80% did consume them. Conversely, almost all farmers (98%) who were willing to buy UCs also consumed them. This pattern underscores that familiarity with UCs, including their flavors, culinary applications, and health benefits, significantly enhances the likelihood of purchasing and consuming them. Research by Knez et al. (2024) supports this, demonstrating that when consumers are educated about the health benefits and various uses of lesser-known foods, their propensity to buy and consume these foods rises substantially.

Farmers group membership also showed a significant association with UC consumption ($p < 0.05$). Farmers who were members of farmer organizations were more likely to consume UCs (95.65%) compared to non-members (87.01%). Group membership likely provides better access to information, resources, and peer support, encouraging greater consumption of UCs (Raneri et al., 2019).

4.2 Factor analysis of attitude and perception variables

Table 3 presents the results of the Factor Analysis (FA), which identified four key attitudinal and perceptual factors influencing underutilized crop (UC) consumption. Consumer perception on production accounted for 22.67% of the total variance, indicating that farmers' views on the feasibility and productivity of UCs significantly shape their consumption decisions. Consumer perception of taste explained 12.70% of the variance, highlighting that sensory attributes strongly influence food choices. Consumer perception of awareness accounted for 7.53% of the variance, showing that knowledge of the nutritional and economic benefits of UCs affects consumption behavior. Lastly, consumer perception of availability contributed 6.14% of the variance, suggesting that access to UCs plays a role in determining their adoption of household diets.

4.2.1 Binary logistic results

Table 5 presents the parameter estimates for the logistic regression model. The results indicate that multicollinearity was not a concern, as all predictor variables exhibited VIF values below 10. This confirms that the independent variables were sufficiently independent, allowing for unbiased and reliable coefficient

TABLE 4 Justification for inclusion of hypothesized independent variables.

Variable	Type	Expected Influence	Justification	Reference
Education level	Categorical (1 = No School, 2 = Primary, 3 = Secondary, 4 = Tertiary)	(+)	More educated farmers may have greater awareness of the nutritional benefits of UCs, leading to increased consumption.	Malkanthi (2016)
Household size	Continuous	(+)	Larger households require a diverse food basket, making them more inclined to include UCs in their diet.	Imathiu (2021)
Marital status	Categorical (0 = Not Married, 1 = Married)	(−/+)	Married individuals may have different food consumption patterns due to shared decision-making and cultural dietary influences.	Zulu et al. (2022)
Access to credit	Categorical (0 = No, 1 = Yes)	(+)	Farmers with access to credit may have more resources to experiment with diverse food sources, including UCs.	Jerop et al. (2018)
Government grant	Categorical (0 = No, 1 = Yes)	(+)	Financial support from the government may enable farmers to diversify their diets, including UC consumption.	Jerop et al. (2018)
Gender	Categorical (0 = Female, 1 = Male)	(+/−)	Women play a larger role in food preparation, potentially influencing UC consumption within households.	Zulu et al. (2022)
Willingness to buy UCs	Categorical (0 = No, 1 = Yes)	(+)	Consumer willingness to purchase UCs is a strong predictor of actual consumption patterns.	Nilssen et al. (2019)
Off-farm income	Continuous	(−)	Farmers with off-farm income may shift toward purchasing commercially available foods instead of relying on UCs.	Mayes et al. (2012)
Extension visits	Continuous	(+/−)	Extension officers provide information that can either encourage or discourage UC consumption.	Mudau et al. (2022)
Training	Categorical (0 = No, 1 = Yes)	(+)	Farmers who receive training are expected to be better informed about the benefits of UCs.	Mabhaudhi et al. (2022)
Farmer Group membership	Categorical (0 = No, 1 = Yes)	(+)	Farmer groups provide platforms for discussing food choices and agricultural practices, potentially promoting UC consumption.	Carnegie et al. (2020)
Perception of production feasibility	Factor Score	(+)	If farmers believe UCs are easy to grow, they are willing to consume them.	Senyolo et al. (2014)
Perception on taste	Factor Score	(+)	Taste plays a critical role in food choices; farmers who enjoy UCs are more likely to consume them.	
Perception on awareness of UC health benefits	Factor Score	(+)	Farmers who are aware of the benefits of UCs are more likely to include them in their diets.	
Perception on availability	Factor Score	(+)	If UCs are readily available, farmers are more likely to incorporate them into their diets.	

estimation in the regression model. Out of 15 identified socio-economic and demographic parameters, 11 socio-economic and demographic parameters had a statistically significant effect on the decision to consume underutilized crops. These parameters were consumer perception of higher production, consumer perception of taste, consumer perception of awareness of the benefits of UC, education, household size, marital status, government grant, gender, willingness to buy underutilized crops, off-farm income, and group membership.

4.2.1.1 Perception of higher UC production

The logistic regression results in Table 5 demonstrate a significant and negative impact of the perception that UCs achieve higher production on the decision to consume UCs at a 1% significant level.

TABLE 5 Binary logistic regression analysis.

The decision to consume	Odds ratio	Std. err.	$P > \|z\|$	Marginal effects	VIF
The perception that they achieve higher production	0.516	0.086	**0.000*****	−0.009***	1.160
The perception that UCs taste better	1.373	0.232	**0.061***	0.005*	1.410
Awareness about underutilized crops benefits	0.690	0.142	**0.072***	−0.005*	1.180
The perception that they are available	1.144	0.356	0.666	0.002	1.140
Education	1.565	0.412	**0.088***	0.007*	1.050
Household size	1.163	0.075	**0.019****	0.002**	1.040
Marital status	6.864	4.049	**0.001*****	0.039***	1.120
Access to credit	0.549	0.403	0.415	−0.007	1.030
Government Grant	5.225	3.765	**0.022****	0.024**	1.040
Gender	0.316	0.184	**0.048****	−0.019**	1.120
Willingness to buy	0.019	0.016	**0.000*****	−0.057***	1.380
Off-farm income per month	0.999	0.000	**0.034****	−0.000**	1.060
Extension office visit	0.478	0.268	0.188	−0.012	1.080
Training	2.095	1.159	0.182	0.011	1.100
Group membership	0.184	0.136	**0.022****	−0.018**	1.260
_cons	0.209	0.369	0.375		
Mean VIF					1.14

Number of obs = 300 LR $chi^2(15) = 96.00$ Prob > $chi^2 = 0.001$ Pseudo $R^2 = 0.4618$. *, **, ***, means the coefficient is statistically significant at 10, 5 and 1% levels.

This suggests that when farmers perceive UCs as highly productive, they consider these crops more suitable for commercial markets rather than for personal consumption. This observation aligns with the findings by Mayes et al. (2012), who reported that the commercial orientation of crop production can detract from local consumption due to market-driven cultivation practices focusing on profitability rather than local food security.

4.2.1.2 Perception of UCs has pleasant taste

The logistic regression analysis showed that a positive perception of the taste of underutilized crops significantly increases their likelihood of consumption. Specifically, for each unit increase in positive taste perception, the odds of consuming UCs increase by 1.373 odds. This finding implies that when farmers or consumers perceive UCs as having a better taste, they are more inclined to include them in their diet. This effect of sensory perception on food choice is well-documented, where taste is a crucial determinant in the adoption of new or less familiar foods (Senyolo et al., 2014).

4.2.1.3 Awareness about underutilized crops health benefits

The results in Table 5 show that an increase in awareness about the benefits of UCs paradoxically results in a statistically significant and negative impact ($p < 0.1$) on their consumption, with a decrease in the likelihood by 0.5% for each unit increase in awareness. This counterintuitive result suggests that while awareness of UCs health benefits is increasing, it does not necessarily translate into higher consumption rates. According to Nkwonta et al. (2023) cultural norms and perceptions play a significant role in food choices. Even when aware of the benefits, farmers may prefer staple crops due to traditional dietary habits or perceptions of UCs as "poor people's food," leading to their underutilization (Nkwonta et al., 2023). Farmers and consumers still undervalue these crops due to entrenched dietary habits or a lack of immediate economic incentives to switch from well-established agricultural practices to those involving UCs. Moreover, Mkhize et al. (2023) argued that for UCs to be more widely accepted, specific interventions are needed that address not only the gaps in knowledge but also the practical and economic barriers to their cultivation and consumption.

4.2.1.4 Education

Higher education levels positively influence the consumption of UCs, showing a statistically significant impact ($p < 0.1$) on their consumption. This indicates that for every single unit increase in education, there is a corresponding change of 0.007 in the predicted probability that an individual will choose to consume UCs. The result shows the role that education plays in enhancing understanding and appreciation of the benefits associated with UCs, leading to increased consumption. The positive correlation between education and UC consumption may be attributed to the fact that education tends to broaden individuals' perspectives on nutritional diversity and environmental sustainability, which are key features of UCs. Educated individuals are more likely to be exposed to information regarding the health benefits and ecological advantages of diversifying their diets with UCs. Research conducted by Zulu et al. (2022) supports this finding, highlighting that educated farmers are more likely to adopt UCs due to their better understanding of the complex interplay between agriculture, nutrition, and health. These farmers are more receptive to new agricultural techniques and scientific evidence supporting the cultivation and consumption of UCs.

4.2.1.5 Household size

Household size had a statistically significant and positive impact on the consumption of UCs. For each additional member in the household, the likelihood of consuming UCs increases by 0.2%, with a significance level noted at $p < 0.05$. This outcome highlights the influence of larger household sizes on UCs' dietary choices and consumption patterns. The increase in UC consumption with household size can be attributed to that larger households require a more diversified diet to meet the nutritional needs of their varied members, which include individuals across different age groups with differing dietary requirements (Zondi et al., 2022a,b). This necessity drives the exploration and inclusion of a broader range of food items, including UCs, which are nutrient-rich and can provide unique health benefits. Furthermore, larger households have a greater propensity to cultivate their food, particularly in rural or semi-rural settings where space and labor resources allow (Zondi et al., 2022a,b). Underutilized crops, which are typically less resource-intensive and adaptable to local conditions, become appealing choices for household cultivation due to their low maintenance and adaptability to diverse climatic conditions. This is supported by research, such as the findings of Zondi et al. (2022a,b), which observed that household size directly affects dietary diversity and the incorporation of UCs into regular meals, as larger families are more likely to engage in subsistence farming of diverse crop varieties.

4.2.1.6 Marital status

The results show that marital status had a positive and statistically significant impact on the decision to consume UCs ($p < 0.001$). The marginal effect shows that married farmers had a 3.9% increased probability of consumption. The results imply that having a spouse or partner provides social and economic support, allowing the farmer to take risks and try new things, such as planting and consuming crops that may not have been grown or consumed previously. A spouse or partner also provides additional labor and resources to help plant and harvest and ultimately cook for household distribution. These findings are aligned with the results of Zulu et al. (2022), who revealed that married farmers were more likely to consume UCs.

4.2.1.7 Off-farm income and government grant

Both off-farm income and receiving government had a negative and statistically significant impact on the decision to consume UC at a 5% significant level. The findings are consistent with the work of Jerop et al. (2018), who found that farmers with additional income sources have more financial stability. Moreover, the author highlights that farmers are more willing to take risks to explore options for crop diversification for planting and consumption. Off-farm and government grant income provide a farmer with additional resources, such as money to purchase seeds, inputs, and equipment, which makes it more feasible to cultivate these crop varieties. In addition, off-farm income also increases farmers' awareness of the benefits of consuming UCs, which may be less known or expected in their area and not widely produced (Jerop et al., 2018).

4.2.1.8 Gender

The results in Table 5 show that gender demonstrates a statistically significant and negative impact on the consumption of UCs, with males showing a 1.9%-point decrease in the likelihood of consumption compared to females ($p < 0.05$). This gender disparity in dietary preferences may be influenced by cultural roles and nutritional awareness that typically differ between males and females (Brandt et al., 2025; Lombardo et al., 2024; Feraco et al., 2024). Females have primary responsibility for household meal preparation and decision-making about food, which leads to greater exposure and a more favorable attitude toward UCs, known for their nutritional benefits (Jerop et al., 2018; Brandt et al., 2025; Lombardo et al., 2024; Feraco et al., 2024). This involvement allows women to incorporate a variety of nutritious and diverse food options, including UCs, into their family's diet more regularly. Conversely, men might not engage as frequently with meal preparation or dietary planning, which limits their exposure to and interest in UCs.

4.2.1.9 Willingness to buy

The odds ratio related to the willingness to buy UCs indicates a significant decrease in their consumption, with an odds ratio of 0.019. The results imply that individuals who are unwilling to purchase UCs are less likely to consume them, highlighting a strong negative impact on consumption likelihood due to purchasing reluctance. This reluctance stems from a variety of factors, including perceived cost, lack of availability, and unfamiliarity with their preparation and culinary uses (Mayes et al., 2012). Economic factors play a crucial role; if consumers perceive UCs as expensive or not providing sufficient value for money, they are less likely to make a purchase. Moreover, if UCs are not readily available in local markets or if consumers are not aware of how to prepare them, this can further hinder their willingness to buy (Mayes et al., 2012).

4.2.1.10 Group membership

Table 5 reveals that group membership had a significant decrease in the consumption of UCs, with an odds ratio of 0.184. This low odds ratio indicates that individuals who are members of farming groups are less likely to consume UCs, demonstrating a strong negative association between group membership and UC consumption. Farmers who are members of farming groups are less likely to consume underutilized crops (UCs) due to several factors, including economic incentives, risk aversion, conformity to group norms, and limited knowledge about these crops (Carnegie et al., 2020). Primarily, these groups tend to prioritize commercial crops that guarantee market stability and profitability, steering clear of UCs perceived as economically risky due to their lesser-known market demand (Carnegie et al., 2020). The collective decision-making processes inherent in these groups further exacerbate this trend, as individual preferences may be overshadowed by the majority's choice, which typically leans toward crops with proven returns (Carnegie et al., 2020).

5 Conclusion and recommendations

This study examined the socio-economic, demographic, attitudinal, and perceptual factors influencing smallholder farmers' decisions to consume underutilized crops (UCs), focusing on taro roots and sweet potatoes in KwaZulu-Natal, South Africa. The findings provide key insights into the drivers of UC consumption and their potential role in enhancing food security, nutrition, and rural development. The binary logistic regression analysis revealed that household size, marital status, gender, and perception of taste were positively associated with UC consumption. In contrast, a lack of awareness of the benefits of UCs and financial stability (government grants and off-farm income) were negatively associated. The findings indicate that while larger households tend to incorporate UCs into their diets, farmers receiving government support or off-farm income may shift away from UCs, possibly due to access to more commercially available foods. Furthermore, group membership was negatively associated with UC consumption, suggesting that collective farming structures may prioritize staple crops with stronger market integration.

5.1 Policy implications and recommendations

The findings of this study have significant policy implications for promoting the consumption of underutilized crops (UCs) among smallholder farmers. One of the key barriers identified was low awareness of the benefits of UCs, which suggests an urgent need for targeted educational programs to inform farmers about the nutritional, economic, and agronomic benefits of UCs. Agricultural extension services should incorporate UC promotion into training and outreach programs, while demonstration farms could showcase their production feasibility and market potential. These interventions can help shift perceptions and encourage farmers to integrate UCs into their agricultural systems. The study also highlights financial barriers as a potential deterrent to UC consumption.

Contrary to expectations, receiving government grants or off-farm income was negatively associated with UC consumption, suggesting that financial stability does not necessarily translate into increased adoption. Instead, this indicates that farmers with greater financial resources shift toward more commercially available food crops. To address this, policies should focus on integrating UCs into formal markets, ensuring that they are not perceived as inferior or last-resort food options. Governments and development organizations should provide subsidies and incentives that support UC commercialization, seed supply, and value-added processing, helping farmers recognize their economic potential.

Furthermore, social structures such as farmer groups play a crucial role in shaping agricultural practices, yet the study found that group membership was negatively associated with UC consumption. This may be due to group farming models prioritizing staple crops with stronger market integration. Policymakers should work toward introducing incentives that encourage farmer groups to integrate UCs into their production systems by linking them to UC-specific market opportunities, supply chains, and agro-processing industries. Furthermore, peer-led initiatives that focus on knowledge-sharing, collective marketing, and innovative recipe adaptation could help increase UC acceptance within farming communities. Gender dynamics also emerged as an important factor in UC consumption, with female farmers being more likely to consume UCs than their male counterparts. This underscores the need for gender-inclusive agricultural policies that recognize women's role in household food security and nutrition. Interventions should focus on enhancing women's access to agricultural resources, including land, financing, and training programs, to further support UC production and utilization. Promoting women-led agricultural cooperatives and strengthening community-driven nutrition education programs could also contribute to wider acceptance and adoption of UCs.

5.2 Limitations of the study

This study has some limitations. First, it lacks direct variables on households' economic capacity and market integration in the regression model (Table 5). While off-farm income and government grants serve as proxies, they may not fully capture the ability to pay and food availability. Future studies should include household wealth indicators and market access metrics for a more comprehensive analysis. Second, the study focuses on two rural areas in KwaZulu-Natal, limiting its generalizability to other regions with different economic and agricultural conditions. Expanding research to other provinces or developing countries could improve external validity. Despite these limitations, the study offers valuable insights for policy and future research on promoting UC consumption.

Data availability statement

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

Ethics statement

The studies involving humans were approved by Research Ethics Office's Humanities and Social Sciences Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

TC: Writing – review & editing, Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft. XM: 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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