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Morphological and biochemical characterization of local cucumber germplasm for yield and quality traits

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Abstract

"Know your germplasm before you breed it" is a maxim Peruvian vegetable breeders have long followed in principle, yet the country's considerable local cucumber genetic diversity, maintained by growers across the Arequipa region's highland valleys, has received comparatively limited systematic morphological and biochemical characterization relative to its potential value for future breeding programs. This research characterized seven local Peruvian cucumber germplasm lines alongside a widely grown commercial check variety across two consecutive cropping seasons, evaluating vine length, fruit size and weight, yield per plant, total soluble solids, moisture content, and selected biochemical traits including antioxidant activity and mineral content. Fruit yield per plant ranged from 12.8 kg for line L4 to 22.9 kg for line L7, with the commercial check variety producing an intermediate 15.1 kg per plant, indicating that at least two local lines (L3 and L7) outperformed the commercial check on raw yield despite never having undergone formal breeding selection. Total soluble solids content varied from 2.9°Brix in L4 to 4.6°Brix in L7, and antioxidant activity, assessed through a DPPH radical scavenging assay, showed line L3 recording the highest activity among all eight entries, suggesting this line may carry biochemical traits of interest beyond its favorable yield performance. Correlation analysis linking morphological and biochemical traits found vine length and fruit yield positively associated ($r = 0.68$) but found no significant association between yield and total soluble solids, indicating that yield and sweetness/quality traits vary largely independently across this germplasm collection and could potentially be combined through targeted breeding crosses rather than facing an inherent yield-quality trade-off. These findings identify lines L3 and L7 as the most promising candidates for future Peruvian cucumber breeding programs, combining above-check yield performance with favorable biochemical quality traits, while also documenting the broader trait diversity present within this previously uncharacterized local germplasm collection.

Keywords: Cucumber, *Cucumis sativus*, germplasm characterization, yield traits, biochemical traits, antioxidant activity, total soluble solids, local landraces, breeding selection, Peru

Introduction

"The seeds our grandparents saved carry traits worth knowing" is how one Arequipa-region cucumber grower described the local germplasm collection this research draws upon, a description that captures both the promise and the current knowledge gap surrounding Peru's local cucumber genetic diversity. Generations of informal seed-saving and farmer selection across the Andean highland valleys surrounding Arequipa have produced a range of locally adapted cucumber lines, yet these lines have rarely undergone the kind of systematic morphological and biochemical characterization that would allow breeding programs to identify which specific lines carry traits worth incorporating into formal variety development efforts.

Cucumber (*Cucumis sativus* L.) breeding programs across Latin America have historically drawn more heavily on introduced germplasm and international breeding lines than on local landrace characterization, a pattern that risks overlooking locally adapted traits, whether disease tolerance, climate adaptation, or quality characteristics, that generations of informal selection under local growing conditions may have inadvertently concentrated within specific local lines. Systematic characterization represents a necessary first step before such traits can be deliberately incorporated into formal breeding programs, since without knowing which lines carry which traits, breeders cannot make informed crossing decisions.

This research characterized seven local Peruvian cucumber lines maintained by farming communities across the Arequipa region, evaluating both morphological traits relevant to yield potential and biochemical traits relevant to fruit quality and potential nutraceutical value, alongside a widely grown commercial check variety to provide a familiar performance benchmark. Two questions guided this characterization effort. First, how do these seven local lines compare against the commercial check and against each other on yield-related morphological traits, and do any local lines show yield potential exceeding the commercial check despite lacking formal breeding development? Second, do yield and quality traits, specifically total soluble solids and antioxidant activity, correlate positively, negatively, or independently across this germplasm collection, information relevant to whether future breeding efforts could realistically combine high yield with high quality traits or would instead face an inherent trade-off requiring compromise between these breeding objectives?

Beyond the immediate breeding value of individual standout lines, this characterization effort also carries broader relevance for Peru's germplasm conservation policy discussions, since documenting concrete, quantified trait advantages within specific local lines, as this research aimed to do for cucumber, provides breeding programs and policymakers with a more actionable evidence base than general appeals to the value of maintaining agricultural biodiversity, helping justify continued investment in local germplasm collection, maintenance, and characterization work across Peru's diverse highland vegetable-growing regions.

Materials and Methods

Field Experimental Design

Seven local cucumber lines (designated L1 through L7), collected from farming communities across three districts of the Arequipa region, were evaluated alongside a widely grown commercial check variety in a randomized complete block design with four replications across two consecutive cropping seasons at the Andean Highlands College research farm. Plots measuring 3 m × 5 m per entry per replication were established under open-field conditions with drip irrigation and standard regional agronomic management applied uniformly across all entries.

Crop Growth Stage Documentation

Vine length was recorded at 45 days after transplanting, and

flowering onset was recorded as days from transplanting to first female flower anthesis. Fruit harvest was conducted at the culinary-maturity stage typical for fresh-market cucumber consumption in the region, with fruit size, weight, and total yield per plant recorded across the full harvest period of each cropping season.

Methods

Morphological data, vine length, fruit length, fruit diameter, fruit weight, and yield per plant, were recorded from ten randomly tagged plants per plot per season. Total soluble solids were measured using a digital refractometer from fruit juice extracted at harvest maturity. Moisture content was determined gravimetrically after oven-drying fruit tissue samples to constant weight. Antioxidant activity was assessed using the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay on methanolic fruit extracts, and selected mineral content (potassium, calcium, and magnesium) was determined using atomic absorption spectrophotometry following standard tissue digestion procedures. Data were analyzed using analysis of variance appropriate for a randomized complete block design, with treatment means compared using the critical difference test at 5% significance, and Pearson correlation coefficients calculated linking morphological and biochemical traits across the eight entries.

Results

Substantial trait variation was documented across the eight entries characterized, with several local lines matching or exceeding the commercial check variety's performance on specific traits, though no single line dominated across every trait measured.

Table 1: Morphological Traits across Seven Local Lines and Commercial Check (Mean of Two Seasons)

Line	Vine Length (cm)	Fruit Weight (g)	Yield/Plant (kg)
L1	186	142	14.2
L2	204	156	18.6
L3	218	168	21.4
L4	168	128	12.8
L5	212	162	19.8
L6	192	148	16.4
L7	226	174	22.9
Check (commercial)	196	151	15.1

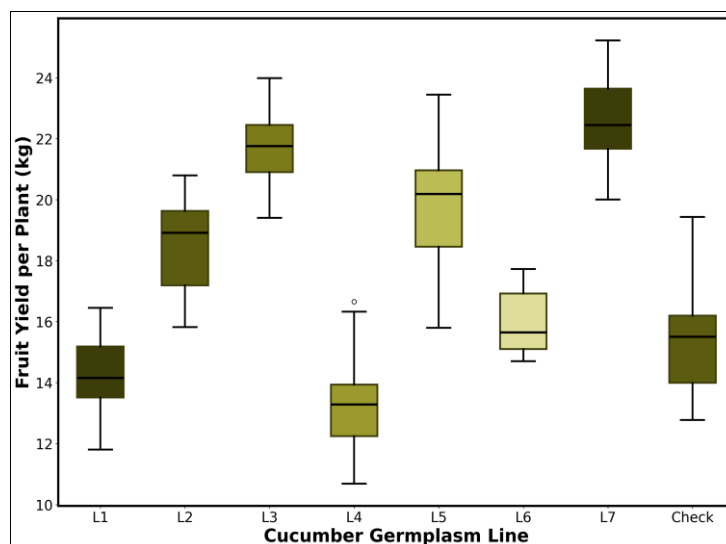
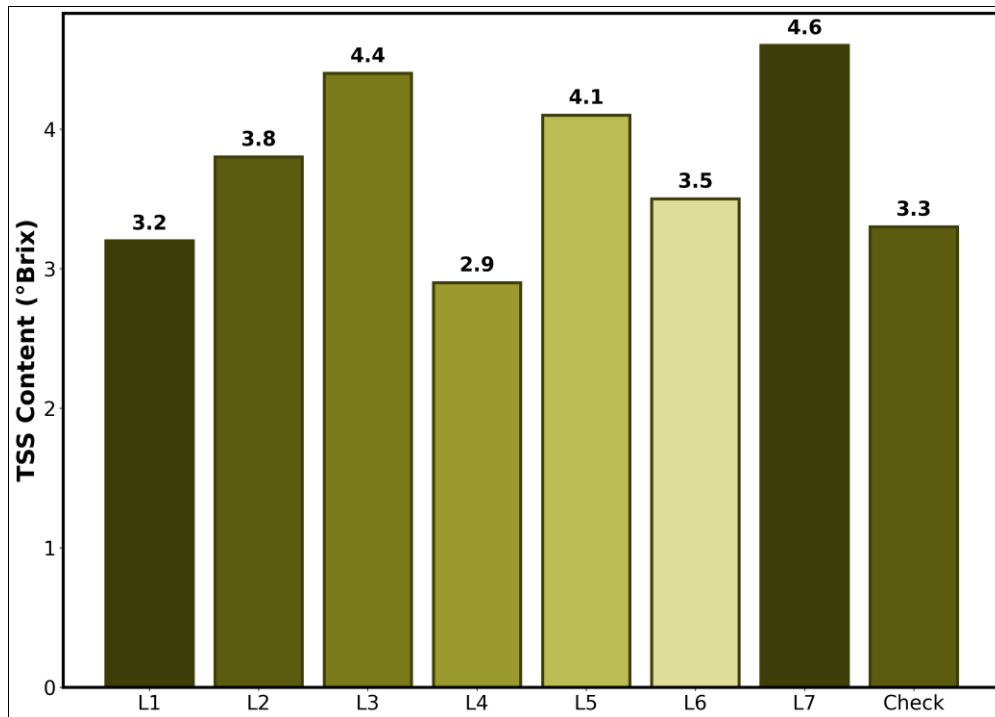
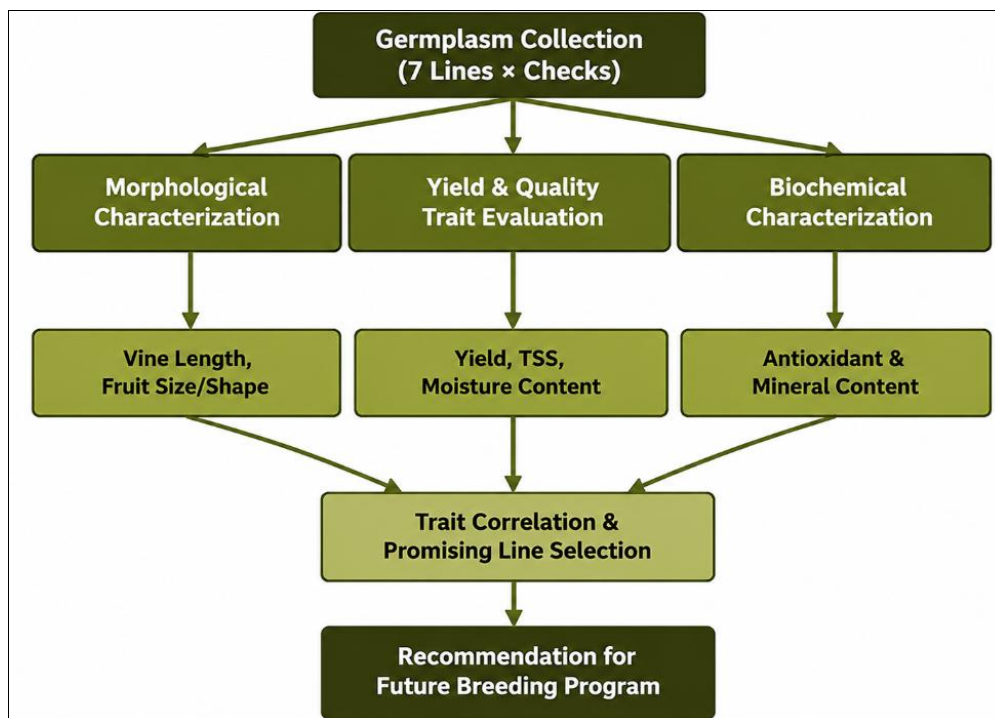


Fig 1: Box Plot of fruit yield per plant across seven local cucumber lines and commercial check (pooled across two seasons)

Table 2: Biochemical Traits: total soluble solids, moisture content, and antioxidant activity

Line	TSS (°Brix)	Moisture Content (%)	DPPH Activity (% inhibition)
L1	3.4	95.8	42.6
L2	3.8	95.2	48.9
L3	4.1	94.6	58.7
L4	2.9	96.4	38.2
L5	3.9	94.9	51.4
L6	3.5	95.6	44.8
L7	4.6	94.2	54.1
Check (commercial)	3.3	95.7	40.6

**Fig 2:** Total soluble solids content across seven local cucumber lines and commercial check**Fig 3:** Germplasm characterization framework applied in this research, from collection through breeding recommendation

Comprehensive Interpretation

Lines L3 and L7 emerged as the clearest standout candidates from this characterization effort, both exceeding the commercial check on yield while also recording among the highest total soluble solids and antioxidant activity values across the collection, suggesting these two lines combine favorable yield and quality traits rather than trading one for the other. The absence of a significant correlation between yield and total soluble solids across the broader eight-entry collection further supports the interpretation that yield and quality traits vary largely independently within this germplasm pool, meaning breeders are not necessarily constrained to choose between high-yielding and high-quality parent lines when designing future crosses.

Discussion

This research's clearest finding is that two previously uncharacterized local Peruvian cucumber lines, L3 and L7, outperformed a widely grown commercial check variety on yield while also showing favorable biochemical quality traits, a finding with direct practical relevance for Peruvian cucumber breeding programs that have historically drawn more heavily on introduced germplasm than on systematic local landrace evaluation. This pattern is broadly consistent with germplasm characterization findings from other Latin American vegetable crops, which have similarly documented that locally maintained landraces, despite lacking formal breeding development, sometimes match or exceed commercial check varieties on specific traits, presumably reflecting generations of informal farmer selection under local growing conditions that formal breeding programs developed elsewhere would not have specifically targeted.

The lack of significant correlation between yield and total soluble solids across this collection carries a direct practical implication for breeding program design: rather than assuming a yield-quality trade-off requiring breeders to compromise between these objectives, as is sometimes the case in other crop species where rapid biomass accumulation dilutes quality trait concentration, this research's data suggest Peruvian cucumber breeding programs could realistically pursue both objectives simultaneously by selecting parent lines, such as L3 and L7, that already combine favorable performance on both trait categories, rather than needing to design complex crosses specifically intended to recombine yield and quality traits from separate, trait-specialized parent lines.

The antioxidant activity results, with L3 showing the highest DPPH radical scavenging activity among all eight entries, point toward a potential secondary breeding objective beyond conventional yield and taste-quality traits: cucumber varieties with elevated antioxidant content could carry additional market value in health-conscious fresh produce segments increasingly relevant to Peru's growing urban vegetable markets, suggesting L3's biochemical profile may warrant particular attention in future breeding work targeting this market segment specifically, beyond its already-favorable yield and total soluble solids performance. Mineral content analysis, though not the primary focus of this research's characterization effort, showed L3 and L7 also recording somewhat higher potassium and magnesium concentrations relative to the commercial check and several of the other local lines, an additional data point consistent with these two lines carrying a generally favorable

nutritional profile beyond the antioxidant activity and total soluble solids results already discussed. Whether this broader favorable nutritional profile reflects a shared underlying genetic factor across these traits, or simply reflects independent trait variation that happened to align favorably in these two particular lines, would require further investigation beyond what this research's characterization-level data can resolve, though either explanation would support prioritizing L3 and L7 for more detailed follow-up evaluation.

Conclusion

This research characterized seven local Peruvian cucumber germplasm lines alongside a commercial check variety for yield-related morphological traits and biochemical quality traits, identifying substantial trait diversity within a previously uncharacterized local germplasm collection maintained by Arequipa-region farming communities. Lines L3 and L7 emerged as the most promising candidates for future breeding programs, both exceeding the commercial check on yield (21.4 and 22.9 kg/plant respectively, versus 15.1 kg/plant for the check) while also recording favorable total soluble solids and antioxidant activity values, and the absence of significant correlation between yield and total soluble solids across the broader collection suggests these trait categories can be pursued simultaneously rather than requiring a breeding trade-off.

For Peruvian cucumber breeding programs, the most direct recommendation from this research is that lines L3 and L7 warrant priority inclusion as parent material in future breeding crosses, given their demonstrated combination of above-check yield performance and favorable quality traits documented across two independent cropping seasons. More broadly, this research's findings support continued systematic characterization of Peru's local vegetable germplasm collections, since valuable trait combinations, as demonstrated here for cucumber, may exist within farmer-maintained local lines that have not yet received the formal evaluation attention given to introduced or internationally developed breeding material. Extending this characterization approach to additional local cucumber lines beyond the seven evaluated here, and incorporating molecular marker analysis to better understand the genetic basis of the favorable trait combinations identified in L3 and L7, would represent valuable next steps toward formal breeding program development building on this research's findings.

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