AGRICULTURAL AUTOMATION, CLIMATE CHANGE-ACTION AND FOOD SECURITY: GLOBAL ISSUES & LOCAL PERSPECTIVES

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Preface

This book adopts an exegetical approach as well as a pedagogic model, making it attractive agriculture and environmental economics teachers, professional practitioners and scholars. It is eschews pedantry and lays bars the issues in such clarity that conduces to learning. The book elaborates on contemporaneous Agricultural Automation, Climate Change-Action and Food Security issues of global significance and at the same time, is mindful of local or national perspectives making it appealing both to international and national interests. The book explores the ways in which Agricultural Automation, Climate Change-Action and Food Security issues are and should be presented to increase the public's stock of knowledge, increase awareness about burning issues and empower the scholars and public to engage in the participatory dialogue Agricultural Automation, Climate Change-Action and Food Security necessary in policy making process that will stimulate increase in food production and environmental sustainability. Agricultural Automation, Climate Change-Action and Food Security**:** *Global Issues & Local Perspectives* is organized in three parts. Part One deals with The Concept of Agricultural Automation, Part Two is concerned with The Concept of Climate Change-Action and Part Three deals with the Concept of Food Security

Eteyen Nyong; October 2026

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Chapter Eleven

Snake Gourd (*Trichosanthes cucumerina*) as an Underutilized Food and Genetic Resource for Climate-Resilient Agri-Food Systems in Southeast Nigeria

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Introduction

Global and national food systems remain vulnerable when production, diets and research investment are concentrated in a small group of crops. A narrow crop base can simplify supply chains, but it also concentrates exposure to climatic shocks, pests, price volatility and dietary monotony. Neglected and underutilized crops offer a complementary strategy: they extend the portfolio of foods available to households and breeders, preserve culturally relevant knowledge and create opportunities for small-scale processing. Recent syntheses emphasize that their contribution depends on simultaneous progress in agronomy, seed systems, value addition and markets rather than on nutritional composition alone (Knez,

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Ranić, & Gurinović, 2024; Ndlovu, Scheelbeek, Ngidi, & Mabhaudhi, 2024; Purba & Krishnaswamy, 2025; Obembe, Obadire, Aworunse, & Bello, 2024).

Snake gourd is a climbing cucurbit cultivated in tropical and subtropical regions. The immature fruit is commonly prepared as a vegetable, while leaves, flowers, ripe pulp and seeds have documented or potential uses. The crop is conspicuous in some farming communities but remains less visible in formal Nigerian seed catalogues, extension packages and commodity statistics. Farmers may exchange seed lots under names based on locality or source. Such materials may contain useful variation, yet their identity, stability and performance require documentation through replicated trials.

This chapter treats snake gourd as an agrobiodiversity and food-system resource rather than as a vegetable of marginal interest. Its relevance rests on four connected features: visible and quantitative diversity provides raw material for crop improvement; multiple plant parts may expand food-use opportunities; the crop may widen seasonal production options; and research on indigenous germplasm can strengthen local breeding capacity and rural livelihoods. The central question is how validated germplasm, safe food use, consumer acceptance and viable markets can be assembled into a dependable contribution to food availability, access, utilization and stability.

Problem statement

Despite the continued use of indigenous vegetables in household food systems, many remain weakly represented in formal breeding, seed supply, extension and market-development programmes. In Southeast Nigeria, locally maintained snake-gourd seed lots are commonly identified by source or locality, but their genetic identity, agronomic performance, nutritional attributes and adaptation across production environments are not sufficiently documented. This evidence gap limits the ability of farmers, researchers and processors to distinguish promising materials, develop reliable production recommendations and build consumer confidence. The practical problem addressed here is the lack of locally grounded evidence pathway linking germplasm characterization, food-use assessment, production stability, processing and market development.

Purpose, objectives and value added

The chapter aims to assess the potential of snake gourd as an underutilized food and genetic resource for more diverse and climate-resilient agri-food systems in Southeast Nigeria. Specifically, it (i) reviews the crop's biology, uses and production constraints; (ii) describes agro-morphological variation among eight provenance-labelled accessions evaluated at Awka; (iii) presents compositional and selected in-vitro screening results for flowers, leaves and immature fruits; and (iv) identifies research, breeding, seed-system, processing and market priorities. Its value added is the integration of locally generated field and laboratory observations with a practical development pathway. The chapter distinguishes observed results from proposed opportunities and identifies limitations that must be addressed before recommendations on adaptation, food safety, health benefits or commercial release can be made.

Food Security and the Case for Crop Diversification

The four dimensions of food security

Food availability concerns the physical supply of food from production, stocks, trade and distribution. Snake gourd can contribute by adding a vegetable to household gardens and diversified farms, but only if seed, management knowledge and suitable planting windows are available. Food access concerns whether households can obtain food economically and physically. Local seed networks and short value chains may reduce dependence on purchased vegetables, while surplus fruit and processed products may create income. Food utilization concerns diet quality, food safety, preparation and the body's ability to use nutrients. Compositional data are relevant but insufficient without information on processing losses, antinutrients, bioavailability and usual serving sizes. Stability concerns whether the other three dimensions persist through seasons and shocks. Diverse crops with different phenologies and market niches may spread risk, although resilience must be demonstrated across environments.

Crop diversification is therefore a form of risk management at farm and food-system scales. Underutilized vegetables can fill seasonal gaps, contribute dietary diversity and generate income from small land areas. They also retain options for future breeding because farmer-maintained seed lots may contain variation absent from standardized commercial pools. The food-security value of diversity is greatest when materials are conserved, described and made usable through breeding and seed delivery (Alercia, Diulgheroff, & Mackay, 2015; Dhillon *et al*., 2020; Ndlovu *et al*., 2024).

Why neglect persists

Neglect is created by institutions as much as by biology. Research funding often favours established commodities; extension agents may lack tested production guides; seed enterprises face uncertain demand; processors encounter inconsistent raw materials; and consumers may perceive indigenous crops as old-fashioned or difficult to prepare. These constraints reinforce one another. Weak demand discourages seed and processing investment, while unreliable supply prevents market development. Correcting this cycle requires technically credible evidence communicated in forms usable by farmers, processors and policy makers.

Snake gourd also faces taxonomic and naming ambiguity. Cultivated long-fruited forms have been referred to as *Trichosanthes cucumerina* var*. anguina*, *T. anguina* and snake tomato in different contexts. Clear nomenclature, passport information and accession codes are essential if results are to be compared and germplasm conserved without duplication. Provenance labels such as Anambra-SG or Lagos-SG are useful working identifiers, but they do not prove genetic purity, variety status or state-specific adaptation (Pradheep, Pani, & Bhatt, 2015).

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Snake Gourd: Biology, Uses and Production Potential

Botany and reproductive biology

Snake gourd belongs to the Cucurbitaceae, a family that includes cucumber, melon, pumpkin and other gourds. It is a tendril-bearing vine with alternate, often lobed leaves. Male flowers generally occur in racemes, whereas female flowers are solitary or less numerous and possess an inferior ovary. The white fringed flowers are conspicuous and support insect-mediated pollination. Sex expression and fruit set can respond to genotype, temperature, moisture, nutrition, plant condition and pollinator activity. A single flowering count is therefore a snapshot rather than a complete measure of reproductive capacity (Bharathi, Behera, Sureja, John, & Wehner, 2013; Osuagwu, Aguoru, Omoigui, & Olasan, 2023).

Fruit diversity is central to use. Long slender fruits, thicker cylindrical types and shorter oval forms may suit different culinary preferences, packaging needs and market channels. Immature fruit is used as a vegetable; fully ripe fruit develops red pulp that may be explored as a pigment-rich ingredient or tomato complement, subject to processing, sensory and safety validation. Leaves and flowers expand possible food-use options, while seed may support planting and further ingredient research. Whole-plant utilization should respect harvest trade-offs: removing too many leaves or flowers can reduce photosynthesis or fruit set.

Agronomy and appropriate automation

The climbing habit requires support to improve light interception, fruit quality and harvest access. Stakes or trellises represent practical production technologies. Other possible innovations include seed grading, germination testing, reusable nursery trays where transplanting is appropriate, low-cost drip irrigation, soil-moisture monitoring, digital field records and simple harvest crates. Automation should be proportionate to farm scale and solve specific labour, water or quality problems. The goal is not to force a minor crop into a capital-intensive model, but to reduce drudgery and improve consistency.

Digital accession registers can connect passport data, photographs, field performance and seed stocks. Smartphone-based image capture can standardize records of leaf lobing, fruit curvature and colour. Small weather stations can document rainfall and temperature that affect flowering and yield. Solar drying with temperature control may improve the safety and stability of leaf or flower powders, provided microbial quality and nutrient retention are assessed.

Materials and Methods

Field evaluation

Eight provenance-labelled accessions from Anambra, Ebonyi, Imo, Lagos, Ogun, Ondo, Osun and Oyo were evaluated during the 2026 rainy season at the Teaching and Research Farm of Nnamdi Azikiwe University, Awka. The experiment was laid out as a randomized complete block design (RCBD) with three blocks and 24 plots. Each plot measured 1.2 m × 2.0 m. Three seeds were sown per planting hole, with approximately

18 seeds established per plot; stands were thinned to nine plants per plot and supported with bamboo stakes. Cured poultry manure mixed with sawdust was applied at the reported rate of 5 t ha^{-1}.

The chapter indicates genotypic and phenotypic variance components, genotypic and phenotypic coefficients of variation (GCV and PCV), broad-sense heritability and genetic advance as a percentage of the mean (GAM), calculated on an entry-mean basis. Principal component analysis (PCA) and Ward's hierarchical clustering were used to describe multivariate patterns.

Whole-plant analytical characterization

Flower, leaf and immature-fruit samples were analysed at Federal Analytical Global Concept, Enugu East, Enugu State. Proximate, mineral, vitamin and phytochemical determinations were conducted using duplicate technical readings. DPPH, ABTS and FRAP antioxidant assays and an alpha-amylase-inhibition assay were used to screen concentration responses. The duplicate readings represent analytical repeatability and are not independent biological replicates.

Agro-morphological Diversity and Food Availability

Recorded emergence ranged from 67.79% in Anambra-SG to 96.29% in Lagos-SG. The result indicates higher emergence means for Ebonyi-SG, Lagos-SG, Ogun-SG, Ondo-SG, Osun-SG and Oyo-SG. Vine length, plant height, internode length and leaf dimensions were reported as non-significant. Ogun-SG had the largest numerical leaf area (251.00 cm^2), whereas Anambra-SG had the smallest (140.40 cm^2).

Table 1. Emergence and vegetative growth traits of the evaluated snake-gourd accessions

Accession	Emergence (%)	Vine length (cm)	Plant height (cm)	Internode length (cm)	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)
Anambra-SG	67.79	27.33	32.17	12.11	15.00	14.00	140.40
Ebonyi-SG	86.56	25.00	30.17	14.00	17.67	17.33	232.75
Imo-SG	69.35	34.83	34.17	17.78	17.00	18.00	234.57
Lagos-SG	96.29	38.33	38.33	16.67	17.67	16.67	226.50
Ogun-SG	92.59	30.83	38.00	16.11	18.33	17.67	251.00
Ondo-SG	87.50	26.83	31.17	13.89	17.00	17.00	216.75
Osun-SG	88.88	28.50	30.67	14.44	16.00	17.67	212.25

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Oyo-SG	91.67	32.17	37.83	18.00	16.67	16.67	214.00
LSD (0.05)	0.239	NS	NS	NS	NS	NS	NS

Flowering time provided additional descriptive differentiation. Imo-SG was reported as earliest for male flowering (45.0 days) and female flowering (47.5 days). Lagos-SG was latest for male flowering (49.0 days), while Ogun-SG was latest for female flowering (52.33 days). Earliness may be useful for fitting production into seasonal windows, but its value must be assessed alongside emergence, fruit set, marketable yield and performance across seasons. Male- and female-flower counts were reported as non-significant; repeated censuses, flower longevity, pollen viability, stigma receptivity, fruit-set percentage and pollinator observations would strengthen future reproductive characterization.

Table 2. Fruit traits and yield performance of the evaluated snake-gourd accessions.

Accession	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruits per plant	Yield (t ha^{-1})
Anambra-SG	200.07	24.00	3.65	14.77	9.60
Ebonyi-SG	217.40	45.57	5.32	15.87	9.80
Imo-SG	447.42	53.50	4.36	14.70	20.51
Lagos-SG	368.70	47.50	5.64	23.11	26.34
Ogun-SG	263.75	47.00	4.07	19.87	16.64
Ondo-SG	317.07	47.00	4.44	16.93	16.82
Osun-SG	317.40	42.50	5.48	16.80	16.24
Oyo-SG	322.52	48.00	5.98	18.77	19.98
LSD (0.05)	131.016	12.971	1.186	NS	NS

Yield is reproduced as reported in the source dataset; its accession effect was not statistically significant.

Fruit weight (P = 0.0227), diameter (P = 0.0072) and length (P = 0.0106) differed significantly among accessions according to the reported analysis. Imo-SG had the highest mean fruit weight (447.42 g) and the greatest mean fruit length (53.50 cm), while Oyo-SG had the largest mean fruit diameter (5.98 cm). Anambra-SG represented a shorter- and lighter-fruited phenotype. Fruit dimensions and individual fruit weight are relevant to culinary use, handling, consumer preference and breeding objectives. Similar studies have identified fruit dimensions and yield components as useful descriptors of snake-gourd diversity (Devi, Mariappan, Arumugam, & Anandakumar, 2017; Islam, Rahman, Zakaria, Hoque, & Hasan, 2022; Khatun, Islam, Ahmed, Jahan, Islam, Ahmed, & Jahan, 2023; Kumar, Rekha, Ramana, Rajani, & Suneetha, 2024).

Lagos-SG ranked highest numerically for fruits per plant and yield in this trial. However, the accession effect for the reported yield variable was not statistically significant; therefore, Lagos-SG should be described as having the highest numerical mean, not as a proven superior-yielding accession. Multi-

location and multi-season evaluations are needed to determine whether Lagos-SG maintains fruit number and yield, whether Imo-SG consistently produces heavy, long fruits, and whether the greater diameter of Oyo-SG matches consumer and processing preferences.

Table 3. Estimates of genetic variability parameters for selected traits.

Trait	GCV (%)	PCV (%)	Broad-sense H^2	GAM (%)
Fruit weight	22.12	26.22	0.712	45.57
Fruit diameter	15.31	17.29	0.784	31.54
Fruit length	17.29	19.79	0.763	35.61
Fruits per plant	8.47	16.27	0.271	17.46
Seeds per fruit	0.00	12.80	0.000	0.00
Derived yield	19.33	32.67	0.350	39.81

H^2 = broad-sense heritability; GAM = genetic advance as percentage of the mean.

PCV exceeded GCV for each listed trait, indicating that phenotypic variation was greater than the estimated genotypic component under the conditions and assumptions of this trial. Fruit weight, diameter and length had higher broad-sense heritability estimates than fruit number and the reported yield variable. These estimates suggest that fruit dimensions may be useful preliminary selection criteria in this material. However, broad-sense heritability from a single environment includes genetic effects expressed under that environment and does not by itself predict response to selection across locations or seasons. The comparatively low heritability estimate for fruit number and the yield variable suggests that these traits require evaluation in more environments and with improved precision before strong selection decisions are made.

Nutritional and Bioactive Evidence for Food Utilization

Table 4. Selected compositional values for flower, leaf and immature-fruit samples.

Trait	Flower	Leaf	Immature fruit
Protein (%)	9.530	10.530	13.750
Crude fibre (%)	4.340	4.540	5.950
Potassium (mg 100 g^{-1})	25.500	32.345	36.750
Calcium (mg 100 g^{-1})	8.115	9.325	12.830
Iron (mg 100 g^{-1})	0.325	0.625	0.950
Phenolics (mg GAE 100 g^{-1})	5.960	4.830	6.360

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Vitamin A (mg 100 g^{-1})	8.205	5.830	5.315
Vitamin C (mg 100 g^{-1})	5.425	8.535	9.050

Values are presented as supplied in the source material; units and analytical basis should be checked against the original laboratory certificates before final typesetting.

Among the sampled materials, immature fruit recorded the highest reported means for protein (13.75%), crude fibre (5.95%), potassium (36.75 mg 100 g^{-1}), calcium (12.83 mg 100 g^{-1}), magnesium (18.245 mg 100 g^{-1}), phosphorus (8.47 mg 100 g^{-1}), iron (0.95 mg 100 g^{-1}), zinc (0.196 mg 100 g^{-1}), phenolics (6.36 mg GAE 100 g^{-1}), flavonoids (4.155 mg 100 g^{-1}), vitamin C (9.05 mg 100 g^{-1}), vitamin E (0.635 mg 100 g^{-1}) and vitamin K (4.045 mg 100 g^{-1}). These are descriptive values for the materials analysed and identify immature fruit as a candidate for further food-formulation assessment; they do not establish dietary adequacy or health benefit.

Flowers also showed potentially useful compositional attributes. They had the highest reported mean values for vitamin A (8.205 mg 100 g^{-1}), ash (2.825%), tannins (1.245 mg 100 g^{-1}) and glycosides (1.635 mg 100 g^{-1}). Leaves had the highest carbohydrate mean (67.98%) and vitamin B1 (0.245 mg 100 g^{-1}), while their vitamin C value was close to that of immature fruit. Liyanage, Nadeeshani, Jayathilake, Visvanathan, and Wimalasiri (2016) also reported nutritional and bioactive constituents in snake-gourd aerial parts. Recent reviews and food-characterization studies further emphasize the need to connect compositional screening with processing, product quality and validated food-use pathways (Omah, Etzbach, & Schweiggert-Weisz, 2026; Fernandes, Cunha Junior, Silva, Campos, Morgado, Souza, & Nascimento, 2025; Radharamanan & Siddhuraju, 2025).

Antioxidant and alpha-amylase screening

All extracts showed concentration-dependent responses in the reported DPPH and ABTS assays. At 1,000 µg mL^{-1} in the DPPH assay, leaf extract recorded 57.20% scavenging, fruit 56.74% and flower 52.54%; the ascorbic-acid reference recorded a higher response. In the ABTS assay at the highest tested concentration, flower recorded 44.41%, fruit 42.35% and leaf 41.18%. The ranking therefore differed between assays, as expected when assays involve different reaction mechanisms.

Alpha-amylase inhibition increased with concentration in the reported assay. At 100 mg mL^{-1}, flower extract recorded 53.19% inhibition, fruit 51.70% and leaf 49.36%, while acarbose reached 84.47%. These in-vitro findings indicate assay activity under the tested conditions; they do not demonstrate antidiabetic efficacy, safe human doses, clinical benefit or suitability for therapeutic use. Further work should use standardized extracts, appropriate controls, validated dose ranges and relevant safety assessments.

The tested samples showed signals for tannins, oxalate, saponins, alkaloids and glycosides. These compounds should not be classified as uniformly harmful or beneficial without considering their chemical identity, concentration, bioavailability, serving size and the effects of customary processing. Oxalate was

reported as highest in immature fruit (0.925 mg 100 g^{-1}), while tannin was highest in flower. Food-use recommendations require confirmation of analytical methods and units, assessment of relevant antinutritional factors and evaluation of the effects of cooking or other processing.

Climate Resilience and Production Stability

Crop diversification can contribute to system-level resilience by spreading production and market risks across crops with different growth habits, harvest windows and uses. This potential benefit should be distinguished from demonstrated physiological tolerance to drought, heat, flooding or pests. Snake gourd's climbing habit may allow vertical use of space in home gardens, field margins or mixed horticultural systems, but its response to water stress, temperature extremes, pests and diseases, as well as its competition for light and labour, requires direct testing.

Climate-smart management options

Research on climate-smart management should evaluate seed priming, nursery establishment, organic amendments, mulching, irrigation regimes and trellis designs in replicated trials. Low-cost soil-moisture monitoring may support irrigation scheduling, while drip systems can improve the efficiency of water delivery where feasible. Planting-date trials can test whether establishment or flowering coincides with periods of heat or moisture stress. Integrated pest monitoring and threshold-based management are preferable to routine calendar spraying, particularly where leaves and flowers are intended for food use.

Recent work on indigenous-food processing in West Africa likewise highlights preservation and value addition as important links between crop availability and usable food products (Amissah, Adjei, Amissah, Asem, & Kolog, 2025). Postharvest loss is also a food-security and resource-efficiency issue because spoiled produce represents wasted land, water and labour. Shade at harvest, ventilated crates, rapid sorting and cool storage should be evaluated. Solar drying may stabilize surplus leaves, flowers or fruit slices, but dryers require temperature and humidity control to protect quality and prevent microbial contamination. These are practical areas where appropriate technology can improve reliability without displacing smallholders.

From Germplasm to Seed Systems and Breeding

A viable snake-gourd sector requires seed that is correctly identified, viable and available when farmers need it. The immediate foundation is a germplasm register containing accession code, collection site, collector, date, farmer name where consent permits, local name, photographs, storage history and regeneration records. Seed lots should be tested for germination, moisture and health. Regeneration must maintain adequate population size and prevent unintended pollen contamination.

The Awka trial identifies starting material for a pre-breeding programme. Imo-SG merits attention for fruit weight and length; Lagos-SG for its numerical fruit number and yield; Oyo-SG for fruit diameter; and Anambra-SG as a distinctive short-fruited phenotype. Parent choice should also incorporate disease response, flower sex ratio, fruit quality, consumer preference and molecular relationships. Controlled

crosses, clear pedigree records and evaluation of segregating families can convert diversity into improved populations.

Processing, Markets, Gender and Livelihoods

Product pathways

A whole-plant strategy can create several possible product streams: fresh immature fruit; minimally processed slices; ripe pulp or puree; dried leaf or flower ingredients; and seed for planting or further research. Product development should begin with familiar foods and local preparation practices. Consumer panels can assess colour, aroma, bitterness, texture, convenience and willingness to pay. Nutrient retention and safety should be measured in the same processed products that consumers evaluate.

Fresh-market development requires regular supply, grading and simple quality standards. Useful descriptors include length class, diameter, curvature, colour, tenderness, freedom from damage and maturity. Standard crates reduce bruising; harvest calendars and aggregation improve reliability for retailers. For processed products, specifications should cover moisture, particle size, microbial limits, packaging barrier properties and shelf life. Market research should identify likely buyers, purchase frequency, preferred product forms and acceptable prices.

Costing should include raw materials, energy, labour, packaging, transport, quality testing, equipment depreciation and rejected batches. Pilot enterprises can compare sun, solar and cabinet drying; manual and mechanical slicing; and different package sizes. Traceability from accession and farm to batch will allow product quality to be linked to genotype and management.

Women, youth and equitable innovation

Women frequently hold practical knowledge of indigenous vegetables, household preparation and local marketing. Their participation should extend from consultation to decision-making, ownership and benefit-sharing. Research schedules must account for care responsibilities; training should be accessible; and equipment should be designed for safe operation and reduced drudgery. Credit, group processing facilities and transparent contracts can help women capture value rather than supply low-priced raw material only.

Young people can contribute through nursery enterprises, digital accession records, trellis installation, irrigation services, aggregation, branding and online marketing. Universities can support incubation, quality testing and prototype development. Intellectual contributions by farming communities should be recognized, especially when local seed or knowledge becomes the basis of a commercial product. Farmers should not be encouraged to expand production before demand, seed quality and extension support are credible. Food-security interventions should monitor whether commercialization improves household income without reducing access to the crop among the households that have conserved it.

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Conclusion and Research Priorities

Snake gourd has a promising, but not yet fully validated, case as an underutilized food and genetic resource in Nigeria. The eight-accession field evaluation at Awka revealed variation in emergence, flowering time and fruit characteristics. Fruit weight, length and diameter showed clearer accession differences than fruit number and the reported yield variable. Imo-SG had the highest mean fruit weight and length, Oyo-SG had the greatest mean fruit diameter, and Lagos-SG ranked highest numerically for fruit number and yield; however, the yield accession effect was not statistically significant. The results therefore point to complementary phenotypes rather than one accession that is superior for all traits.

The compositional screening indicates that flowers, leaves and immature fruits may offer complementary food-use attributes. Immature fruit recorded higher means for several measured nutrients and phytochemicals, while flowers and leaves showed other potentially useful constituents. The in-vitro antioxidant and alpha-amylase-inhibition results are preliminary laboratory observations.

The strongest food-security proposition for snake gourd is an integrated development pathway. Germplasm should be conserved, correctly identified and evaluated across locations and seasons; breeding objectives should reflect farmer, processor and consumer preferences; agronomic recommendations should be based on replicated management trials; and food products should undergo processing, sensory, microbiological and safety assessment. Market development should be inclusive and should protect the interests of communities that maintain the crop. With these steps, snake gourd could contribute to dietary diversification, broaden the local vegetable portfolio, strengthen crop-breeding capacity and support livelihood opportunities.

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