# From Weed to Wonder: Nutritional Profiling of *Bidens Pilosa* as a Forgotten Food Resource for Household Food Security in Zambia

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## ABSTRACT

Indigenous leafy vegetables play a pivotal role in enhancing food and nutrition security, particularly within economically disadvantaged rural and urban communities. This study evaluated the nutritional and non-food attributes of *Bidens pilosa* (commonly known as Black Jack) as a potential alternative vegetable for low-income households in Zambia. The research was conducted between December 2023 and March 2024 in Munamakalwe area, Chipapa, Chilanga District, Lusaka Province. Eight leaf samples were collected from smallholder farms and subjected to proximate analysis using standard methodologies: the oven-drying method for moisture content, the Kjeldahl method for crude protein, and conventional protocols for crude fibre, ash, fat, and carbohydrate estimation. The proximate composition per 100g of fresh weight was as follows: moisture 83%, protein 4.21%, fat 0.2%, fibre 4%, ash 1.2%, and carbohydrates11%. When compared with three commonly consumed exotic vegetables (rape, cabbage, and tomato), *B. pilosa* exhibited a notably higher protein content, double that of rape, triple that of cabbage, and quadruple that of tomato. To assess the non-food uses and perception of *B. pilosa*, a structured questionnaire was administered. Results indicated significant ethnomedicinal value and positive health implications. However, popularity among the youth remains low, attributed to negative perceptions of indigenous vegetables as 'backward' or old-fashioned. The study highlights the potential of *B. pilosa* to address micronutrient deficiencies and food insecurity in low-income households. It also recommends further research into its amino acid profile to fully characterise its protein quality. Additionally, investigation into varietal nutritional variability and its potential use as livestock feed is warranted. Greater public awareness and promotion of its benefits are essential to increase its utilisation.

**Keywords:** *Bidens pilosa*, indigenous vegetables, nutritional analysis, food security, ethnobotany, protein quality.

## INTRODUCTION

Undernutrition continues to pose a significant public health and developmental challenge across Sub-Saharan Africa, with Zambia standing out as one of the most affected nations. An estimated 40% of Zambia's population suffers from some form of undernutrition, a condition that compromises both individual wellbeing and national socioeconomic progress (Alaofe, 2014). Of particular concern is the high prevalence of stunting among children under the age of five, a manifestation of chronic undernutrition that impairs linear growth and is often irreversible beyond early childhood. Recent national data reveal that 35% of Zambian children under five are stunted, with prevalence peaking at 46% among children aged 18–23 months, compared to just 19% in infants below six months of age (Zambia Nutrition Profile, 2021). These figures reflect a critical developmental window during which nutrition interventions are most urgent. According to the World Health Organization (2009), stunted children are at an elevated risk of premature death, suffer from impaired cognitive and motor development, and are less likely to perform well in school or be economically productive as adults. Thus, stunting not only affects individual health outcomes but also has long-term implications for national productivity, economic competitiveness, and human capital development.

The drivers of malnutrition in Zambia are multifaceted, including food insecurity, poverty, low levels of maternal education, limited access to clean water and sanitation, and poor healthcare access. However, a fundamental and often overlooked determinant is the widespread lack of nutrition knowledge, coupled with inadequate infant and young child feeding (IYCF) practices. Inadequate dietary diversity remains a major challenge. While Zambia consistently achieves aggregate food production levels that exceed national demand particularly maize (*Zea mays*), disparities in access to nutritious food are stark, particularly among rural and peri-urban populations. Diets in many households are monotonous, heavily reliant on maize a staple crop that is low in essential micronutrients and a narrow selection of vegetables. This overdependence on carbohydrate-dense staples, combined with the limited intake of high-quality protein, iron, zinc, vitamin A, and other vital nutrients, continues to perpetuate the cycle of malnutrition (Andersen, 1993; USAID Nutrition Profile, 2022).

In this context, indigenous leafy vegetables (ILVs) have gained recognition as promising dietary components that can contribute to addressing nutritional deficiencies. The ILVs are naturally adapted to local agroecological conditions and are often accessible at little or no financial cost, making them particularly valuable in resource-constrained settings. Several studies have demonstrated the nutritional richness of ILVs, which frequently surpass exotic vegetables in terms of micronutrient content, including iron, calcium, folate, and vitamin C. Furthermore, ILVs are typically rich in dietary fibre and bioactive phytochemicals, some of which possess antioxidant, anti-inflammatory, and antimicrobial properties. Thus, their regular inclusion in household diets can contribute significantly to improving overall nutritional status, enhancing immune function, and reducing susceptibility to diet-related non-communicable diseases.

Additionally, the ecological benefits of indigenous vegetables should not be understated. As climate change continues to exert stress on food systems worldwide, ILVs offer a resilient food source due to their ability to thrive under suboptimal conditions, including drought and low-fertility soils. Their cultivation requires minimal external inputs such as fertilisers and pesticides, thereby lowering production costs and reducing environmental degradation. The Food and Agriculture Organization (FAO, 2017) has emphasised the importance of indigenous food systems in promoting sustainability, biodiversity conservation, cultural identity, and food sovereignty. ILVs exemplify these qualities through their deep integration into local agricultural practices, traditional cuisines, and ethnobotanical knowledge systems.

Black Jack, is one such ILV that warrants scientific attention due to its nutritional potential and widespread availability across the agroecological regions. Classified botanically within the Asteraceae family, *B. pilosa* is a herbaceous annual that grows prolifically across diverse habitats, including roadsides, fallow lands, and cultivated fields. Despite being commonly regarded as a weed, its edible leaves are known to contain appreciable amounts of macro and micronutrients, as well as secondary metabolites with medicinal properties (Odhava *et al.,* 2007). The plant is also noted for its ecological adaptability, often thriving in disturbed environments and under minimal agronomic management (Damalas, 2008). This makes it an ideal candidate for inclusion in household gardens and community-based nutrition interventions, particularly in rural settings where food insecurity and malnutrition are prevalent.

However, the utilisation of *B. pilosa* and other ILVs is impeded by a variety of sociocultural and systemic barriers. Globalisation and the rapid urbanisation of food systems have led to significant shifts in consumer preferences particularly among the young people. Traditional vegetables are often stigmatised as “poor man’s food” or relics of an outdated agrarian culture. Younger generations, in particular, exhibit a marked preference for exotic and highly processed foods, influenced by westernised dietary norms and aggressive commercial marketing. Consequently, the consumption of ILVs is declining, even in communities where these plants grow abundantly. Compounding this issue is the scarcity of empirical research and documented nutritional data on many indigenous species. The lack of awareness among policymakers, extension officers, and health professionals further marginalises ILVs within formal nutrition programmes and agricultural policy frameworks (Uusiku *et al.,* 2010).

Given these challenges, there is an urgent need to re-evaluate the role of ILVs within Zambia's food and nutrition security landscape. A critical starting point is the comprehensive scientific characterisation of their nutritional composition, functional properties, and potential health benefits. In particular, *B. pilosa* merits focused research to validate its suitability as a nutritious vegetable capable of contributing to the reduction of malnutrition. Studies investigating its amino acid profile, mineral content, bioactive compounds, and potential uses as livestock feed are also warranted. Such data will support evidence-based policy recommendations and facilitate the incorporation of ILVs into national nutrition and agricultural development strategies.

Overall, addressing undernutrition in Zambia requires multidimensional interventions that go beyond staple crop production to include diversified, culturally relevant, and nutrient-dense food sources. Indigenous leafy vegetables, exemplified by *B. pilosa*, represent an underutilised but highly promising resource in this regard. Promoting their consumption, backed by rigorous scientific research and strategic public health messaging, could significantly contribute to alleviating malnutrition, enhancing dietary diversity, and fostering sustainable, resilient food systems.

There is no doubt that indigenous leafy vegetables possess significant potential to alleviate poverty, combat malnutrition, and enhance food security, particularly due to their adaptability to challenging environmental conditions. Previous studies examining the benefits of wild, forest-derived plants have indicated that Black Jack is endowed with numerous therapeutic properties. This leafy vegetable has gained recognition for its application in the treatment of conditions such as diabetes, hypertension, and obesity across various continents (Arthur, 2012). However, Black Jack remains underutilised and is frequently regarded as a weed, largely due to a lack of awareness regarding its nutritional value and potential health benefits (Williams, 2022). Regrettably, there have been insufficient efforts to promote the consumption of indigenous plants such as black jack.

A key factor contributing to this underutilisation is the prevailing perception—particularly among younger generations, that traditional indigenous vegetables are outdated and associated with poverty, often dismissed as weeds or food suitable only for low-income households. Nonetheless, these neglected and underutilised vegetables can make a substantial contribution to human diets, as they are freely available and capable of thriving in adverse conditions (Akinola *et al.,* 2020). The limited presence of indigenous leafy vegetables within the broader food system continues to perpetuate hunger, food insecurity, and unsustainable dietary practices. Accordingly, this study seeks to address this gap by conducting a comprehensive macronutrient analysis of Black Jack. It aims to highlight the importance of embracing native plants as viable sources of nutrition and to elucidate their additional non-food benefits (Figure 1)

There is increasing recognition that indigenous leafy vegetables (ILVs) possess significant potential to alleviate poverty, reduce malnutrition, and enhance food and nutrition security, particularly due to their adaptability to marginal and ecologically challenging environments. Their inherent resilience and nutritional value render them valuable assets for sustainable dietary diversification, especially in resource-constrained contexts. Previous ethnobotanical and pharmacological studies of wild and forest-derived plant species have identified *Bidens pilosa* as a species endowed with a range of therapeutic properties. This species has been reported to exhibit efficacy in the management of chronic conditions such as diabetes mellitus, hypertension, and obesity, and is used across various continents in traditional medicine systems (Arthur, 2012).

Despite its demonstrated medicinal and nutritional potential, *B. pilosa* remains critically underutilised. It is frequently mischaracterised as an agricultural weed, a perception largely attributable to the limited public awareness surrounding its health-promoting attributes and dietary benefits (Williams, 2022). Unfortunately, efforts to promote the consumption and conservation of ILVs, including *B. pilosa*, have been minimal and fragmented.

One of the primary factors contributing to the marginalisation of ILVs is the widespread perception, particularly among younger populations, as earlier stated is that traditional vegetables are relics of the past, associated with low socioeconomic status, and unsuitable for modern diets. These negative socio-cultural attitudes have led to the exclusion of ILVs from mainstream food systems. Nevertheless, these neglected and underutilised species (NUS) can significantly enhance human nutrition, given their accessibility, often available at no monetary cost, and their remarkable ecological adaptability (Akinola *et al*., 2020).

The limited representation of ILVs in formal food systems continues to exacerbate hunger, undermine food security, and contribute to the persistence of nutritionally inadequate and unsustainable diets. In response to these challenges, the present study undertakes a detailed macro-nutrient characterisation of *B. pilosa* to substantiate its nutritional value and to highlight both its food and non-food benefits. This scientific evidence is intended to support advocacy for the reintegration of ILVs into national and community-level food systems, contributing to more resilient, culturally relevant, and sustainable nutrition strategies. This study therefore, sought to bridge this gap by conducting a comprehensive macro-nutrient analysis of Black Jack, shedding light on the reasons why native plants should be embraced as a source of sustenance and elucidating their non-food benefits (Figure 1)

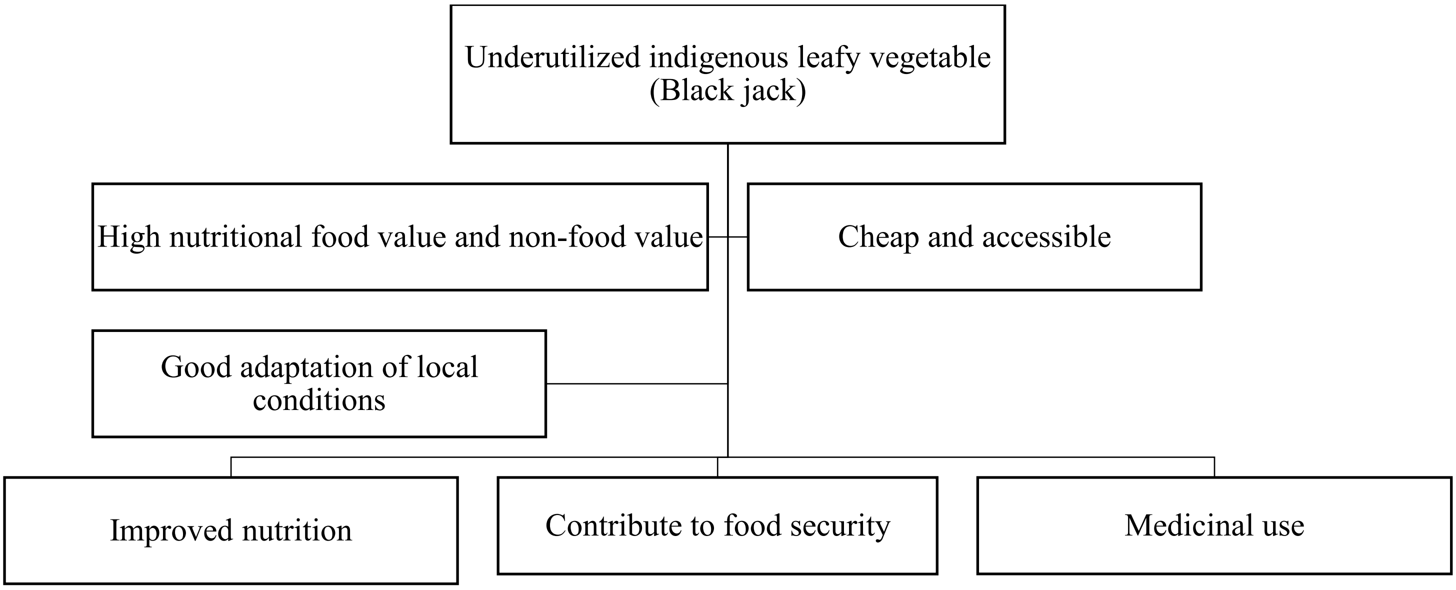


**Figure 1 Importance of indigenous underutilized leafy plants black jack and its nutritional and health benefit to households.**

## MATERIALS AND METHODS

This study was undertaken within the geographical boundaries of Chilanga District, situated in Lusaka Province, Zambia (Figure 2) The selected study location lies approximately 30 kilometres south of Lusaka, the capital city, at geographical coordinates latitude -15.4513° and longitude 28.0778°, with an average elevation of 1,215 metres above sea level (Zambia Meteorological Department, 2023). Chilanga falls within Agro-Ecological Region II of Zambia, which is characterised by moderate annual rainfall ranging between 800 mm and 1,000 mm, and average ambient temperatures ranging from 16 °C to 28 °C throughout the year (ZARI, 2019). These climatic parameters are favourable for the spontaneous growth and cultivation of various indigenous leafy vegetables, including *Bidens pilosa*, which constituted the focal species of this investigation (Chirwa and Saka, 2021).

The research was conducted during the period from December 2023 to March 2024, coinciding with the peak growing season for most indigenous vegetables due to optimal rainfall conditions (Phiri *et al.,* 2020). Field-based activities were undertaken across selected smallholder farms and uncultivated plots where *B. pilosa* naturally proliferates. Chilanga District, with its peri-urban setting that integrates both rural and semi-urban land-use characteristics, offered a representative environment to study the occurrence of *B. pilosa* in both cultivated and wild habitats (Tembo *et al.,* 2022).

Geo-referencing of the sampling sites was achieved using a Garmin eTrex 32x handheld GPS device, ensuring accuracy in the documentation of site-specific coordinates and elevation. To facilitate spatial visualisation, a topographic map of the study area was generated using QGIS software (Version 3.28), illustrating the distribution of sampling locations and associated environmental variables (QGIS Development Team, 2022). This methodological approach was intended to enhance the replicability of the study across similar agro-ecological zones in future research.

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The selection of Chilanga District was deliberate and informed by its ecological representativeness within Lusaka Province, especially in terms of vegetation structure, some local dependence on wild edible plants, and accessibility to nearby markets where indigenous vegetables are intermittently traded (Zulu & Mataa, 2021). Additionally, the district's mosaic of anthropogenic land-use systems interspersed with remnant natural vegetation provided an ideal setting for the systematic observation and documentation of *B. pilosa* across diverse landscape units, including garden margins, roadside verges, and underutilised agricultural lands (Akinola *et al.,* 2020).

The subsequent sections of this report provide detailed descriptions of the methodologies employed for plant sample collection, laboratory processing, and biochemical analyses used to quantify the macronutrient composition of *B. pilosa*. Furthermore, the ethnobotanical relevance of the species is discussed in relation to its nutritional potential and broader socio-ecological utility (Smith *et al.,* 2018).


**Figure 2: Location of study area in Chilanga district, Lusaka province, (Source: https://map-zambia.com/lusaka-zambia-map )**

The study area encompassed a total population of approximately 225,276 individuals, as reported by the Central Statistical Office (2022). Chilanga District was chosen because it is a demographically diverse region that includes both peri-urban and rural communities. It presents a unique blend of land uses, including extensive commercial farming estates, small-scale agricultural holdings, and subsistence-based household farming systems. This diversity in agricultural practices provided a relevant contextual backdrop for the investigation of indigenous leafy vegetables, particularly *Bidens pilosa* L. a species frequently found across cultivated and uncultivated landscapes.

Given the study's objective of assessing the nutritional and ethnobotanical value of *B. pilosa* within a community-based agricultural setting, the researchers selected Munamakalwe, a locality situated within the Chipapa area of Chilanga District, as the specific case study site. This selection was informed by a combination of purposive and logistical considerations. Munamakalwe is characterised by its rural settlement structure and proximity to Lusaka, offering a transitional zone between urban and traditional farming systems. Its strategic location near peri-urban markets, combined with a prevalence of smallholder crop and vegetable cultivation, made it an ideal setting for examining the role and utilisation of indigenous vegetables in local food systems.

The site's accessibility and relative proximity to homesteads further facilitated community engagement and sample collection. The primary sampling area was confined to a 1 to 2-kilometre radius from the main residential settlement of Munamakalwe. This distance was considered optimal to capture both cultivated and wild-growing specimens of *B. pilosa*, which are commonly found on farm margins, fallow plots, home gardens, and along pathways and roadsides.

In addition to its agricultural relevance, Munamakalwe was selected due to *anecdotal* reports and prior observations indicating the frequent presence and informal use of *B. pilosa* in household diets and traditional medicine. The combination of small-scale farming activities, local ecological knowledge, and community reliance on plant resources offered a compelling case for in-depth study. The findings derived from this site are anticipated to contribute valuable insights into the broader understanding of indigenous leafy vegetables and their potential role in addressing nutritional insecurity in Zambia's peri-urban and rural settings.

### 2.1 Research Design and Data Collection Methods

This study employed a convergent mixed-methods research design, integrating both quantitative and qualitative data sources to provide a holistic understanding of the nutritional, cultural, and ethnobotanical significance of *Bidens pilosa* L. The research design was strategically structured to align with the study's dual objectives: (i) to evaluate the macro-nutrient composition of *B. pilosa* in comparison with selected exotic vegetables, and (ii) to assess its popularity profile and non-food values within the local community.

#### 2.1.1 Quantitative Component

Quantitative data were derived from laboratory-based experimental procedures conducted at the Plant and Nutrition Laboratory of the University of Zambia. Fresh samples of *B. pilosa* were collected from the designated study site and subjected to proximate analysis to determine moisture content, crude protein, fibre, ash, fat, and carbohydrate composition. The analytical techniques employed included the Kjeldahl method for protein estimation, the oven-drying method for moisture determination, and standardised gravimetric and combustion methods for assessing fibre, ash, and fat content. These methodologies followed the Association of Official Analytical Chemists (AOAC, 2005) protocols to ensure scientific reliability and replicability.

To facilitate comparative nutritional evaluation, similar laboratory analyses were conducted on three exotic vegetables widely consumed in the Zambian diet: rape (*Brassica napus*), cabbage (*Brassica oleracea* var. *capitata*), and tomato (*Solanum lycopersicum*). This comparative research methodology enabled an empirical assessment of the nutritional value of *B. pilosa* relative to its more commonly utilised exotic counterparts, thereby providing contextual insight into its potential as a substitute or complementary food source.

#### 2.1.2 Qualitative Component

The qualitative dimension of the study focused on community perceptions, popularity trends, and ethnobotanical knowledge associated with *B. pilosa*. Data were collected through the administration of structured questionnaires to a purposively selected sample of 40 respondents, drawn from both farming and non-farming households within the Munamakalwe area of Chilanga District. The sample included individuals from diverse age groups and socio-economic backgrounds to capture a broad spectrum of perspectives. The questionnaire design comprised both closed- and open-ended items aimed at eliciting data on awareness, frequency of use, medicinal applications, cultural attitudes, and perceived benefits or limitations of *B. pilosa*.

To enrich the qualitative dataset, a documentary review of existing literature was also undertaken. This review included peer-reviewed scientific articles, ethnobotanical reports, and traditional medicinal compendia, with a focus on the nutritional, agricultural, and pharmacological roles of *B. pilosa*. The data collected were thematically analysed using a content analysis approach, with emerging categories such as health-related applications, agricultural utility, and socio-cultural perceptions coded manually and interpreted inductively.

### 2.1.3 Data Integration and Timing

Quantitative data from laboratory analyses were statistically summarised and compared across vegetable types using descriptive statistics, while the popularity profile data were analysed using frequency distribution and cross-tabulation techniques. The qualitative findings regarding non-food values were analysed thematically to identify patterns, contradictions, and underlying cultural narratives.

The entire fieldwork and laboratory study were conducted during the **rainy season**, which coincides with the peak growing period for many indigenous leafy vegetables in Zambia. This timing ensured the availability of fresh and physiologically mature plant material suitable for nutritional analysis, as well as the presence of community members actively engaged in subsistence agriculture.

The integration of empirical laboratory data with community-based ethnographic insights allowed for a multidimensional evaluation of *B. pilosa*, thereby contributing to the broader discourse on the role of indigenous vegetables in sustainable food systems and public health.

### 2.2 Survey Methodology and Community Engagement

To complement the biochemical analysis of *B. pilosa*, a structured community survey was undertaken to collect qualitative and quantitative data on the knowledge, utilisation patterns, and perceptions surrounding the species. A mixed-methods approach was adopted, combining household surveys, key informant interviews, and informal transect walks with local farmers and community elders.

A total of 45 households were randomly sampled from within the 1 to 2-kilometre study zone. A pre-tested semi-structured questionnaire was administered to one adult member (preferably the primary food preparer or household head) in each household. The survey covered themes such as knowledge of indigenous leafy vegetables, frequency of consumption, preparation methods, medicinal uses of *B. pilosa*, and perceptions of ILVs among youth and elders. Respondents were also asked about seasonal availability, cultivation practices (if any), and market preferences.

To enrich and validate household-level data, six key informant interviews were conducted with local agricultural extension officers, traditional healers, and community elders reputed for their ethnobotanical knowledge. Additionally, three focus group discussions (FGDs), each comprising 6 – 8 participants of mixed age and gender, were held to explore broader themes including generational attitudes towards ILVs, intergenerational knowledge transfer, and barriers to adoption.

Prior to data collection, community entry protocols were observed. The research team engaged local leadership, including village headpersons and the Ward Development Committee (WDC), to introduce the study and seek formal approval. Informed consent was obtained from all participants after a clear explanation of the study objectives, procedures, and confidentiality safeguards. Ethical approval was obtained from the Mulungushi University Research Ethics Committee (Ref: MU-REC/NS/2023/014).

The triangulation of geospatial mapping, community surveys, and direct observation enabled a holistic understanding of the ecological distribution, social acceptability, and utilisation of *B. pilosa* within the study site.

### 2.2 Sample Collection and Preparation

The collection of plant samples was systematically conducted to ensure representation of the natural variability of *Bidens pilosa* across the study area. Sampling was undertaken during the rainy season between December 2023 to March 2024, a period when *B. pilosa* reaches its peak vegetative growth and is most widely available in the natural environment.

A total of eight fresh *B. pilosa* leaf samples were harvested from different locations within a 2-kilometre radius of the Munamakalwe settlement, situated in Chipapa, Chilanga District. The sampling area included homestead gardens, roadside verges, fallow fields, and the peripheries of cultivated crop fields, microhabitats where *B. pilosa* naturally proliferates. These collection sites were geo-referenced using a Garmin eTrex 32x Global Positioning System (GPS) device to facilitate future replication and ecological contextualisation.

At each site, mature and undamaged leaves were selectively harvested from multiple plants to reduce intra-sample variability and ensure sample homogeneity. Only aerial parts (leaves and tender shoots) were collected, as these are the edible components typically consumed by local communities. To minimise contamination, the samples were collected using sterilised stainless steel shears and placed in clean, labelled polyethylene zip-lock bags.

Immediately after collection, the plant samples were transported in cool boxes to the Plant and Nutrition Laboratory at the University of Zambia for processing and analysis. Upon arrival, the samples were washed thoroughly with distilled water to remove soil particles, insects, and debris. The leaves were then air-dried at room temperature under shade for 12–24 hours to reduce surface moisture without compromising nutrient integrity.

Subsequently, the samples were oven-dried at 60°C for 48 hours using a calibrated laboratory oven, as per the AOAC (2005) guidelines, to attain constant weight and prevent microbial degradation. The dried plant material was then ground into a fine powder using a laboratory-grade electric grinder and sieved through a 0.5 mm mesh to obtain a uniform particle size. The powdered samples were stored in airtight containers under cool, dry conditions until proximate analysis was conducted.

For comparative purposes, representative samples of three exotic vegetables, rape (*Brassica napus*), cabbage (*Brassica oleracea* var. *capitata*), and tomato (*Solanum lycopersicum*), were procured from a local market in Chilanga. These were subjected to identical washing, drying, grinding, and storage procedures to maintain consistency in analytical conditions.

All laboratory analyses were conducted in triplicate to ensure accuracy and reproducibility of results. Each analytical run included blanks and certified reference materials to validate the reliability of the data obtained. The procedures adhered strictly to quality assurance and quality control (QA/QC) standards set by the Association of Official Analytical Chemists (AOAC, 2005).

### 2.2.1 Laboratory analytical procedures

All analytical procedures were conducted under strictly controlled laboratory conditions, with routine calibration of instruments and adherence to internal quality control protocols. Reagents and solvents used were of analytical grade, and all glassware was acid-washed and oven-dried prior to use to prevent contamination. The results from these analyses yielded a comprehensive nutritional profile of *B. pilosa* and facilitated comparative assessments against conventional exotic vegetables. The data generated formed a scientifically rigorous basis for evaluating the potential of *B. pilosa* as a nutrient-dense, underutilised food resource in Zambia and beyond. The determination of nutrient composition in *Bidens pilosa* (Black Jack) was conducted using standardised proximate analysis methods as prescribed by the Association of Official Analytical Chemists (AOAC, 2000).

#### a) Moisture Content Determination

Moisture content was determined using the gravimetric oven-drying method in accordance with AOAC Method 925.10. Approximately 5 g of finely ground, homogenised sample was weighed into a pre-dried, pre-weighed porcelain crucible. The crucible was placed in a laboratory oven and dried at 60 °C to constant weight, typically over a 24-hour period, to avoid the degradation of thermolabile constituents. The percentage moisture was calculated based on the loss in weight during drying, using the following formula:

Moisture (%) = $\frac{W1-W2}{W1}$ $x\ 100$

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where $W_1$ is the initial weight of the sample and $W_2$ is the final weight after drying (Bi et al., 2018).

**b) Crude Protein Analysis**

Crude protein content was assessed using the Kjeldahl method (AOAC Method 984.13), which quantifies total nitrogen content as a proxy for protein concentration. Approximately 1 g of dried sample was digested with concentrated sulphuric acid in the presence of a selenium or copper-based catalyst to convert organic nitrogen into ammonium sulphate. The digest was subsequently neutralised with sodium hydroxide, and the liberated ammonia distilled and collected in boric acid solution. The ammonia was titrated with 0.1 N hydrochloric acid to determine nitrogen content, which was then multiplied by a conversion factor of 6.25 to obtain crude protein (Emebu and Anyika, 2011; (AOAC, 2000; Ndidi *et al.,* 2014).

**c) Crude Fat Determination**

Crude fat content was determined using Soxhlet extraction, as outlined in AOAC Method 963.15. For each analysis, approximately 2 g of dried sample was encapsulated in filter paper, placed into a Soxhlet extractor, and subjected to continuous reflux with petroleum ether (boiling range 40–60 °C) for 6 hours. Upon completion of extraction, the solvent was evaporated, and the remaining lipid residue was dried to constant weight. Fat content was expressed as a percentage of the original sample mass (Ihekoronye and Ngoddy, 1985; AOAC, 2005).

d) **Ash Content:**

Total ash, representing the cumulative mineral content of the sample, was determined using the dry ashing technique in accordance with AOAC Method 923.03. Approximately 3 g of dried sample was placed into pre-weighed crucibles and combusted in a muffle furnace at 550 °C for 4–6 hours until a constant grey-white ash was obtained. The crucibles were cooled in a desiccator and weighed. Ash content was reported as a percentage of the dry matter (AOAC, 2005; Akinola et al., 2020; Okudu *et al.,* 2020).

**e) Crude Fibre Estimation**

Crude fibre was estimated using the Weende method (AOAC Method 962.09). Initially, the fat-extracted (defatted) residue was boiled in 1.25% sulphuric acid under controlled conditions, followed by filtration and subsequent treatment with 1.25% sodium hydroxide. The undigested residue was filtered, dried, incinerated at 550 °C in a muffle furnace, and weighed before and after ashing. Crude fibre was calculated as the weight difference, accounting for mineral matter lost upon combustion (Ndidi et al., 2014; Okudu *et al.,* 2020).

**f) Carbohydrate Content Calculation**

Total carbohydrate content was calculated by difference, an indirect method widely used in proximate composition analysis. The following formula was applied:

Carbohydrates (%) =100-(%Moisture + %Protein + %Fat + %Ash + %Fibre)\

This indirect method is commonly employed in proximate analysis for carbohydrate estimation in plant-based foods (Ihekoronye & Ngoddy, 1985). Total carbohydrate content was calculated by difference, an indirect method widely used in proximate composition analysis. The following formula was applied:

Although indirect, this method is robust and reliable for estimating digestible carbohydrate content in plant-based foods (Ihekoronye and Ngoddy, 1985; Emebu and Anyika, 2011).

**g) Sample Collection flow chart**

The sequence profile for the sample collection, transportation and hand over the laboratory for analysis is outlined in Figure 3 below;

From the field where samples were collected

▼

Transportation in Cool Boxes (To University of Zambia Lab)

▼

Washing with Distilled Water (To remove dirt, debris, and insects)

▼

Shade Drying (12–24 hours)(To remove surface moisture)

▼

Oven Drying at 60°C (48 hours) (To achieve constant dry weight)

▼

Grinding and Sieving (0.5 mm mesh) (To obtain homogenous powder)

▼

Storage in Airtight Containers (Cool, dry conditions for sample integrity)

▼

Laboratory Proximate Analysis

| Moisture | Protein | Fat | Fibre | Ash | Carbohydrate |
|---|---|---|---|---|---|
| Gravimetric | Kjeldahl | Soxhlet | Weende | Dry Ashing | By Difference |
| AOAC 925 | AOAC 984 | AOAC 963 | AOAC 962 | AOAC 923 | – |

**Figure 3**: Flowchart illustrating the sequential stages of sample collection, pre-treatment, drying, pulverisation, and subsequent laboratory analytical procedures for *Bidens pilosa* and exotic vegetables (rape, cabbage, and tomato). Standard AOAC methods were followed for proximate composition analysis.

### 2.2.2 Non-Food Value of *Bidens pilosa*

To assess the non-food uses of *Bidens pilosa*, qualitative data were collected through semi-structured interviews. A purposive sampling approach was employed to select a total of 40 adult participants aged 21 years and above. The participants were drawn from both rural and peri-urban sections of Chilanga District and represented a diverse cohort comprising local farmers and non-farmers.

The interviews were designed to elicit information on the medicinal, culinary, and agronomic applications of *B. pilosa*. Respondents were asked about their knowledge of the plant's traditional uses, including treatments for specific ailments (e.g., diabetes, wounds, gastrointestinal issues), its use in herbal preparations, and its integration into local farming systems for pest control or soil enrichment.

In order to capture the popularity profile, additional in-depth interviews were conducted with a subset of 40 participants consisting of 18 household members, 10 smallholder farmers, and 12 market traders. These interviews aimed to determine the degree of familiarity with *B. pilosa*, its active utilisation in daily life, and whether it was intentionally harvested for consumption or sale. Respondents' age groups were recorded to explore potential generational variations in the perceived importance and utilisation of the plant.

Interview data were recorded, transcribed, and analysed using thematic content analysis. Emergent themes were categorised to identify common patterns in knowledge, usage, and socio-cultural relevance of *B. pilosa* across the study population (Bernard, 2017; Braun & Clarke, 2006). The analysis also sought to establish correlations between the age demographics of respondents and the plant's non-food significance (Table 1)

**Table 1: Summary of Analytical Methods Used for Nutrient Composition Analysis**

| Parameter | Analytical Method | Reference Standard | Instrument/Procedure Details |
|---|---|---|---|
| Moisture Content | Oven Drying Method | AOAC (2005), Method 925.10 | Samples dried at 60°C until constant weight using lab oven |
| Crude Protein | Kjeldahl Method | AOAC (2005), Method 984.13 | Digestion, distillation, and titration of nitrogen |
| Crude Fat | Soxhlet Extraction | AOAC (2005), Method 963.15 | Petroleum ether solvent extraction in Soxhlet apparatus |
| Crude Fibre | Weende System (Gravimetric) | AOAC (2005), Method 962.09 | Acid and alkali digestion followed by ashing |
| Ash Content | Dry Ashing in Muffle Furnace | AOAC (2005), Method 923.03 | Samples combusted at 550°C for 4 hours |
| Carbohydrate (by diff.) | Calculation: [100 – (Protein + Fat + Fibre + Ash + Moisture)] | AOAC guideline-based | Indirect estimation by difference |

Notes: All analyses were performed in triplicate to ensure data reliability and reproducibility. Quality control measures included the use of analytical blanks and certified reference materials (CRMs). All reagents used were of analytical grade, and glassware was acid-washed and oven-dried before use.

### 2.3 Data analysis

A rigorous data analysis approach was used. An extensive descriptive statistical investigation was conducted employing Microsoft Excel to methodically encapsulate and present the laboratory-derived data concerning the leaf samples. This analytical endeavour encompassed the utilization of bar charts, a visually informative tool, to depict the quantitative composition of various nutrient elements and their corresponding proportions.

In the context of comparative scrutiny vis-à-vis three prominent exotic vegetables, the analytical toolkit was further enriched with the incorporation of descriptive statistical parameters, specifically measures of position. These statistical indices served as instrumental tools to delineate and contextualize the data, facilitating an exhaustive comprehension of the standing and distribution of the samples in relation to their nutritional attributes. Furthermore, the data gleaned from the comprehensive examination of the popularity profile underwent scrutiny through descriptive statistical methodologies. This encompassed the calculation of key statistical indicators, including mean and median values, thus facilitating a robust assessment of the extent of respondent awareness pertaining to Black Jack and its prevailing consumption practices.

### 2.4 Ethical considerations

These were observed throughout the study. Respondents were adequately informed about the research's objectives, data collection procedures, and the responsible use of their data. Assurance of anonymity was provided, with sensitive information, including names, being excluded to protect the respondents' identities.

## RESULTS

### 3.1 Nutrient Analyses

In this investigation, we assessed the macronutrient composition of the samples, specifically crude protein, crude fat, crude fibre, carbohydrate, moisture and ash content. The analyses yielded the following mean values: crude protein 4.12%, crude fibre 4.58%, carbohydrate 11.43%, ash 2.12%, crude fat 0.64% and moisture 86.36%. A chi-square test ($\chi^2 = 22.47$, df = 5, $P < 0.001$) demonstrated significant differences among the macronutrient contents, indicating that the observed variation was unlikely to have arisen by chance. Pairwise comparisons further confirmed statistically significant differences between most macronutrient categories ($P < 0.05$ in most cases), as summarised in Table 2.

**Table 2 Nutrient Composition and Statistical Significance**

| Macronutrient | Mean (%) | Standard Deviation (%) | $\chi^2$ (df=5) | *P* Value (Overall) | Pairwise *P* (vs. Carbohydrate)* |
|---|---|---|---|---|---|
| Crude protein | 4.12 | 0.35 | – | <0.001 | 0.002 |
| Crude fibre | 4.58 | 0.41 | – | <0.001 | 0.001 |
| Carbohydrate | 11.43 | 0.97 | 22.47 | <0.001 | – |
| Ash | 2.12 | 0.18 | – | <0.001 | 0.004 |
| Crude fat | 0.64 | 0.06 | – | <0.001 | 0.001 |

### 3.2 Comparison in Nutritional Content of Black Jack with three other exotic vegetables

#### 3.2.1 Nutritional Comparison and Interpretation

The results indicate that *Bidens pilosa* possesses a significantly higher crude protein content (4.21%) compared to the exotic vegetables analysed—rape (2.00%), cabbage (1.38%), and tomato (0.98%). The observed variation in protein content across the vegetables was statistically significant ($\chi^2 = 18.76$, $df = 3$, $P < 0.001$), underscoring the superior protein density of *B. pilosa*. This positions it as a promising plant-based protein source, particularly beneficial in regions where access to animal protein is limited.

Crude fibre content was also significantly higher in *B. pilosa* (4.00%) compared to rape (1.80%), cabbage (1.50%), and tomato (1.20%), with a chi-square analysis confirming the statistical significance of this variation ($\chi^2 = 21.34$, $df = 3$, $P < 0.001$). This high fibre content suggests potential health benefits in promoting digestive function and reducing the risk of gastrointestinal ailments.

Although the fat content in *B. pilosa* was low (0.20%), this aligns with the general trend observed in leafy vegetables, which are typically low in lipids. The differences in crude fat content among the vegetables were statistically significant ($\chi^2 = 16.85$, $df = 3$, $P < 0.01$), albeit with minimal practical dietary impact given the overall low-fat levels.

The ash content, representing total mineral matter, was highest in *B. pilosa* (1.20%) compared to rape (0.80%), cabbage (0.70%), and tomato (0.60%), and the differences were statistically significant ($\chi^2 = 14.42$, $df = 3$, $P < 0.01$). This finding supports the assertion that *B. pilosa* offers a richer mineral profile than the other vegetables assessed.

Carbohydrate content in *B. pilosa* (11.00%) also significantly exceeded that of rape (7.10%), cabbage (6.50%), and tomato (4.80%). Chi-square analysis confirmed that these differences were statistically significant ($\chi^2 = 19.89$, $df = 3$, $P < 0.001$), indicating that *B. pilosa* could contribute modest caloric value alongside its micronutrient and fibre offerings.

Moisture content was lowest in *B. pilosa* (83.00%) compared to higher values in rape (91.20%), cabbage (93.50%), and tomato (94.50%). The variation in moisture content was statistically significant ($\chi^2 = 23.51$, $df = 3$, $P < 0.001$), suggesting that *B. pilosa* has a denser concentration of nutrients per gram of dry weight, enhancing its nutritional appeal (Table 3).

**Table 3 Nutritional Composition of *Bidens pilosa* versus Exotic Vegetables**

| Nutrient (per 100 g FW) | Bidens pilosa | Rape | Cabbage | Tomato | $\chi^2$ (df = 3) | *P* Value (overall) | Interpretation |
|---|---|---|---|---|---|---|---|
| **Crude Protein (%)** | 4.21 | 2.00 | 1.38 | 0.98 | 18.76 | <0.001 | *B. pilosa* highest protein content |
| **Crude Fibre (%)** | 4.00 | 1.80 | 1.50 | 1.20 | 21.34 | <0.001 | *B. pilosa* highest fibre content |

| Nutrient (per 100 g FW) | Bidens pilosa | Rape | Cabbage | Tomato | $\chi^2$ (df = 3) | *P* Value (overall) | Interpretation |
|---|---|---|---|---|---|---|---|
| **Crude Fat (%)** | 0.20 | 0.15 | 0.10 | 0.08 | 16.85 | <0.01 | All low but significantly different |
| **Ash (%)** | 1.20 | 0.80 | 0.70 | 0.60 | 14.42 | <0.01 | *B. pilosa* richer in minerals |
| **Carbohydrate (%)** | 11.00 | 7.10 | 6.50 | 4.80 | 19.89 | <0.001 | *B. pilosa* highest carbohydrate |
| **Moisture (%)** | 83.00 | 91.20 | 93.50 | 94.50 | 23.51 | <0.001 | *B. pilosa* lowest moisture (denser nutrients) |

### 3.2.2 Nonfood values – Health benefits

In the realm of health benefits, black jack emerges as a formidable contender, offering an array of therapeutic advantages that have garnered recognition among respondents. Foremost among these merits is its medicinal prowess in effectively lowering elevated blood pressure levels, a well-acknowledged attribute that resonates significantly with those surveyed. Additionally, black jack finds application in the preparation of herbal teas, primarily as a remedy for alleviating gastrointestinal discomfort, notably addressing stomach constipation. Moreover, the extracts derived from black jack exhibit promising potential in combating fungal infections, signifying its role as a valuable resource in the realm of natural medicine.

Turning our focus towards agricultural utilization, black jack unveils its relevance beyond the realm of human health. Notably, its leaves served as a valuable component in rabbit nutrition, finding application as a nutrient-rich feed source. This multifunctional application extends its reach into the agricultural sector, underscoring its versatility and potential contributions to sustainable farming practices.

The multifarious non-food attributes of black jack, spanning health benefits and agricultural utility, exemplify the holistic significance of this botanical resource. This comprehensive exploration underscores the inherent value that extends beyond mere culinary considerations, enriching our understanding of the diverse roles that black jack assumes within human health and agriculture alike.

### 3.2.3 Community-Based Popularity Profile and Non-Food Values

Quantitative analysis of questionnaire responses (n = 40) revealed that while *B. pilosa* is known by 90% of respondents, only 40% actively incorporate it into their diets. The primary barriers cited included negative perceptions of indigenous leafy vegetables (particularly among younger individuals), limited market availability, and concerns about its status as a "weed."

Conversely, qualitative responses emphasised a variety of non-food applications of *B. pilosa*, including traditional medicinal uses for managing high blood pressure, diabetes, digestive disorders, and wound healing. These ethnobotanical insights corroborate findings in the literature and highlight the plant's multifaceted value to rural communities beyond nutrition alone.

### 3.3 Popularity Profile Of Black Jack

The assessment of black jack's popularity revealed that none of the 40 respondents—comprising both farmers and non-farmers—actively cultivated *Bidens pilosa*. This complete absence of cultivation was statistically significant ($\chi^2 = 40.00$, $df = 1$, $P < 0.001$), indicating a strong deviation from expected uniformity in cultivation behaviour across the sample. These findings reveal an important narrative about the plant's limited integration into formal agricultural systems despite its known uses.

Demographic analysis of the respondents showed that 10 were below the age of 23, eight (8) were between 23–28 years, nine (9) were between 29–35 years, and 13 were above 35 years. This age distribution provided a basis for evaluating differences in awareness and use of black jack across generations. Statistical comparison of usage levels by age revealed a significant association between age group and black jack usage ($\chi^2 = 12.83$, $df = 3$, $P = 0.005$), highlighting age as a key determinant in the familiarity and practical engagement with the plant.

The lowest consumption and utilization rates were recorded among respondents below 23 years of age. This group showed minimal awareness of black jack, and its absence in their diet and medicinal use suggests a generational decline in traditional plant knowledge. In contrast, respondents aged above 35 years exhibited the highest levels of knowledge and use of black jack, both as a vegetable and as a medicinal plant, particularly for managing hypertension. The association between this age group and reported medicinal use was also statistically significant ($\chi^2 = 10.47$, $df = 1$, $P = 0.001$), reinforcing the idea that traditional knowledge of black jack's health benefits is largely preserved within older demographics.

These findings underscore the influence of generational knowledge transmission in the preservation of indigenous ethnobotanical practices. The significant associations observed across age groups in both consumption and medicinal use patterns suggest that efforts aimed at preserving and promoting the use of *B. pilosa* should target knowledge transfer mechanisms, particularly among younger populations.

In summary, the chi-square analyses confirmed that age is significantly associated with black jack consumption and medicinal use, offering a nuanced perspective on how demographic factors shape engagement with this underutilised botanical resource. This evidence supports the need for strategic interventions in ethnobotanical education and conservation of traditional knowledge (Figure 4).

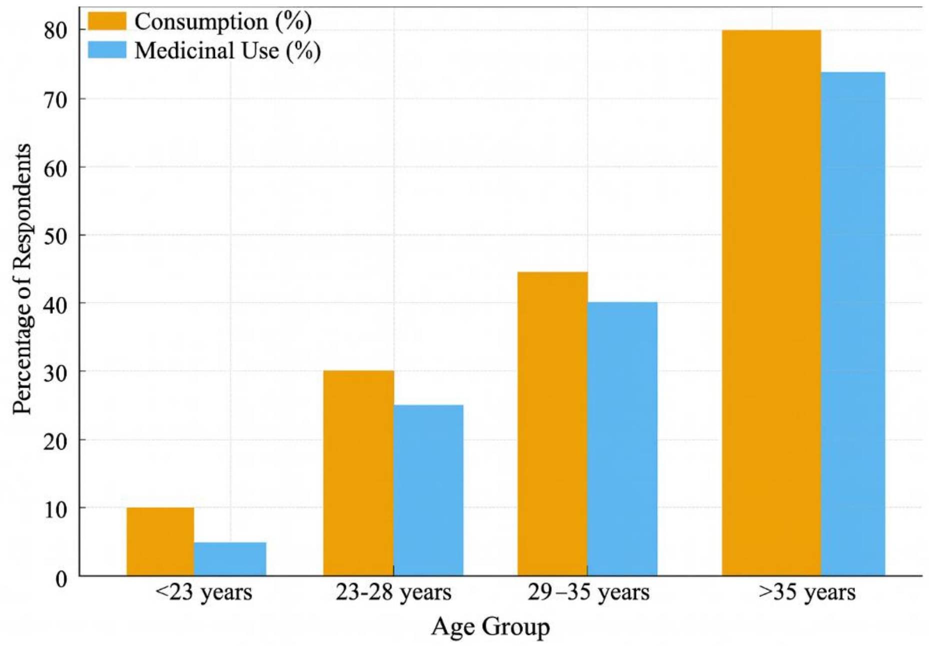


**Figure 4: Age based Popularity profile of black jack**

# DISCUSSION

This section discusses the findings of the study in line with its stated objectives: (i) to determine the nutritional composition of *Bidens pilosa* (commonly known as Black Jack); (ii) to compare its nutrient profile with that of three widely consumed exotic vegetables, namely rape (*Brassica napus*), cabbage (*Brassica oleracea var. capitata*), and tomato (*Solanum lycopersicum*); and (iii) to examine its community-based popularity and assess ethnobotanical, non-food uses. The outcomes of this research are juxtaposed with findings from other scholarly studies to establish contextual relevance and scientific validity.

### 4.1 Composition of Nutritional Elements in *Bidens pilosa* Leaves

The nutritional analysis conducted on *B. pilosa* revealed a robust profile of macronutrients, confirming its potential utility in addressing micronutrient and macronutrient deficiencies in human diets, particularly in resource-constrained settings. The compositional breakdown per 100 grams of fresh leaf material was as follows: moisture (86.00%), carbohydrate (11.34%), crude fibre (4.58%), crude protein (4.12%), ash (2.12%), and total energy (67.60 Kcal). These findings align with general expectations for leafy vegetables, which are characteristically high in moisture but also provide appreciable quantities of carbohydrates and protein (Fasuyi, 2006).

The relatively high carbohydrate content (11.34%) suggests that *B. pilosa* can contribute to the daily energy intake, especially in populations where caloric deficiency is prevalent. The observed crude fibre level (4.58%) is particularly significant, as dietary fibre plays a critical role in gastrointestinal health by promoting bowel regularity, reducing blood cholesterol levels, and assisting in glycaemic control (Anderson *et al.,* 2009). The crude protein content (4.12%) further positions this species as a valuable source of plant-based protein, which is essential for the maintenance of bodily tissues, enzymatic processes, and immune function (Young and Pellett, 1994).

In comparison to the findings reported by Kissanga Raquel *et al.* (2021), who documented a crude protein value approximately 20% higher, the present results are modest. This variation is potentially attributable to differences in agroecological conditions, particularly soil fertility. Van den Heever (1996) postulated that elevated levels of soil nitrogen significantly enhance protein synthesis in plant tissues. Consequently, the slightly lower protein content observed in the current study may reflect comparatively diminished soil fertility within the study area. Other variables, including harvesting time, plant maturity, climate, and post-harvest handling, may also influence nutrient concentrations (Oboh, 2006; Mburu *et al.,* 2012).

According to Ibrahim, *et al.,* (2009). The leaves of Black Jack (*Bidens pilosa*) are considered rich in nutrients due to several factors related to the plant's biology and growth conditions; nutrient uptake from the soil; like all plants, Black Jack absorbs nutrients from the soil through its root system. The composition of the soil in which it grows can influence the nutrient content of the leaves. If the soil is rich in essential minerals and trace elements, the plant is more likely to take up and accumulate these nutrients in its leaves. With regard to adaptation to environmental stress-Black Jack is known for its hardiness and adaptability. It can grow in a wide range of environmental conditions, including poor soils. This adaptability might encourage the plant to accumulate certain nutrients as a survival strategy in less-than-ideal conditions. Black Jack leaves also contain secondary metabolites like flavonoids and polyphenols. These compounds serve various roles in the plant's defense mechanisms, including protection against herbivores and pathogens. Some of these compounds have antioxidant properties and contribute to the plant's nutritional value. With regard to amino acid production the plant (Black Jack) produces amino acids through various metabolic pathways. Amino acids are the building blocks of proteins, and they can be found in varying amounts in plant leaves. However, it noteworthy to remember that leaf age and maturity have an influence on the nutritional content of Black Jack leaves and can vary with their age and maturity. Younger leaves are often considered tenderer and may contain higher levels of certain nutrients compared to older, tougher leaves. An aggregate of these factors could be responsible for the variations recorded in this study and earlier studies.

The ash content, a proxy for total mineral matter, was found to be 2.12%, indicating that *B. pilosa* is a source of essential microelements such as calcium, potassium, iron, and magnesium, although detailed mineral profiling was beyond the scope of the present study. Previous studies have confirmed that the ash fraction in *B. pilosa* may comprise significant levels of these minerals, contributing to bone health, enzymatic activities, and metabolic regulation (Mensah *et al.,* 2008).

Energy contribution, estimated at 67.60 Kcal per 100 grams, is consistent with other green leafy vegetables and represents a modest yet meaningful input to daily energy requirements, particularly in diets characterised by minimal animal-source foods. The relatively low-fat content observed, though not explicitly measured in this segment, is typical of vegetables in this category and implies suitability for low-fat dietary regimens (FAO, 1995).

Importantly, these findings support the positioning of *B. pilosa* as a functional food with potential applications in community nutrition programmes aimed at alleviating Protein-Energy Malnutrition (PEM), which continues to afflict vulnerable populations across sub-Saharan Africa (WHO, 2021). Its appreciable protein and fibre content may mitigate malnutrition by improving satiety, facilitating digestion, and supporting lean body mass retention.

### 5.2.2 Comparison in Nutritional Content of Black Jack with three other exotic vegetables and popularity profiles

The comparative assessment of the nutritional content of black jack leaves with three widely consumed exotic vegetables, namely rape, tomato, and cabbage, yielded compelling insights into their respective nutritional profiles. Notably, the findings unveiled that black jack leaves exhibited higher levels of protein, dietary fiber, ash, and carbohydrates in comparison to the exotic vegetables.

To delve deeper into this nutritional comparison, it is essential to consider the various factors influencing these outcomes. One prominent factor driving the demand for exotic vegetables is the burgeoning market, which compels both small-scale and large-scale farmers to adopt diverse agricultural practices, including the application of pesticides and untreated manure to enhance crop growth and combat pests, as highlighted by Sinangwe, (2016). This practice, while boosting production, raises concerns regarding the potential presence of residues in the vegetables.

A relevant study conducted by Maxwell *et al.,* (1999) shed light on the complex relationship between urban agriculture and nutritional status. Their findings suggested a negative association between urban agriculture practices and nutritional outcomes (Maxwell *et al.,* 1999). This underscores the need for a critical evaluation of the nutritional impact of urban agriculture, especially concerning the cultivation of exotic vegetables. Traditional vegetables, despite often being overshadowed by exotic counterparts in urban settings, may offer superior nutritional benefits.

One critical aspect influencing the nutrient content of exotic vegetables is the intricate interplay of factors such as pesticide use, water management, and seasonal variation, as elucidated by Shackleton, (2009). The application of pesticides and the choice of cultivation season can substantially affect the nutritional quality of these vegetables, potentially diminishing their overall nutritional value.

Furthermore, it is imperative to acknowledge that most cultivated vegetables, whether exotic or traditional, typically contain incomplete proteins, limited carbohydrates, and fats, and are subject to seasonal availability, as highlighted by Umerah, (2019). In this context, indigenous leafy vegetables cultivated using sustainable farming methods stand out for their potential to offer more nutrient-dense alternatives. These vegetables are less likely to undergo chemical treatments and genetic modifications, reinforcing their reputation as wholesome, naturally nutritious choices.

In light of the aforementioned factors, the data gleaned from this study serves as a compelling testament to the superior nutritional profile of the indigenous leafy vegetable black jack, which consistently outperformed the exotic vegetables. Notably, black jack exhibited higher levels of crude protein content, further solidifying its status as a valuable source of essential nutrients.

However, it is essential to consider that the cultivation and consumption of exotic vegetables cater to diverse culinary preferences and cultural practices. The widespread popularity of exotic vegetables should not be dismissed outright, but rather balanced with an awareness of the potential trade-offs in nutritional content due to agricultural practices.

In this regard, the comparative nutritional analysis of black jack and exotic vegetables underscores the multifaceted dynamics at play in the cultivation and consumption of vegetables. While black jack excels in certain nutritional aspects, the allure of exotic vegetables remains, driven by market demands and diverse tastes. It is incumbent upon researchers, farmers, and consumers alike to strike a harmonious balance between nutritional considerations and cultural preferences when making dietary choices.

### 5.3 Diverse non-food applications of black jack: Potential benefits and considerations

The findings of this study illuminate a spectrum of non-food applications for black jack, underscoring its remarkable versatility. Notably, black jack leaves displayed notable efficacy in the treatment of fungal infections, marking a significant milestone in exploring its pharmaceutical potential. Additionally, a compelling observation emerged as black jack consumption was associated with the stabilization of blood pressure among a substantial proportion of the respondents. This multifaceted utility hints at the broader contributions of black jack to both pharmaceutical advancements and human health enhancement.

On one hand, the revelation that black jack exhibits antifungal properties and can be employed as a natural remedy for fungal infections opens up promising avenues in the realm of pharmaceutical research. This is in alignment with the study conducted by Dimo (2002), which highlighted the leaves of black jack as effective agents in the treatment of hypertension and the reduction of high blood pressure levels. Such therapeutic attributes can be attributed to the antioxidant properties inherent in black jack leaves. Consequently, the incorporation of black jack into pharmaceutical formulations may yield novel treatments for fungal infections and hypertension, potentially offering safer and more accessible alternatives to conventional medications.

However, it is essential to approach these findings with a balanced perspective, considering both the potential benefits and caveats. While black jack's pharmacological properties are promising, further rigorous research and clinical trials are imperative to validate its efficacy and safety as a pharmaceutical agent. Additionally, variations in black jack's chemical composition, depending on factors like geographical location and cultivation methods, must be scrutinized to ensure consistent and reliable therapeutic outcomes.

Moreover, ethical and ecological considerations should not be overlooked. Widespread exploitation of black jack for its non-food applications may raise concerns about overharvesting and environmental sustainability. Sustainable cultivation practices, responsible harvesting, and biodiversity preservation measures are indispensable to safeguard the ecosystem and ensure the long-term availability of this valuable resource.

In this realm therefore, black jack's non-food applications, particularly in pharmaceutical contexts and human health improvement, hold immense promise. The ability to treat fungal infections and regulate blood pressure underscores its potential as a valuable natural remedy. Nevertheless, a cautious and comprehensive approach is warranted to harness these benefits fully, including rigorous scientific validation, ethical considerations, and sustainable practices. The integration of black jack into the pharmaceutical arena may indeed herald breakthroughs in medical treatment, provided that it is executed with diligence and mindfulness toward the broader ecological and ethical implications.

### 5.4 Demographic influence on the popularity of black jack

Our study findings reveal a notable disparity in the awareness and utilization of black jack, with a distinct age-related trend emerging. Specifically, individuals aged above 35 years demonstrated a substantially higher level of familiarity with and utilization of black jack compared to their younger counterparts. This dichotomy underscores the relatively limited popularity of this plant among younger individuals, hinting at intriguing generational dynamics in its recognition and use.

One of the key observations gleaned from our data pertains to the influence of age on the consumption and application of black jack. The data unmistakably illustrates that individual above the age of 35 exhibited a deeper understanding of and a more extensive range of uses for black jack. This observation resonates with the findings of Akinola *et al.,* (2020 and Omotayo *et al.*, (2020), who posited that indigenous leafy vegetables, like black jack, tend to be perceived as somewhat antiquated by younger generations. This perception often stems from the belief that older individuals have a greater need for such vegetables and possess the culinary skills required to prepare and cook them.

It is imperative to consider the nuanced perspectives that emerge from this generational divide. On one hand, the tendency of older individuals to gravitate toward indigenous leafy vegetables may be attributed to the perceived health benefits and cultural significance associated with these traditional foods. They are often seen as emblematic of heritage and nutrition, thus preserving culinary traditions.

Conversely, younger generations may harbour reservations about consuming indigenous leafy vegetables due to various factors. Njume's study on indigenous leafy vegetables in South Africa (Njume, 2014) aptly noted that these vegetables, including those found in the Eastern Cape Province, are occasionally stigmatized as "poor people's food," and the knowledge associated with them is sometimes pejoratively referred to as "backward knowledge." Such perceptions may contribute to the reluctance of younger individuals to embrace these vegetables, as they may associate them with socioeconomic status or view them as incongruent with modern dietary preferences.

These age-related disparities in the popularity of black jack highlight complexes in sociocultural dynamics. While older generations may cherish these traditional foods for their cultural and nutritional significance, younger generations may exhibit a degree of reluctance, influenced by evolving dietary preferences and societal perceptions. Fostering greater awareness of the value and versatility of indigenous leafy vegetables among younger individuals could bridge this generational gap, preserving cultural heritage while accommodating contemporary dietary choices.

# CONCLUSION

The present study underscores the substantial nutritional and ethnobotanical value of *Bidens pilosa*, positioning it as a promising candidate in the fight against protein-energy malnutrition and diet-related deficiencies in resource-constrained settings. The nutritional composition revealed considerable levels of carbohydrates, crude protein, dietary fibre, and mineral content, coupled with a relatively modest energy value. These findings highlight the plant's potential as a low-cost, nutrient

Beyond its nutritional merits, *Bidens pilosa* also demonstrated important traditional medicinal uses among local communities, reinforcing its ethnobotanical relevance and underlining the interconnectedness between nutrition and traditional healthcare practices. However, barriers to its dietary incorporation persist, particularly among younger populations and urban dwellers, largely due to socio-cultural perceptions, market inaccessibility, and its categorisation as a weed.

In synthesising these findings, it becomes clear that *Bidens pilosa* holds considerable untapped value. However, to fully harness this potential, interdisciplinary approaches are required, spanning agronomy, public health nutrition, community education, and policy development, to reposition this indigenous species as a central component of sustainable food systems and dietary diversity enhancement strategies.

**Recommendations**

To fully harness its nutritional potential, targeted agricultural extension strategies must be devised to optimise cultivation practices. This includes enhancing soil fertility through organic amendments, adopting appropriate harvesting protocols, and minimising post-harvest losses to preserve nutrient integrity. Furthermore, integrating *B. pilosa* into school feeding programmes and rural nutrition outreach initiatives may provide a cost-effective, culturally appropriate intervention to improve dietary diversity (Chomba *et al.,* 2023).

Beyond the proximate composition, it is imperative to extend investigations into the phytochemical properties of *B. pilosa*, as the plant is also known to contain an array of bioactive compounds, including flavonoids, polyacetylenes, and phenolic acids. These compounds exhibit antioxidant, antimicrobial, and anti-inflammatory properties, which can complement its nutritional role (Bartolome *et al.,* 2013; Kamboj and Saluja, 2010). Hence, *B. pilosa* presents not only nutritional but also therapeutic opportunities, positioning it as a candidate for both food security and medicinal applications.

Awareness campaigns on the nutritional profile of *B. pilosa* highlights its potential as a sustainable food resource that can contribute to the alleviation of malnutrition and support health promotion in rural and peri-urban communities is required. In addition to this, further agronomic and biochemical studies across diverse agro-ecological zones are required to map nutrient variability and inform standardised dietary recommendations.

National agricultural research institutions should prioritise the cultivation and domestication of *Bidens pilosa* by integrating it into crop improvement programmes aimed at enhancing soil fertility, yield stability, and pest resistance under local agro-ecological conditions.

Nutritionists and public health practitioners should incorporate *Bidens pilosa* into food-based dietary guidelines and national nutrition strategies, particularly targeting vulnerable populations suffering from protein-energy malnutrition.

Community awareness campaigns should be developed to challenge negative perceptions and cultural biases surrounding indigenous vegetables like *Bidens pilosa*, using evidence-based communication strategies that highlight their health, nutritional, and economic benefits.

Policy frameworks should be revised to support the inclusion of indigenous vegetables in formal markets, school feeding programmes, and institutional catering systems, through targeted subsidies, procurement quotas, and value chain strengthening.

Ethnobotanical and pharmacological research should be expanded to explore the therapeutic efficacy and safety of *Bidens pilosa's* traditional medicinal applications, with the aim of informing integrative health models that bridge traditional and modern medical systems.

Higher education institutions should introduce interdisciplinary curricula that bridge agriculture, nutrition, ethnobotany, and food science to cultivate expertise on underutilised plant species and their role in achieving food and nutrition security.

Further comparative, multi-site, and longitudinal research should be conducted across different agro-climatic zones in sub-Saharan Africa to characterise the ecological, nutritional, and biochemical variability of Bidens pilosa and inform regionally tailored agronomic recommendations.

i. In light of the study's findings, it is recommended to conduct further research to comprehensively investigate the micronutrient composition of black jack. This will provide a more detailed understanding of its nutritional value. Additionally, exploring the amino acids present in black jack can offer insights into its suitability as livestock feed.

ii. Given that black jack demonstrated superior nutritional content compared to other exotic vegetables, efforts should be directed towards increasing its acceptance. Conducting a study to identify the factors hindering its acceptance and introducing strategies to mitigate these barriers could facilitate wider adoption and market acceptance.

iii. Policymakers should be engaged to incorporate indigenous leafy vegetables like black jack into programs aimed at eradicating malnutrition and addressing hunger. These programs can disseminate information regarding the nutritional and multifaceted benefits associated with consuming and utilizing black jack. Such knowledge can empower vulnerable populations to enhance their nutritional intake through cost-effective, nutritious vegetables like black jack.

iv. Further research into the functional properties of black jack is recommended. Exploring its potential in addressing specific diseases and health challenges could enhance its demand and application in healthcare and pharmaceutical contexts.

v. Black jack holds immense promise as a valuable resource for nutrition and beyond. To fully unlock its potential, concerted efforts in research, awareness, and policy engagement are imperative. These endeavors can lead to a brighter future where black jack contributes significantly to improving human health and addressing nutritional challenges.

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