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CONSTRAINTS TO THE VALUE CHAIN ACTIVITIES OF BAMBARA GROUNDNUT, COWPEAS AND ORANGE-FLESHED SWEET POTATOES IN MPUMALANGA, SOUTH AFRICA

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ABSTRACT

There is a renewed interest in integrating underutilized crops (UC) into the food market to ensure access to nutritious and affordable food. Underutilized crop species are still recognized in the local, national and international communities. Still, they are out of reach due to challenges facing the value chain activities of the crops. Current research in South Africa has mainly been at the production level with limited focus on constraints to the value chain activities of underutilized crops. There is enough literature on the qualitative perceptions of the challenges along the value chain activities of underutilized crops. The quantitative understanding of challenges facing value chain activities of underutilized crops in South Africa remains unknown. This study analysed the constraints to value chain activities of underutilized crops (Bambara groundnut, cowpeas and Orange-fleshed sweet potatoes (OFSP)) in Mpumalanga, South Africa. One hundred and fifteen (115) value chain actors were selected for the study using the snowballing technique. The study employed the Principal Component Analysis (PCA) to identify important constraints facing the value chain activities of the selected underutilized crops. The PCA results revealed that the most critical constraints to Bambara groundnut, cowpeas and OFSP production were low-quality inputs, storage facilities and adverse weather conditions. The PCA results showed that farmers' most important constraints to UC marketing were poor storage and processing techniques, high cost of processing, high cost of transportation and lack of contractual agreement. The PCA results for constraints to Bambara groundnut, cowpeas and OFSP marketing by traders were improper stall structures, lack of vehicular access to the market, poor marketing channels and irregular/insufficient crop produce. These constraints were evident in the fragmented nature of the selected underutilized crop value chain activities. The absence of other actors like processors and distributors made the constraints obvious, and there is a need for all relevant stakeholders to address these barriers to the value chain activities of the underutilized crops. District, provincial and national governments should invest in raising awareness and promoting the usage of underutilized crops to address food insecurity in the country. Farmers and other value chain actors are encouraged to form cooperatives to strengthen their bargaining power, enhance access to credit and improve their influence on government policies.

Key words: Underutilized crops, Value Chain, Constraints, Principal Component Analysis

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INTRODUCTION

In many agricultural systems, the prevailing dominance and over-reliance on conventional crops such as maize, rice and wheat hinder efforts to enhance the cultivation and utilization of underutilized crops [1]. Research and development attention have focused on improving the production and utilization of these conventional crops, leaving other crops under-researched and underutilized. The over-dependence on major crops like rice, wheat, or maize, which often lack resilience against climatic and economic shocks due to insufficient diversity and redundancy, has resulted in the transition in local food systems [2].

The neglected and underutilized crop species (NUCS), also known as "forbidden or orphan crop species," are indigenous to a particular tribe, usually semi-domesticated or wild [3]. These crops are characterized by their scientific and ethnobotanical evidence of nutritional benefits, adaptability to agro-ecological conditions, rare ex-situ collections, underdeveloped supply chains, and limited focus from various stakeholders, including scientists, farmers, policymakers, technologists and consumers [4]. The underutilized crops qualify as viable alternatives for addressing food insecurity and malnutrition because of their high nutritional profile and better tolerance to numerous abiotic stressors [5]. However, research suggests that the benefits and value of indigenous foods within the African context have yet to be fully recognized and integrated into output markets [6]. However, current studies on UCs remain limited relative to the constraints on the commercialization potential of the crop [7]. The constraints hinder the understanding and recognition of the markets for underutilized crops [8]. According to literature from other developing nations, factors such as age, income source, health, education level and access to market knowledge limit the commercialization of indigenous crops [9]. However, the strategies for large-scale production of the crops face multiple challenges related to cultivation practices, infrastructure and linkages [10].

Underutilized crops are grown by resource-poor small-scale producers who cannot compete with world markets and large farms regarding productivity, quality and efficiency [11]. The farmers face poor access to infrastructure, inputs, markets and tenure insecurity [12]. The value chains of underutilized crops are described as immature with few activities and actors [13]. While underutilized crops have the potential to respond to ending hunger and poverty, the value chain activities of the crops are weak and fragmented [13]. The value chain of underutilized crops in each subcomponent is poorly developed and poorly connected, and it occurs mainly in informal domains [14]. In South Africa, the lack of crop improvement and development of value chains limit the market viability of neglected and underutilized crops [15]. The negligence and underutilization of the indigenous crops are attributed to value chain fragmentation and low recognition of their potential to reach South

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African markets. The smallholder farmers in the country produce and sell underutilized crops through informal systems [16].

Current research in South Africa has mainly been at the production level with limited focus on constraints to the value chain activities of underutilized crops. There is enough literature on the qualitative perceptions of the challenges along the value chain activities of underutilized crops [13, 17-26]. The quantitative understanding of challenges facing value chain activities of the crops in South Africa remains unknown. This study sought to fill the gap by answering the research question – What are the significant constraints to the value chain activities of the selected underutilized crops in Mpumalanga, South Africa? The study's findings have policy implications for mainstreaming underutilized crops into food production systems for food and nutrition security through unbroken value chain activities.

MATERIALS AND METHODS

Study Area and data collection method

Mpumalanga province in South Africa has a high density of rural farmers who plant underutilized crops like Bambara groundnut, cowpeas and orange-fleshed sweet potatoes (OFSP). The study was conducted in Makoko and Mzinti villages located between 25°41'49"S and 31° 44'46"E and 25°41'49"S and 31° 44'46"E, respectively. Makoko and Mzinti villages are under the Mbombela and Nkomazi local municipalities of the Ehlanzeni district municipality in Mpumalanga province. The criteria for participation were that household heads were involved in at least one value chain activity of three selected underutilized crops (Bambara groundnut, Cowpeas and Orange-fleshed sweet potato). Information used for the study was obtained from value chain actors under the InnoFood Africa Project in August 2023 using survey questionnaires. Data collected included the socioeconomic characteristics of value chain actors, farm data on the selected underutilized crops and information on constraints of the value chain activities of underutilized crops.

Sampling procedure

The study was conducted in the Mpumalanga province (as indicated in Figure 1). A two-stage sampling technique was utilized for the study. Firstly, there was a purposive selection of the Ehlanzeni district, which comprises the Mbombela and Nkomazi local municipalities. Secondly, a snowball sampling technique was used by the InnoFood Africa project to select 66 farmers and 50 traders of the selected underutilized crops for the study. There were no respondents for processing the selected underutilized crops in the study areas, though the crops were processed by farmers for home consumption.

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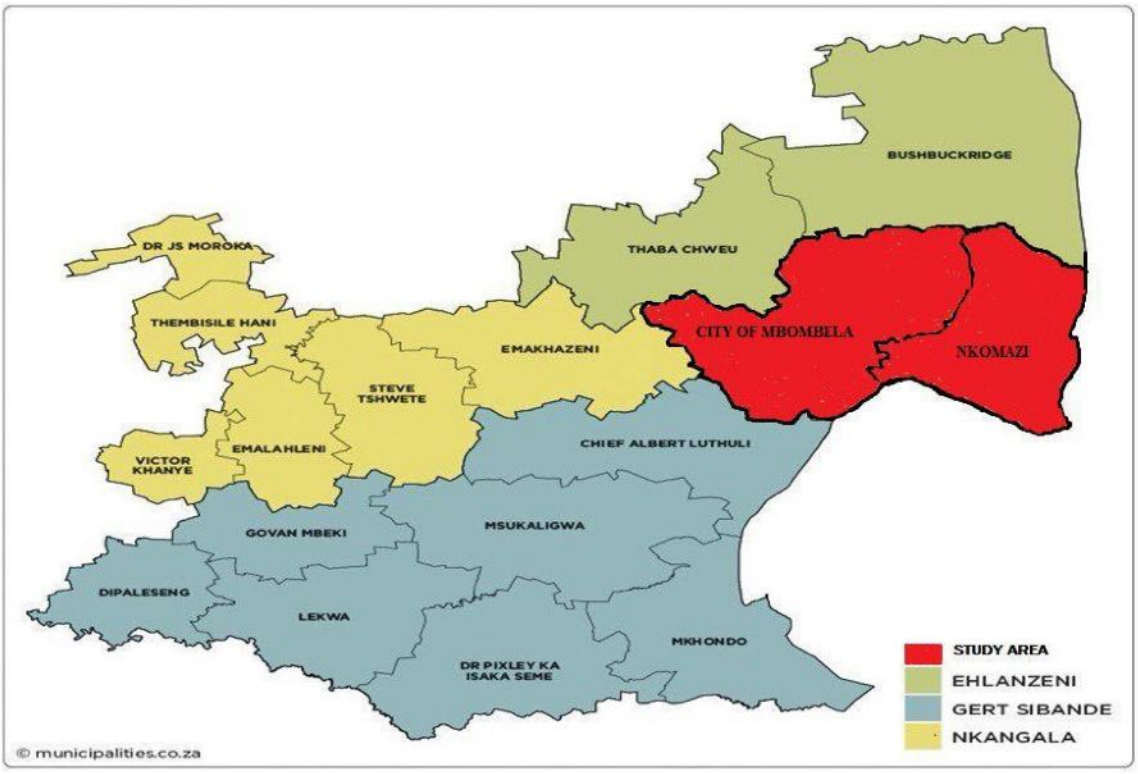

Figure 1: Map showing the Mpumalanga province and municipalities
Source: https://municipalities.co.za/provinces/view/6/mpumalanga (2023)

Methods of Data Analysis

The study employed Descriptive statistics and the Principal Component Analysis for the data analysis. The descriptive statistics provided a statistical summary of the socio-economic features of the farmers. At the same time, the PCA was used to identify the challenges faced by UC in the value chain activities.

Principal Component Analysis

Principal Component Analysis is a multivariate statistical method that reduces the dimensions in a dataset and derives the best components with a high percentage variance [27]. The principal components (PC) applied matrix decomposition to the correlation matrix and derived a linear combination of the original variables. The PC retains the largest variance with the highest explanatory values (Eigenvalues) in the smallest possible variables [27]. The prime objective of PCA is to minimize the dimensionality of the dataset with a large set of interrelated variables while tackling multicollinearity issues and preserving as much variance as possible [28]. One strategy to get around this impediment is to randomly group constraints into a smaller number of cases. This study uses PCA's data reduction techniques to condense the constraint statements into a few dominant numbers without compromising the broader image presented by these constraints. Principal component analysis helps

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to compartmentalize the weighted items into components to show the most important constraints. The new linear combination of PCA can be expressed as:

$$X_{ak} = \sum_{j=1}^{p} a_{jk} x_j \quad (1)$$

Where X_{ak} is the principal component of the dataset of value chain activities of the selected underutilized crops, $a_{jk}$is the PC loadings, whereas the elements of the linear combinations $X_{jk}$are called the PC scores – the values everyone would score on a given PC. Principal component is a linear combination of x_j^*, which the centred variables with the generic element $x_{ij}^* = x_{ij} - \underline{x}_j$, where $\underline{x}_j$ denotes the mean value of the observations on variable *j* and *x* is the original socioeconomic and demographic factors with pattern *j = 1 …. p.* The PCs are usually difficult to interpret due to the more significant *p* that many variables have non-trivial coefficients in the first few components. Simplifying the interpretation involves the rotation of PCs, which shows the situation where the total variance of the q components was more evenly distributed between components after rotation.

Fifteen constraint attributes were measured on a 5-point Likert scale (with scores of 5, 4, 3, 2 and 1 for very great extent, great extent, moderate extent, small extent and not at all) and farmers were asked to rank their responses on this 5-point Likert scale. Analytically, it was cumbersome to analyze all 15 attributes since some are interrelated, and the study was interested in the most dominating and correlated ones. One strategy to get around this impediment was to randomly group constraints into a smaller number of cases. As a result, the study hinges on and uses data reduction techniques like principal component analysis (PCA) to condense the constraint statements into a few dominant numbers without compromising the broader image presented by these constraints.

RESULTS AND DISCUSSION

Table 1 shows the descriptive statistics of the farmers' socioeconomic and demographic characteristics. About 71% of the respondents were female with an average age of 50 years. Underutilized crops are associated with specific gender roles with women being seen as particularly significant in the production [29]. However, women are usually constrained by less access to land, technology, credit, poor agricultural output and limited access to resources and information provided by extension practitioners [30]. Only 52% of the farmers were married, 52% of the respondents had primary school education and 48% had secondary education. The average household size was three. The sampled farmers with such few family

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members could not use family labor, increasing the production cost of underutilized crops.

The average farm income per production cycle was R55110, and the average non-farm income was R3333. The farmers had to travel an average distance of 50km to sell their produce. The results also showed that 56% had a farm size of less than 1ha, 69% had an average yield of less than 1 tonne per ha, and 93.85% owned their land. The majority (89%) of the respondents did not have access to credit, while only 45% had access to inputs. This further lowers their investment in agricultural production, as capital is an essential factor in agricultural production activities [31].

About 45% of the farmers belonged to farmers 'cooperatives while 74% of the farmers did not have access to extension services, and 59% did not have access to market information. Farmers' cooperatives are social networks that encourage collaboration, which is crucial for improving farming practices [32]. Only 15% had contractual agreements with buyers whereas 38% had a marketing outlet (transporting goods to market) and 34.5% sold at the farm gate. On average, 58% had a marketing chain (farmers – consumers) and could sell their produce directly to consumers without involving other actors.

Table 2 shows the descriptive statistics of the traders' socioeconomic and demographic characteristics. About 84% of the respondents were female, with an average age of 41 years—gender and age disparities in trading underutilized crops in Mpumalanga, South Africa. Women produce underutilized crops for home consumption to feed their families and sell off the excess produce for income [33]. About 46% of the respondents had secondary education, while 44% had tertiary education. This shows a high level of literacy among traders of underutilized crops. The average household size was two, and 57% of the traders were single women.

The average income from sales was R50,558. The average capital to start trading was R11,966. The average distance to convey crop produce to market was 13km. Eighty-eight (88%) of the traders' business was small-scale. Approximately, 92% of the respondents did not have access to credit for their trading activities, and 70% did not belong to any cooperative associations. About 44% had access to market information on underutilized crops. Sixty percent (60%) had vehicle access to convey goods to markets, and 32% had contractual agreements with buyers. Thirty four percent (34%) of the traders bought their crop produce from Mozambique, either from farmers or traders, and 84% arranged to get their produce via phone. Only 16% travelled to get their crop produce. Forty percent (40%) used taxis to convey their produce to the markets, and 76% of the traders indicated that producers had contacted them to sell their crop produce.

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Figure 2 shows the distribution of crops produced by sampled farmers. Only 34% planted Bambara nut, 23% planted cowpea, 23% planted OFSP and 20% planted other crops. Other crops include green beans, sugar beans, peanuts, white beans, cassava and lettuce.

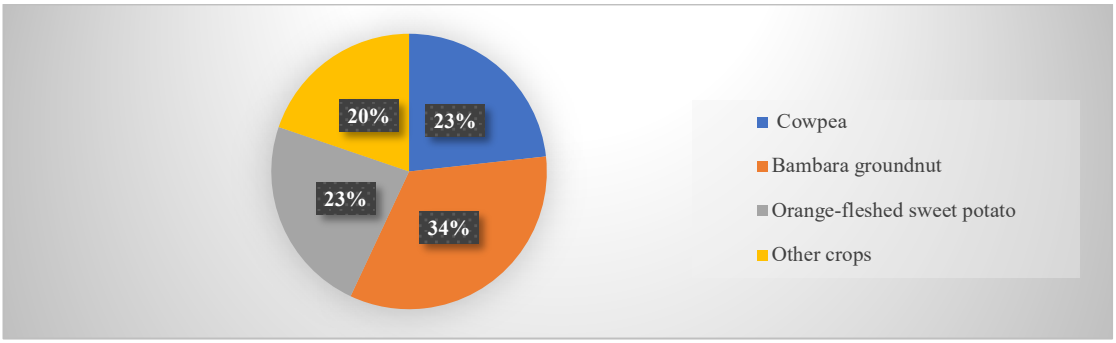

Figure 2: Distribution of crops produced by sampled farmers

Figure 3 shows the uses of crops among the sampled farmers. About 74% of the sampled farmers consumed and marketed underutilized crops, 15% used underutilized crops for home consumption only, and 11% exclusively commercialized underutilized crops for livelihood. Most rural households may consume indigenous foods and sell their excess in informal markets [34].

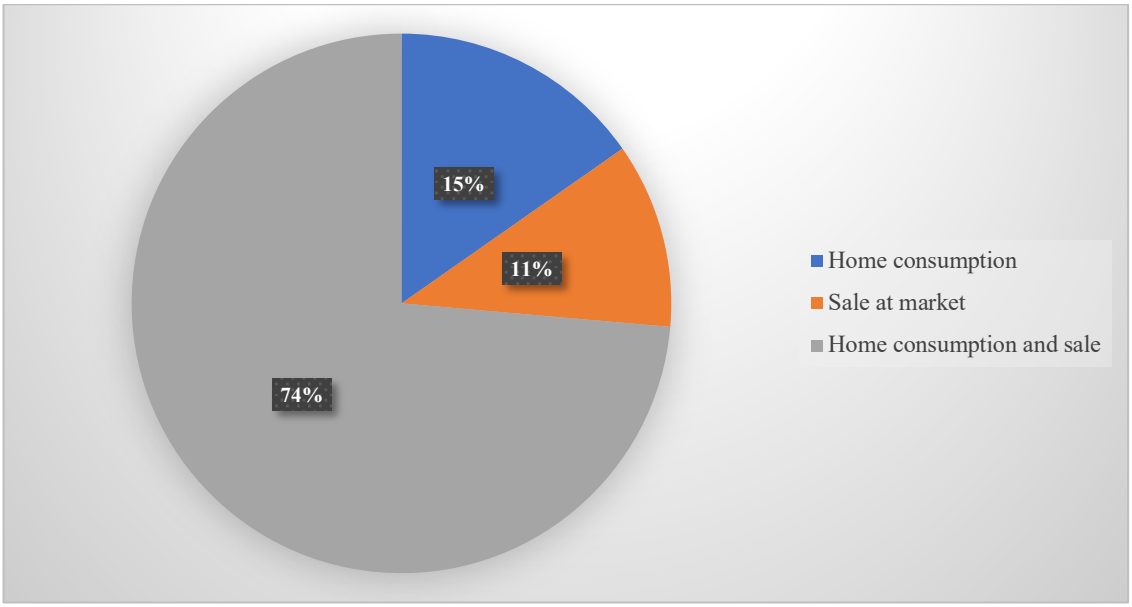

Figure 3: Uses of crops produced by sampled farmers

Figure 4 shows the distribution of crops sold by sampled traders. The results showed that 31% of the respondents sold Bambara nut, 26% sold cowpea, 18% sold OFSP, and 25% sold other crops. Traders commercialized these crops around township malls, around busy markets where other numerous sellers operate in open spaces or temporary setups and along the roadsides.

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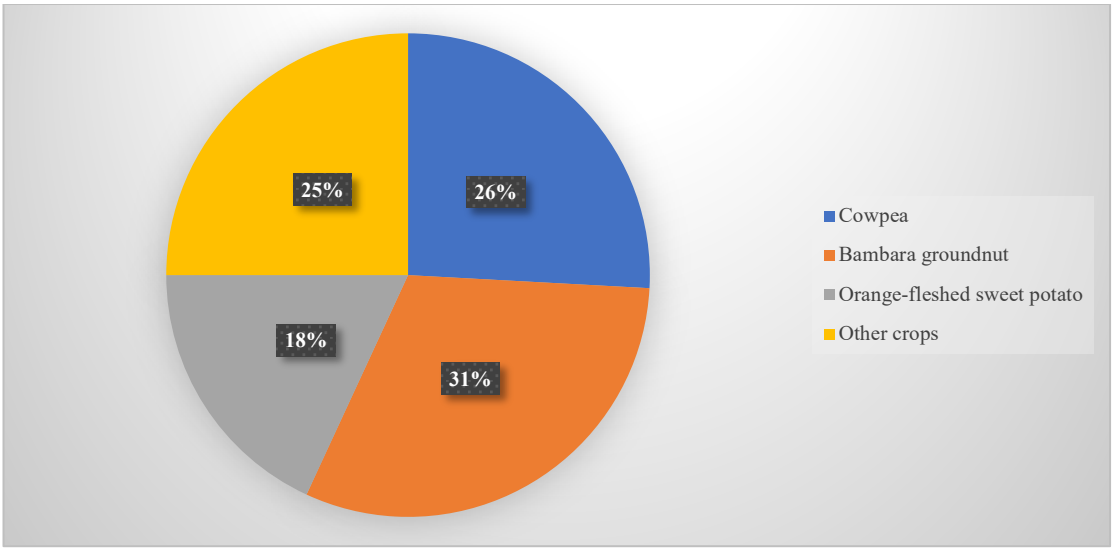

Figure 4: Distribution of crops sold by sampled traders

Table 3 shows the factor loadings of PCA for UC production constraints. The Kaiser-Meyer-Olkin (KMO) sampling adequacy criterion was used to know whether the dataset contains sufficient correlation to justify PCA. The cumulative KMO index for producers and traders was greater than 0.50 [35], satisfying the rule of thumb greater than 0.40. This study offered interpretation through three components with dominant variables and scree plots greater than one.

For the Aggregate dataset, the results in Table 3 show that low-quality inputs (Q1), storage facilities (Q2), and adverse weather conditions (Q13) with the scoring coefficients of 0.32, 0.32, and 0.31, respectively were highly loaded in PC1 to explain the variance in production constraints. Agricultural inputs are essential resources used to enhance crop production. Most farmers cannot store their surplus due to lack of storage infrastructure which might be linked to their poverty status. Farmers may not be aware of recent developments regarding climate variability/change adaptations and the necessary adaptation strategies [36]. The lack of storage facilities and adverse weather conditions have been noted as barriers to the value chain activities of crops [36, 37]. Low educational status (Q3), skills and experience (Q6), limited market access (Q10), low access to credit (Q11), and poor modern tools (Q12) with scoring coefficients of -0.33, -0.38, 0.34, 0.39 and 0.34 were highly loaded in PC2 to explain production constraints. Inadequate agricultural equipment affects the production output, thus reducing the quality produced by farmers. Low literacy levels and lack of technical skills have been identified by Smidt and Jokonya [38] as major barriers for small-scale farmers along the agricultural value chains. Labor intensive (Q4), low access to credit (Q11), poor modern tools (Q12), and adverse weather conditions (Q13) with scoring coefficients -0.42, 0.50, 0.33 and -0.32 were highly loaded in PC3 to explain production constraints. Given the

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dominance of PC1 over PC2 and PC3 in scree plot score, low-quality inputs, storage facilities and weather conditions were considered paramount constraints affecting the UC production stage of value chain activities. Labor costs and limited access to credit have been identified as challenges to crop production [39].

The results showed that low market information (Q5), inadequate extension services (Q9), limited market access (Q10), adverse weather conditions (Q13), and poor-quality standards (Q14) with the scoring coefficient of 0.34, 0.30, 0.35, 0.32 and 0.33 were highly loaded in PC1 to explain the variance in production constraint in Mbombela. Transportation problems, lack of standardization for the local market and little or no credit were ranked as the top three major constraints affecting Bambara production [40]. Information sharing among rural subsistence farmers was hampered by the inadequate effectiveness of extension workers and officers [41,43, 44]. Low storage facilities (Q2), educational status (Q3), skills and experience (Q6), poor access to credit (Q11), and low government support (Q15) with the scoring coefficient of 0.34, 0.38, 0.41, -0.34 and -0.36 were highly loaded in PC2 to explain the variance production constraints in Mbombela. Lack of UC farmer cooperatives (Q8), low access to credit (Q11), inadequate modern tools (Q12), and low government support (Q15) with the scoring coefficients of -0.53, -0.43, 0.41, -0.34 and -0.36 in PC3 were highly loaded to explain the variance in production constraints in Mbombela. Inadequate storage facilities to store produce leads to loss of crop or immediate consumption [41].

The results showed that low-quality inputs (Q1), lack of UC farmer cooperatives (Q8), low access to credit (Q11), inadequate modern tools(Q12) and low government support (Q15) with scoring coefficients of 0.31, 0.33, 0.31,0.32 and 0.36 were highly loaded in PC1 to explain the variance in production constraint in Nkomazi. The high cost of good seeds and farming equipment is the major constraint to the quality of potatoes produced in Nigeria [41]. Low-quality inputs (Q1), labour-intensive (Q4), high cost of labour (Q7) and limited market access (Q10) with the scoring coefficient of -0.32, 0.49, 0.51 and 0.34 were highly loaded in PC2 to explain the variance production constraint in Nkomazi. Low educational status (Q3), skills and experience (Q6), limited market access (Q10), poor access to credit (Q11) and inadequate modern tools (Q12) with the scoring coefficient of -.051, -0.46, 0.37, 0.34 and 0.34 in PC3 were highly loaded to explain the variance in production constraints in Nkomazi. Table 4 shows the factor loadings of PCA for constraints to UC marketing by farmers. In the Aggregate dataset, the results revealed that poor storage and processing technique (Q1), high cost of processing (Q2), high cost of transportation (Q4) and lack of contractual agreement (Q12) with scoring coefficients of 0.36, 0.35, 0.35 and 0.33 were highly loaded in PC1 to explain the variance in constraint to UC marketing by sampled farmers. High cost of processing (Q2), low UC market

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promotion (Q3), low government support (Q7), low market patronage for UC (Q10), and low contract services (Q12) with scoring coefficients of -0.36, -0.39, 0.33, 0.60 and 0.31 were highly loaded in PC2 to explain the variance in constraint to UC marketing by sampled farmers. Lack of storage and processing technique (Q1), lack of market promotion for crops (Q3), poor access to marketing channels (Q6), long distance to convey produce to market (Q9) with scoring coefficients of -0.37, 0.30, 0.44 and 0.59 were highly loaded in PC3 to explain the variance in constraint to UC marketing. Neglected and underutilized crops' commercial value was low, which invariably discourages further investment in their post-harvest management [42].

In Mbombela, lack of storage and processing technique (Q1), high cost of processing (Q2), lack of UCs' market promotion (Q3), high cost of transportation (Q4), poor marketing channels (Q6), poor transportation network (Q11) and lack of contractual agreement (Q12) with scoring coefficient of 0.32, 0.32, 0.32, 0.36, 0.36, 0.33 and 0.31, respectively were highly loaded in PC1 to explain variation in constraints to marketing by farmers. Lack of storage and processing technique (Q1), high cost of processing (Q2), lack of membership of market cooperatives (Q5), lack of UCs' market information (Q8) and low market patronage for UCs (Q10) with the scoring coefficient of -0.33, -0.40, -0.31, 0.41 and 0.47, respectively were highly loaded in PC2 to explain variation in constraints to marketing by farmers in Mbombela. Also, the lack of UC market cooperatives (Q5), low government support (Q7) and long distance to market (Q9) with the scoring coefficient of 0.46, -0.41, and 0.67 were highly loaded in PC3 to explain variation in constraints to marketing by sampled farmers in Mbombela.

In Nkomazi, lack of storage and processing technique (Q1), high cost of processing (Q2), lack of market promotion for UC (Q3), high cost of transportation (Q4), poor marketing channels (Q6) and lack of market information (Q8) with the scoring coefficient of 0.39, 0.43, 0.36,0.33, 0.38 and 0.39 in PC1 to explain the variance in constraint to UC marketing by sampled farmers. Poor marketing channels (Q6), low government support (Q7), low market patronage for UC (Q10) and poor transportation network (Q11) with the scoring coefficient of -0.31, 0.40, 0.50 and 0.47 in PC2. Lack of membership of market cooperatives (Q5), low government support (Q7) and long distance to market (Q9) with the scoring coefficient of -0.43, 0.38 and 0.58 in PC3.

Table 5 shows the factor loadings of PCA for the constraint to UC marketing by traders. In the Aggregate dataset, the results revealed that improper stall structures (Q5), lack of vehicle access to the market (Q6), poor marketing channels (Q7), and irregular/insufficient crop produce (Q11), with scoring coefficients of 0.39, 0.42, 0.39 and 0.34, were highly loaded in PC1 to explain the variance in traders' constraints on UC marketing. In PC2, lack of storage facility (Q2), lack of owned capital (Q4),

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theft (Q8), high transportation cost (Q9) and pest infestation (Q10), with scoring coefficients of -0.35, -0.38, 0.41, 0.42 and 0.44, were highly loaded to explain the variance in the constraints. Lack of access to market information (Q1), lack of storage facility (Q2), improper stall structures (Q5) and poor marketing channels (Q7) with scoring coefficients of 0.38, 0.61, -0.37 and -0.35 were highly loaded in PC3.

In Mbombela, lack of access to market information (Q1), lack of market promotion for crop products (Q3), lack of owned capital (Q4), improper stall structures (Q5), lack of vehicle access to the market (Q6) and irregular/insufficient amount of crop produce (Q11) with scoring coefficient of 0.38, 0.37, 0.42, 0.37, 0.39 and 0.35, respectively were highly loaded in PC1 to explain the variance in the constraints on UC marketing by sampled traders. In PC2, theft (Q8), high transportation cost (Q9) and pest infestation (Q10) with the scoring coefficients of 0.51, 0.52 and 0.50, respectively were highly loaded to explain the variance in the constraints on UC marketing by sampled traders. The main challenges affecting Bambara production were infestation of insects, especially aphids and termites, squirrels and rodents [45]. In PC3, the lack of storage facility (Q2), lack of market promotion for UCs (Q3), improper stall structures (Q5) and lack of a vehicle to market (Q6) with the scoring coefficient of 0.41, 0.42, -0.43 and 0.67, respectively were highly loaded to explain the variance in the constraints on UC marketing by sampled traders.

In Nkomazi, lack of storage and processing technique (Q1), high cost of processing (Q2), lack of market promotion for UC (Q3), high cost of transportation (Q4), poor marketing channels (Q6) and lack of market information (Q8) with the scoring coefficient of 0.39, 0.43, 0.36,0.33, 0.38 and 0.39, respectively were highly loaded to explain the variance in the constraints on UC marketing by sampled traders. The high cost of transportation was the major constraint to the marketing of Bambara groundnut [43]. In PC2, lack of vehicular access to market (Q6), poor marketing channels (Q7), low market patronage for UC (Q10) and poor transportation network (Q11) with the scoring coefficients of -0.31, 0.40, 0.50 and 0.47, respectively were highly loaded to explain the variance in the constraints on UC marketing by sampled traders. Poor marketing outlets and high incidence of pests and diseases are identified to affect crop production [39]. In PC3, lack of UCs market cooperatives (Q5), low government support (Q7) and long distance to market (Q9) with the scoring coefficient of -0.43, 0.38 and 0.58, respectively were highly loaded to explain the variance in the constraints on UC marketing by sampled traders. Poor transportation infrastructure, bad roads and the long distances to take produce from the rural to urban areas are challenges identified to limit the production of sweet potatoes [41].

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CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

Underutilized crop production is common among rural households in Mpumalanga, South Africa. However, underutilized crop value chains face interrelated constraints in their activities. The study examined the constraints to the value chain activities of underutilized crops. The study employed principal component analysis (PCA) to agglomerate and extract the relevant constraints to the value chain activities of UCs from three main components in local municipalities. The findings revealed that the most critical constraints to UC production were low-quality inputs, storage facilities, and adverse weather conditions. The PCA results showed that farmers' most important constraints to UC marketing were poor storage and processing techniques, high cost of processing, high cost of transportation and lack of contractual agreement. The PCA results for constraints to UC marketing by traders were improper stall structures, lack of vehicle access to the market, poor marketing channels and irregular/insufficient crop produce. The study's findings have policy implications for promoting food and nutrition security through UC's unbroken value chain activities. Governments at the district, provincial, and national levels must invest in the awareness and promotion of the potential benefits of UC along food value chains. Farmers and other value chain actors are encouraged to form cooperatives, strengthening their bargaining power, enhancing access to credit and improving their influence on government policies.

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Conflict of interest declaration

The authors declare no conflicts of interest.

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Table 1: Socioeconomic characteristics of producers

Socioeconomic attributes	Minimum	Maximum	Mean	Standard Deviation
Age	24	72	50.754	12.444
Age (female)	24	72	50.456	13.070
Age(male)	28	68	51.474	11.077
Household size	1	15	2.770	2.037
Farm income	1000	90000	55170	176831
Non-farm income	0	13500	3333	3696
Distance to market	0	150	50.167	37.086
Variables		**Frequency**		**Per cent**
Gender				
Male		19		29
Female		46		71
Marital Status				
Single		18		28
Married		34		52
Divorced		1		1.5
Widowed		12		18.5
Educational Level				
Primary		33		52
Secondary		32		48
Farm size				
Less than 1ha		36		56.3
1 – 10ha		17		26.5
10 – 50ha		8		12.5
More than 50ha		3		4.7
Average crop yield				
Less than 1 tonne/ha		45		69.2
1 – 2 tonnes/ha		16		24.6
2 – 3 tonnes/ha		2		3.1
3 to 4 tonnes/ha		2		3.1
Land ownership type				
Owned		61		93.85
Not owned		4		6.15
Access to credit				
Yes		7		11
No		58		89
Cooperative membership				
Yes		29		45
No		36		55
Access to inputs				
Yes		29		45
No		36		55

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Access to extension services				
Yes		17		26
No		48		74
Access to market information				
Yes		27		41.5
No		38		58.5
Contractual agreement with buyers				
Yes		10		15
No		55		85
Marketing outlets				
Sale at the farm gate		19		34.5
Transporting goods to market		21		38.2
At home		15		27.3
Marketing chains				
Farmers - Rural traders – Consumers		19		30.7
Farmers – Urban traders – Consumers		6		9.7
Farmers – Wholesalers – Retailers – Consumers		1		1.6
Farmers – Consumers		36		58

Table 2: Socioeconomic characteristics of traders

Socioeconomic attributes	Minimum	Maximum	Mean	Standard Deviation
Age	19	68	42.5	12.656
Age (Female)	19	68	41.6	12.484
Age (Male)	27	60	47	13.448
Household size	1	3	2.08	0.665
Income from sales	1260	208000	50558	51873.81
Distance to market	0	60	13.832	15.190
Capital to start trading	100	500000	11966	70464.91
Variables		**Frequency**		**Per cent**
Gender				
Male		8		16
Female		42		84
Marital Status				
Single		28		57
Married		13		27
Divorced		1		2
Widowed		6		12
Separated		1		2
Educational Level				
Primary		2		4
Secondary		23		46
Tertiary		22		44
Vocational training		3		6

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Size of business				
Small scale		44		88
Medium scale		6		12
Access to credit				
Yes		4		8
No		46		92
Cooperative membership				
Yes		15		30
No		35		70
Access to market information				
Yes		22		44
No		28		56
Vehicle access to output market				
Yes		30		60
No		20		40
Contractual agreement with buyers				
Yes		16		32
No		34		68
Location of crop supplies				
Ekukhanyeni/ Ematahefeni		8		16
Thapito		3		6
Hazybiwe		2		4
Local farms		4		8
Magweni		3		6
Local market		2		4
Mozambique		21		42
Nelspruit main market		1		2
Tonga		3		6
Water river		3		6
Mode of goods procurement				
By Phone		42		84
By travel		8		16
Mode of transportation				
Bakki		3		6
Minibuses		8		16
Taxis		20		40
Self		4		8
Private car		4		8
Transport arranged by farmers		6		12
Truck		5		10
Producers sale of UC surplus				
Yes		38		76
No		12		24

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Table 3: Factor loadings of PCA for constraints to UC production by farmers

	Aggregate				Mbombela				Nkomazi			
Variables	**PC1**	**PC2**	**PC3**	**Unexplained**	**PC1**	**PC2**	**PC3**	**Unexplained**	**PC1**	**PC2**	**PC3**	**Unexplained**
Low quality inputs(Q1)	0.32			0.25					0.31	-0.32		0.12
Poor storage facilities(Q2)	0.32			0.10		0.34		0.10				
Low educational status(Q3)		-0.33		0.29		0.38		0.40			-0.51	0.23
Labor intensive(Q4)			-0.42	0.30						0.49		0.22
Low market information for UC(Q5)					0.34			0.27				
Low Skills & Experience(Q6)		-0.38		0.22		0.41		0.27			-0.46	0.31
High cost of labor(Q7)										0.51		0.28
Lack of UCs' farmer cooperative(Q8)							-0.53	0.43	0.33			0.23
Inadequate extension services for UCs (Q9)					0.30			0.19				
Limited market access(Q10)		0.34		0.21	0.35			0.17		0.34	0.37	0.38
Poor access to Credit(Q11)		0.39	0.50	0.07		-0.34	0.43	0.19	0.31		0.34	0.08
Inadequate modern tools(Q12)		0.34	0.33	0.23			0.44	0.22	0.32		0.34	0.10
Adverse weather conditions(Q13)	0.31		-0.32	0.17	0.32			0.26				
Cost of quality standards(Q14)					0.33			0.16				
Low government support(Q15)						0.36	0.37	0.12	0.36			0.12

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	Aggregate				Mbombela				Nkomazi			
Variables	**PC1**	**PC2**	**PC3**	**Unexplained**	**PC1**	**PC2**	**PC3**	**Unexplained**	**PC1**	**PC2**	**PC3**	**Unexplained**
Poor storage and processing techniques(Q1)	0.36		-0.37	0.17	0.32	-0.33		0.21	0.39			0.29
High cost of processing(Q2)	0.35	-0.36		0.15	0.32	-0.40		0.18	0.43			0.20
Lack of UCs' market promotion(Q3)		-0.39	0.30	0.24	0.32			0.48	0.36			0.15
High cost of transportation(Q4)	0.35			0.34	0.36			0.22	0.33			0.47
Lack of UCs' market cooperatives(Q5)						-0.31	0.46	0.43			-0.43	0.46
Poor marketing channels(Q6)			0.44	0.22	0.36			0.30	0.38	-0.31		0.17
Low government support(Q7)		0.33					-0.41	0.30		0.40	0.38	0.30
Low market information(Q8)						0.41		0.38	0.39			0.39
Long UCs' market distance(Q9)			0.59	0.42			0.67	0.19			0.58	0.37
Low market patronage for UC(Q10)		0.60		0.26		0.47		0.30		0.50		0.33
Poor transportation network(Q11)					0.33			0.41		0.47		0.49
Lack of contractual agreement(Q12)	0.33	0.31		0.28	0.31			0.45				

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Table 5: Factor loadings of PCA for constraints to UC marketing by traders

	Aggregate				Mbombela				Nkomazi			
Variables	**PC1**	**PC2**	**PC3**	**Unexplained**	**PC1**	**PC2**	**PC3**	**Unexplained**	**PC1**	**PC2**	**PC3**	**Unexplained**
Low market information(Q1)			0.38	0.42	0.38			0.26			0.48	0.41
Lack of storage facility(Q2)		-0.35	0.61	0.13			0.41	0.40		0.41	0.50	0.21
Lack of UCs' market promotion(Q3)					0.37		0.42	0.06				
Lack of own capital(Q4)		-0.38		0.28	0.42			0.11		0.54		0.23
Improper stall structures(Q5)	0.39		-0.37	0.14	0.37		-0.43	0.13	0.37			0.22
Lack of vehicle to UCs' market(Q6)	0.42			0.21	0.39		-0.33	0.05	0.42			0.30
Poor marketing channels(Q7)	0.39		-0.35	0.15					0.42		-0.34	0.15
Theft (Q8)		0.41				0.51		0.03	0.34			0.44
High transportation cost(Q9)		0.42		0.25		0.52		0.02			0.34	0.42
Pest infestation(Q10)		0.44		0.22		0.50		0.06	0.32			0.33
Insufficient UCs' supply(Q11)	0.34			0.46	0.35				0.32		0.98	0.41
Low prices of UCs(Q12)				0.49						0.31		0.49

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