Asian Crops Overview: Consumer Preference and Cultivar Growth on the East Coast of the United States

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Abstract. The rapid expansion of Asian populations in the United States presents significant opportunities and challenges for the eastern U.S. produce sector to take advantage of their close proximity to densely populated areas. Initial crop studies followed by ethnic consumer and crop surveys were conducted to examine vegetable, leafy green, and herb consumption and expenditures among Chinese, Asian Indians, and other Asian groups. Consumer choices were used to prioritize subsequent production trials. Family expenditures were determined for specific Asian produce types and total produce purchases. This market data were extrapolated to the east coast Asian populations to assess potential market size (90% confidence interval, error margin 5.6%). Chinese consumer values ranged from \$245 to \$296 million per annum and Asian Indians ranged from \$190 to \$230 million per annum. The average annual fresh fruit and vegetable expenditures by both Asian groups were 2 to 3.5 times respective national averages. Leading Chinese vegetables determined by average expenditures were baby bok choy, pak choy, oriental eggplant, snow pea, oriental spinach, and napa cabbage. Highest expenditure of leafy greens and herbs for Chinese consumers were chives and garland chrysanthemum. This market-driven survey reported consumption of over 100 Asian crops and 42 cultivars were ranked “feasible” to grow in the eastern section of the United States. Horticultural matrices of selection criteria narrowed the list to the most promising candidates for production. As a result, 28 cultivars were then grown in University research and demonstration plots at Massachusetts, New Jersey, and Florida in determining growth characteristics and yield to focus horticultural crop producers. Leading vegetable cultivars for Asian Indian consumers were bitter melon, eggplant, fenugreek leaves, cluster beans, and bottle gourd. Leading leafy greens and herbs for Asian Indians were turmeric, fenugreek, sorrel spinach, and radish greens. Most of these Asian cultivars were demonstrated to grow well in the three main growing zones of 5, 7, and 9. Phytochemical attributes such as antioxidant activity, polyphenols, and mineral contents were analyzed for several of the leading crop candidates. This initial field and laboratory data shows that many of these ethnic crops can be grown in the eastern United States to direct production opportunities and are nutrient rich to help drive consumer demand.

Economic opportunities have arisen for specialty agriculture catering to ethnically diverse consumers along the eastern coast of the

United States (Tubene, 2001). U.S. Census data shows that the overall average American population increases from 2000 to 2012 were 9.5% as compared with 32% for the subgroup of Asians (U.S. Census Bureau, 2011). U.S. Census data (2011) had shown that the mainstream population of this eastern region increased by 13% from 1990 to 2000 as compared with 48% for Asian populations. Total U.S. Asian populations are expected to rise to ≈25 and 40 million people by 2030 and

2050, respectively. The ethnic population boom from 1990 to 2005 along the east coast was even more pronounced where Asian population hubs in the northeast region reached 60% growth or more during this period (Govindasamy et al., 2007c). With large Asian populations in New York City, Newark, Baltimore, and Washington D.C., local growers can adopt new ethnic crops to engage these emerging markets.

By identifying new specialty vegetables, greens, and herbs that can be grown economically

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Table 1. East coast study area and Asian populations per state 2014—U.S. Census data.

State	Total population (estimate)	% Asian population	Total Asian population
Connecticut	3,596,677	4.5	161,850
Delaware	935,614	3.8	35,553
Florida	19,893,297	2.8	557,012
Georgia	10,097,343	3.8	383,699
Maine	1,330,089	1.2	15,961
Maryland	5,976,407	6.4	382,490
Massachusetts	6,745,408	6.3	424,961
New Hampshire	1,326,813	2.5	33,170
New Jersey	8,938,175	9.4	840,188
New York	19,746,227	8.5	1,678,429
North Carolina	9,943,964	2.7	268,487
Pennsylvania	12,787,209	3.3	421,978
Rhode Island	1,055,173	3.5	36,931
South Carolina	4,832,482	1.5	72,487
Vermont	626,562	1.6	10,025
Virginia	8,326,289	6.3	524,556
Washington DC	658,893	4.0	26,356
Total	116,816,622	5.1	5,874,135

on the east coast, our concept was to connect more precisely with consumer interest which mitigates grower risk and creates more opportunities for local agricultural production. We hypothesized that if ethnic consumers were searching for and/or purchasing specific fresh horticultural produce, this rising demand provides alternative production options for U.S. farmers to grow new crops that are not easily found in the traditional markets in their region.

The overall objective was to focus on the ethnic produce market segments along the east coast where Chinese and Asian Indian consumers were chosen to survey for their strong

recent growth and continued growth expectations (Govindasamy et al., 2007a, 2007b, 2007c, 2010a, 2010b, 2014). This demographic approach applied market survey results of consumer preference to identify and prioritize crop types of specific Asian cultivars for research investigation and commercial demonstration.

University extension trials continue to work on production practices for these new crop introductions (Ayeni et al., 2010a, 2010b, 2010c; Mangan et al., 2012; Park et al., 2007; Sciarappa 2003; Sciarappa et al., 2004a, 2004b). Local farmers can benefit from targeting food crops in higher demand and

catering to the special culinary needs of this sizable ethnic market as well as expanding local production into Asian markets and penetrating established mainstream institutions (Govindasamy et al., 2010a, 2014a).

Market penetration of new food crops can be improved by documenting human health functionality by noting native properties of the produce (Goldman, 2014). Recent research efforts have begun to better understand phytonutrient content of vegetable crops (Newell-McGloughlin, 2008). Concurrently, more consumers are choosing foods with suspected health benefits and

Table 2. Chinese produce ranking for consumer frequency and volume of specific produce purchased based on average weekly expenditure (\$)—Govindasamy et al. (2007).

Produce	Rank based on criteria (weekly purchases)						Expenditure
	Avg exp ^z (includes all respondents)	Avg exp ^y (purchasers only)	Produce purchase frequency/week	Volume of produce bought	Avg rank	Overall rank	Avg exp ^z (includes all respondents)
Baby pak choy	1	1	2	2	1.5	1	\$2.26
Pak choy	2	5	1	1	2.25	2	\$1.77
Oriental eggplant	3	2	5	4	3.5	3	\$1.60
Snow peas	4	4	6	6	5	4	\$1.29
Oriental spinach	5	7	4	5	5.25	5	\$1.28
Napa cabbage	7	10	3	3	5.75	6	\$1.04
Luffa	6	3	8	7	6	7	\$1.10
Edamame	8	8	7	9	8	8	\$0.79
Oriental mustard	9	9	9	8	8.75	9	\$0.71
Malabar spinach	11	6	12	12	10.25	10	\$0.20
Basil	10	12	10	10	10.5	11	\$0.22
Perilla	12	11	11	11	11.25	12	\$0.19

^zAvg exp (expenditures); ranking of total dollars spent weekly which includes all consumer responses (whether the respondent purchased a particular item, or reported "0").

^yAvg exp (expenditures); ranking of total dollars spent weekly which includes only consumers who purchased the item (excludes purchases equal to "0").

Table 3. Indian produce ranking for consumer frequency and volume of specific produce purchased based on average weekly expenditure (\$)—Govindasamy et al. (2007).

Produce	Rank based on criteria (weekly purchases)						Expenditure
	Avg exp ^z (includes all respondents)	Avg exp ^y (purchasers only)	Produce purchase frequency	Volume of produce bought	Avg rank	Overall rank	Avg exp ^z (includes all respondents)
Bitter gourd	1	2	3	2	2	1	\$2.48
Eggplant	2	6	1	1	2.5	2	\$2.23
Fenugreek leaves	3	8	2	3	4	3	\$1.48
Cluster beans	4	3	6	5	4.5	4	\$1.33
Bottle gourd	5	7	5	4	5.25	5	\$1.31
Mustard leaves	6	1	8	7	5.5	6	\$1.06
Ridge gourd	7	5	7	6	6.25	7	\$0.94
Mint leaves	8	10	4	8	7.5	8	\$0.68
Amaranth	9	4	10	10	8.25	9	\$0.61
White pumpkin	10	9	9	9	9.25	10	\$0.56

^zAvg exp (expenditures); ranking of total dollars spent per week which includes all consumer responses (whether the respondent purchased a particular item, or reported "0").

^yAvg exp (expenditures); ranking of total dollars spent per week which includes only consumers who purchased the item (excludes purchases equal to 0).

Table 4. Asian ethnic produce market estimates—Govindasamy et al. (2007).

Survey sample data	Chinese	Indian
No. of respondents (survey N)	213	234
Avg ethnic produce expenditure/year/ person	\$385	\$326
SD (produce expenditure/year/person)	\$319	\$287
SE (produce expenditure/year/person)	\$22	\$19
Avg produce expenditure/year/person estimate; lower bound (90% CI)	\$349	\$295
Upper bound (90% CI)	\$421	\$357
Margin of error (90% CI)	5.64%	5.37%
Produce market estimates		
East coast population (Census 2000)	884,748	812,576
Estimated east coast population purchasing ethnic produce (≈79%, based on survey findings)	702,099	644,826
East coast produce market estimate; lower bound (90% CI)	\$245,255,771	\$190,308,137
Upper bound (90% CI)	\$295,679,025	\$230,079,604
Margin of error (90% CI)	5.64%	5.37%

Expenditure estimate for ethnic population mean (sample mean ± 1.645 SE).

^zCI = confidence interval.

superior nutritional qualities (Cappellano, 2009). Increased consumption of a diversity of vegetables in the diet may provide beneficial health outcomes (Bellavia et al., 2013). Several indigenous Asian crops in the *Allium* (chives), Brassicaceae (broccoli and cabbage), and herb families are associated with medicinal and health properties (Block, 2010; Janick, 2003). The Working Group of Asian Horticulture held a workshop entitled 'Asia's Indigenous Horticultural Crops' at the 2009 annual conference of the American Society of Horticultural Scientists to share research information and increase awareness among members (Mou and Wang, 2012). Similarly, this paper from the 2015 Working Group of Asian Horticulture Colloquium presents highlights to illustrate the use of a market-first analysis of new crops to determine research steps targeting ethnic consumers and crop producers.

MATERIAL AND METHODS

Rutgers University–New Jersey Agricultural Experiment Station led an Ethnic Vegetable Team bringing together research and extension personnel from the land-grant universities of New Jersey, Florida, Massachusetts, and Pennsylvania. U.S. Census data were used to develop demographic information for the east coast populations from Maine to Florida. A private firm, Wats Room Inc., was outsourced to conduct phone interviews with computer-assisted telephone interview technology to survey a statistically significant sample of the Asian population per state. Bilingual consumer surveyors speaking Mandarin, Cantonese, or Hindi interviewed the principal grocery shopper in each household totaling 685 Asian-Americans in regards to their expenditures for species-specific vegetable and herb purchases. Follow-up questions were developed for smaller focus groups and internet bulletin boards (Govindasamy et al., 2011). From this consumer feedback, market potential was determined for specific Asian vegetables, leafy greens, and herbs which were identified as to species, named in Asian languages, and chosen for their horticultural feasibility in east coast markets. This selection process of leading crop candidates was first conducted as part of the U.S. Department of Agriculture–National Resources Inventory program for Asian vegetables in general and then more specifically as the U.S. Department of Agriculture–Specialty Crop Research Initiative program for the leafy greens and herbs crop group (Govindasamy et al., 2007a). Chaput's field guide was used to identify the species to ensure correct cultivar selection for trials (Chaput, 1998).

This selection process ranked leading Chinese and Asian Indian crops that were grown from 2007 to 2014 in New Jersey, Massachusetts, and Florida. Plasticulture was used in raised beds with trickle irrigation (Sciara, 2001) and standard management practices for all cultivars as appropriate for each region. Small plot, replicated trials, and field demonstrations were used to evaluate

Fig. 1. Selection process for ethnic specialty crops—Govindasamy et al. (2007).

various parameters of morphological features, plant growth, and yield. Features such as plant height, plant spread, and leaf length were measured in cm. Plant uniformity and vigor were both assessed on a 1–5 scale, which is visually described as 1 = poor, 2 = marginal, 3 = fair, 4 = good, and 5 = excellent. Since some indigenous Asian cultivars have been shown to provide potential health-promoting properties and have Asian popularity (Molinar, 2012; Patel et al., 2012), especially in the Curcubitaceae, Fabaceae, Gramineae, Solanaceae, and Cruciferae, a preliminary analysis was conducted for phytochemical composition of a few promising cultivars in east coast trials.

RESULTS AND DISCUSSION

Demographics. Updated data on populations of Asian-Americans in year 2014 on the Atlantic Coast total 5,874,135 people constituting 5.1% of the total entire regional population (Table 1). Rapid population growth across the entire United States is expected to continue and total ≈40 million citizens by year 2050. This current and future expansion of Asian populations strengthened our hypothesis that significant opportunities exist for vegetable, leafy green, and herb growers who farm closely to densely populated areas.

Asian crop expenditures. Chinese and Asian Indian consumers showed distinct differences in expenditures for preferred food crops. Chinese consumers spent from \$1.00 to \$2.20/week on baby pak choy, pak choy, oriental eggplant, oriental spinach, snow pea, napa cabbage, and luffa, whereas Asian Indians spent \$1.00 to \$2.43/week on mustard leaves, bottle gourd, cluster beans, fenugreek leaves, eggplants, and bitter gourd.

Using the criteria of average expenditure, purchase frequency, and volume purchased provided a 1–12 ranking for Chinese vegetable cultivars and a 1–10 ranking for Asian Indian vegetable cultivars (Tables 2 and 3).

Asian market estimation. In the survey of the Asian consumer market segment, a representative sampling of households and individuals interviewed 434 Asians living on the east coast. Ethnic produce expenditures for vegetables per household were extrapolated to estimate the Chinese annual purchases with a range of \$245 to \$296 million and the Asian Indian at \$190 to \$230 million annually within a 90% confidence interval with a margin of error of 5.6% or better (Table 4). A high percentage had previously indicated a willingness to purchase locally grown produce (Puduri and Govindasamy, 2011).

Asian crop preferences. With leafy greens and herbs, the major Chinese selections preferred by consumers were shanghai bok choy (*Brassica rapa* var. *chinensis*), pak choy, and mizuna (*Brassica rapa* var. *chinensis* and var. *japonica*), chinese broccoli (*Brassica oleracea*), chinese mustard (*Brassica juncea*), sugar pea (*Pisum sativum*), chives (*Allium schoenoprasum*), garland chrysanthemum (*Chrysanthemum coronarium*), and shepherd's-purse (*Capsella bursa-pastoris*). Major leafy greens and herbs preferred by east Indian consumers were fenugreek (*Trigonella foenum*), Indian sorrel (*Rumex acetosa*), tricolor radish (*Raphanus sativa*), amaranth (*Amaranthus* sp.), roselle also called hibiscus (*Hibiscus sabdariffa*), lemon balm (*Melissa officinalis*), swiss chard (*Beta vulgaris* subsp. *cycla*), and malabar spinach (*Basella alba* cv. *Rubra*) (Govindasamy et al., 2014b, 2014c).

Crop selection. Market survey data provided a list of 100 potential Asian crops. Selection criteria winnowed this large group

Fig. 2. Bok choy: average morphological characters (in cm) from field-grown plants in Florida, New Jersey, and University of Massachusetts.

Fig. 3. Bok choy: plant uniformity and plant vigor (scale: 1–5) over 2 years and three locations, Florida, New Jersey, and University of Massachusetts.

Fig. 4. Sugar pea: average morphological characters (in cm) from field-grown plants in New Jersey, and University of Massachusetts, in 2011 and 2012.

Fig. 5. Indian sorrel spinach: average morphological characters (in cm) from field-grown plants in New Jersey, and University of Massachusetts.

down to 28 key crops for horticultural evaluation. Of those, 12 key crops were delegated for demonstrational trials and 16 for replicated field trials over 2 years in each three states (Fig. 1).

Horticultural assessments. Direct comparisons of the field production for ethnic crops over 2 years in multiple locations were challenging due to differences in timing, climatic variation, and more. Since the main goal was to identify market demand and to determine whether selections can be grown in each state, reach maturity, and be commercially grown, a few highlights are presented. Representative examples of various production parameters show chinese bok choy growing consistently well in Florida, New Jersey, and Massachusetts in year 2011 and similarly for 2012, except for New Jersey dropping 1–2 points lower in both plant vigor and uniformity (Figs. 2 and 3). Chinese sugar pea and indian sorrel in New Jersey and Massachusetts grew sufficiently well in both

2011 and 2012 in terms of plant height, plant spread, leaf length, and leaf width (Figs. 4 and 5). Fresh weight yields of indian sorrel spinach were similar for both years in New Jersey and Massachusetts, averaging 144.4 and 83.3 compared with 175.3 and 84.7 g per plant respectively, whereas Florida had very different results. Comparisons of vegetables, greens, or herbs grown in specific regions may vary among other regions. This site-specific data are necessary for local growers to review and decide which cultivars and yields are economically viable for commercial production.

Amaranth profile. Amaranth was among the most promising new ethnic crops and in demand despite the reluctance of many growers to consider this plant as a crop rather than as a weed. These horticulturally bred cultivars may need to be considered as potentially invasive species. Current agricultural methods such as crop rotation, cultivation, and herbicide use that are used for wild weed

species such as redroot pigweed, *Amaranthus retroflexus*, should suffice if a field was not managed properly and allowed to go to seed.

Amaranth plant height, spread, and leaf length and width were consistent within the three regions and grew well for both years in New England, the Mid-Atlantic, and the southeast (Fig. 6). A similar trend was measured for plants uniformity and vigor (Fig. 7). Nonetheless, yield comparisons were significantly different with the selected cultivar having high consistent weights of 372.7 and 326.6 g per plant in New Jersey for years 2011 and 2012, respectively, whereas fresh harvest weights in Florida and Massachusetts averaged far lower by large margins ranging from $\approx 2\times$ to $8\times$ less (Fig. 8). The cause for higher yield in New Jersey is unclear and more applied studies are needed as to fertility levels, soil type, pest control, and climate differences to develop better recommendations and protocols.

Fig. 6. Amaranth: average morphological characters (in cm) from field-grown plants in Florida, New Jersey, and University of Massachusetts in 2011 and 2012.

Fig. 7. Amaranth: plant uniformity and plant vigor (scale: 1–5) over 2 years and 3 locations, Florida, New Jersey, and University of Massachusetts.

Phytochemistry. In addition to taste and visual appearance, today's healthy choice for food calls for increased nutritional value from eating a diversity of horticultural crops. Mainstream consumers may find expanded even better choices from ethnic Asian vegetable, leafy green, and herb cultivars. Several Asian crops were identified that can be easily grown in a similar manner now employed by growers with other horticultural produce. Nutritional analysis showed these crops to be nutrient dense and a rich source of minerals and vitamins (Table 5). Examples of more detailed phytochemical analysis include amaranth and edamame cultivars. The average value for the top three amaranth varieties selected for high yield had 5.4% content for nitrogen, 5.36% for potassium, and 4.24% for calcium with significant differences among them (Fig. 9; Table 5).

In edamame soy, the isoflavones, daidzein, genistein, glycitein, and their derivatives were found to be the main phenolic compounds. These phytoestrogen compounds

show striking similarity to the human estradiol and have exhibited bioactivity to lower the risk of cancer, heart disease, osteoporosis, and relief of menopause symptoms. Four of 10 hydrolyzed edamame cultivars showed 0.1% content or greater of isoflavones (Shen et al., 2011) with a diversity of molecular structures identified (Fig. 10). This work confirmed that edamame soybeans can be grown in the east coast (Sciarappa et al., 2004) and provide a nutritionally rich food crops as an added benefit.

Outreach. This project has generated unique production and consumer-based marketing data on preferred Asian vegetable crops that was outreached through extension channels for farmers, advisors, and marketers (Govindasamy et al., 2007a; Simon et al., 2012). Selected results of these ongoing studies have been compiled into fact sheets and outreach literature (Ayeni et al., 2010a, 2010b, 2010c; Park et al., 2007; Sciarappa and Quinn, 2004a, 2004b). Other outreach resources, such as the worldcrops.org website

Fig. 8. Amaranth: fresh weight and dry weight (grams/plant).

Fig. 9. Amaranth: nutritional value of high-yielding varieties field-grown in New Jersey.

(Van Vranken, 2010), helps to connect east coast growers with emerging ethnic markets as well as individual university websites. University researchers in this specialty crop area regularly present at agricultural conferences, horticultural workshops, and on-farm tours. Our extension outreach is an attempt to strengthen the economic viability of the east coast vegetable industry while contributing to the culinary and nutritional needs and preferences of a diversity of ethnic and mainstream consumers.

Comments and conclusions. This market-driven model has demonstrated a shift from a production paradigm approach to a market-consumer-driven approach in focusing crop research. The combination of consumer feedback directing university testing of Asian crops worked well to quantify and target the most promising specialty ethnic vegetables, herbs, and leafy greens. Grower, advisor, and distributor response to this blend of agribusiness data and horticultural research has been highly supportive. They recognize the value

Table 5. Mineral composition of Asian ethnic greens, herbs, and vegetables field grown in New Jersey.

Crop names	%N	%P	%K	%Ca	%Mg
Indian sorrel	4.49	0.96	7.71	1.92	1.29
Radish	5.18	0.34	4.00	5.58	0.53
Red leaf amaranth	4.49	0.69	7.7	4.41	1.17
Malabar spinach	2.76	0.34	6.22	6.27	2.57
Amaranth	4.44	0.61	7.15	4.80	1.39
MeiQing bok choy	4.50	0.76	8.25	4.24	0.51
Pak choy	4.18	0.53	6.34	4.72	0.56
Sugar pea	4.38	0.53	3.9	1.17	0.26
Garlic chives	4.06	0.60	3.73	1.77	0.49
Chinese chives	4.22	0.55	3.07	1.13	0.39

Fig. 10. Molecular structure of edamame isoflavones compared with human estradiol—Shen et al. (2011).

in surveying, selecting, and pretesting potential crops that can be grown successfully in their areas. A grower can use these results to more knowledgeably project retail sales, customer number needed, and potential profit based on his crop budgets. Similarly, a wholesaler or retailer could estimate potential costs, markups, and profits based on expected crop quantity being grown for an extended distribution chain.

These applied results help minimize production risk through improved planning, pricing, and marketing that more effectively penetrates emerging and expanding Asian markets. Such economic information, purchasing calculations, consumer preference, and research demonstration allows the grower as well as the distributor to more accurately decide on specific farm crops and better determine distribution strategies. Ultimately, the consumer may be better served with wider choices, greater availability, and fresher quality.

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