Amaranth greens as a model for nutrient-dense, culturally preferred produce in an urban setting

Tori Rosen
Rutgers University - New Brunswick/Piscataway, trr54@scarletmail.rutgers.edu

Ramu Govindasamy
Rutgers University - New Brunswick/Piscataway

Albert Ayeni
Rutgers University - New Brunswick/Piscataway

James E. Simon
Rutgers University - New Brunswick/Piscataway

See next page for additional authors

Abstract

Demand for culturally preferred leafy greens in the United States is rising rapidly due to increased awareness among cultural groups about their culinary heritage and the desire for diverse and healthy diets. This demand is further amplified by the disproportionate effects of food insecurity on minoritized ethnic populations. The health and nutrition of immigrant populations in the US tend to deteriorate over time due to acculturation, as these communities replace their traditional diets and cultural practices with American ones. Leafy green amaranth (*Amaranthus spp.*) is an economically and nutritionally significant crop among ethnic minority communities in the Northeastern US and globally. Amaranth is a heat-resistant, drought-tolerant crop with strong resilience to climate change and abiotic stress. It is an excellent supplement to locally grown spinach in summer due to its similar flavor and nutrient density. Its rapid growth allows it to adapt quickly in urban and peri-urban settings with limited agricultural resources. However, production is limited by inconsistent germplasm, a lack of standardized growing practices, and a general lack of mainstream consumer awareness of this nutritious leafy green. Consumer surveys were disseminated along the Eastern US from 2010-2022, identifying amaranth as one of the top 10 desired leafy greens among Asian Indian, Chinese, and Mexican consumers. Once the market demand was established, variety trials of globally collected amaranth seeds took place from 2021-2022, beginning with 97 lines collected from the USDA-GRIN seed bank, the World Vegetable Center, American commercial lines, and Rutgers advanced breeding lines. From the original 97 distinct lines, 37 lines were selected for continued evaluation based on field performance, cultural preference, and nutrient density. Our leafy amaranth selections meet or exceed the iron, magnesium, and protein levels in spinach, creating the opportunity for a locally sourced substitute in the summer. Several of these amaranths are available to use and others are now poised for further selection and breeding in order to develop improved varieties for introduction into urban spaces with large migrant and diaspora communities with aims to increase healthy eating habits through culturally preferred food choices.

Keywords

Culturally Preferred Produce; New Leafy Greens; Nutrition and Human Health; Climate-Resilient crops; Food Security; Orphan Crops

Disciplines

Agriculture | Other Nutrition | Plant Breeding and Genetics

Presenter Information

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Tori Rosen[1], Ramu Govindasamy[1,2] , Albert Ayeni[1] and James E. Simon[1]
[1]Center for Agriculture Food Ecosystems (RUCAFE) and New Use Agriculture & Natural Plant Products Program, Department of Plant Biology
[2]Department of Agricultural, Food and Resource Economics (DAFRE),
School of Environmental and Biological Sciences, Rutgers, The State University of New Jersey

Abstract

Demand for culturally preferred leafy greens in the United States is rising rapidly due to increased awareness among cultural groups about their culinary heritage and the desire for diverse and healthy diets. This demand is further amplified by the disproportionate effects of food insecurity on minoritized ethnic populations. The health and nutrition of immigrant populations in the US tend to deteriorate over time due to acculturation, as these communities replace their traditional diets and cultural practices with American ones. Leafy green amaranth (*Amaranthus spp.*) is an economically and nutritionally significant crop among ethnic minority communities in the Northeastern US and globally. Amaranth is a heat-resistant, drought-tolerant crop with strong resilience to climate change and abiotic stress. It is an excellent supplement to locally grown spinach in summer due to its similar flavor and nutrient density. Its rapid growth allows it to adapt quickly in urban and peri-urban settings with limited agricultural resources. However, production is limited by inconsistent germplasm, a lack of standardized growing practices, and a general lack of mainstream consumer awareness of this nutritious leafy green. Consumer surveys were disseminated along the Eastern US from 2010-2022, identifying amaranth as one of the top 10 desired leafy greens among Asian Indian, Chinese, and Mexican consumers. Once the market demand was established, variety trials of globally collected amaranth seeds took place from 2021-2022, beginning with 97 lines collected from the USDA-GRIN seed bank, the World Vegetable Center, American commercial lines, and Rutgers advanced breeding lines. From the original 97 distinct lines, 37 lines were selected for continued evaluation based on field performance, cultural preference, and nutrient density. Our leafy amaranth selections meet or exceed the iron, magnesium, and protein levels in spinach, creating the opportunity for a locally sourced substitute in the summer. Several of these amaranths are available to use and others are now poised for further selection and breeding in order to develop improved varieties for introduction into urban spaces with large migrant and diaspora communities with aims to increase healthy eating habits through culturally preferred food choices.

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INTRODUCTION

With rising awareness of ethnocultural traditions and practices comes an increased desire to explore culturally significant foods, particularly those historically recognized to contribute to human health (Monterrosa et al., 2020; Hearst et al., 2021). This trend coincides with significant demographic changes in the US, particularly in urban areas. For example, between 2000 and 2012, the US Asian population increased by 32% compared to 9.5% for the entire population. The US Asian population is expected to rise from 16 million in 2016 to 25 and 40 million people by 2030 and 2050, respectively (Sciarappa et al., 2016). This demographic shift has a lasting influence on consumer dietary preferences, particularly in the market for ethnic leafy greens that are seen in a diverse array of international cuisines. Market research throughout the Eastern United States has identified significant economic opportunities for specialty crop farmers to serve ethnic groups with the highest buying power, especially those that are willing to spend money on fresh produce indicative of their cultural background (Govindasamy et al., 2007; Sciarappa et al., 2016; Govindasamy et al., 2022). Chinese and Asian Indian families exert a strong market influence, with annual household expenditures ranging from $245–296 million and $190–230 million, respectively. These groups spend 2 to 3.5 times the national average on fruits and vegetables. Among Asian Indian, Chinese, and Mexican communities, vegetable amaranth (*Amaranthus spp.*), also known as yen choy in Chinese communities or red-leaf in Indian communities, consistently ranks among the top 10 most preferred greens and herbs.

Amaranth is a versatile crop of global significance, valued for both its grains and leaves, yet it is still under-recognized. Its widespread cultivation reflects its resilience to environmental stresses such as drought and heat, as well as increasing recognition of its high nutritional value (Shukla et al., 2006; Huerta-Ocampo et al., 2009; Weller et al. 2015; Joshi et al., 2018; Simon et al., 2020). Amaranth is predominantly consumed as a leafy green in Sub-Saharan Africa, the Caribbean, and South and Southeast Asia, while its grains are widespread in Central and South America (National Research Council, 1984). As a C4 photosynthetic plant, amaranth's hardiness and nutritional profile make it a promising candidate for addressing global food insecurity and malnutrition (National Research Council, 1984; Achigan-Dako, Sogbohossou, & Maundu, 2014). Amaranth leaves are rich in protein, lysine, carotenoids, and essential minerals like iron and zinc, which are crucial in combating malnutrition (Das, 2016). The plant also contains unique antioxidant pigments derived from betalamic acid, found exclusively in the *Caryophyllales* order (Sarker & Oba, 2019; Sadowska-Bartosz & Bartosz, 2021). Amaranth demonstrates remarkable tolerance to salinity (Bhargava & Srivastava, 2020) and drought (Huerta-Ocampo et al., 2009), which are common challenges in food-insecure regions and under-resourced urban environments (Elouafi et al., 2020). Its heat tolerance enables summer cultivation, distinguishing it from other popular leafy greens like spinach and chard (Das, 2016). This research aims to identify leafy amaranth varieties that combine these beneficial properties while meeting the market demands of ethnocultural groups, ultimately facilitating its integration into mainstream urban agricultural systems.

MATERIALS AND METHODS

Consumer surveys

Market research on ethnic community preferences involved a multi-phase approach spanning several years. Initial in-person interviews and online focus groups with Chinese, Indian, Mexican, and Puerto Rican communities across 16 East Coast states and DC helped identify culturally preferred leafy greens and herbs. These communities were selected based on total and projected population growth (2000 Census data) and their high expenditure on fresh produce. A panel of marketing, crop specialists and field/extension faculty reviewed the list and excluded greens with production barriers that could limit marketability. Participants were selected through stratified random sampling based on population proportions along the US East Coast. The study included voluntary participants who self-identified as Asian Indian (n=277), Chinese (n=276), Mexican (n=288), and Puerto Rican (n=232). All participants were the primary food shoppers in their households. Data collection was conducted through phone surveys using the Computer-Assisted Telephone Interviewing (CATI) System. Surveys were offered in English, Mandarin, Cantonese, Hindi, and Spanish. Questions included frequency, proximity, purchase locations, quantity, price and expenditures of culturally preferred leafy greens and herbs (Govindasamy et al. 2007). The results revealed leafy amaranth's cultural significance and established the foundation for the subsequent variety trials and crop selection for leafy amaranth as nutrient-dense culturally preferred produce.

Amaranth variety trials

Two consecutive outdoor variety trials were performed in 2021 and 2022 at NJAES Rutgers Horticulture Farm 3 to evaluate a global collection of germplasm within the *Amaranthus* genus, coming from the USDA-GRIN, the World Vegetable Center, American commercial sources, and Rutgers breeding lines. These variety trials were conducted using a randomized complete block design (RCBD), with three replicates of the 97 varieties. Each plot of a single variety had eight plants, with the middle five evaluated for yield and nutrition. There were six species within the *Amaranthus* genus represented –*A. caudatus* (n=6), *A. cruentus* (n=10), *A. hybridus* (n=1), *A. hypochondriacus* (n=8), *A. tricolor* (n=45), and *A. viridis* (n=1) – and 17 accessions of unknown species. Yield-related traits were evaluated six weeks after transplanting, including flowering time (emergence of first inflorescence), plant height (cm), stem diameter (mm), leaf area using Image J software (cm^2), petiole length (cm), whole plant fresh, and dry weight (kg). Data were analyzed using Anova and Least Significant Differences (LSD). Ninety-seven lines were evaluated in year one and 37 of the 97 were selected for evaluation in year two.

Amaranth nutritional analysis

Whole plants were dried for two weeks in at 35ºc. A subsample of each plant was homogenized, and two grams were used for analysis. Elemental micronutrient analysis was performed on dried plant material at the Penn State Agricultural Analytical Services Laboratory using inductively coupled plasma mass spectrometry. Protein content was calculated by multiplying total nitrogen by 6.25 (AOAC, 2000).

RESULTS AND DISCUSSION

This research builds upon a consumer market survey to provide a foundation upon which our market-driven approach is applied to identify and study crops of biocultural importance among immigrant groups across the US East Coast. Survey questions ranged from demographic information and shopping patterns to willingness to pay a premium for selected culturally preferred produce. From an initial pool of 100 leafy greens and herbs of international importance, consumer surveys conducted across 16 East Coast states and Washington D.C. identified the top 10 greens and herbs purchased by communities from India, China, Mexico, and Puerto Rico (Fig. 1, from Govindasamy et al. 2007). Within each ethnic community, there was some overlap in the greens selected, including Malabar spinach, purslane, and roselle (Indian sorrel). Amaranth – or yen choy – was uniquely identified as a top 10 purchased green with Chinese, Indian, and Mexican communities. (Table 1 a-c). Asian Indian groups identified both green and purple amaranth as important crops, while the Mexican population did not specify a particular appearance of amaranth, and the Chinese population noted *yen choy* as a top 10 leafy green. These findings suggest a gap that exists within diverse urban areas to grow amaranth as a culturally relevant produce option.

Amaranth variety trials

With insights into consumer demand and preference for amaranth greens, a global germplasm collection of amaranth cultivars was gathered and evaluated at Rutgers Hort Farm III in East Brunswick, New Jersey, for yield, nutrient density, and cultural suitability. The 97 distinct cultivars of amaranth were analyzed in the summer of 2021, including seven *Amaranthus* species (Fig. 2). In the first year, informal visual selections with local farmers that serve New Jersey's diverse community were made for varieties to continue into year two. Thirty-seven varieties were selected to be grown in 2022. Selection criteria included leaf shape and color, and plant stature, based upon internode length, leaf area, fresh and dry weight. The 37 varieties from year two were analyzed using ICP mineral analysis, and total iron, magnesium, and protein content were determined. This micronutrient makeup was compared to raw spinach (FoodData Central, 2024).

Evaluation of micronutrient content

According to United States FDA guidelines, a "good source" of a nutritional component is defined as having at least 10% of the daily intake requirements and an "excellent source" contains at least 20% of the daily intake requirements (FDA, 2013). Following these guidelines, amaranth has been identified as a good source of iron, and magnesium, with average values of 2.32 mg $\cdot 100\ g^{-1}$, and 144 mg $\cdot 100\ g^{-1}$, respectively (Byrnes, 2018). Within the US, 30% of adults have some level of iron deficiency, which may lead to anemia, heart failure, or chronic kidney disease (Tawfik et al., 2024). Although often overlooked, 48% of the US population consumes less than the recommended daily amount of magnesium (Rosanoff et al., 2012). Our leafy amaranth selections range from 1.68 to 5.54 mg $\cdot 100\ g^{-1}$ iron and 75 to 243 mg $\cdot 100\ g^{-1}$ magnesium (Fig. 3 a,b). For reference, raw spinach has an average of 2.71 mg $\cdot 100\ g^{-1}$ of iron and 79 mg $\cdot 100\ g^{-1}$ of magnesium (FoodData Central, 2024). Similarly, our amaranth cultivars are an excellent source of protein, ranging from 2.0 to 3.5 mg $\cdot 100\ g^{-1}$ compared to spinach with an average protein content of 2.91 mg $\cdot 100\ g^{-1}$ (Fig. 3 c).

Limitation and next steps

The initial consumer surveys did not include questions regarding consumer preferences relative to appearance and taste. And, as we only received feedback from a small group of farmers relative to the field performance of the amaranths more can be done linking consumers to farmers to ensure the right variety is selected and grown for the specific consumer market. This study was conducted over two years in a single location. Expanding to multiple locations across the US East Coast would provide a better understanding of genotype-by-environment interactions and yield more robust nutritional data. Next steps are needed to compare the phytochemistry of amaranth to each other and to other leafy greens for health and nutrition. Amaranth greens are known to be high in antioxidants, largely due to the presence of betalain pigment compounds betacyanin, betaxanthin, polyphenols, each of which have been studied for health-promoting effects, particularly in reducing oxidative stress which leads to age-related, non-communicable diseases (Pulipati et al., 2017, Sarker & Oba, 2019). Commercially available leafy amaranths in Southeast Asia outperformed spinach and lettuce in terms of total polyphenol content, averaging at 14.0% dry weight compared to spinach at 9.5% and lettuce at 8.0%. Antioxidant content of leaves also averaged 35.8% dry weight in leafy amaranth, compared to 31.32% in spinach and 36.8% in lettuce (Khanam et al., 2012). Thus, generating this foundational information in the MidAtlantic and Northeast region of the USA would provide insight as to the overall nutritional expectations of these greens for the fresh produce industry, while acknowledging the cultural expectations from communities that frequently buy them.

CONCLUSION

Our research employs a market-driven approach to identify culturally relevant varieties of produce and develop consistent production strategies, aiming to increase the accessibility and affordability of these essential foods. Amaranth plants are tolerant of low soil fertility, heat, and drought stress. With minimal input costs, amaranth leafy greens have the potential to serve as a substitute for locally grown spinach during the summer months, meeting the cultural demands of communities that have historically relied on this plant. Agriculture in the Northeastern United States relies on high-value specialty crops that require minimal land and cater to the state's diverse population. Although amaranth is a staple in many diets worldwide, it is still often considered a weed and undervalued by most consumers. Its neutral to slightly bitter flavor is comparable to that of spinach, and it shares many of the same nutritional properties. By engaging with growers and consumers from South Asian, East Asian, African Diaspora, and Latin American communities, we aim to develop cultivars that are well-suited to the Northeastern United States climate, nutritionally rich, and culturally significant.

ACKNOWLEDGEMENTS

Support for this project came from the New Jersey Department of Agriculture Specialty Crop Block Grant 2022-2025, “Developing Culturally Preferred, Nutrient-Dense Leafy Greens as Promising Specialty Crops for New Jersey Farmers” and USDA NE SARE Graduate Student Fellowship 2022-2024, “Standardizing Farming Practices of Leafy Green Amaranth in the Northeast to Ensure Cultural Availability and Nutrient Density” awarded to Dr. James Simon, Dr. Ramu Govindasamy, and Ph.D. student Tori Rosen. Partial funds were also provided by NJAES Hatch Project # NJ12170. Special thanks to Rutgers New Use Agriculture Program, to John Bombardiere and the staff at Rutgers NJAES Hort Farm III, and to Joseph Florentine and his staff at the NJAES Research Greenhouse. Thanks and recognition go to the undergraduate students on our team, including Erin Quinn, Norah Pereira, Layla Elkhatib, La Raven Gordon, Disha Pal, Peter Mahoney, Amanda Nieves, and Michelle Gavrikov.

Literature cited

AOAC (2000). Official methods of analysis. 17th Edition, The Association of Official Analytical Chemists, Gaithersburg, MD, USA. Methods 925.10, 65.17, 974.24, 992.16.

Achigan-Dako, E., Sogbohossou, O., and Maundu, P. (2014). Current knowledge on *Amaranthus* spp.: research avenues for improved nutritional value and yield in leafy amaranths in sub-Saharan Africa. Euphytica. 197. 10.1007/s10681-014-1081-9.

Bhargava, A., and Srivastava, S. (2020). Response of *Amaranthus* sp. to salinity stress: a review. Environ & Policy, 245–263. https://doi.org/10.1007/978-3-319-90472-6_10

Byrnes, D. R. (2018). Improvement of African indigenous vegetables for stable delivery of micronutrients. ProQuest Dissertations & Theses.

Das, S. (2016). Amaranths: the crop of great prospect. Amaranthus: A promising crop of future, 13–48. https://doi.org/10.1007/978-981-10-1469-7_3

Elouafi, I., Shahid, M.A., Begmuratov, A., & Hirich, A. (2020). The contribution of alternative crops to food security in marginal environments. Environ & Policy, 1–23. https://doi.org/10.1007/978-3-319-90472-6_1

FoodData Central. (2024). Usda.gov. https://fdc.nal.usda.gov/fdc-app.html#/food-details/168462/nutrients

Govindasamy, R., Sciarappa, W., Puduri, V.S., VanVranken, R., Ayeni A., Pappas, K., Simon, J.E., Mangan, F., Lamberts, M., and McAvoy, G. (2007). A market driven approach to ethnic crop production for the US east coast. In: Janick, J and Whipkey, the 6th New Crops Symposium: Creating markets for economic development of new crops and new uses. ASHS Press, Alexandria, VI, pp. 261-273.

Govindasamy, R., Ayeni, A.A., Kelley, K.M., Simon, J.E., Sciarappa, W.J., Van Vranken, R.W., Nitzsche, P., Schilling, B., Komar, S. J., and Arumugam, S. (2022). Ethnic crop consumption and marketing in the Eastern United States: Trends Prospects Mediterr Agric Sci, 35(3), 155–165. https://doi.org/10.29136/mediterranean.1163714

Hearst, M.O., Yang, J., Friedrichsen, S., Lenk, K., Caspi, C., and Laska, M.N. (2021). The availability of culturally preferred fruits, vegetables and whole grains in corner stores and non-traditional food stores. Int J of Environ Res and Public Health, 18(9), 5030–5030. https://doi.org/10.3390/ijerph18095030

Hodge, C. and Taylor, C. Vitamin A deficiency. [Updated 2023 Jan 2]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK567744/

Huerta-Ocampo, J.Á., Cerecero, E.P.B., Hernández, G.M., Rodríguez, A.D.L., and de la Rosa, A.P.B. (2009). Proteomic analysis of amaranth (*Amaranthus hypochondriacus* L.) leaves under drought stress. Int J of Plant Sci, 170(8), 990–998. https://doi.org/10.1086/605119

Joshi, D.C., Sood, S., Hosahatti, R., Kant, L., Pattanayak, A., Kumar, A., Yadav, D., and Stetter, M.G. (2018). From zero to hero: the past, present and future of grain amaranth breeding. Theor Appl Genet 131, 1807–1823 https://doi.org/10.1007/s00122-018-3138-y

Khanam, U.K.S., Oba, S., Yanase, E., and Murakami, Y. (2012). Phenolic acids, flavonoids and total antioxidant capacity of selected leafy vegetables. J of Funct Foods, 4(4), 979–987. https://doi.org/10.1016/j.jff.2012.07.006

Kraujalis, P., Venskutonis, P.R., Kraujalienė, V., and Pukalskas, A. (2013). Antioxidant properties and preliminary evaluation of phytochemical composition of different anatomical parts of amaranth. Plant Foods Human Nutr, 68(3), 322–328. https://doi.org/10.1007/s11130-013-0375-8

Lichtenthaler, H.K., and Buschmann, C. (2001). Chlorophylls and carotenoids: measurement and characterization by UV-VIS spectroscopy. Curr Protocols in Food Anal Chem, 1(1), F4.3.1-F4.3.8. https://doi.org/10.1002/0471142913.faf0403s01

Monterrosa, E.C., Frongillo, E.A., Drewnowski, A., de Pee, S., and Vandevijvere, S. (2020). Sociocultural influences on food choices and implications for sustainable healthy diets. Food and Nutr Bull, 41(2_suppl), 59S73S. https://doi.org/10.1177/0379572120975874

National Research Council, 1984. Amaranth modern prospects for an ancient crop. National Academy Press. https://doi.org/10.17226/19381.

Pulipati, S., Babu, P.S., Naveena, U., Parveen, S.K.R., Nausheen, S.K.S., and Sai, M.T.N. (2017). Determination of total phenolic, tannin, flavonoid contents and evaluation of antioxidant property of *Amaranthus tricolor* (L). Intl J of Pharmacogn and Phytochemical Res, 9(6). https://doi.org/10.25258/phyto.v9i6.8184

Rosanoff, A., Weaver, C.M., & Rude, R.K. (2012). Suboptimal magnesium status in the United States: are the health consequences underestimated?. Nutr reviews, 70(3), 153–164. https://doi.org/10.1111/j.1753-4887.2011.00465.x

Sadowska-Bartosz, I. and Bartosz, G. (2021). Biological properties and applications of betalains. Molecules, 26, 2520. https://doi.org/10.3390/molecules26092520

Sarker, U. and Oba, S. (2018). Drought stress enhances nutritional and bioactive compounds, phenolic acids and antioxidant capacity of *Amaranthus* leafy vegetable. BMC Plant Biol 18(1), 258. https://doi.org/10.1186/s12870-018-1484-1

Sarker, U. and Oba, S. (2019). Antioxidant constituents of three selected red and green color *Amaranthus* leafy vegetable. Sci Reports, 9(1), 18233. https://doi.org/10.1038/s41598-019-52033-8

Sciarappa, W.J., Simon, J., Govindasamy, R., Kelley, K., Mangan, F., Zhang, S., Arumugam, S., Nitzsche, P., Van Vranken, R., Komar, S. et al. (2016). Asian crops overview: consumer preference and cultivar growth on the East Coast of the United States. HortScience, 51(11), 1344–1350. https://doi.org/10.21273/HORTSCI11040-16

Shukla, S., Bhargava, A., Chatterjee, A. et al. Genotypic variability in vegetable amaranth (*Amaranthus tricolor* L.) for foliage yield and its contributing traits over successive cuttings and years. Euphytica 151, 103–110 (2006). https://doi.org/10.1007/s10681-006-9134-3

Simon, J.E., Weller S., Hoffman, D., Govindasamy, R., Morin, X., Merchant, E.V., Dinssa, F.F., Van Wyk, E., Byrnes, D., Odendo, M. et al. (2020). Improving Income and Nutrition of Smallholder Farmers in Eastern Africa using a Market-First Science-Driven Approach to Enhance Value Chain Production of African Indigenous Vegetables. Journal of Medicinally Active Plants 9, (4):289-309. https://scholarworks.umass.edu/jmap/vol9/iss4/10

Weller, S.C., Van Wyk, E., and Simon, J.E. (2015). Sustainable production for more resilient food production systems: Case study of African indigenous vegetables in Eastern Africa. International Horticultural Congress, Brisbane, Australia. Acta Horticulturae 1102:289-298 10.17660/ActaHortic.2015.1102.35

Velioglu, Y. S., Mazza, G., Gao, L., & Oomah, B. D. (1998). Antioxidant activity and total phenolics in selected fruits, vegetables, and grain products. Journal of Agricultural and Food Chemistry, 46(10), 4113–4117. https://doi.org/10.1021/jf9801973

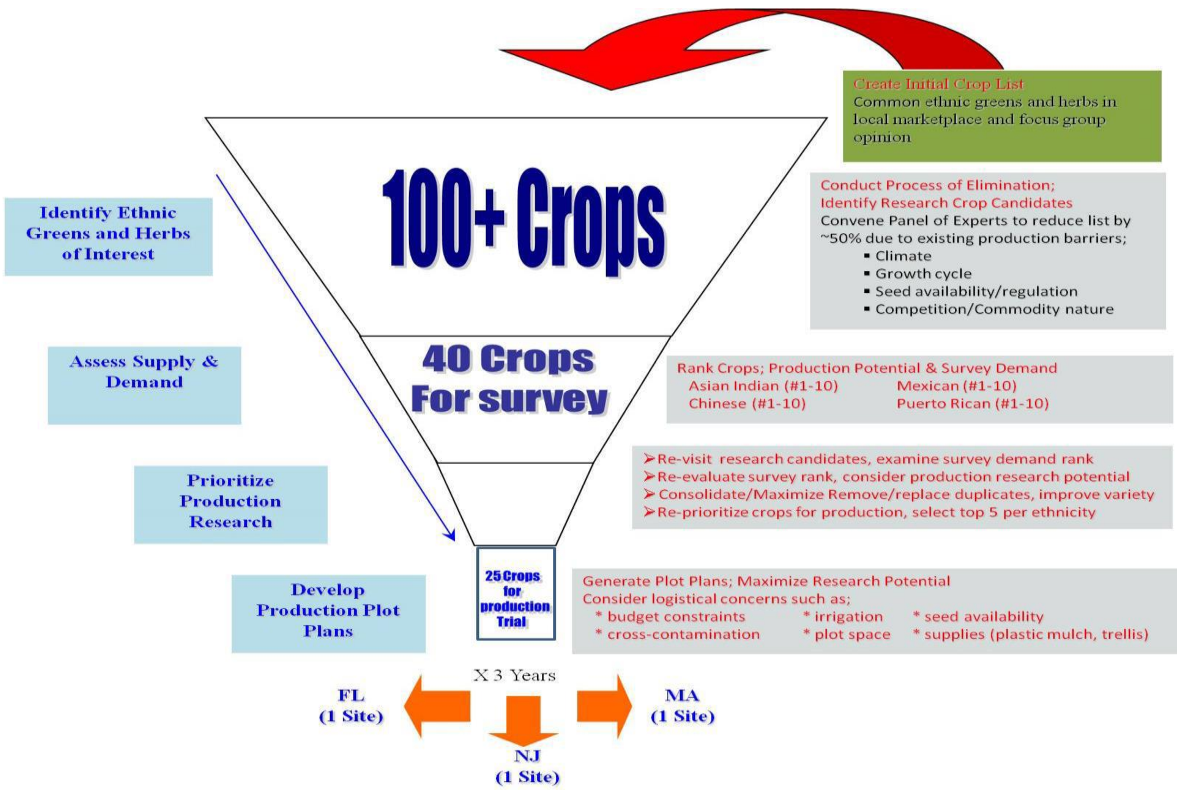

Figure 1. Ethnic Greens Selection Process. Source: Govindasamy et al. (2007)

Table 1. Top 10 purchased culturally preferred leafy greens in Asian Indian (a), Chinese (b), and Mexican (c) consumer groups based on 2011 survey data along the Eastern US. Source: Govindasamy et al. (2022).

(a)

Crops	Asian Indian					
	Respondents Purchase Behavior					
	Regular		Seasonal		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Precent
Purslane/Veradolaga	17	6%	18	7%	35	13%
Nightshade	15	5%	35	13%	50	18%
Fenugreek	110	40%	90	32%	200	72%
Indian Sorrel Spinach	107	39%	56	20%	163	59%
Indian Sorrel	8	3%	11	4%	19	7%
Malabar Spinach	15	5%	31	11%	46	17%
Radish Greens	106	38%	99	36%	205	74%
Amaranth (Purple)	16	6%	13	5%	29	10%
Amaranth (green)	28	10%	32	12%	60	22%
Turmeric	133	48%	70	25%	203	73%

Note: Percentage calculated based on total 277 respondents and the total below 100% indicates non-response.

(b)

Crops	Chinese					
	Respondents Purchase Behavior					
	Regular		Seasonal		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Precent
Shanghai bok choy	198	72%	40	14%	238	86%
Chinese broccoli	151	55%	48	17%	199	72%
Chives & Flowers	66	24%	42	15%	108	39%
Garland Chrysanthemum	30	11%	55	20%	85	31%
Lycium Leaf	10	4%	10	4%	20	7%
Malabar Spinach	39	14%	17	6%	56	20%
Potherb Mustard	29	11%	18	7%	47	17%
Spinach	152	55%	48	17%	200	72%
Sugar Pea tops/bean	76	28%	38	14%	114	41%
Yen choy	51	18%	27	10%	78	28%

Note: Percentage calculated based on total 276 respondents and the total below 100% indicates non-response.

(c)

Crops	Mexican					
	Respondents Purchase Behavior					
	Regular		Seasonal		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Precent
Amaranth	18	6%	16	6%	34	12%
Chard	41	15%	63	23%	104	37%
Lambsquarter	36	13%	49	18%	85	30%
Epazote	71	25%	52	19%	123	44%
Lemon Verbena	14	5%	7	3%	21	8%
Lipia	36	13%	29	10%	65	23%
Papalo	25	9%	35	13%	60	21%
Purslane/Verdolaga	65	23%	68	24%	133	48%
Roselle	84	30%	59	21%	143	51%
Vine Vegetables	84	30%	10	4%	94	34%

Note: Percentage calculated based on total 280 respondents and the total below 100% indicates non-response .

Figure 2. Evaluation of the field performance of 97 amaranth lines at Rutgers Hort Farm III, East Brunswick, NJ (40.4618500, -74.4287100).

Figure 3. Nutrient contents of 37 amaranth accessions compared to spinach using reference source: FoodData Central (2024). Iron content (a), protein content (b), and magnesium content (c).