"Prospects for Vegetable Soybean in India and its Market Acceptance"

Research and Cultural Experiences in Hyderabad, India

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Introduction

When I was first introduced to the World Food Prize at the end of my junior year in high school, I did not expect it to bring me to the other side of the planet one year later. My environmental science teacher and environmental club adviser, Mrs. Jane Hunt, told me about the opportunity to participate in the Global Youth Institute at Ohio State. I was intrigued; recently I had developed an interest in the humanitarian and environmental issues of sub-Saharan Africa. And so, somewhat on a whim, I decided to research and write the paper over the summer.

My original plan was to focus on environmental degradation in Kenya. However, inspired by Barbara Kingsolver's historical fiction novel *The Poisonwood Bible*, I was at the time writing a paper about the assassination of Patrice Lumumba, the first and only elected leader of the Democratic Republic of Congo (DRC), for my two-year IB World History course. Thinking I would get more out of both projects with a greater knowledge of the region, I decided to write my paper about the DRC, focusing on the ongoing war's impact on food production and humanitarian aid.

It was a good choice, for with my paper and presentation I earned one of Ohio's six spots to be a youth delegate to the 2010 World Food Prize ceremony in Iowa. After flying there with my five fellow Ohio youth delegates and our teacher mentors for that weekend in October, we attended conferences and listened dialogues, and ate meals among farmers, professors, and politicians from all over the world. Additionally, we assembled food packages for Tanzania, took part in a Hunger

Banquet, and presented our reports at the Global Youth Institute. This presentation was much more intimidating than the one at Ohio State, as the facilitators were leaders in the fields we had just begun to explore and understand.

After participating at the Youth Institute, we were eligible to apply for the Borlaug-Ruan Internships. I applied with the hopes of visiting Kenya, or some other distant country, without much confidence, sure it was a matter of luck in a pool from so many other qualified students. I didn't fully appreciate what I was applying for, not even when I qualified for an interview. Even when I received the congratulatory email that winter, amid the frenzy of the end high school, it seemed surreal: I would be spending two months in India.

India had never been on my radar, and I knew little about it, but I warmed to it quickly. As a long-time vegetarian, fan of Indian food and yoga, India seemed like a good match. I had very little idea of what I would be doing in this country that was half-way around the world, and would not find out until I got there.

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AVRDC – The World Vegetable Center

The Asian Vegetable Research and Development Center was founded in 1971 in Taiwan. Its mission is to alleviate "poverty and malnutrition in the developing world through the increased production and consumption of safe vegetables." Its primary fight is against "hidden hunger", or dietary deficiencies like malnutrition, with four principles: germplasm (theirs is the largest vegetable gene bank in the world), breeding (to develop more productive, nutritious varieties), production (facilitating more efficient farming), and consumption (helping to promote the vegetables). Examples of their achievements include developing varieties of tomatoes with 3 to 6 times the normal amount of Vitamin A, disease-resistant mung beans, high-yield, and heat-tolerant sweet peppers. It develops "home garden" systems, which are vegetable gardens designed to sustain one family for a year with complete nutritional needs.

Since its founding, AVRDC has expanded with centers around the world and changed its name to the World Vegetable Center. Presently, it continues to operate as a not-for-profit organization, now with a budget of some $18 million. Their Regional Center for South Asia (RCSA) opened in 2006 in Hyderabad, India, the locale at which I would be the second Borlaug-Ruan intern. My mentor would be Dr. Ramakrishnan M. Nair, a breeder of legumes.

My Work at AVRDC

Among the World Vegetable Center's present projects is the quest to improve the quality and marketability of vegetable soybean. Vegetable soybean (or edamame), which account for about 2% of world soybean production, differs from its grain counterpart in that it is picked earlier (at the green stage) and eaten fresh as opposed to being dried or used for oil. It is packed with protein and vitamins. For this reason, the World Vegetable Center hopes to introduce it more commonly in India, where malnutrition and specifically protein and iron deficiencies run rampant. However, taste-tests have shown that South Asians generally dislike the "beany" taste of vegetable soybean. To create a variety more favorable to Indians, the World Vegetable Center is working on cultivating a variety that has a more "basmati" (like the fragrant rice) flavor, so that it might be more marketable and beget its nutritional benefits to the Indian population. After learning about the World Vegetable

Center, plant biology, and researching vegetable soybean, I conducted my own small taste-test experiment. Five different lines of vegetable soybean (AGS 406, AGS 456, AGS 457, AGS 459 and AGS 461) were presented at the ICIRSAT campus canteen at lunch one day, and participants were asked to complete a survey to evaluate them on appearance and taste. The following are my review of literature on vegetable soybean research and the report from my taste test survey.

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Review of Literature: "Prospects for Vegetable Soybean and in India and its Market Acceptance"

Overview

As a developing nation, home to almost 1.2 billion people, India hosts a significant part of the world's poverty and health problems, providing a clear target for global initiatives against hunger (CIA). The vastness of the country in geography and population creates difficulties in generalizing to address any one issue; however, it is clear that hunger and malnutrition are prevalent, urgent problems. For example, in 2006 the World Health Organization reported very high levels of malnutrition. Almost half of children under five were underweight and/or stunted, and over half of women had BMIs indicating they were moderately or severely underweight (WHO NLIS). This is due to a number of causes – social practices and traditions, environmental degradation and climate change, government inefficiencies, and so on - and as such there are a number of dimensions to the solution. An important method is to promote more diverse, nutritional crops to the greater Indian population to facilitate a healthier, more balanced diet. Vegetable soybean, rich in protein and other nutrients, is a viable and promising option to improve nutrition in India.

The traditional Indian diet, though varied between regions, is well-balanced, rich in whole grains, vegetables, fruits and beneficial spices. However, a wholesome diet is not within easy reach of the poor - if the proper knowledge of nutritional needs is even present - and around 25% of Indians live below the poverty line (CIA). Cereal crops comprise the base of Indian meals, ranging from rice to breads made of wheat flour. Due to investments in research on cereal crops, these production levels should be able to meet the needs of the growing population. However, the emphasis on cereal crops is disproportionate; in India's prime agricultural land, rice and wheat comprise 80% of crops grown, and their widespread implementation came at the expense of 20 other varieties (Keatinge et. al. 2011). These staple crops provide much energy in the form of carbohydrates but lack sufficient amounts of protein, fats and micronutrients, especially after processing.

Vegetable soybean is similar to its grain counterpart – it is the same species, but harvested earlier, when pods are bright green, yielding bigger, sweeter seeds. While obscure in much of the world, the vegetable soybean, or edamame, has been cultivated for perhaps thousands of years in East Asia, and is a popular snack in Japan, China, Thailand and Taiwan. It is highly nutritious, rich in protein, cholesterol-free fat, fiber, iron, zinc, calcium, phosphorous, folate, magnesium, potassium, isoflavones and tocopherol (Shanmugasundaram, Self). Compared to the grain soybean, it has a more pleasant flavor – milder, sweeter, and nuttier – and texture, and is easier to cook. Soybeans, of the common Asian legumes, are the richest in protein, iron and calcium (Keatinge et. al. 2011). It has short growth duration, permitting it to fit into narrow windows in a crop rotation, and yields high values: around 40 tons/hectare, of which 10 t/ha is consumable and the rest is usable as fodder or green manure, in 65-75 days (Shanmugasundaram 2004). As legumes, vegetable soybean plants have nitrogen-fixing nodules on their roots, meaning they can be used after harvest as a natural fertilizer for subsequent crops or a nutritious stover for livestock. There is great potential and promise for its widespread implementation in India.

Protein deficiency is prevalent in India, compounded by the fact that many Indians are vegetarian which, of course, excludes meat as an option to obtain protein. Vegetable soybean, producing among the highest yields of crop protein per unit area, could help to fill this gap (Keatinge et. al. 2011). Legumes are the cheapest good source of protein. Anemia, caused by deficiencies in iron, zinc, and protein also

particularly plagues Indian women and children, causing high maternal, pregnancy and infant mortality (Mittal). Incorporation of vegetable soybean into Indian diets would increase iron and zinc intake to reduce these risks.

Pulse crops are another staple in India, though far behind cereal staples in prevalence, and average consumption is going down – from 60g a day in 1970-1 to 36g a day in 2007-8 (Kadakia). The World Health Organization recommends 80g of pulses per day for Indians. To meet the needs of the growing population, this means a need to increase pulse production by 38 million tons by 2017-18 (Kadakia).

Vegetable soybean, as an under-utilized hearty, versatile, tasty, nutritious pulse, can help to meet this need. The potential benefits of the widespread introduction of vegetable soybean in India seem great. The following are more specific considerations.

Consumption

In Japan, by far the world's top consumer, edamame is eaten as a snack with alcohol, especially beer. Consumption occurs at a high concentration during the summer months (July-September) when the domestically-grown fresh, and so better tasting, crop is available (Nakano 1991). Despite increasing Americanization, traditional foods such as edamame remain popular (Lumpkin 1991). It is suspected that introduction of imported fresh vegetable soybean would increase consumption year-round, though Japanese standards for edamame quality are very high. This still creates market opportunities for tropical growers.

Vegetable soybean can be sold as a convenient snack and versatile ingredient. Pods are boiled in brine and consumed as a snack food by placing a pod in the mouth and pulling it through the teeth to extract the grain or the pods are shelled and the seed eaten as a fresh green vegetable. As the role of women changes in developed countries like Japan and there is more female employment outside of the house, the appeal of frozen foods for easy preparation should also increase (Lumpkin 1991). This too should provide more flexible opportunities for foreign countries to export.

One marketing strategy could be to tout vegetable soybean as a "weight loss" snack. "Self" Magazine, for example, rates frozen edamame as a top source of nutrients and as very filling per calorie (Self). This could find a niche in middle-upper classes, where healthy foods that help one get in shape are in demand. The same nutritious qualities make the bean so important in enriching the diets of the poor, under- and malnourished can be used as a nutritiously-dense snack that fills one up quickly, thereby eating less.

Market

Vegetable soybeans grown in India would ideally be used as a local fresh crop for domestic consumption so that the Indian population gets the nutritional benefits. As a crop suited to hand-harvest in small production areas, it would be suited to sustenance or smallholder farms and local markets. Vegetable soybean has been introduced to rural farmers across developing Africa with positive results. In Zambia, farmers were interested in utilizing vegetable soybean seeds provided in nutrition kits. In Sudan, vegetable soybean seeds distributed to 2,000 households have been proliferated and passed on. In Tanzania, farmers given seeds liked the crop and its easy utilization. And in Mauritius, vegetable soybean is growing in popularity, with fresh green pods selling for a decent price of about $2/kg, helping many poor farmers to earn an income (Chadha 2004). This bodes well for small farmers in India either looking to feed a family or earn an income.

Should it catch on as popular in the Indian diet, among other staple legumes, vegetable soybean could rise quickly in demand. If one assumes a5 kg consumption per capita per year in only 20% of the Indian population, it would create a demand of over one million tons of vegetable soybean (Ali).

Vegetable soybean could also become an export cash crop to Japan or, increasingly, the U.S. and Europe (Keatinge et. al. 2011). Promotion in different areas of Indian culture, then, would be advantageous for farmers in creating more demand for the crop.

Improving Eating Quality (Sweetness, taste, flavor, texture)

Consumers in Africa and South Asia have expressed dislike for the 'beany' flavor of vegetable soybeans, indicating a need for improved taste before successful, widespread introduction can take hold in India. The brown-seeded variety *Dadachamame* has the aroma of fragrant rice, which is more appealing to such consumers. Research to transfer this "Basmati flavor" to varieties with green, yellow and black beans is underway (Shanmugasundaram 2004).

The major chemical compounds related to taste are sucrose, glutamic acid and alanine (Masuda 1991). Unacceptable traits like bitterness, astringency and off-flavors have been attributed to saponins and isoflavins. Boiling vegetable soybean enhances its characteristic flavor because of heat-induced ketones and furans and by rupturing cells and tissues to release volatiles for evaporation. In boiled vegetable soybean, the components of the flower-like flavor come from *cis*. Jasmine, (Z)-3-hexenyl-acetate, linalool and acetophenone. Components of beany flavor, 1-octen-3-ol, 1-hexanol, hexanal, 1-pentanol, (E)-3-hexen-1-ol, 2-hepta-none and 2-pentylfuran are also detectable. Freezing creates cell ruptures that create undesirable flavors from lipid peroxides (Masuda 1991).

Farming techniques impact the eating quality as well. Different cultivars can be used for adaption of vegetable soybean into almost any crop rotation, but early maturing summer varieties generally are rated lower in taste than later maturing autumn varieties (Kokobun 1991). Overall quality of earlier varieties is generally lower, but they are a useful fit for a narrow crop window or to supplement other crops. Optimal fertilization can maximize yield as well as quality. It was found that the ideal fertilization for flavor and sweetness was half chemical fertilizer (N-P-K at 30-40-30 kg/ha) with half chicken manure or fermented pig dung (Hung 1991). The time of harvest plays a role, as sucrose increases in the early stages of green soybean growth, peaking at or after around 35 days after flowering (Chiba 1991). Furthermore, sucrose levels seem to specifically peak during the mid to late afternoon (Masuda 1991), although the AVRDC guide to Vegetable Soybean Production recommends beginning harvest around midnight when it is cool to maintain freshness; if harvesting is done in the sun, harvested pods should at least be kept in the shade (Lal 2001). There is a narrow window of optimal harvest time for taste, usually around 35-39 days after flowering. After harvest, sugar levels drop swiftly, especially at high temperatures. Measures should be taken to preserve the high quality of beans with cooling and keeping high humidity (Chiba 1991).

Further research should be done to maintain superior taste with other desirable qualities of vegetable soybean. Fortunately, there are tests besides the sometimes cumbersome taste test to detect sugar content. The broad scope heritability for sugar content is fairly high, enabling selection for high sugar content. Furthermore, it has been found that there is a strong negative correlation between sugar and oil content in vegetable soybean, as well as a highly negative correlation between sugar content and oil + protein content (Shanmugasundaram 2001). Oil content can thus be used as an indirect selection method for sweeter varieties. Taste surveys have been conducted in Africa with representatives from 23 countries, and four promising lines (AGS 292, AGS 329, AGS 338 and AGS 339) were found to have good flavor (Chadha 2004). These lines could also perform favorably in South Asia, where, like in Africa, there were complaints of beany flavor.

Variety Kaohsiung No. 1, the AVRDC-developed variety widely introduced in Asia, has been reported to be low in flavor, perhaps due to the lack of the isozyme lipoxygenase, an iron-containing enzyme responsible for different functions in plants like growth and development (Tsou 1991). This could provide a good starting point for improvement. Generally, early maturing and more disease-resistanct varieties have lower-rated tastes. Nor is there a definitive taste solution, as different demographics prefer different varieties. For example, older tasters seemed to prefer varieties higher in alanine while younger tasters preferred varieties high in sucrose and lower in alanine (Lumpkin 1991). There are many directions for the research to improve taste to go. Mutation instead of cross-breeding could be used with vegetable soybean, as with developing sweet corn (Masuda 1991). Starch content changes with maturity, peaking at around the mid-pod-filling stage at 22%. Were genetic suppression of starch synthesis enzymes employed in high-starch varieties such as Koito-zairai and Tururan-daizu, it might be possible to convert them into high-sucrose types (Masuda 1991).

Employment/Labor

The main problems experienced with vegetable soybean farming in Taiwan were high production cost and shortage of labor for harvest, leading to demand for types suited to mechanized harvest (Cheng, S. 1991). In India, where the unemployment rate hovers close to 11% (CIA), the need for harvest laborers could be well-met. The work is accessible to most; in Japan it has been found to be easily manageable for women and the elderly due to lighter weights and simple harvest procedures (Nakano 1991).

Unfortunately, there is a narrow window of opportunity for optimal harvesting, when the pods are bright and green and are 85-95% filled with their seeds. As for the best sugar and amino acid levels, the ideal time is 36-39 days after flowering (Chiba 1991). In these few days, about 60-80% of the labor of the entire planting process must occur (Kokobun 1991).

Cropping and Harvesting

Vegetable soybean is hearty and versatile and could grow almost anywhere in India. Soybeans have been successful in each of India's four broadly-defined agronomic zones (northern hill, northern plain, central and south) (Trikha 1991). In Taiwan, edamame was found to require well-drained sandy loam or loam soil with irrigation (Cheng 1991). Most varieties are "short-day" plants, though this is not too problematic as much of India has consistent, average-length days (Miles 2000). The widely-accepted AGS292 line is photo-resistant, further reducing that problem. A soil test should be taken prior to planting to determine the specific needs of the field. The ideal soil pH for vegetable soybeans was found to be 6.0, which can be adapted with lime (Miles 2000). If legumes have been grown in the field previously, fertilization is not greatly needed. But if it is a new field, Rhizobia inoculation at the rate of 10g/kg of seed will suffice to boost nitrogen-fixing levels (Lal 2001). Although there have not been many studies on it, a safe temperature range for vegetable soybeans seems to be between 10-15 degrees Celsius (at night) and 25-30 degrees Celsius (during the day) (Kokobum 1991). However, they have been seen to do quite well in warmer tropical climates. Transplanted crops tend to have shorter stems and a lighter top weight, but a greater ratio of pods to total weight. This is advantageous for farmers selling pods at the market off the stem, which some may prefer for the greater freshness (Kokobun 1991).

Vegetable soybean is best utilized as a part of a mixed cropping system; not only does it achieve a higher yield but so do the other crops. The nitrogen-fixing nodules of the legume reduce the need for fertilizer, and when plowed back into the soil, return nutrients to the field. In Taiwan, where there is a high population density and limited available land, vegetable soybean fits neatly into crop rotations during all times of the year. In particular, it has seen success in systems before and after rice crops, but is also used with maize, tobacco, peanut, melon, and other crops (Tsay 1991). In Africa, using vegetable soybean as green manure on Amaranthus gave the best biological and economic yields over using cowpea as green manure and using none at all (Chadha 2004). In India, grain soybean intercropping has proven to increase yields as well. For example, in southern India, soybean is beneficial when intercropped with sorghum, cotton, sugarcane, pigeonpea, or peanut; a particularly promising combination is wheat-soybean-finger millet-beans. Soybean can also be used with rice fallows to replenish the land, or in lieu of low-density rain-fed crops (Trikha 1983). Soybean is harvested in its R8 stage of growth, compared to vegetable soybean in the R6 stage – when even more nutrients remain in the growing shoots, meaning vegetable soybean should have even greater results in boosting yields (Tsay 1991). There is good potential for vegetable soybean to fit into most cropping niches in India.

After harvest it is of course to important to properly store the crop. If the vegetable soybean is going to be sold fresh, it is best to get them to a local market quickly. Keeping the pods attached to branches and selling by the bundle maintains freshness for longer. Temperatures should be kept low and humidity high. The ideal storage conditions were found to be packing in polyethylene bags, precooling, and keeping the temperature at 0 degrees Celcius – this minimizes fresh weight loss, discoloration, loss of Vitamin C, and hardening (Lung-Ming 1991). These sorts of facilities, however, will be difficult for most small farmers in India to come across. For longer-term storage, beans can be blanched and frozen or dried to maintain good quality.

Sustainability in India

Environmental degradation and climate change are factors that will compound future efforts to alleviate poverty and hunger. Degraded soils will yield fewer crops; erratic weather will cause more extremes like floods and droughts; increasing heat and humidity can facilitate the spread of pests and disease. Hardest hit will be the areas already suffering most, sub-Saharan Africa and southern Asia. It is projected, for example, that while the population continues to grow, crop-net revenues in Asia could be reduced by 5-30% by 2050 due to environmental changes, particularly affecting smallholder farmers (Keatinge et. al. 2011). The environmental impact of any future plans must be considered to achieve food production levels that meet the needs of the population but that can also be maintained.

Farmers are over-fertilizing in general, increasing the acidity of soil and presence of chemicals. This makes the growth of vegetable soybeans, when inoculated with the nitrogen-fixing bacteria Rhizobia, advantageous. Rhizobium inoculation is simple and cheaper than inorganic fertilizers, and even further improves yield (Hung 1991). Education about this practice needs to be more widespread.

Constraints and Resistance

There has not yet been very much research on resistance in vegetable soybean specifically – mostly it has been borrowed and adapted from information pertaining to grain soybean. The major disease to effect vegetable soybean is rust (*Phakopsora pachyrhizi* Syd), which detrimentally effects seed/pod quality and yield. A resistant commercial variety has yet to be developed (Srisombum 2004). Typical pests for vegetable soybean include beanfly, whitefly and the pod borer.

Weeds can pose another problem, especially during the rainy season. Pre-emergence herbicide and weeding by hand together are the presently recommended technique to control weeds. In fact, chemical use is suggested for most disease, pest and weed treatment (Srisombum 2004). Further research is needed to develop resistant varieties that do not have poor eating quality.

Cooking and Alternatives

Vegetable soybean is versatile in the ways it can be consumed. It can be eaten fresh directly from the pod, or frozen or canned and used later. The diverse potential for uses of vegetable soybean is perhaps under-explored. Beyond the traditional uses in Japan as a snack, or in China as a stir fry component, there could be production of edamame tofu, candied edamame, or incorporation of edamame in more diverse recipes. Due to its lower cell density, vegetable soybean needs less time to cook than its grain counterpart. Cooking vegetable soybean has the benefit of doubling the iron bio-availability (Chadha 2004). Vegetable soybeans can be substituted for green peas or lima beans in any recipe (Miles 2000). See below for ideas for vegetable soybean use in Indian and other recipes (Appendix 1).

Vegetable soybeans in India may be considered a residual crop only for growth during the rainy season (Kadakia). However, they have the capacity to grow in almost all times of the year. They can serve as an alternate to seasonal crops such as green peas. Vegetable soybeans have nutritious advantages over green peas that could better meet some of the pressing deficiencies in India– higher calorie, protein, lipid, and calcium content, for example (Masuda 1991).

Vegetable soybean compared to similar cooking legumes:

Legume (100 g)	Energy (kcal)	Protein (g)	Total Lipid (g)	Dietary Fiber (g)	Sugar (g)	Calcium (mg)	Iron (mg)	Zinc (mg)
Edamame, frozen, unprepared	100	10.25	4.73	4.8	2.48	60	2.1	1.32
Green pea, frozen, unprepared	77	5,22	.40	4.5	5.0	22	1.53	0.82
Lima bean, immature, fordhook, frozen, unprepared	106	6.40	.35	5.5	1.39	24	1.51	.49

Source: USDA National Nutrient Database

Potential for Vegetable Soybean in Different Regions

While vegetable soybean is hardy enough to grow in most areas, of course there are some conditions more favorable than others. Within India, by nature of the country's geographic largeness and diversity, there are different agricultural regions. All are subject to extremes of weather, particularly the monsoons, which, as noted before, are becoming increasingly erratic with global climate change. Some regional divisions can be made for easier observation.

The Himalayan region, despite decent rainfall, is mostly too rugged for agriculture – only about 10% of land here is used for farming (Heitzman). However, the fertile, loamy, sandy soils of the Vale of Kashmir – including the states of Kashmir and Jammu – make for very good farming, primarily of cereal crops, potatoes, temperate-zone fruits and tea to the east (Heitzman). There is not a strong soybean presence in the area, but they could be intercropped among the area's other produces.

One example of potential in the Himalayan region is the state of Uttarakhand, where cool weather provides opportunities for off-season farming and ample river systems enable irrigation, but harsh, steep environments sometimes hinder infrastructure . In a 2008 AVRDC survey, farmers in the area with accessibility to irrigation were found to farm vegetables (AVRDC). Vegetable soybean was not a common crop. However, some findings from the survey indicate that it might have some potential. For one, the temperate summers, loamy, clay-like soil and access to irrigation could physically enable the growth of vegetable soybean. Green peas were found to be major crops in high demand in the area (AVRDC). As vegetable soybean can be used as a substitute for green pea, it could supplement the pea crop to provide villagers with the nutritional advantages – increased protein and iron content, for example. Furthermore, it was found that almost every family has cattle, for which vegetable soybean would be healthful, convenient fodder. Vegetable soybean's use as green manure would be especially important as the village was experiencing decreasing vegetable yields and there was no preference given to organic crops (AVRDC). Intercropping vegetable soybean with other crops and using it as green manure could help restore fertility to the soils. Constraints in the area would be lack of infrastructure and the resulting problems of storage and transportation, frost and cold weather, and the presence of pests like pod borers. Despite these limitations, vegetable soybean could find a spot in these local markets.

The Indo-Gangetic Plain, as one of the top agricultural regions of the world, would provide ample opportunities for vegetable soybean growth. Already, the area is used for grain soybean cultivation, which of course bodes well for the growth of vegetable soybean. Sufficient rainfall usually comes from the monsoons, though there is the ever-present risk of drought (Heitzman). Usually, however, in this area irrigation is available, which is important as vegetable soybean plants need to be well-watered.

Finally, the Indian Peninsula, consisting of the east and west coasts and coastal plains, could provide some opportunity. While not a common place for grain soybean, 25-50% of some of these areas are under cultivation with the benefit of the monsoon season (Heitzman). Common are rice and other cereal crops, which vegetable soybean have been shown to benefit when intercropped or alternated with them. The state of Andhra Pradesh, part of the peninsular region, has some potential for vegetable soybean growth. About half of the soil in Andhra Pradesh is red sandy loams, which is ideal for vegetable soybean growth (Andhra Pradesh Department of Agriculture).

Grain or oilseed soybean is grown far more in India than the vegetable version; areas where it grows successfully can be used as indicators for prime areas for vegetable soybean introduction. The main soybean producing areas in India are Madhya Pradesh, Chhattisgarh, and Maharashtra, with other production in areas of Karnataka, Gujarat, Andhra Pradesh, Jharkhand, Sikkim, West Bengal and Uttaranchal (MapsofIndia.com).

Conclusion

Although it has been used for thousands of years in East Asia, vegetable soybean is a relatively obscure crop in much of the world. Widespread introduction of vegetable soybean in India would be ideal to help combat malnutrition, particularly protein and iron deficiencies. Its versatility and tastiness mean it has potential for popularity. It is a feasible option in India. Some improvements need to be made, such as

developing a bean with a flavor more acceptable in South Asia, maintaining good eating quality in resistant and high-yielding plants, and improving logistical concerns of harvesting and marketing. However, based on the improvements made to grain soybean, these are attainable. Vegetable soybeans are have the added benefit of helping to farm sustainably as the plants can be used as healthy fodder or green manure. The expansion of the consumption of vegetable soybean in India would help to meet a great need and is achievable.

Results from Survey of Vegetable Soybean Quality
27 July 2011
AVRDC-RCSA

Introduction

Hunger and malnutrition are major issues that plague much of India's population of almost 1.2 billion. While the traditional India diet is well-balanced, many Indians do not have the means to obtain properly nutritious foods. Cereal crops, specifically rice and grains in unleavened breads, comprise the basis of the Indian diet. These provide ample carbohydrates but are lacking in protein, fats, vitamins and minerals. As such, protein and iron deficiencies are widespread in India. AVRDC, the World Vegetable Center, is working to combat such problems by developing and promoting improved vegetable varieties. One project focuses on vegetable soybean. Vegetable soybean is similar to its more common grain counterpart, but is harvested at an earlier, green stage. It is rich in protein, cholesterol-free fat, fiber, iron, zinc, calcium, and other nutrients. Pods are boiled in brine and consumed by placing a pod in the mouth and pulling it through the teeth to extra the grain as a snack food or the pods are shelled and the seed eaten as a fresh green. Vegetable soybean would be greatly benefit the health of the Indian population were it widely accepted. However, past taste-tests have found that South Asians, Indians included, generally do not like the "beany" flavor of vegetable soybean. AVRDC is working to develop a variety that Indians will find more favorable.

Materials and Method

Five soybean varieties (Table 1, Fig. 1) were sown into pots on 16 May of 2011 and raised in a greenhouse maintained at 25° to 30°C on ICRISAT Campus in Patancheru, India. Pods were harvested by hand during the R6 stage - when pods were bright green and seeds filled 85-90% of the pod, were clearly defined, and hard when squeezed - as is suggested by AVRDC (Lal 2001). As the pods matured at different rates, harvesting was done at three times on July 11, July 15, and July 19.

Table 1 – The Five Vegetable Soybean Varieties

AGS 406	The one non-basmati variety. Parentage: Neu Ta Pien 2 x {[(Vesoy 2 x PI 6302) x D62-7812] x KS 1}Purple flower and grey seed coat. Notable for lack of pubescence and resulting resistance to pod borer pest. Harvest yield was high and pods were ready for harvest at one time. Was the earliest variety to flower but not to pod.
AGS 456	Basmati variety. Parentage: Dada Cha 2000* x (Taisho Shiroge x Neu Ta Pien 1). Purple or white flower, brown seed coat.
AGS 457	Basmati variety. Parentage: Dada Cha 2000 x [Dada Cha 2000 x (Taisho Shiorge x Neu Ta Pien 1)]. White flower and brown seed coat.
AGS 459	Basmati variety. Parentage: Dada Cha 2000 x KS 7. White flower and black seed coat. Harvest yield was low.
AGS 461	Basmati variety. Parentage: Dada Cha 2000 x KS7. White flower and brown seed coat.

**Dada Cha is the line that imparts basmati aroma and flavor.*

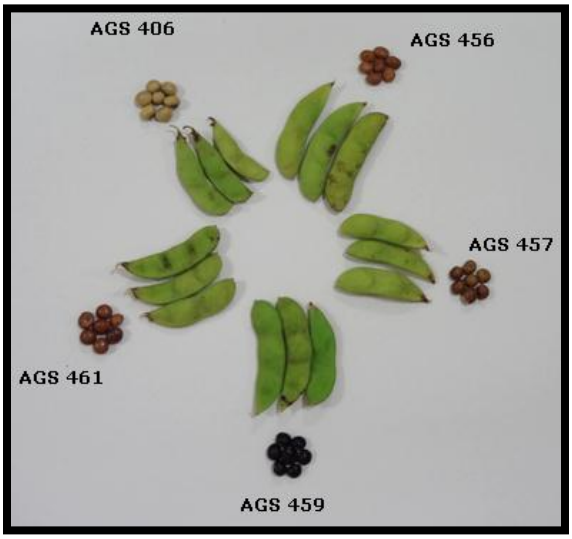

Figure 1 - The Five Vegetable Soybean Varieties

Vegetable Soybean Preparation

To maintain consistency, a uniform procedure was used to prepare and store the pods. Within hours of harvest, pods were rinsed in water, boiled in water in a pot with a glass cover slightly askew, sprinkled with about ½ teaspoon of salt at 7 minutes of boiling, and removed from heat after 12 minutes. The pods were then drained and let to sit outside and dry for a few hours. Pods were then placed in Tupperware containers and stored in a freezer. On the day of the survey, the pods were microwaved until thawed and warm.

Taste-Test Survey

The survey was conducted on Wednesday 27 July 2011 at the 205 "Indian" canteen on the ICRISAT campus in Patancheru, India. The survey (Appendix 2) was prepared and offered in print in both English and Telugu. During the lunch hour (12-1 PM) the survey was open to anyone who came into the canteen. The five varieties were presented in separate containers labeled as follows: A (AGS 406), B (AGS 456), C (AGS 457) D (AGS 459) and E (AGS 461). Participants were given the survey, directions, and small plates on which to examine and taste pods one at a time. Cups of water were provided to encourage drinking between samplings. Participants tasted both before and after eating lunch. It must be noted that due to a low yield, there was not enough of the AGS 459 variety for each participant to be able to try it. This may have affected its resulting performance.

79 surveys were collected, of which 13 had to be disregarded as participants did not provide the necessary personal information or properly follow the rating system. Of the 66 usable surveys, 60 were Indian (other nationalities were Swiss, American, French, Japanese, Vietnamese and Bangladeshi). Ages ranged from the under 20 to 50-60 range (Fig. 2). Most participants were middle-aged men, with a concentration of teenaged girls due to a class from an all-girls school visiting the canteen and taking part. The gender breakdown was 27 females (41%) and 38 males (58%) with 1 participant not disclosing his or her gender (Fig. 3).

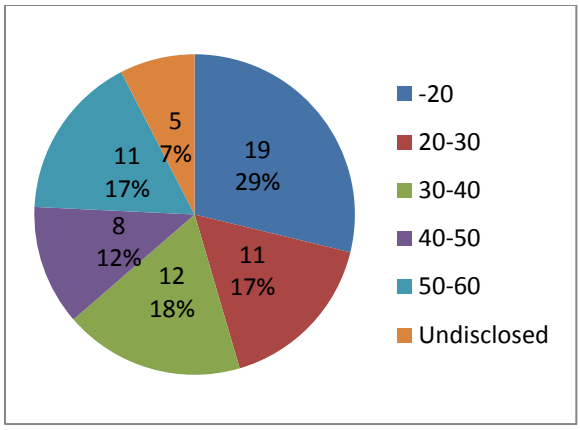

Figure 2 - Breakdown of Age of Participants

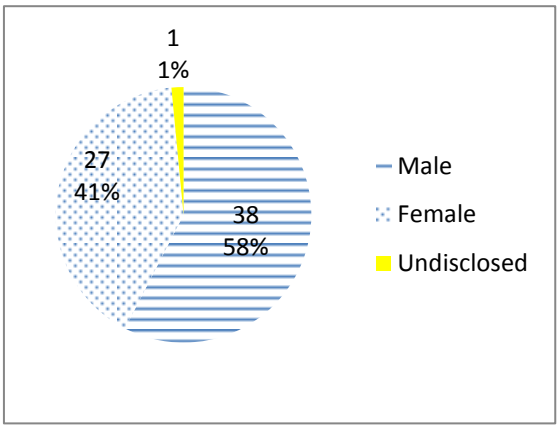

Figure 3 - Breakdown of Gender of Participants in Survey

Results

A non-parametric test (the Kruskal-Wallis method) was used to analyze the data, some of which is graphically represented below. Due to the small size of the survey, only data for which results at a 10% level of significance have been reported. Statistical significance was not present for many of the evaluated qualities, but those results that were significant have been presented. For all participants, available results were ratings on pod appearance (Fig. 4), pod color (Fig. 6), seed color (Fig. 9), seed texture (Fig. 12), taste (Fig. 13) and overall quality (Fig. 15). For female participants, available results were ratings on pod appearance (Fig. 5) and pod color (Fig. 7). For male participants, available results were ratings on seed color (Fig. 10) and taste (Fig. 14). For participants over 20 years old, available results were ratings on pod color (Fig. 8) and seed color (Fig. 11). No results for participants under 20 years old were significant. As no corresponding categories between male and female or under and over 20-year-old participants were significant, the effect of gender and age on preference of vegetable soybean variety could not be evaluated.

Pod Appearance

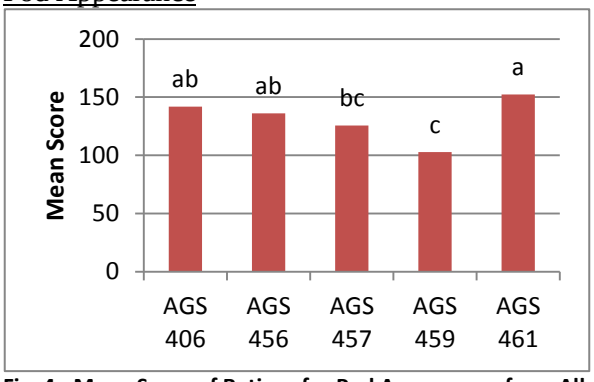

Fig. 4 - Mean Score of Ratings for Pod Appearance from All Participants

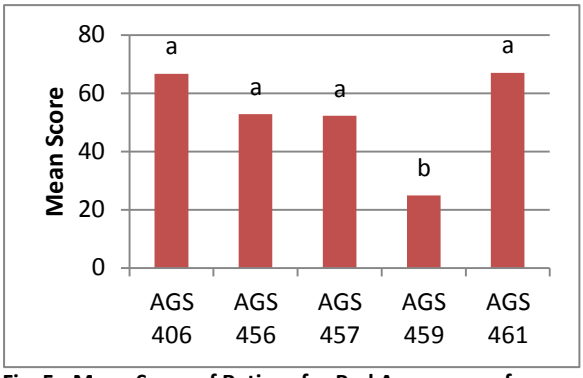

Fig. 5 - Mean Score of Ratings for Pod Appearance from Female Participants

Pod Color

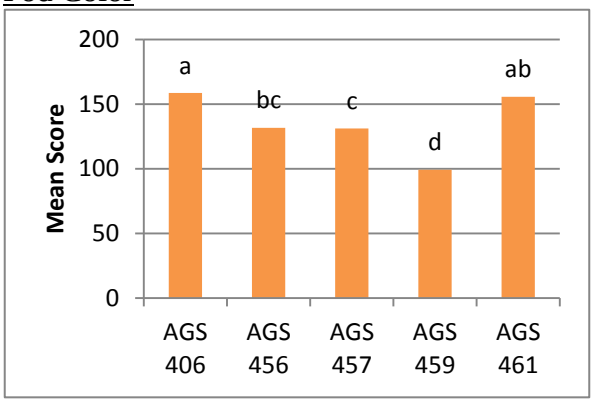

Fig. 6 - Mean Score of Ratings for Pod Color from All Participants

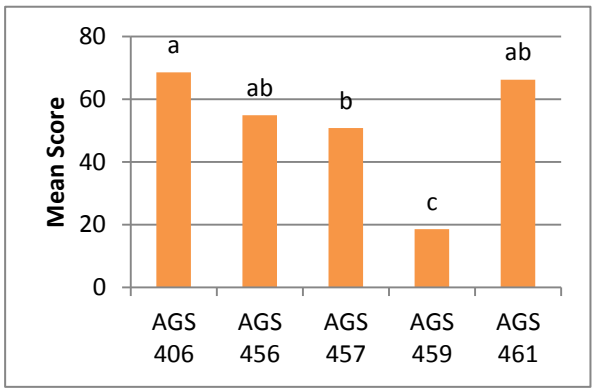

Fig. 7 - Mean Score of Ratings for Pod Color from Female Participants

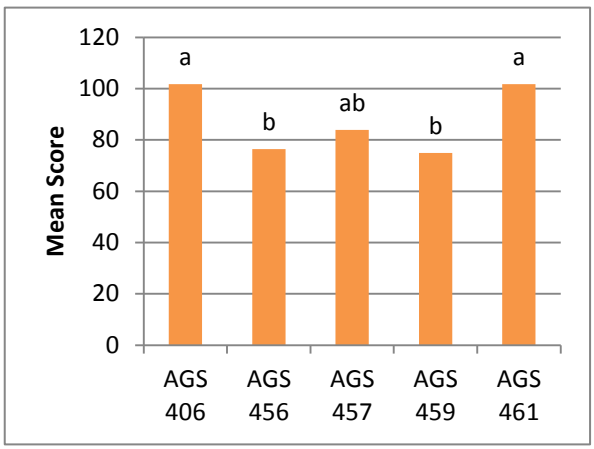

Fig. 8 - Mean Score of Ratings for Pod Color from Participants Over 20 Years Old

Seed Texture

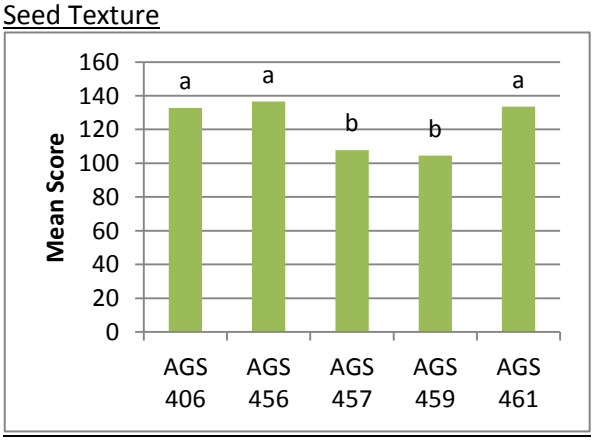

Fig. 9 - Mean Scores of Ratings on Seed Texture from All Participants

Seed Color

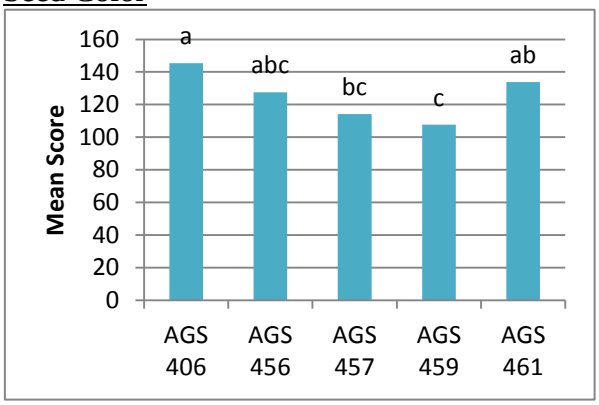

Fig. 10 - Mean Score of Ratings on Seed Color from All Participants

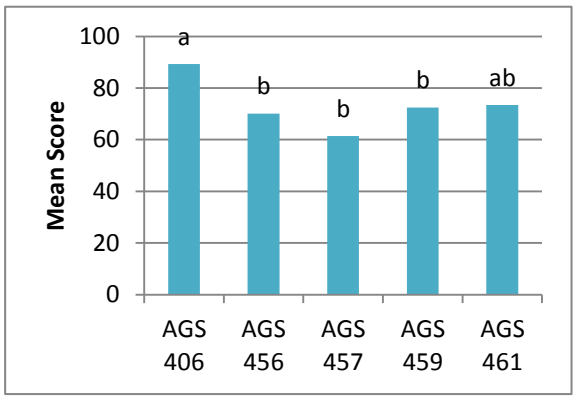

Fig. 11 - Mean Score of Ratings on Seed Color from Male Participants

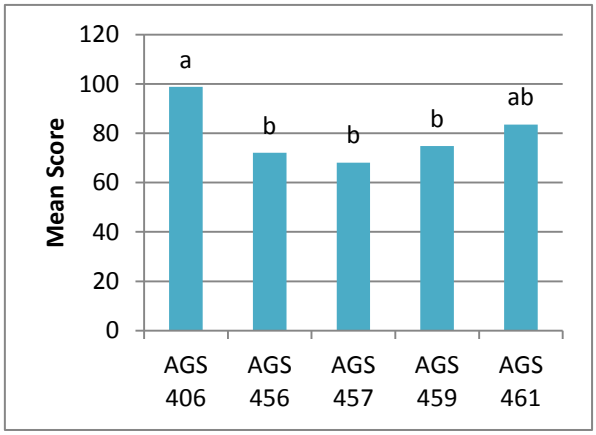

Fig. 12 - Mean Scores of Ratings on Seed Color from Participants Over 20

Taste

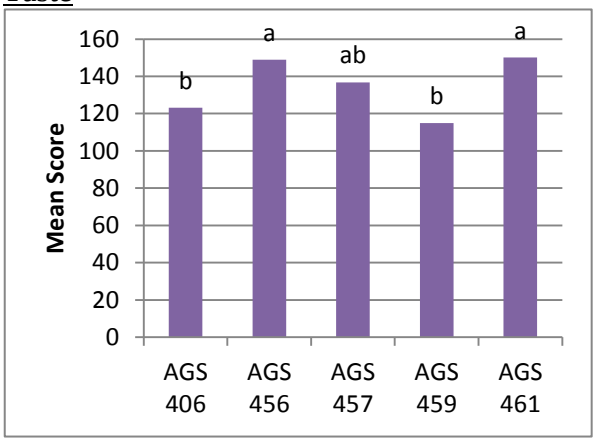

Fig. 13 - Mean Scores of Ratings on Taste from All Participants

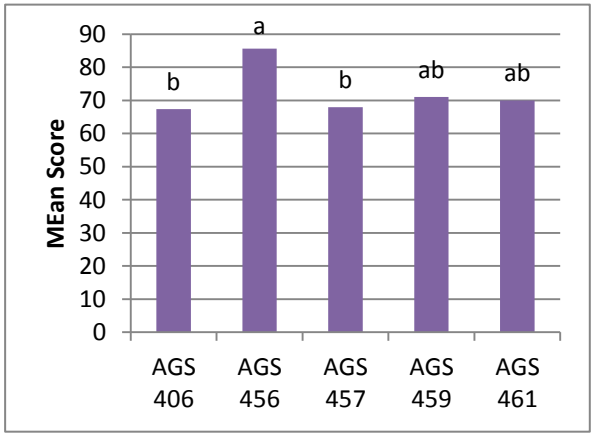

Fig. 14 - Mean Scores of Ratings on Taste by Male Participants

Overall Quality

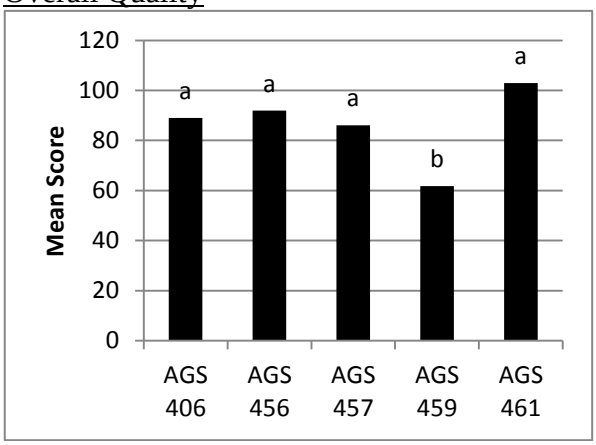

Fig. 15 - Mean Scores of Ratings on Overall Quality from All Participants

Discussion

While not all of the results were statistically significant, the basmati varieties were generally favored over the one non-basmati variety (AGS 406) in taste, while AGS 406 performed well in appearance. AGS 459 performed worst in each of the evaluated qualities. However, data for variety AGS 459 were limited, as the yield was quite low and there were not enough pods for each participant to try. This may have contributed to the poor performance of AGS 459.

In terms of appearance, AGS 406 performed very well, scoring highest in pod color, pod texture, seed appearance and seed color. AGS 406 was notable for its bright green pod and lack of hairs, which may be favorable to consumers. AGS 456 was favored for its pod appearance, seed smell, and seed texture. This may indicate favor for basmati fragrance and gray seed color. Finally, in the two most important categories of taste and overall quality, variety AGS 461 performed best.

Conclusion

This taste survey was intended as a preliminary test of AVRDC vegetable soybean varieties. It was small and somewhat limited in scope. As such, further tests need to be done on a larger scale to legitimize any findings. Tentative conclusions based on patterns from this data seem to indicate that certain qualities are found favorable by Indians: basmati flavor and aroma, green pod color and lack of pubescence, and gray seed color.

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Acknowledgments

I thank Dr. Ramakrishnan M. Nair, legume breeder, AVRDC, for his guidance as a mentor.
I thank Mr. Abhishek Rathore, Biometrician, ICRISAT for statistical analysis.

Harvesting soybeans

Preparing soybeans

The taste-test survey

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AVRDC Experiences

Beyond my vegetable soybean research report and survey, I learned much about the workings of AVRDC and plant science. While my adviser was away, I was able to try cross-breeding Mungbean with another legume breeder in the office. This was, in a way, a more straight-forward process than I expected: with a tweezer, one emasculates the "female" flower by removing its pollen. Then, pollen is taken from the "male" flower and put inside the bud of the female flower. I also dissected a soybean flower.

I was able to see the AVRDC plots in the ICRISAT fields, and observe a Mungbean and soybean crop grow after they were sown. I saw their example Home Gardens, carefully designed vegetable plots that yield enough to provide a family with food and proper nutrients for a year. I visited both a weekly city and daily village vegetable market. I was given tours of the various ICRISAT facilities; the gene bank and genomics lab, for example, to broaden my knowledge of plant research and biology.

I was welcomed warmly to the AVRDC office. I had my own laptop and cubicle, situated, thrillingly, just below the air-conditioning vent. Whenever I had a problem or question, it was willingly answered, and everyone showed much concern for my health and enjoyment. I always looked forward to the afternoon tea break when the office would come together to chat.

At a village vegetable market

Huyen observes as I dissect a soybean flower

Part of the group on the ICRISAT campus tour

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Volunteer Work – IACD

At the beginning of July, I enquired about options for volunteering in or around ICRISAT. As my work in the office was processing and I had some spare time, I thought I should utilize the opportunity to the fullest. I hoped to get in touch with a more "real" sense of India, as the ICRISAT campus could sometimes feel isolated from the realities of the outside. I was referred to the

ICRISAT Association for Community Development (IACD), and was truly impressed by my first introduction. The center is located on the edge of campus, and is part of ICRISAT's mission to assist with local community development. The IACD evolved from the ICIRISAT Ladies Association for the Welfare of Women and Children (ILAWWAC), founded in 1980. Now it serves as place to help young men and women get an education and skills training. Classes are offered at a highly reduced price for local villagers or students who might not otherwise be able to afford school fees. They offer courses such as spoken English, computer skills, accounting and mathematics. They also have classes for women to learn marketable skills like tailoring, stitching, cloth-painting, and making products like soap, shampoo and chocolates, which are sold in the ICRISAT campus gift shop to help fund the IACD.

After meeting with two of the teachers, Surekheh and Lakshmi, and getting an overview of the programs, I volunteered to help with the spoken English courses. To help me prepare, they lent me a few grammar books to read. When I returned after a few days later during which a two-day city-wide strike closed the school, I expected to be an assistant, or to help with corrections, so I sat with the students. Instead, to my surprise, Lakshmi gestured to the front of the room and invited me to begin. I went blank. I blundered through introductions – tell me your name, how to spell it, your age, about your family, your interests. It was a diverse group, ranging from 17-year-old students to 'house-wives'. I finally turned to Lakshmi and asked what lesson they were on. They had just finished tenses, so I tried to do some review of this, but was asked by on girl to please teach something new – they were bored with tenses. So, for the rest of class we played little word games on the white board. I felt unsure the entire time, but it was still fun because the students were welcoming and seemed enthusiastic, even when we couldn't fully understand each other. After the class we took a group picture, and I promised to bring back copies.

The subsequent classes became easier. Although I came at a regular time, the class was never the same – students attended at random, it seemed. Nonetheless, I eventually began to learn names and become familiar with some of the regulars. We became more comfortable with each other and were able to have a better time, laughing freely and communicating more smoothly. We spent more classes conversing almost purely in stilted English. I learned a lot about Indian culture by asking about the school system, politics, festivals, celebrations, food, and in turn invited them to ask me anything about the United States. On a few days I brought in my laptop to show them a picture slideshow I put together of my home and family and of famous sites in the U.S. I shared no-bake cookies with them, and was given Indian treats and a birthday rose. As a parting gift, one of the students, Bushpa, even gave me henna (*mehindi)* on my hand. I really enjoyed my time at the IACD, and loved to meet all the students, who were kind, patient, and eager. I think the "service" nature of the work made my internship much more meaningful. I sincerely hope I was helpful.



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Cultural/Personal Experiences

Simply being able to experience the day-to-day life of another culture was one of the most valuable parts of the internship. There were of course many differences, both big and small, between the American and Indian cultures. For example, small differences included driving and walking on the left side of the road; light switches turning "on" in the opposite direction; a side-to-side bobble of the head indicating "yes" as opposed to the expected nod. Bigger adjustments included the language barrier, adapting to different social etiquette, and coping with the lesser status of women.

The traffic in India lived up to its reputation as it was frighteningly chaotic. Each expedition outside of the ICIRSAT campus was like a little adventure, whether travelling by car, auto-rickshaw or bus. I never got used to the U-turns sometimes taken in the direction of oncoming traffic, or the tight squeezes between trucks painted with "Honk Please," or the boldness of pedestrians dashing across the street and cab drivers weaving off the road. I watched entire families perched on motorbikes and women riding sidesaddle while clutching one or two babies, upwards of ten adults packed into the little three-wheeled yellow taxis, nimble teenager's riding atop the cargo in the beds of trucks, and shepherds leading herds of goats or cattle along the street.

Sahima, Helene, Mari, myself, and Milind in an auto-rickshaw

Cattle plowing rice paddies in Kothapully

Cooking with Mari, Sahima, Amita and Helene

As a vegetarian and fan of Indian cuisine, I loved the food. I had little trouble adjusting to the canteen's Indian, albeit westernized, menu. For the first month or so, I tried new dishes whenever I could, and soon developed some favorites. I had lots of *chapati*, or the staple thin bread, and plain yogurt, or curd, once or twice a day – at first to negate the spice, but then out of habit. I tried many different vegetable dishes, often without knowing exactly what they were, but rarely tasted one I didn't like. Two of my favorites were *daal* (lentils) and palak (spinach), especially with paneer (a distinctly Indian cheese that is a bit like ricotta). After a while, when the canteen's menu became a bit redundant, I got creative – adding sugar, vanilla extra and banana slices to the curd to make a parfait, or making a peanut butter and banana sandwich with chapati.

One of the best parts of the internship was being able to meet so many amazing fellow interns from around the world. I became good friends with Helene from France, Daniel from Switzerland, Sahima from Bangladesh, Mari from Puerto Rico, Harshal, Millind, Amita, Uma and Pooja from India. I am so grateful to them, and of course my fellow Borlaug-Ruan intern Shraddha, for making the stay fun. It was with them that I travelled outside the campus and toured the city, watched movies (lots of Harry Potter), swam, bird-watched, did yoga, and enjoyed myself outside of work. Cooking together was one of the best parts, and we found many excuses to have little feasts. Although the dorm kitchenettes did not have ovens, I managed to make some No-Bake Cookies (chocolate, peanut butter, and oat cookies) on a hot plate. Additionally, I picked up some new recipes from around the world: Banoffee Pie (a British dessert), Indian gravy, Afghani-style rice, as well as improvised some American staples like potato salad. And, for Huyen's last week at AVRDC, I prepared a carrot cake in the office microwave.

Sight-seeing was one of my favorite parts of the trip. My first major excursion was to the Charminar, the classic, four-tired icon of Hyderabad, and neighboring Laad Bazaar, famous for its selection of bangles. My favorite destination was the Golconda Fort, a sprawling, 500-year-old stone fortress on a beautiful hillside which afforded breathtaking vistas. We came once on the day of a festival, and after being welcomed heartily with my own bindi and almost witnessing a goat sacrifice, Helene and I were swept to the fore-front of one of the parades winding up the Fort's steps, as a man possessed by a god slowly ascended to see a goddess. I returned a second time with Daniel on a more serene day, and had a guided (and slightly embellished) tour to learn about the history. Here, and in the nearby tombs, I had many requests for pictures and was led around by my enthusiastic, helpful locals. I visited many other memorable historical and cultural sites with my friends like the Mecca Masjid Mosque, where I had to cover my head with a scarf, the peaceful Qutub Shahi and Paigah Tombs, and the extravagant Chowmahalla Palace.

In front of the Charminar

Daniel and I pose at the Golconda Fort

Daniel, myself, Shraddha and Sahima at the Chowmahalla Palace

As a tall, green-eyed, western-dressed girl, I was apparently conspicuous – especially when wearing my surgical mask to protect against pollution. This made things more interesting. I received much attention outside of campus; for example, at the Golconda Fort, I once had a queue of almost thirty people waiting to take their picture with me. People were usually quite friendly, introducing themselves and wanting to know how I liked India. The only downside was automatically being marked by vendors for the higher "tourist" price for almost anything – street food, auto-rickshaw fairs, or a souvenir at the market – but at least I got to try my hand at bargaining.

Aside from customary tourist destinations, I enjoyed simply getting outside of the campus. In my first few days, I visited the local police station three times, and even experienced a Hyderabad hospital from the inside. I saw a range of places, from the upscale malls of the ritzy Banajara Hills, where we shopped and ate at a Hard Rock Café, to the local Vijeta Grocery store near the ICRISAT campus, to the rural village Kothapully with Helene for her own research project.

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Reflection

I can sometimes be quite critical of America policies and standards while seeing the best in the traditions and values of foreign countries. During my stay in India, I had much time to re-evaluate. As an outsider, I had the chance to more objectively observe a culture than can someone anchored within it. I was perplexed by the contrast between the penchant for hospitality and friendliness from strangers and the tendency for vendors to try to take advantage of foreigners at every opportunity. I was bothered by the widespread treatment of women as second-class and the vestiges of a rigid and, to me, unfair caste system, and alarmed by the rampant poverty and

pollution. Subsequently I feel that I now have a fairer view of my own country and its role in the world; certainly not perfect, but I can better appreciate my own freedoms and securities. I don't feel any wiser in the ways of the world, just a little less ignorant.

I know I got only a very limited view of one city in India. The ICRISAT campus sometimes felt like a bubble; the sereneness and cleanliness of the sweeping lawns, greenery and fresh air were in stark contrast to the dusty, bustling chaos of "outside." It was easy to sometimes feel disconnected from the problems that the internships are designed to help us experience and confront. I am very glad to have been able to volunteer at the IACD; aside from being a worthwhile way to spend my time, I loved to meet the students. It provided a forum for me to hear from a much more diverse and raw sampling of Indians. I was fascinated to hear the takes on Indian customs, such as arranged marriage, from people my own age.

While it was always fascinating to venture "outside," it was not easy. Aside from it being physically taxing – I wore a surgical mask because my asthma was so bothered by the pollution – it was difficult to face the stark reality of the subcontinent. There are four times as many people in India as in the U.S., but the country is one third of the size. By my American standards, everything seemed filthy. The air was gray and hazy, vehicles emitted visible fumes, and dirt caked the roads, buildings, stalls, and cars. Garbage was heaped on the sidewalks, in the gutters, in water bodies, in fields. Men candidly relieved themselves on the sides of the road. Pungent smells abounded – decomposition, stagnant water, defecation. I saw hardly any trashcans, let alone recycling bins.

And poverty was everywhere. Slums of ramshackle dwellings made of blue tarps or pieces of corrugated metal were commonplace. I passed beggars everywhere, and rather than getting used to it, I felt increasingly wretched. I hated ignoring them, but I did, and am not proud of it. A few vivid instances remain with me. Once, when we were in an auto-rickshaw coming home from the Charminar, while stalled in traffic, a stooped old man thrust his arm – only a swollen stump cut off at the elbow – into the taxi. I gasped and recoiled, relieved that we had begun to move again. Helene reminded me that we couldn't do anything; he must've been mutilated as a child to become a more pitiable beggar, and wouldn't benefit from a donation anyway, as it would just go back to his boss. Another time, while waiting at a bus station, a woman spent long minutes alternately tapping each of us on the arm, showing us her hand upturned, and pointing at her big, watery-eyed baby's mouth.

I did sometimes feel disconnected, and part of this feeling of detachment came from the knowledge that soon, I would be leaving and returning to the comforts of home. I was relieved by this, but ashamed of this relief. I was not sure how much responsibility I would feel I needed to bring back with me. This has certainly been an impetus to live my own life more responsibly. I will be much more conscious of the ample food accessible to me. I have much more to consider my choices and actions. Should I because I can? Should I not because others can't?

In the beginning of the internship, I was often frustrated and homesick. However, by the end of the two months, I had made new friends whom I was very sad to leave. My appetite has be whetted for travel abroad; I now long, more than ever, to keep exploring the world, of which I have seen such a limited amount, and to keep meeting new, fascinating people.

Beyond the intended motivation to join the fight against hunger, my time in India has further stoked my interest in working for women's rights and the environment. My tentative plan for the near future is to major in Environmental Science with a minor in International Studies at Oberlin College. I will certainly continue my work as an environmentalist and human rights volunteer work. In India

I learned of many of the ways to join the cause to help alleviate poverty, and I am confident that I can find productive role and a pathway to it.

At the Mecca Masjid Mosque with new friends

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Appendix 1 – Edamame Recipes

Edamame Chickpea Burger

From http://recipes.sparkpeople.com/recipe-detail.asp?recipe=550297

Ingredients
1 15 oz can of Chickpeas, drained
1 cup of shelled Edamame
2 garlic cloves
1 chopped scallion
1 tsp Cumin

Directions
Place ingredients in a blender and combine together to form patties. Use a nonstick skillet and cook until each side is a crunchy golden color.

Number of Servings: 4
Analysis of nutrition per serving:

Ingredient	Energy (kcal)	Protein (g)	Total Lipid (g)	Dietary Fiber (g)	Sugars (g)	Calcium (mg)	Iron (mg)	Zinc (mg)
Chickpeas, canned (100 g)	119	4.95	1.14	4.0	--	32	1.35	1.06
Edamame, frozen, prepared (39 g)	47	4.2	2.01	2.03	.85	24.5	.88	.53
Garlic (.5 clove)	2	.09	.01	.05	.01	2.5	.02	.02
Scallion (.25 medium)	1.25	.07	.01	.1	.09	2.75	.05	.015
Cumin (.25 tsp whole)	2	.09	.12	.05	.01	5	.35	.025
Total	171.25	9.4	3.29	6.23	.96	66.7	2.65	1.65

Kerala-Style Edamame Curry
From http://www.joanne-eatswellwithothers.com/2011/03/kerala-style-edamame-curryeatlivebe-for.html

Ingredients
Serves 5-6, adapted from Vegetarian Times

1 tbsp anise seeds or fennel seeds
1 tbsp brown mustard seeds
2 tsp cumin seeds
2 tsp olive oil
1 large onion, half chopped, half sliced, divided
4 cups low sodium-vegetable broth
1 can light coconut milk
1 large butternut squash, seeded and diced (about 4 lb)
1 medium head cauliflower, cut into bite-sized pieces
2 tbsp minced fresh ginger
1 tsp ground turmeric

1 tsp coarse salt
2 cups frozen shelled edamame
sriracha, to taste
6 tbsp unsweetened flaked or shredded coconut
1/2 cup chopped cilantro

Directions
1. Heat anise/fennel, mustard, and cumin seeds in a dry skillet over medium-low heat. Cover and cook 2 minutes or until mustard seeds begin to pop, shaking the pan occasionally. Turn off heat and keep skillet covered until popping subsides.

2. Heat 1 tsp oil in large saucepan over medium heat. Add chopped onion and saute 6 minutes. Add 1 cup broth, stirring the bottom of the saucepan to lift off any brown bits, then add remaining 3 cups broth and coconut milk. Stir in squash, cauliflower, ginger, turmeric, salt and toasted spices. Bring mixture to a boil. Reduce heat to low and simmer, uncovered, 25 minutes. Add edamame and cook 10 minutes more. Add sriracha/hot sauce and salt to taste.

3. Meanwhile, toast coconut in a small skillet over medium heat for 3-4 minutes or until browned and fragrant. Set aside.

4. Heat remaining 1 tsp oil in medium skillet over medium heat. Add sliced onion. Saute 12 minutes or until golden.

5. To serve, spoon into 6 bowls and garnish each serving with golden onion slices, toasted coconut and cilantro.

Edamame and Cauliflower with Indian Spices
From http://www.mangotomato.com/2010/09/cauliflower-and-edamame-with-indian.html

Ingredients
1 tablespoon canola oil
1 teaspoon mustard seeds (I used black mustard seeds my friend Radha gave me!)
1/2 teaspoon cumin seeds
1/2 teaspoon coriander seeds, crushed
1 head of cauliflower, cut into medium sized florettes
1/2 teaspoon turmeric
1/2 teaspoon ground ginger
1/2 teaspoon cayenne
8 ounces frozen edamame
toppings: thinly sliced red onion, cilantro leaves

Directions
1. Heat oil in a pan. Add mustard seeds, cumin seeds and crushed coriander seeds. Wait until seeds pop; add cauliflower, the rest of the spices, and season with salt and pepper.
2. Let the cauliflower cook for about 5 minutes. You might have to add a bit of water to get the process going.
3. Add edamame, stir. Cover the pan with a lid and let the vegetables cook until they reach the level of tenderness you prefer.
4. Serve this dish hot or at room temperature with thinly sliced red onion and leaves of cilantro. You can also add a heaping tablespoon of yogurt.

Appendix 2 – Taste Test Survey

SURVEY OF VEGETABLE SOYBEAN QUALITY

27 July 2011

Please fill out the personal information and rate the five different vegetable soybean varieties below. Please take pods one at a time so as not to confuse varieties. Examine pods and open by hand to evaluate seeds before consuming. Take a drink of water between each tasting.

Age:	Under 20 __ 20-30 __ 30-40__ 40-50__ 50-60__ 60+__
Gender:	Female / Male
Native Country:	
If India, native state:	
Have you ever tasted vegetable soybean before?	Yes / No

Please rate the vegetable soybeans by the following scale:

1	2	3	4	5
Poor	**Fair**	**Moderate**	**Good**	**Excellent**

	A	B	C	D	E
POD					
Appearance					
Color					
Texture					
SEED					
Appearance					
Color					
Smell					
Texture					
Taste					
Comments (specific taste, defects, etc.)					
OVERALL					

Thank you for your participation!