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Indigenous Vegetables in Tanzania

Significance and Prospects

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AVRDC—The World Vegetable Center is an international not-for-profit organization committed to ensuring the world's food security through research, development, and training.

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1 Introduction

African indigenous vegetables play a highly significant role in food security of the underprivileged in both urban and rural settings (Schippers, 1997). They can serve as primary foods or secondary condiments to dishes prepared from domesticated varieties. They are also valuable sources of energy and micronutrients in the diets of isolated communities (Grivetti and Ogle, 2000). Further, they may serve as income sources and may be marketed or traded locally, regionally, even internationally, and the primary importance of edible wild species during periods of drought and or social unrest or war is well documented (Humphry et al., 1993, Smith et al., 1995, Smith et al., 1996). However, the important role of African indigenous vegetables in Tanzania's health sector, diets and as an income source is threatened through extinction of the genetic resources of these species. Many landraces of vegetables are in the process of being replaced by modern varieties (FAO, 1998).

In fact, nowadays only a small number of all vegetables available as foods are produced in highly intensive cropping systems (Table 1.1).

Table 1.1. Biodiversity of vegetables in numbers

1500 – 2000	used as supplementary foods
500	primitive cultivation
200	home cultivation
80	labor-intensive market garden
20	highly intensive crop systems

Source: Siemonsma and Piluek (1994)

In this study, indigenous refers to a crop species or variety genuinely native to a region, or to a crop introduced into a region where over a period of time it has evolved, although the species may not be native. Crops bred scientifically are excluded from this definition. In contrast, exotic crops are crops that have been imported to a certain region (Engle and Altoveros, 2000).

African indigenous vegetables are considered valuable because of their ability to fit into year-round production systems, their nutritional value, and the danger of their extinction. However, crops should be selected for domestication only if there is real nutritional or economic need (Engle and Altoveros, 2000). The objective of this study therefore was to identify priorities for research. The study was funded by GTZ/BMZ as a complementary study to the project “Promotion of Neglected Indigenous Vegetable Crops for Nutritional Health in Eastern and Southern Africa”.

2 Purpose and Approach

2.1 Purpose

The purpose of the study is to provide recommendations for enhancing the role of indigenous vegetables (IVs) for improved nutrition, healthy diet, and diversified income generation in home garden production and commercial farming systems in Tanzania. The study uses a multidisciplinary approach to identify market demand and to analyze values for nutrients that are known to be commonly deficient in the diets of the majority of people in Tanzania. Several of the IV crops that we focused on in this study are those identified by the complementary project "Promotion of Neglected Indigenous Vegetable Crops for Nutritional Health in Eastern and Southern Africa" as target IV crops (see Table 2.1). There are also a variety of indigenous fruits in use and consumed, which are purposely excluded from this study.

2.2 Approach

As mentioned, this study is complementary to the BMZ/GTZ funded project on "Promotion of Neglected Indigenous Vegetable Crops for Nutritional Health in Eastern and Southern Africa". Thus, the outline of this study partly reflects requirements of the companion project. In particular, this holds true for the selection of the sampled area and the crops included into the study. Thus, the four regions covered are Arusha, Singida, Dodoma and Tanga, all in northeastern Tanzania. In addition, we identified several large cities for the willingness-to-pay (WTP) analysis, namely Arusha, Morogoro and Dar es Salaam.

Data were collected using both quantitative and qualitative approaches. Since the companion project includes a large baseline survey component using both qualitative (focus groups) and quantitative approaches (household surveys), rather than duplicating efforts we summarize some of the information derived from these surveys. The focus group meetings, which covered both production and consumption aspects, were supervised by a German MSc student, and the detailed results of those can be found elsewhere (Keller, 2004).

This publication is divided into five different chapters, each one assessing the relevance of IVs from a different angle. In Chapter 3, we provide an overview on the nutritional value of important indigenous vegetables. In Chapter 4, we link these results to factors related to consumption of IVs by rural and urban consumers in Tanzania. Production aspects of IVs, including significance for farm incomes,

Table 2.1. Overview on IVs within the BMZ/GTZ funded project

English	Swahili	Scientific name	Family
African eggplant	Ngogwe	*Solanum aethiopicum* L., *S. macrocarpon* L., *S. anguivi* L.	Solanaceae
Nightshade	Mnavu	*Solanum americanum* Mill., *S. scabrum* Mill., *S. villosum* Mill., *S. eldoretum*	Solanaceae
Spiderflower	Mgagani	*Cleome gynandra* L.	Capparaceae
Amaranth	Mchicha	*Amaranthus* spp.	Amaranthaceae
Bambara groundnut	Njugu mawe	*Vigna subterranean* (L.) Verdc.	Papilionaceae
Cowpea	Kunde	*Vigna unguiculata* (L.) Walp.	Papilionaceae
Crotalaria	Sunn hemp	*Crotalaria brevidens* Benth., *C. ochroleuca* G. Don	Papilionaceae
Ethiopian mustard	Sukuma wiki, loshuu	*Brassica carinata* A. Braun	Brassicaceae
Hyacinth bean	Fiwi	*Lablab purpureus* (L.) Sweet	Papilionaceae
Jute mallow	Mlenda	*Corchorus olitorius* L.	Tilaceae
Moringa, drumstick tree	Mlenda	*Moringa oleifera* Lam.	Moringaceae
Okra	Bamia	*Abelmoschus caillei* (A. Chev.) Stevels, *A. esculentus* (L.) Moench	Malvaceae
Pumpkin	Maboga	*Cucurbita pepo* L., *C. moschata* (Duschesne ex Lam.) Poir., *C. maxima* Duch.	Cucurbitaceae

Source: compiled by Keller (2004).

economics of production and marketing, are discussed in chapter 5. In Chapter 6 we then turn toward the input side of IV production and assess the seed sector for these crops. Chapter 7 provides a brief overview on the current status of collected germplasm in Tanzania. Since the materials and methods used for each perspective vary, they are discussed in detail within each chapter.

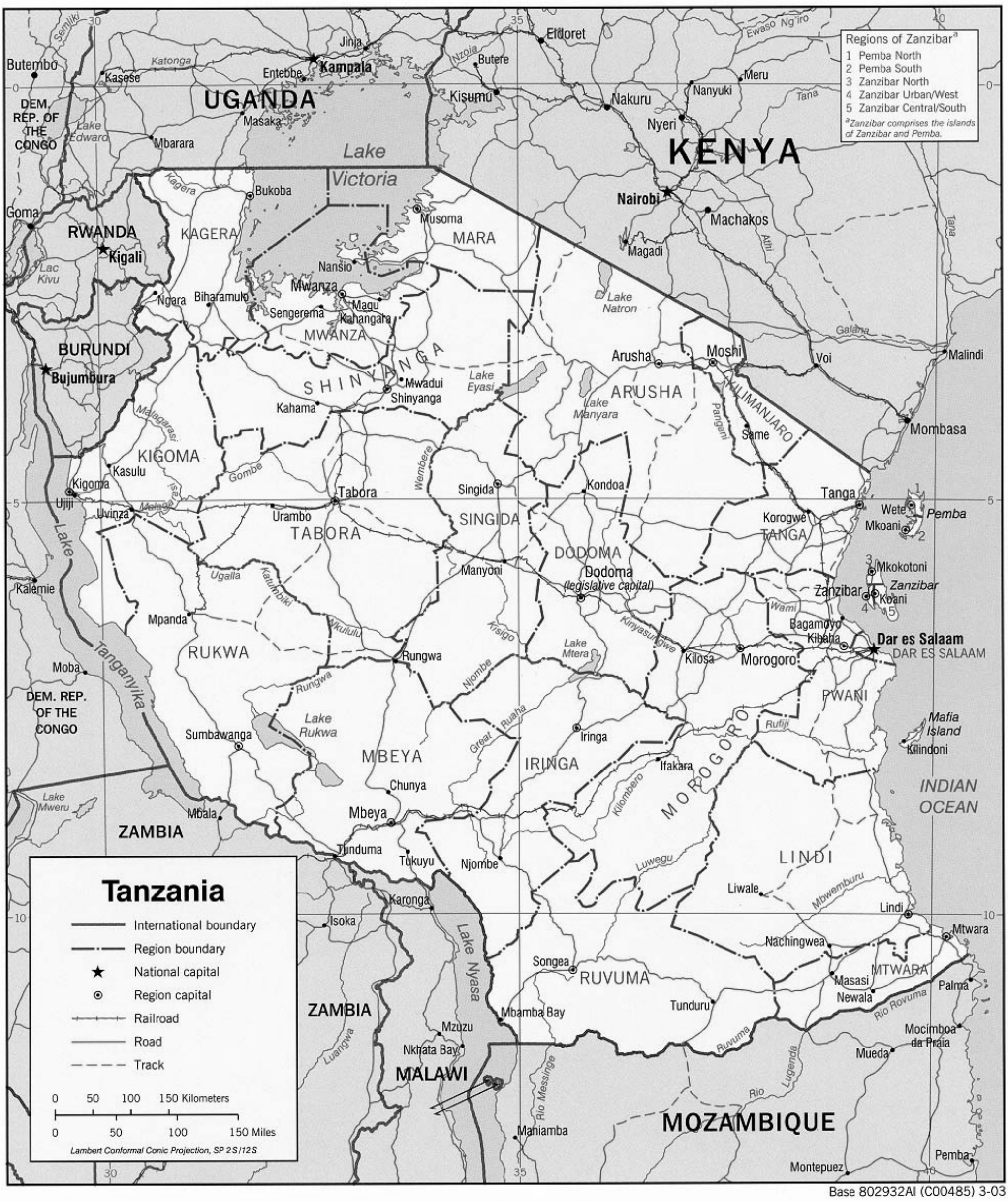

Figure 2.1. Map of Tanzania

3 Nutritional Analysis

3.1 Fieldwork procedures

Four areas were visited, namely Singida, Kongwa, Arumeru and Muheza districts. The research team visited Singida and Kongwa from 12–20 January 2004, and was in Arumeru and Muheza from 24 January– 2 February 2004. The first step in the fieldwork involved selecting a few villages to represent each respective district. Key informants were used to distinguish in each district different social, cultural and ecological zones, which formed the bases for selecting participating villages.

Government officers from the District Agricultural Offices were the first contacts for this exercise. At least one village was picked from each identified distinct zone. The second step involved identification of the indigenous vegetables that are commonly consumed by people in those particular areas. This step called for use of focus group discussions as well as key informants. Members of the focus groups were carefully selected to include both male and female community members, and from varying socio-economic and age groups. The third step in the fieldwork was collection of samples from the respective identified indigenous vegetables.

Administratively, Singida district consists of 7 divisions, 28 wards and 146 villages whereby 2 socio-cultural and ecological zones were distinguished. Two villages were then selected accordingly, namely Kituntu and Kinyeto. Unlike in Singida, Kongwa district is comprised of 3 divisions, which were categorized into 4 socio-cultural and ecological zones. Accordingly, four villages were selected to take part in the study, namely Mlanga, Sagara, Chamkoroma and Mlali. Similarly, Arumeru district has 3 divisions and was categorized into 4 zones, and hence 4 villages were picked, namely Sembetini, Sekei, Temi, and Lemara. On the other hand, Muheza district is comprised of 6 divisions, which were distinguished into 4 zones, and therefore 4 villages were selected, namely Masuguru, Kisiwani, Makole and Duga.

It was initially planned that both raw and cooked vegetables would be collected for analyses. However, due to varying methods of vegetable processing and preparation, which were realized during the fieldwork, the research team gave up on the idea. It was noted, for example, that different ingredients are added at varying proportions and therefore it would have been extremely difficult to obtain a standard recipe. The recipes included adding coconut milk or cream, different types of oil seeds or cooking oils or fat, tomato, onion and milk.

3.2 Methodology of analytical procedures

After collection of the samples in the field, they were carefully handled to ensure that their quality was maintained. This involved keeping them at low temperatures and away from direct sunlight while on transit to the laboratory where they were frozen. Samples that were sent to AVRDC's laboratories in Taiwan for β-carotene analyses were freeze-dried and packed in airtight plastic bags.

3.2.1 Determination of iron and zinc

The atomic absorption spectrophotometer (AAS) method was applied to determine iron and zinc content (AOAC, 1995). A total of 0.5 g of sample was weighed into a digestion tube. Then, 5 ml of 68% nitric acid was added and let stand overnight. The digestion tube was placed in the digestion block and temperature set at 1250ºC and digested for one hour. It was then removed and the tube cooled. A total of 5 ml of 30% hydrogen peroxide (H_2O_2) was added and heated to about 700ºC. After cooling, 5 ml of 30% H_2O_2 was again added and heated once more to 700ºC. The treatment was repeated until the digest was colorless. Temperature was increased to 1800ºC and continued digesting to almost dryness, and was let to cool. A total of 10 ml of 10% nitric acid was added and the dissolved digest transferred quantitatively to a 50 ml volumetric flask. The flask was filled to mark with distilled water and mixed. The solution was then used to determine iron and zinc contents by the AAS.

3.2.2 Determination of ß-carotene

The ß-carotene content was determined using the high-performance liquid chromatography (HPLC) method. One gram of vacuum-dried vegetable was mixed thoroughly with 100 ml of 6 hexane:4 acetone (v/v) solution, and 0.1 g $MgCO_3$ in a homogenizer. Acetone was then washed out five times with salt-saturated water. The hexane extract was filtered with a 0.45-µmol filter. Analyses were performed using HPLC (HPLC; Waters, Milford, Mass.) equipped with a 717 plus autosampler, 600 controller, 996 photodiode array detector with a 125 × 4-mm LiChrospher 100 RP-18e column, 5 µm (Merck, Darmstadt, Germany) under isocratic conditions at ambient temperatures. The mobile phase was 75 acetoniltrile : 25 methanol (v/v) at a flow rate of 1.5 mL/min. ß-carotene quantification was carried out at a single wavelength of 436 nm. Concentration of the TLC purified ß-carotenoid standard (Sigma Chemical Co., St Louis, MO) was calculated by absorption coefficient $A^{1\%}$ 1 cm in ethanol prior to HPLC analysis for calibration.

3.3 Micronutrient content

3.3.1 Mineral contents of amaranth, African nightshade and African eggplant

a) Iron (Fe)

General observation

Of the three target vegetables, amaranth had the highest Fe contents (up to 37.05 mg per 100 g of edible portion) followed by African nightshade (up to 15.90 mg)(Table 3.1). The African eggplant has the lowest contents of Fe (being as low as 2 mg per 100 g of the edible portion). The table also shows that there are great variations within same species between districts (the locations where the vegetable samples were grown and collected), and also across varieties. For example, the highest value for Fe contents in amaranth was recorded in samples collected from Kongwa (37.05 mg per 100 g of edible portion) as compared to only 6.50 mg found in one sample from Arumeru. Variations in varieties collected from same districts were noted among six amaranth varieties in Muheza and Arumeru districts, and also between two African nightshade varieties in Arumeru district.

Comparison with others in literature

Recent studies by researchers from the Sokoine University of Agriculture on indigenous vegetables in Iringa and Morogoro regions (Kinabo et al., 2004) reported contents of Fe in African nightshade of 6.10 mg per 100 g edible portion, which compares well with values recorded for Arumeru and Muheza (Table 3.1). Other studies with findings comparable to the current study include Mwajumwa et al. (1991) in Kenya who reported contents of Fe of 11.8 ± 6.4 mg in African nightshade and 10.6 ± 5.1 mg in amaranth. Raja et al. (1997) reported Fe contents of 13.43 mg per 100 g in amaranth sold in Dar es Salaam markets.

b) Zinc

General observation

Like for the case of Fe, it appears that amaranth has the highest contents of Zn (as high as 0.885 mg per 100 g edible portion) followed by African nightshade. Again, the least Zn contents are found in African eggplant, having as low as 0.120 mg. Inter-district variations among the species as well as differences among varieties are also common.

Comparison with others in literature

Kinabo et al. (2004) reported contents of Zn in African nightshade to be 0.57 mg/100 g edible portion, which is slightly higher than those observed in the current study (Table 3.1). Raja et al. (1997) reported even a higher value of 4.08 mg/100 g for amaranth collected in various markets in Dar es Salaam. Studies from other parts of Africa (Ogle and Grivetti, 1985) show values of Zn in amaranth and nightshade grown in Swaziland to be 1.20 ± 0.44 and 1.34 ± 0.45 mg per 100 g, respectively. Both values are higher than those observed in the current study.

3.3.2 ß-carotene contents of amaranth, African nightshade and African eggplant

General observation

Amaranth and nightshade have the highest ß-carotene contents of up to 7.54 mg per 100 g of the edible portion (Table 3.1). The African eggplant has the lowest contents (as low as 0.04 mg per 100 g of the edible portion).

Variations within same species between districts, and also across varieties are again exhibited. For example, the highest value for ß-carotene contents in African nightshade was recorded in samples collected from Muheza (5.02 mg per 100 g of edible portion) as compared to only 1.09 mg found in one sample from Singida. Variations in varieties collected from same districts were noted among six amaranth varieties in Muheza and Arumeru districts, and also between two nightshade varieties in Arumeru district.

Comparison with others in literature

To some extent, the scanty literature values available do compare well with results of this study. Mwajumwa et al. (1991) reported contents of ß-carotene in *Amaranthus* spp. collected from three locations in Machakos district in Kenya to vary between 7.0 ± 0.2 and 7.9 ± 2.4 mg per 100 g of edible portion. Ogle and Grivetti (1985) reported a value of 5.616 mg for the same type of vegetable in Swaziland. These results only compare well with that of one variety from Muheza district (broadleaf mchicha) from this study (Table 3.1). On the other hand, Latham (1997) reported a value of 1.75 mg[1] for amaranth from vari-

[1]Calculated from the given value of vitamin A content (292 mg per 100 g edible portion) by assuming that 6 parts of ß-carotene are equivalent to 1 part retinol (vitamin A).

Table 3.1. Iron, zinc and ß-carotene contents of amaranth, nightshade and African eggplant (mg/100 g)

Vegetable/ District/ Vegetable type	Fe	Zn	ß-carotene
Amaranth			
Kongwa	37.05	0.433	3.29
Singida	22.95	0.363	2.70
Muheza			
-variety 1 (common type)	13.55	0.372	3.79
-variety 2 (spiny type)	7.95	0.489	0.86
-variety 3 (broadleaf type)	5.95	0.885	7.54
Arumeru			
-variety 1 (dark leaf type)	13.15	0.810	1.71
-variety 2 (broadleaf type)	8.60	0.534	2.10
-variety 3 (indigenous type)	6.50	0.512	0.13
Nightshade			
Kongwa	8.90	0.261	3.23
Singida	14.55	0.351	1.09
Muheza	6.95	0.205	5.02
Arumeru			
-variety 1 (common type)	15.90	0.374	3.97
-variety 2 (broadleaf type)	9.75	0.380	1.82
African eggplant			
Kongwa	2.20	0.120	0.04
Singida	2.45	0.325	0.19
Muheza	2.80	0.176	0.29
Arumeru	2.00	0.218	0.11

ous parts of Africa, which seems to agree well with two varieties from Arumeru district. However, ß-carotene content of nightshade reported by Mwajumwa et al. (1991) in Kenya (10.0 ± 1.2 mg) is higher than those from this study.

3.3.3 Mineral contents of other identified indigenous vegetables

a) Iron (Fe)

General observation

Results of Fe contents of other IVs are presented in Annexes 1 through 4. It is evident that amounts of Fe found in these vegetables do differ not only according to type of vegetable but also according to the place or district where it was obtained. Indigenous vegetables that have shown the highest contents of Fe (exceeding 18.0 mg per 100 g edible portion) include: spiderflower plant, bitter lettuce (mchunga), jute mallow (mlenda, pumbwiji) and pumpkin leaves from Kongwa district.

In Singida district the highest values are found in spiderflower plant, bitter lettuce, muganji, ndelo-aghwara, kasipa, kituntu (makanja), kabuhi and maimbe. Only one type of vegetable each in Muheza and Arumeru districts has values exceeding 18.0 mg per 100 g edible portion. The vegetables are limi ja ng'ombe in Muheza district and cowpea leaves in Arumeru.

Vegetables that are common in the four districts do not necessarily have values of Fe contents that are comparable. For example, cowpea leaves were identified and collected from all the four districts; however, their values were quite different, varying from 17.90 mg in Kongwa, 6.60 in Singida, 7.75 in Muheza and 18.70 in Arumeru per 100 g of edible portion.

Comparison with others in literature

It has been reported that Fe contents in vegetables vary according to iron availability or plant uptake at different collection sites (Ogle and Grivetti, 1985). Since the vegetable samples were collected from four districts that have different soil characteristics, the observed intra-species variations in the current study are therefore not surprising. Other findings in Tanzania that are comparable to the current study include those on cowpea leaves (Raja et al., 1997), cassava leaves (Lyimo et al., 2003) and bitter lettuce (Ndossi and Sreeramulu, 1991). However, findings of other vegetables have shown mixed findings. For example, values for black jack and bitter lettuce (Lyimo et al., 2003) are lower than those observed in the current study while values reported for jute mallow (Kinabo et al., 2004) are higher. On the other hand, Mwajumwa et al. (1991) have reported similar findings for cowpea leaves and pumpkin leaves in Kenya.

b) Zinc

General observation

Results for Zn contents of the identified indigenous vegetables are also presented in Annexes 1 through 4. Again, it is evident that amounts of Zn found in these vegetables do differ not only according to type of vegetable but also according to the place or district where it was obtained. Indigenous vegetables that have shown relatively highest contents of Zn are pumpkin leaves and puncture vine, having more than 1.0 mg per 100 g edible portion and both being from Arumeru district.

Again, vegetables that are common in the four districts do not necessarily have values of Zn contents that are comparable. For example, pumpkin leaves varied among the four districts from 0.196 mg in Kongwa to 0.272 in Singida, 0.297 in Muheza and 1.631 in Arumeru (per 100 g of edible portion). Other common indigenous vegetables include spiderflower plant, sweet potato leaves and cassava leaves. The observed intra-species variations are probably due to differences in soil characteristics in the four districts.

Comparison with others in literature

Kinabo et al. (2004) reported contents of Zn in jute mallow to be 0.47 mg/100 g edible portion, which is comparable with the value for the vegetable from Singida district. Raja et al. (1997) reported higher values of more than 2.0 mg/100 g of dry weight (as opposed to fresh weight used in the current study) for cowpea leaves and pumpkin leaves sold in various markets in Dar es Salaam. Studies from other parts of Africa (Ogle and Grivetti, 1985) show values of Zn in jute mallow and black jack to be higher in Swaziland than in the current study.

3.3.4 ß-carotene contents of other identified indigenous vegetables

General observation

Results of ß-carotene contents of the identified IVs are presented in Annex 1 through 4. Indigenous vegetables that have relatively high contents of ß-carotene in each district (exceeding 5.0 mg per 100 g edible portion) include: pumpkin leaves and cassava leaves from Kongwa district, and spiderflower plant, bitter lettuce, jute mallow, *Erythrococoa kirkii*, cassava leaves and chili pepper leaves from Muheza district. Cowpea leaves, cassava leaves, puncture vine and chili pepper leaves from Arumeru district are also in this category. However, none of the indigenous vegetables from Singida district appear in this group, which may indicate presence of a problem in handling of the samples from that particular district. ß-carotene is known to be sensitive to environmental and treatment conditions (Guthrie, 1986).

Comparison with others in literature

Mwajumwa et al. (1991) reported contents of ß-carotene in cowpea leaves collected from three locations in Machakos district in Kenya to be 6.7 ± 1.5 mg per 100 g of edible portion. In Swaziland, Ogle and Grivetti (1985) reported a value of 3.60 mg for pumpkin leaves, 1.80 mg for black jack and 6.41 mg for jute mallow. These results compare well with those of this study. However, ß-carotene content of pumpkin leaves reported by Mwajumwa et al. (1991) in Kenya (9.9 ± 0.8 mg) is higher.

3.4 Discussion of results

It appears that a good number of the analyzed indigenous vegetables in the four districts have a good potential as important sources of the three important micronutrients assessed in the current study. Although many health and nutrition workers in Tanzania have paid much attention on promoting consumption of 'imported' vegetables such as spinach, when it comes to using a food-based approach for combating dietary anemia, they may need to rethink and focus more on some of these indigenous vegetables. For example, while the iron contents of spinach (*Spinacia oleracea*) found in most parts of Africa is known to be 1.7 mg per 100 g edible portion (FAO, 2004), the values observed in this study for amaranth and nightshade are as high as 37 mg. Other noted good sources of iron include spiderflower plant and hairy lettuce (up to about 50 mg per 100 g of edible portion). By the fact that all these four vegetables are not yet fully cultivated, it would be wise to take necessary actions to promote their production and consumption. Increased consumption will likely lead to need for increased marketing of such products. It is by capitalizing on the latter that it will be possible to open the door for full domestication of such vegetables, and hence nutritional security for the households in both rural as well as urban areas.

4 Consumers Perspective

The former chapter has shown that many indigenous vegetables, for instance amaranth and nightshade, have a high iron content and thus hold a good potential to contribute to food-based approaches in combating dietary anemia. However, consumption, next to price and income, largely depends on food preferences of individuals. There is evidence that the 'nutrition transition' has reached developing countries, particularly the urban population there (Millstone and Lang, 2003). This transition is characterized by a decline in consumption of traditional food crops, and increasing consumption of refined and processed foods, fats, sugars, and animal foods. Would increasing production of indigenous vegetables crops thus be met by increasing demand? This chapter outlines the demand for indigenous vegetables by rural and urban consumers in Tanzania.

4.1 Data sources

This chapter summarizes information collected through a household survey that covered a randomly selected sample of 358 rural households in four districts of Tanzania (Arumeru, Singida, Kongwa and Muheza). As the survey described in the next chapter on production aspects, this survey was also determined by requirements of the companion project. In fact, many of the households participated in the same survey, although usually with a different respondent. All respondents within this survey are women. The questionnaire was comprised of a section on socio-economic variables of the household, a general introduction to consumption aspects of IVs, a section of attitude and beliefs concerning IVs, and a detailed 24 h food recall. Administration of each survey took approximately 40 minutes.

In addition, a survey among 287 randomly selected frequenters of urban markets was conducted in Dar es Salaam, Morogoro and Arusha in October 2003. This questionnaire was much shorter and included a section on socio-economic variables, a section on preferred traits in three popularly marketed IVs (amaranth, nightshade and African eggplant), and a section on the willingness to pay for those three IVs. Administration of this survey took approximately 10 minutes.

4.2 Consumption of indigenous vegetables

Indigenous vegetables provide an important contribution to the diet. Based on a 24 h food recall, about 27% of all vegetables consumed the day before were indigenous vegetables (Table 4.1). In the rainy season, they are usually consumed daily to several times a week, while during the dry season frequency of consumption spans from once a week to several times a week. This is similar for all four regions. Yet, the frequency of consumption appears to have decreased over time. In her dietary study in the Usumbara mountains of Tanzania, Fleuret (1979) concluded that wild vegetables accounted for over 80% of all leafy vegetables consumed. Indeed, wild vegetables were the major ingredient in side dishes or condiments to staple foods in 25–43% of the meals recorded in different villages.

Table 4.1 shows the relationship between wealth status of households and intake of vegetables. The table shows the number of different indigenous and exotic vegetables consumed. The share of IV consumption in all vegetables is much higher among poor households (40%) than among the wealthiest households (12%). Also, the variety in consumption of IVs decreases as households become wealthier, while at the same time the variety in consumption of exotic vegetables increases. Interestingly, total variety in vegetable intake remains relatively stable and increases substantially only for the wealthiest among the households, from on average 3.6 to 5.6. Thus, households appear to substitute indigenous with exotic vegetables, as they grow wealthier.

Figure 4.1 shows the relationship between overall food diversity (number of different food items consumed the day before) and diversity in vegetable intake (total, exotic, indigenous) averaged over all households. Total food diversity increases with overall household wealth. In the left side of the graph, households with low food diversity also have a low diversity in vegetable intake—but the average number of IV crops consumed is higher than the average number of exotic veg-

Table 4.1. Household wealth and diversity of vegetable consumption

Wealth parameter	No. IV consumed	No. exotic vegetable consumed	Total no. vegetable consumed	Share IV in total vegetable consumed
0	1.48	2.20	3.68	40.2%
1	1.13	2.52	3.65	30.9%
2	0.95	2.66	3.61	26.3%
3	0.94	2.82	3.76	25.0%
4	0.77	2.77	3.54	21.8%
5	0.67	5.00	5.67	11.8%
Total	1.02	2.66	3.68	27.7%

Note: Wealth parameter was calculated as sum owned out of radio, chicken, bicycle, mobile phone, electricity. Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households.

etables. As overall food diversity increases, so does the number of diversity in intake of exotic vegetables, while the number of different IV crops consumed flattens out.

In Table 4.2 this relationship becomes even more obvious. Since a large share of all food items consumed is either home produced or collected, in order to value them we attributed an opportunity cost to those products, either at the average village level price, or if not available, at the average district level price. The first two columns show the share of indigenous vegetables and all vegetables in total food value. The proportion of indigenous vegetables in the value of all food consumed decreases as households become wealthier. For poor households, the value of IV consumption is approximately 11% of the value of all food consumed. Among the wealthiest group of households this reduces to 2 and 7%, respectively. Interestingly, this relationship also holds in absolute terms. Poor households consume on average, nearly 1US$ worth of IV per capita and month, while among the wealthiest households this is only just 15 cents. For all vegetables, the value of consumption decreases as households become wealthier. Clearly, poor households rely more both on indigenous vegetables as well as on vegetables as a whole as a source of micronutrients than wealthier households. This relationship will be explored in the following sub-chapter.

Table 4.2. Household wealth and value of vegetables consumed

Wealth parameters	Share in total food value		Per capita value (month)	
	IV	All vegetables	IV	All vegetables
0	10.6	18.7	1066	2031
1	4.7	14.0	500	1509
2	4.1	11.4	435	1377
3	3.8	11.4	435	1477
4	3.8	11.3	474	1335
5	1.8	7.2	150	1505
Total	4.5	12.5	492	1478

Note: Wealth parameter was calculated as sum owned out of radio, chicken, bicycle, mobile phone, electricity. Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households.

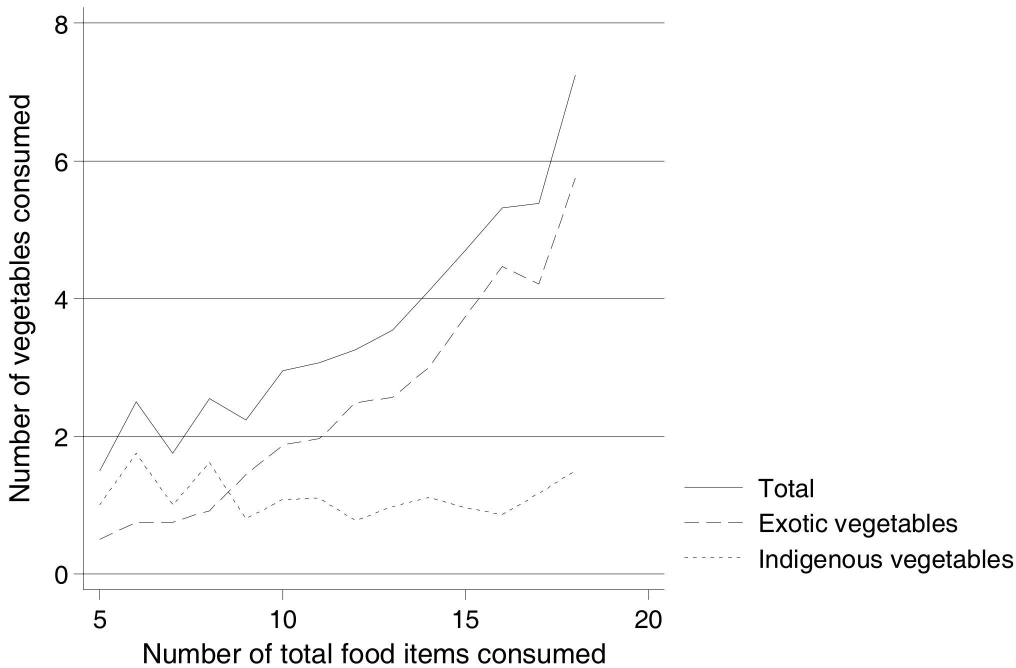

Figure 4.1. Relationship between diversity in food intake and diversity in vegetable intake

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households

4.3 Contribution of indigenous vegetables to dietary requirements

Micronutrient malnutrition is widespread, and particularly iron and vitamin A deficiency affect millions of poor people worldwide (SCN, 2004). Food-based approaches are often regarded as viable instruments to improve micronutrient consumption, especially where infrastructure for supervision of supplementation and fortification is absent (Allen and Gillespie, 2001). However, since the bioavailability of iron from plant sources is low, efficacy of such food-based approaches is usually assumed higher for vitamin A than for iron. In this paragraph we will assess the role that IV consumption plays for fulfillment of daily dietary needs.

Conversion rates for food items into micronutrients were based on two sources. For indigenous vegetables the location specific micronutrient values found and discussed in Chapter 3 were used. For other food values, since a comprehensive database for Tanzania was not available, we used conversion rates from the Kenya food composition table, which is part of the NUTRISURVEY project.[2] Since individual food intake figures were not available (the 24 h food recall recorded household consumption only) we estimated household requirements based on household composition. Detailed information on the composition of age groups within the household was available. Requirements for these age groups were estimated based on the FAO/WHO expert consultation of vitamin and mineral intake (FAO and WHO, 2001). Since the diet among respondents was found to be highly dependent of plant products, requirements for iron intake were estimated assuming a general low bioavailability of the diet of 5%. The conversion rate from ß-carotene to vitamin A is usually assumed to be 6:1, however more recent research has challenged this assumption, mainly based on research by de Pee et al. (1998). Using recent findings, IOM (2002) estimated the retinol equivalency ratio for beta-carotene from food in a mixed diet including fruits and vegetables to be 12:1 and we apply this conversion rate to the estimation of ß-carotene requirements at the household level. For zinc consumption we assumed an average absorption rate of the diet.

The contribution of IVs to fulfillment of the overall requirements of the household is shown in Table 4.3. The table shows that particularly poor households rely in the consumption of IVs to fulfill their daily requirements of micronutrients, particularly vitamin A and iron. In poor households, approximately 50% of all vitamin A requirements and slightly less than one-third of iron requirements are consumed through IVs. This share declines among wealthier households, but on average 17% of all iron requirements and 29% of all vitamin A requirements are fulfilled through consumption of indigenous vegetables. Indigenous vegetables contribute only marginally to required intake of the third micronutrient under consideration, zinc. Here, the average contribution is only 2.3%.

The share is much lower for exotic vegetables. On average, only 1.5% of all iron requirements, 0.5% of all zinc requirements, and 3% of all ß-carotene requirements are fulfilled. While IVs are certainly not a panacea for the elimination of micronutrient deficiencies, these results show that IVs do have an important role to play for maintaining adequate levels of micronutrient consumption. In fact, many of the deficiencies observed may relate to decreasing importance of IVs in the diet.

[2] www.nutrisurvey.de

Table 4.3. Contribution of IVs to fulfillment of daily Fe, Zn, and ß-carotene requirements of household

Wealth parameters	Contribution of IVs to daily household requirements		
	Iron	Zinc	ß-carotene
0	29.5	3.8	53.1
1	22.0	2.6	35.7
2	13.2	1.9	23.7
3	14.6	2.0	24.7
4	10.4	2.8	32.8
5	1.7	0.6	1.7
Total	16.6	2.3	29.0
Mean contribution of exotic vegetables	1.5	0.5	3.0

Source: Conversion rates based on values in Table 3.1, and Table 1 through Table 4, and on values provided by the Kenya food composition table by NUTRISURVEY. Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households

4.4 Sources of indigenous vegetables

In order to assess whether there is potential for increasing demand, it is essential to know the usual source of produce. Thus, this subchapter identifies the degree of food items obtained through home gardens, from markets and collected.

The frequency of growing IVs in home gardens differs across the four regions. In Arumeru, more than half of all respondents grow IVs all year-round. In the other three regions, growing IVs in home gardens is especially important during the dry season. Muheza has the highest share of households (28.3%) not growing IVs in home gardens (Table 4.4). Crops most frequently grown, listed in order, are: amaranth (67% of all households), okra and pumpkin leaves (each 49%), sweet potato leaves (46%) and cowpea (39%).

Table 4.6 shows that the cultivation of IVs in home gardens is location specific and varies widely across regions. As could be expected, the share of households growing indigenous vegetables in a home garden is lower in urban areas, yet still quite common for some of the crops. In all three cities, home garden production of amaranth is most common. More households in Arusha, which is a relatively rural town, produce IVs (53%) as compared to Morogoro (31%), which is still relatively rural, and particularly Dar es Salaam, where on average only one-eighth of all households produce an IV in their home garden.

Table 4.4. Production of IVs in home gardens (rural areas), by season

Season	District				Average
	Arumeru	Kongwa	Singida	Muheza	
No	5.6	24.5	25.5	28.3	22.3
During dry season	22.5	36.8	45.9	25.5	33.3
During rainy season	18.3	15.1	19.4	21.7	18.6
All year round	53.5	23.6	9.2	24.5	25.7
Total	100.0	100.0	100.0	100.0	100.0

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households

Table 4.5. Share of households engaged in cultivation of different IVs (top 10)

	District				Average
	Arumeru	Kongwa	Singida	Muheza	
Amaranth	70.1	75.0	57.5	64.5	66.9
Pumpkin leaves	16.4	73.8	52.1	47.4	48.6
Okra	32.8	33.8	69.9	57.9	48.6
Sweet potato leaves	17.9	57.5	47.9	55.3	45.6
Cowpea leaves	35.8	68.8	13.7	35.5	39.2
Nightshade	71.6	8.8	2.7	13.2	22.6
African eggplant	32.8	7.5	21.9	30.3	22.6
Ethiopian mustard	40.3	20.0	1.4	6.6	16.6
Cassava leaves	1.5	2.5	13.7	17.1	8.8
Wild cucumber	0.0	3.8	28.8	0.0	8.1
Spiderflower plant	20.9	3.8	4.1	0.0	6.8

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households

Table 4.6. Share of households engaged in cultivation of IVs in home gardens (urban areas)

City	Amaranth	Nightshade	African eggplant	Grows IV
Arusha	45.5	45.5	36.4	52.9
Morogoro	31.5	11.5	12.3	30.7
Dar es Salaam	12.0	4.0	0.0	12.6
Total	25.9	12.9	10.6	26.8

Source: Survey conducted by AVRDC in cooperation with Sokoine University, 2003. N = 287 households

Collection of IVs outside the homestead takes place most frequently during the rainy season when crops are most easily available. Approximately 80% of all households collect IV crops during that time, showing the importance of wild food crops for overall consumption (Table 4.7). The highest share of households never collecting IV crops outside the homestead can be found in Arumeru (18.3%), where cultivation of IV crops is most important and markets are easily available. The crops most frequently collected outside the homestead, listed in order, are jute mallow (59% of all households), amaranth (52%), spiderflower plant (36%), wild cucumber (28%) and bitter lettuce (27%).

The types of IVs collected may be specific to location (Table 4.8). For instance, while wild cucumber is not at all common in Arumeru and Muheza district, 70% of all households collect this species in Kongwa.

Table 4.7. Collection of IV crops outside the homestead

	District				
Season	Arumeru	Kongwa	Singida	Muheza	Average
No	18.3	0	1.0	3.8	4.7
During dry season	2.8	0	9.3	3.8	3.9
During rainy season	74.6	90.6	81.4	74.5	80.8
All year round	4.2	9.4	8.2	17.9	10.5
Total	100.0	100.0	100.0	100.0	100.0

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households

Table 4.8. Share of households engaged in collection of various IVs (top 10)

	District				
Vegetable	Arumeru	Kongwa	Singida	Muheza	Average
Jute mallow	15.5	75.5	79.4	48.0	59.2
Amaranth	79.3	36.8	60.8	43.1	51.8
Spider plant	63.8	43.4	42.3	5.9	35.8
Wild cucumber	0.0	69.8	29.9	0.0	28.4
Hairy lettuce	32.8	10.4	12.4	54.9	27.0
Pumpkin leaves	3.4	30.2	28.9	17.6	22.0
Nightshade	55.2	6.6	12.4	27.5	21.8
Cowpea leaves	3.4	35.8	18.6	9.8	18.7
Black jack	1.7	15.1	0.0	47.1	17.9
Sweet potato leaves	3.4	11.3	20.6	16.7	14.0
Cassava leaves	1.7	11.3	8.2	15.7	10.2

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households

Buying IV crops is much more important during the dry season, when approximately two-thirds of all households purchase IV crops at the market. During the rainy season hardly any household buys IV crops since vegetables are either found and collected outside the homestead or produced in home gardens during that period. In Kongwa and Singida one-third of households never buy IV on the market (Table 4.9). The crops most frequently purchased on the market, listed in order, are amaranth (67% of all households), okra (37%), African eggplant (33%), nightshade (25%) and sweet potato leaves (23%). Amaranth is by far the most popular crop to be purchased on markets, and this is true for all districts (Table 4.10). Exotic vegetables are more often purchased at the market than IV crops, which are more often produced at home (Table 4.11).

Table 4.9. Share of households buying IV crops at markets

	District				
Season	Arumeru	Kongwa	Singida	Muheza	Total
No	18.6	32.1	36.7	22.6	28.2
During dry season	61.4	64.2	61.2	65.1	63.2
During rainy season	11.4	0.9	1.0	1.9	3.2
All year round	8.6	2.8	1.0	10.4	5.5
Total	100.0	100.0	100.0	100.0	100.0

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households

Table 4.10. Share of households buying various IVs (top 10)

	District				
Vegetable	Arumeru	Kongwa	Singida	Muheza	Total
Amaranth	45.6	69.4	71.0	74.4	66.3
Okra	21.1	22.2	48.4	53.7	37.4
African eggplant	24.6	16.7	25.8	57.3	32.6
Nightshade	68.4	6.9	1.6	29.3	25.3
Sweet potato leaves	7.0	59.7	16.1	8.5	23.4
Cowpea leaves	10.5	52.8	4.8	14.6	21.6
Pumpkin leaves	1.8	36.1	35.5	9.8	20.9
Jute mallow	3.5	19.4	29.0	1.2	12.8
Ethiopian mustard	22.8	6.9	14.5	7.3	12.1
Watercress	21.1	0.0	1.6	2.4	5.5

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households

Table 4.11. Source of vegetables consumed

Source	Exotic vegetables (N)	Exotic vegetables (%)	Indigenous vegetables (N)	Indigenous vegetables (%)	Total (%)
Purchased	661	65.4	86	22.1	53.4
Produced	331	32.8	232	59.6	40.2
Collected	0	0	67	17.2	4.8
Gift	18	1.8	4	1.0	1.6
Total	1010	100.0	389	100.0	100.0

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households

4.5 Attitudes toward IV crops

Consumers are well aware of IVs. The term ‘asili’ in Swahili literally translated into English means ‘traditional vegetable’. Most of the respondents in our urban market survey could give correct examples for indigenous vegetables (73%). Only 3% had never heard the term, and 9% of respondents claimed to know the term but gave wrong examples.

Also, we attempted to assess the attitude that respondents have toward IV crops by asking a range of yes/ no questions (see Table 4.12). Several issues are remarkable. Firstly, while the overwhelming majority of respondents (90%) state that they serve IV crops to visitors, the majority also would not serve IVs at special occasions, such as weddings and religious holidays. Also, there is an overwhelming agreement within respondents that IVs are an important contribution to the diet when there is food shortage.

In most households adult men eat IVs (although some focus group meetings highlighted that men would not touch these crops in Arumeru district (Keller, 2004)). While virtually all households reported that their children were eating IV crops, a smaller share reported that they were teaching their children how to prepare these vegetables. For instance, in Kongwa 1 out of 5 households do not teach their children how to prepare these food crops. However, if vegetables are not prepared and consumed, this is the first step to their extinction, as farmers themselves remarked in focus group meetings (Keller, 2004). Two-thirds of all households in Singida and slightly more than half of all households in Arumeru agree that genetic erosion within the group of IVs is taking place, while only one-third of households in Kongwa and even less in Muheza (23%) agree.

Table 4.12. Attitudes toward IV crops

Question	District				Avg
	Arumeru	Kongwa	Singida	Muheza	
Do you offer IVs when visitors come to your home?	93.0	85.8	85.7	95.3	89.8
Do you consume IVs at special occasions?	36.6	39.6	37.8	61.3	44.6
Are IVs an important contribution to the diet when there is food shortage?	94.4	94.3	90.8	93.4	93.2
Do adult males in your household eat IVs?	95.8	87.7	93.9	96.2	93.2
Generally, do your children like eating IVs?	100.0	93.3	96.9	96.2	96.3
Are you teaching your children how to prepare IVs?	84.5	80.0	91.8	88.7	86.3
Is it important to be able to identify IVs?	93.0	97.2	83.7	84.0	89.2
Are fewer varieties of IVs to be found nowadays than 20-30 years back?	56.3	35.8	64.3	22.6	43.3

Note: Figure represents the share of respondents who answered "yes". Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households

4.6 Traits demanded by consumers

Having established that IVs are an important part of the diet, and contribute significantly to consumption of selected micronutrients, and that approximately one-quarter of all produce is purchased at markets, we now turn our attention to the willingness to pay of consumers for IVs, and their preferred traits. In particular, we wanted to know how important certain traits of appearance (color, size, form) and organoleptic criteria are for the decision to purchase a certain variety, and what additional price consumers were willing to pay for their preferred attributes.

The following results are based on a survey conducted in October 2003, among randomly selected consumers from urban markets in Arusha (12%), Morogoro (52%) and Dar es Salaam (36%). The total number of consumers interviewed was 287. Markets included into the survey were local markets (65%), wholesale and retail markets (9%) and supermarkets (26%). Based on the consumption survey, we had already identified amaranth, nightshade and African eggplant as the three most widely purchased IVs in Tanzania. With this survey, thus, we focused on these three IVs to assess traits important for consumers, and consumer's willingness to pay for these traits. Consumers were asked about traits and willingness to pay for one of these crops only, and we attempted to interview approximately one-third of all respondents for each crop. The questionnaire forms were completed for amaranth (38%), nightshade (26%) and for African eggplant (29%).

Traits covered both appearance and cooking qualities of crops. Respondents were asked to rank each trait on a scale of five, from not important at all (1) to extremely important (5). The mean value for each trait is weighted by the probability of each trait to have been selected (due to a large number of 'do not know' responses for some of the traits). Not considering these missing values would have resulted in overestimating the importance given to these traits.

Both the absolute value and the relative rank are very similar for the three different crops (Figure 4.2). The color of leaf is the most important trait in amaranth and nightshade; in African eggplant it is the taste (meaning the level of bitterness and sweetness). Taste is the

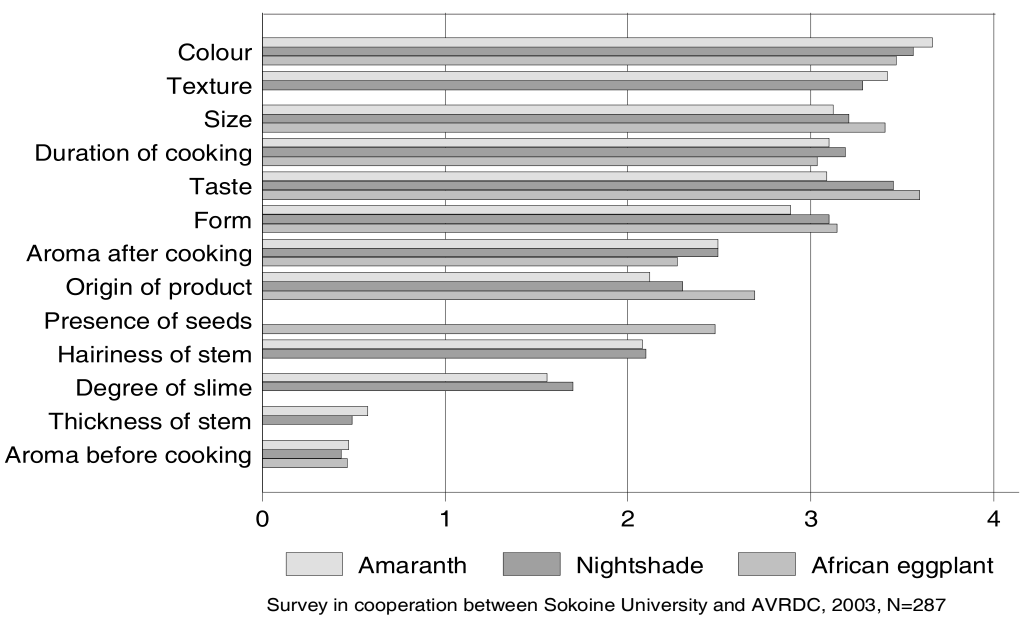

Figure 4.2. Value of traits given to amaranth, nightshade and African eggplant

second most important trait for nightshade, in African eggplant it is color, and in amaranth it is texture. It is interesting to note that taste only ranks fifth place in amaranth. Amaranth is locally known and popular as a crop rich in iron, consumed as a crop with medicinal value to treat anemia. Consumers may appreciate this value, expressed by its color, as it is commonly believed that the red color of the leaf shows a high iron content.

A frequent reaction among respondents was that they believed indigenous vegetables were healthier than exotic ones, because of lower pesticide and fertilizer use. Thus, consumers are well aware of the low input regime used for production of IVs, and are also aware of health hazards related to injudicious use of pesticides. It may be advantageous for an educational campaign to highlight this aspect in the production of IVs.

Based on a cluster analysis performed with SPSS software[3] we identified preferred groups of traits among the three different vegetables (Type I, Type II, Type III). Incidentally, three different groups were identified for each of the three vegetables (Table 4.13, also see Annex 5 through 7 for detailed results). Among amaranth, a Type I variety is a dark green, narrow-leaved variety with small to average size leaves, and a soft texture. Type II is a green and fibrous type with either narrow or broad leaves of average size and slightly aromatic. Type III is of a dark green type with broad leaves, and average to big sized leaves. All consumers disliked amaranth varieties that turned slimy after cooking.

Among nightshade, again three different types can be distinguished, these are: (I) green and broad leaved with an average to big size, fibrous and slightly bitter; (II) dark green and broad leaved, slightly bitter, and with a soft texture that can be cooked for a long period; and (III) a dark green narrow leaved type with small sized leaves, fibrous, and bitter to very bitter. Again, consumers do not appreciate sliminess.

In African eggplants, consumers like: (I) light green or yellow round types; (II) dark green eggplants with a long form, a little bitter; or (III) a milk white, egg shaped type with slight bitterness. The table also shows that these results are highly location specific. While more consumers in Arusha prefer amaranth of type III, in Morogoro and

[3]The procedure of cluster analysis is used to form groups based on different variables. We used the quadratic Euclid distance for binary variables, and a centroid clustering method.

Dar es Salaam the majority of consumers like amaranth of type II. Similarly, consumers in Arusha prefer nightshade of type III, while consumers in Dar es Salaam prefer nightshade of type I, and consumers in Morogoro like both type III and I. The differences are even starker for African eggplant, where consumers in Arusha have a strong preference for the light green or yellow, round type, while consumers in Dar es Salaam and Morogoro favor the slightly bitter, milk white, and egg shape type.

Table 4.13. Summarized results of cluster analysis

	TYPE I	TYPE II	TYPE III
Amaranth	Dark green Narrow leaves Small to avg leaves Soft texture Neutral taste No aroma Not slimy	Green Narrow or broad lvs Average leaves Fibrous texture Neutral taste Some aroma Not slimy	Dark green Broad leaves Avg to big leaves Fibrous texture Neutral taste Some aroma Not slimy
Arusha	38.5%	15.4%	46.2%
Morogoro	27.5%	47.1%	25.5%
Dar es Salaam	16.2%	51.4%	32.4%
Nightshade	Green Broad leaves Avg to big leaves Fibrous texture A little bitter Not slimy	Dark green Broad leaves Average leaves Soft texture Cooks within 30 min, a little bitter Not slimy	Dark green Narrow leaves Small leaves Fibrous texture Very much to some bitterness Not slimy
Arusha	33.3%	16.7%	50.0%
Morogoro	35.3%	23.5%	41.2%
Dar es Salaam	58.6%	27.6%	13.8%
African eggplant	Lt green or yellow Round fruit Average size fruit No aroma	Dark green Elongated fruit Average size fruit Little bitter	Milk white Egg shaped fruit Average size fruit Little bitter, no aroma
Arusha	90.9%	0.0%	9.1%
Morogoro	19.5%	22.0%	58.5%
Dar es Salaam	18.8%	21.9%	59.4%

Survey in cooperation between Sokoine University and AVRDC, 2003, N=287

4.7 Willingness-to-pay for indigenous vegetable crops

Consumers report substantial price differences for the three analyzed crops on markets in Arusha, Morogoro and Dar es Salaam. Prices in Dar es Salaam are two to three times higher as compared to Arusha. The difference is especially large for African eggplant, which is sold at a price 3.3 times in Dar es Salaam as compared to the price in Arusha.

The absolute difference in willingness-to-pay is less dramatic across the three sites. It appears that consumers in Dar es Salaam are the least willing to pay more than what they currently pay, compared to Arusha and Morogoro. In Arusha, consumers are willing to pay an approximate extra 100% on the current prices, consumers in Morogoro are willing to pay an additional 33–66%, depending on the crops, while consumers in Dar es Salaam are willing to pay only 3–15% premium on current prices.

Table 4.14. Average reported price for one kg of IV crop (TSH)

Location	Amaranth	Nightshade	African eggplant
Arusha	190	178	168
Morogoro	247	256	369
Dar es Salaam	347	454	565
Total	276	325	419

Survey in cooperation between Sokoine University and AVRDC, 2003, N=287

Table 4.15. Average willingness to pay for one kg of IV crop

	Amaranth		Nightshade		African eggplant	
Location	Price (TSH)	Increase (%)	Price (TSH)	Increase (%)	Price (TSH)	Increase (%)
Arusha	366	+92	375	+110	333	+98
Morogoro	352	+43	419	+63	491	+33
Dar es Salaam	399	+15	469	+3	598	+6
Total	371	+34	429	+32	516	+23

Survey in cooperation between Sokoine University and AVRDC, 2003, N=287

The purpose of the model was to measure the impact of the most relevant explanatory factors on the individual WTP for selected indigenous vegetables, namely amaranth, nightshade and African eggplant.

Among the different methodological approaches to assess consumers' willingness to pay, the contingent valuation (CV) method was chosen. Although CV is a method primarily used for monetary evaluation of consumer preferences for nonmarket goods (e.g. unpriced natural resources), it is also useful in this context and has been applied to value organic food products (Boccaletti and Nardella, 2000; Fu et al., 1999; Gil et al., 2000). Different approaches to assess WTP through contingent valuation in surveys can be distinguished, i.e. the iterative bidding approach (asking individuals about an initial dollar value and then raising the value until the individual declines), the payment card approach (presenting individuals with multiple dollar values to choose from) and the dichotomous choice approach (presenting individuals with one value which they can decline or accept).

We asked respondents to describe their preferred traits in specific indigenous vegetable crop first. We then used a modified version of the payment card approach, in which we gave respondents the opportunity to choose from one among several values. If they were prepared to pay more than the highest value given, they could specify this value. The WTP was assessed for the crop with all the respondents preferred traits in the crop. Willingness-to-pay was divided into four premium categories of 0%, up to 25%, up to 50%, and more than 50%.

4.7.1 Modeling procedure

The foundation of the modeling technique, called random utility model, is based on the theory that a consumer, when facing alternatives, makes choices to maximize her utility (Greene, 2000). While the utility is not observable, the choices are. Since the choices are indicative of the utility, it is possible to model the consumer perception based on the choices. Letting y* be a latent variables which maximizes the consumer's utility, a relationship between y* and explanatory variables can be specified:

$$y^* = \beta' X + \varepsilon \qquad (1)$$

where X is a vector of explanatory variables which describe the consumer demographic and socioeconomic characteristics. Assuming the consumer's choice variable is y while facing four alternatives, we can then define

$y=0$ if $y^* \leq o$, $y=1$ if $0<y^* \leq \mu_1$, $y = 2$ if $\mu_1 < y^* \leq \mu_2$, $y = 3$ if $\mu_2 \leq \mu_3$.

The m's are the unknown parameters to be estimated with β. We can thus substitute the observable y for y* in equation (1) for the purpose of model estimation, hence

$$y = \beta' X + \varepsilon \tag{2}$$

ε is assumed to be independently and identically normally distributed. Equation (2) can be estimated using maximum likelihood estimation. The probability of y taking a particular value can be found as

Prob $(y=0) = \Phi(-\beta'X)$, Prob $(y=1) = \Phi(\mu_1-\beta'X) - \Phi(-\beta'X)$, Prob $(y=2) = \Phi(\mu_2-\beta'X) - \Phi(\mu_1-\beta'X)$, Prob $(y=3) = \Phi(\mu_3-\beta'X) - \Phi(\mu_2-\beta'X)$

The marginal effects of changes in the regressor can be computed as

$$\frac{\delta Prob[y = 0]}{\delta X} = -\Phi(\beta'X)\beta \tag{3}$$

$$\frac{\delta Prob[y = 1]}{\delta X} = [\Phi(-\beta'X) - \Phi(\mu-\beta'X)]\beta \tag{4}$$

$$\frac{\delta Prob[y = 2]}{\delta X} = [-\Phi(\mu-\beta'X) - \Phi(\mu-\beta'X)]\beta \tag{5}$$

$$\frac{\delta Prob[y = 3]}{\delta X} = -\Phi(\mu-\beta'X)\beta \tag{6}$$

However, these probabilities cannot be calculated for binary variables. These can be assessed by comparing the probabilities that occur when the variable takes its two different values with those that occur with the other variables held at their sample mean.

The empirical specification of the model used for this study is WTP = f(location, crop, market, knowledge, age, sex, education, total per capita food expenditure and share of vegetables in total food expenditure) where WTP is the willingness to pay for an IV crop with all desired traits. The variables are defined in Annex 8.

Since we have identified clusters of different preference types for the three indigenous vegetables under consideration, in a subsequent step we specified WTP as a hedonic function of preferred traits for each crop. The empirical specification of that model is WTP = f(location, cluster type, market, knowledge, age, sex, education, total per capita food expenditure and share of vegetables in total food expenditure) where WTP is the willingness to pay for an IV crop, with traits clustered.

4.7.2 Estimation results and analysis

The results of the ordered logit estimation of our first regression are presented in Table 4.16. The chi-squared statistics from the likelihood ratio test is highly significant, explaining the overall explanatory power of the independent variables. Together, they account for 38.5% of the variance. Of the socio-economic variables, only share of food expenditure spent on vegetables is significant. Neither total food expenditure, age, sex, nor education are significant variables. However, their signs are as expected. Consumers with a lower education level tend to pay less, as do men and older people. Knowledge on IVs contributes significantly to the willingness to pay. Among the other variables, location, market type and crop all contribute significantly to the WTP. Consumers in Arusha and Morogoro, who on average pay less than consumers in Dar es Salaam, have a higher willingness to pay. Also, consumers shopping in supermarkets have a higher WTP than consumers shopping in local or in wholesale markets. While the food expenditure variable was not significant, this result indicates that consumers in high-value outlets are prepared to pay more for IVs.

Table 4.16. Regression results WTP for indigenous vegetables

	Coefficient	SE	Significance
Arusha	4.041***	0.613	0.000
Morogoro	2.463***	0.380	0.000
Local	–1.361***	0.440	0.002
Wholesale	–0.378	0.506	0.455
Eggplant	–0.072	0.295	0.806
Nightshade	0.680*	0.314	0.031
Food	0.000	0.000	0.798
Share	0.036**	0.015	0.014
Age	–0.002	0.014	0.903
Male	0.355	0.255	0.163
Primary	–0.092	0.370	0.804
Secondary	–0.101	0.393	0.798
High school	0.773	0.507	0.127
Know	–0.612*	0.300	0.041
T_1	0.503	0.884	
T_2	1.943	0.890	
T^3	3.332	0.907	

Summary statistics
Number of observations: 250
-2 X Log-likelihood ratio = $\chi 2$ = 111.866
Percent correctly classified = 38.9

Note: Ordered logit. *, **, *** Significance at 0.05, 0.01, or 0.001 levels, respectively.
Survey in cooperation between Sokoine University and AVRDC, 2003, N=250

The results of the second, cluster specific regression are presented in Table 4.17. Again the models are highly significant and location specific variables are more important than individual socio-economic variables. Consumers in Arusha and Morogoro are prepared to spend more compared to current prices than consumers in Dar es Salaam. Consumers purchasing in supermarkets have a higher WTP as compared to consumers that purchase in local markets. Consumers spending a higher share of their total food expenditure on vegetables are also prepared to pay more. While not significant, the variable indicating high school education approaches significance and has a positive sign for amaranth and for African eggplant. The cluster results are significant for amaranth (consumers preferring Type I and Type II have a higher WTP than consumers preferring Type III) and for nightshade (consumers preferring Type II have a lower WTP than consumers preferring Type I and Type III).

In Table 4.18 we summarize predicted probabilities to pay 0%, up to 25%, up to 50% and more than 50% of current prices, respectively, for the three different crops under consideration and by location. The

Table 4.17. Regression results WTP for cluster types

	Amaranth		Nightshade		African Eggplant	
	Coeff	SE	Coeff	SE	Coeff	SE
Arusha	3.608***	0.947	6.443***	2.065	5.712***	1.513
Morogoro	2.195***	0.574	3.334***	0.925	3.506***	0.852
Type I	1.662***	0.584	–0.410	0.695	–0.332	0.719
Type II	0.950*	0.576	–1.584**	0.809	–0.513	0.729
Local market	–1.564**	0.703	–0.584	1.170	–2.409***	0.952
Wholesale market	–1.248	1.060	0.838	1.230	–0.158	1.025
Food expenditure	0.000	0.000	0.000	0.000	0.000	0.000
Share veg. expend.	0.003	0.031	0.058**	0.034	0.043	0.029
Age	–0.037	0.026	0.024	0.031	–0.011	0.033
Male	0.410	0.426	–0.167	0.599	0.355	0.515
Primary	–0.193	0.602	–0.760	0.866	0.573	0.754
Secondary	–0.445	0.643	–0.317	0.915	0.903	0.772
High school	1.210	0.810	–2.341	1.463	1.481	0.927
Knows IV	–0.832	0.522	–0.731	0.755	–0.279	0.594
T_1	–0.677	1.497	0.742	2.160	0.831	1.831
T_2	0.438	1.500	1.994	2.148	3.168	1.866
T_3	1.888	1.508	4.198	2.248	4.443	1.900
Summary statistics						
Number of observations	100		64		80	
-2 X Log-likelihood ratio = $\chi 2$	48.152		44.809		40.337	
Percent correctly classified	41.3		58.6		47.2	

Note: Ordered logit. *, **, *** Significance at 0.05, 0.01, or 0.001 levels, respectively. Survey in cooperation between Sokoine University and AVRDC, 2003, N=244 predicted probabilities show that as a relative share to current prices, the WTP is highest in Arusha and lowest in Dar es Salaam for all three crops, and it is highest for nightshade, and lowest for amaranth in all three places. We estimated predicted probabilities for different cluster types within the three different vegetables as well, but found none or little variation to the predicted values for the overall vegetable (not presented here). Hence, the willingness to pay is more strongly affected by vegetable crop, than by cluster type.

Table 4.18. Predicted probabilities for willingness to pay

Crop/ Probability	Arusha	Morogoro	Dar es Salaam
Eggplant			
0%	0.8	7.7	77.4
up to 25%	2.4	18.4	16.1
up to 50%	8.5	32.5	4.8
more than 50%	88.3	41.3	1.7
Nightshade			
0%	0.5	4.6	66.6
up to 25%	1.4	12.4	22.8
up to 50%	5.3	28.1	7.8
more than 50%	92.8	54.8	2.9
Amaranth			
0%	9.1	47.1	83.1
up to 25%	20.6	31.9	12.3
up to 50%	33.2	14.8	3.4
more than 50%	37.1	6.2	1.2

Survey in cooperation between Sokoine University and AVRDC, 2003, N=250

4.8 Discussion of results

Among the rural population, only about one-quarter of all vegetables consumed are indigenous, the remaining are exotic vegetables. Compared to earlier reports from the 1970s the frequency of consumption has declined. However, IV crops continue to be an important contribution to the diet, particularly so in the rainy season, when they are readily available. Among our rural survey, nearly 80% of households reported that they collected IVs during the rainy season. The share of IV consumption among all vegetables is much higher among poor households (40%) than among the wealthiest households (11%) and also the variety in consumption of indigenous vegetables decreases as households become wealthier, while at the same time the variety in consumption of exotic vegetables increases. By valuing collected IVs produced in local gardens, we found that in the poorest group of households approximately 11% of all food consumed are IVs. The average share for all households is only 4.5%

However, it would be wrong to believe that IVs are a purely subsistence crop for poor consumers. After all, approximately two-thirds of all rural households reported that they purchased IVs at the market during the dry season. Also, our willingness-to-pay analysis among urban consumers indicated that there is considerable scope for higher prices. On average, consumers were willing to pay an additional 34% for amaranth to 23% for African eggplant, although this valued varied strongly across localities. In general, the willingness to pay an additional premium on current prices if all desired traits among crops were available was highest in Arusha (where current prices are lowest) and lowest in Dar es Salaam (where current prices are 2 to 3 times higher than in Arusha). The willingness to pay is more strongly influenced by location and crop than by individual socio-economic characteristics of respondents.

Consumers demand very different types. Consumers in Arusha demand a narrow-leaved, dark green, small-sized nightshade variety, while consumers in Dar es Salaam demand a large, broad-leaved, green variety. Some of the crops, such as amaranth, are demanded for their medicinal value, i.e., respondents often mentioned that amaranth is a cure against anemia (and indeed, amaranth showed the highest iron value among all IVs analyzed). Indigenous vegetables are also popular because consumers believe that production takes place with low input levels—correctly so, as the next chapter will show.

Particularly poor households rely on the consumption of indigenous vegetables to fulfill their daily requirements of micronutrients, particularly vitamin A and iron. In poor households, approximately half of all vitamin A requirements and slightly less than one-third of iron requirements are consumed through indigenous vegetables. Thus, while IVs cannot be considered as a panacea for the elimination of micronutrient deficiencies, these results show that IVs do have an important role to play for maintaining adequate levels of micronutrient consumption.

5 Production Aspects

5.1 Data sources

Results of this sub-chapter are based on results of a detailed household and farm survey, covering both quantitative and qualitative aspects on the production of IV crops. The survey was conducted in four regions of Tanzania: Arumeru, Muheza, Singida and Kongwa. A total of 359 households were randomly selected from a household list available from the villages. Administration of one interview took approximately 60 minutes per household. Approximately 85% of the respondents were men; the remaining 15% were women. The interview schedule was comprised of four sections: a section which treated various socio-economic factors of the household, a section on overall food crop production, a section on production of IVs, and a section on marketing related aspects of IVs. Not all the questions asked have been used in the analysis. Some did not generate sufficiently homogenous data to be useful, and others proved to be less significant than originally thought. Where products are harvested piecemeal, it is difficult for people to estimate how much they produced altogether. Frequency of harvest and availability of the product were used to construct an estimate for the total production. This estimate was in terms of local units, i.e. bags, plastic canisters, bundles or heaps, and was later converted into decimal units based on conversion values obtained from local markets.

Table 5.1. Farm survey characteristics

Region	Number of households	Number of villages
Arumeru	69	6
Muheza	93	14
Singida	96	13
Kongwa	101	12
Total	359	45

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households

5.2 Production of vegetables and other food crops

The average size of farm holdings differs markedly among the four regions covered in this survey, and is twice the size in Kongwa (on average 3.8 ha) compared to the other three regions, where they average from 1.5 to 1.9 ha. The main area is allocated to staples (68.9%), and pulses and oil crops (20.3%). Vegetables occupy 9.2% of all cultivated area. However, the share of vegetables is higher in

Arumeru than in the other three districts, at around 20%. Except for Arumeru, more than 50% of staple foods are usually produced for home consumption. Farmers in Arumeru, who have a big market in Arusha in close proximity, are engaged in commercial production both for staples and for vegetable crops. In the other three districts, a significantly higher share of vegetables (both exotic and indigenous) is sold on the market than staple crops. This points to a higher market integration of vegetable producers, as has been found in other locations as well (Minot et al., forthcoming).

Of the 359 farmers interviewed, 35% were cultivating IV crops, both target and non-target IV crops. The share of farmers reporting that they were cultivating IV crops was largest in Arumeru district (70%) followed by Singida (43%), and Muheza (28%). Production of IV crops is least important in Kongwa, where only 11% of farmers reported to cultivate IV crops. Cultivation of IV crops is more important for smaller farms; over the whole sample within the smallest 60% of the farms (measured in food crop area) approximately 40% of households are engaged in the cultivation of IV crops, while this share decreases to 30 and 26%, respectively, in the fourth and fifth quintile (Table 5.2).

Table 5.2. Percentage of households engaged in the cultivation of IV crops by district and total cultivated food area

	Food crop area quintiles					
District	1	2	3	4	5	Average
Arumeru	76.9	78.6	66.7	53.8	71.4	69.6
Kongwa	10.5	8.7	10.5	10.0	15.0	10.9
Singida	52.6	56.3	54.2	38.9	10.5	42.7
Muheza	27.8	35.3	31.6	27.3	17.6	28.0
Total	39.1	40.0	40.3	30.1	25.7	35.1

Note: Farm households were ranked into quintile groups according to their total area under food crop cultivation within each district. Farms in group "1" cultivate smallest areas, while farms in group "5" cultivate largest areas. Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households

Table 5.3 shows the average area and the share in total food crops area that farmers allocate to the production of indigenous and exotic vegetables. The average area allocated to exotic vegetables is higher than the average area allocated to indigenous vegetables. The absolute area under both exotic and indigenous vegetables increases as farmers have more land available for cultivation. However, the share of both exotic and indigenous vegetables takes a bell curve form. It increases, is largest for households in the third quintile, and then decreases again, however, more sharply so for indigenous vegetables than for exotic vegetables. Within the total sample, 2.8% of all food crop area was allocated to indigenous vegetables, while 4.4% of all area was allocated to the cultivation of exotic vegetables.

Table 5.3. IV and exotic vegetables share in all food crop production

Food crop	IV crops		Exotic vegetables	
area quintiles	Mean (ha)	% area	Mean (ha)	% area
1	0.02	3.0	0.04	4.8
2	0.05	3.8	0.06	4.2
3	0.07	3.9	0.10	5.7
4	0.06	2.5	0.10	4.1
5	0.06	1.1	0.16	3.2
Total	0.05	2.8	0.09	4.4

Note: Farm households were ranked into quintile groups according to their total area under food crop cultivation within each district. Farms in group "1" cultivate smallest areas, while farms in group "5" cultivate largest areas. Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 359 households.

As Table 5.4 shows, there are big differences in the significance of the different IV target crops across the four different project regions. In Kongwa, cowpea is the most important crop. In Singida, it is okra. In Muheza, amaranth stands out. In Arumeru, finally, nightshade occupies the largest IV crop area. There are some differences to the results of the focus group meetings that shall be pointed out here. In Arumeru, nightshade, amaranth and African eggplant, were identified as the three most important IVs. Similarly, in Kongwa, cowpea was identified as the most important, and in Muheza, amaranth was identified as the most important target IV crops within the project. However, for Singida it is a bit puzzling that okra, which appears to occupy nearly half of all IV crop area, is ranked only fifth in the focus group meetings (Keller, 2004). Spiderflower plant and moringa, two target crops within the project, appear to be not cultivated at all in the four districts surveyed.

Indigenous vegetable crops are cultivated both in pure stand (approximately two-thirds of all plots), and intercropped (approximately one-third), with 67% of all plots using line sowing rather than broadcasting. Table 5.5 shows the decision to intercrop appears to be location, rather than crop specific. Intercropping is the predominant cropping pattern in Kongwa, and to a lesser extent in Singida, but is hardly practiced in Arumeru and Muheza districts. Recommendations for pro-

Table 5.4. Share of farmers producing IV crops

	District (% share of farmers)				
Vegetable	Arumeru	Kongwa	Singida	Muheza	Average
Cowpea	6.3	73.1	5.5	26.6	28.1
Okra	7.3	4.8	43.6	17.2	19.0
Amaranth	16.7	8.7	15.5	35.9	17.4
Nightshade	39.6	0	0	6.3	11.2
Pumpkin	1.0	9.6	12.7	3.1	7.2
African eggplant	15.6	1.0	4.5	6.3	6.7
Sweet potato	0	1.9	10.9	3.1	4.3
Ethiopian mustard	13.5	1.0	0	1.6	4.0
Wild cucumber	0	0	6.4	0	1.9
Jute mallow	0	0	0.9	0	0.3
Total	100.0	100.0	100.0	100.0	100.0

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 368 plots

Table 5.5. Frequency of pure stand and intercropping by IV crop

	District (no. of farmers)									
	Arumeru		Kongwa		Singida		Muheza		Average	
Vegetable	MC	IC	MC	IC	MC	IC	MC	IC	MC	IC
Sweet potato	0	0	2	0	10	1	1	1	13	2
Cowpea	2	4	31	43	3	3	10	7	46	57
African eggplant	14	0	0	1	2	3	4	0	20	4
Amaranth	14	1	5	4	14	3	20	3	53	11
Ethiopian mustard	11	2	1	0	0	0	1	0	13	2
Jute mallow	0	0	0	0	1	0	0	0	1	
Nightshade	27	11	0	0	0	0	4	0	31	11
Okra	7	0	3	2	20	27	9	2	39	31
Pumpkin	1	0	7	3	4	10	1	1	13	14
Wild cucumber	0	0	0	0	5	2	0	0	5	2
Total	76	18	49	53	59	49	50	14	234	134

Note: MC = pure stand, IC = intercropped. Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 368 plots.

duction practices of different crops will thus have to take this location specificity into account.

A distinct advantage of many IV crops is that they can be harvested repeatedly. Early maturity (21 days for leafy crops) and prolonged harvest periods were considered to be quality traits of different IV crop varieties because of higher productivity, while late maturity and short harvest periods in general were considered to be negative quality traits (Keller, 2004). Table 5.6 shows the average number of harvests by crop.

Table 5.6. Number of harvests per crop

Vegetable	Mean	Maximum	N
Sweet potato	30.7	180	12
Okra	21.3	90	51
African eggplant	15.0	48	21
Pumpkin	12.6	32	18
Amaranth	9.7	60	56
Nightshade	5.3	40	39
Cowpea	5.3	50	91
Ethiopian mustard	4.5	21	13
Wild cucumber	4.2	9	5
Jute mallow	2.0	2	1
Total	10.8	180	307

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 307 plots

5.3 Labor aspects of IV production

One of the reasons why IV crops are considered important in the context of developing countries is the role women play in producing, harvesting and marketing the crops (Chweya and Eyzaguirre, 1999; Price, 2003). Indeed, women play an important role in various production activities, as Tables 5.7 and 5.8 show. However, their involvement varies by type of activity; it is most important for harvesting and bringing the product to the market, while weeding, which is also considered to be a typical women's activity, is actually mostly shared between men and women. Men's involvement is particularly high in irrigation and pesticide application. Also, hired labor is undertaken nearly exclusively by men. As a whole, more activities were recorded for men alone than for women alone, and joint work as a family (either adults only, or together with their children) was also recorded more frequently than women's work alone. The reason for the relatively large share of male activities may be that many of the crops assessed here are being marketed. Women's role may still be more important as far as collection activities of wild indigenous vegetables are concerned. However, this data does show that female involvement is important and that women farmers have to be involved in the selection process of new and improved varieties.

Table 5.7. Labor distribution in IV production (family labor)

Activity	Men	Women	Men & women	Children	Women & children	Family
Nursery bed/ sowing	109	57	77	3	5	10
Land preparation	142	36	98	2	8	18
Harrowing	59	11	29	0	3	2
Transplanting	34	17	44	1	6	16
Seed broadcasting	11	9	6	0	2	3
Weeding	85	55	127	5	12	32
Mulching	1	0	1	0	0	0
Fertilizer application	36	13	6	0	0	2
Manure application	49	32	39	2	6	13
Pesticide application	71	3	1	0	0	0
Irrigation	121	33	18	2	12	7
Harvest	51	179	43	4	13	16
Transport to market	27	39	8	0	0	1
Total	796	484	497	19	67	120

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 220 plots

Table 5.8. Labor distribution in IV production (hired labor)

Activity	Men	Women	Children	Family
Nursery bed/ sowing	5	1	2	0
Land preparation	24	0	3	0
Harrowing	6	0	1	0
Transplanting	7	2	5	4
Weeding	12	4	1	1
Fertilizer application	2	0	0	1
Manure application	4	2	0	0
Pesticide application	2	0	1	0
Irrigation	4	1	0	1
Harvest	3	6	1	4
Total	69	16	14	11

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 220 plots

5.4 Economics of IV production

Yields vary widely across regions for some of the crops, as Table 5.9 shows, probably in part attributable to different production patterns (pure stand versus intercropped). In particular, yield levels of amaranth are considerably higher in Arumeru and Kongwa as compared to the other two districts, and cowpea yields are higher in Arumeru than in the other three districts. Okra yields are considerably lower in Kongwa as compared to the other three districts.

In general, fewer inputs are required for the production of indigenous vegetables than for exotic vegetables. This becomes obvious when looking at the share of different cost factors. Variable cost on average constitutes only 10% of all cost, which includes family labor, valued at the market price (Table 5.10), with variations (African eggplant requires approximately 30% of variable cost input). This highlights one of the reasons that IVs are particularly attractive for small-scale farmers, that is, since they require relatively little financial input, the risk of financial losses are much smaller than they are for most of the exotic vegetables, which typically require between 50 to 60% of variable in total cost. However, generally, crops for which market involvement are higher are produced with higher levels of variable input.

Table 5.9. Average yield levels (t/ha)

	Arumeru		Kongwa		Singida		Muheza		Average	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Sweet pot.	n.a.	n.a.	n.a.	n.a.	7.56	4.89	1.85	1.71	6.73	3.58
Cowpea	3.32	0.46	0.41	0.14	0.21	0.09	0.27	0.07	0.46	0.12
Afr. eggpl.	10.22	2.77	n.a.	n.a.	14.00	5.23	3.18	0.51	9.46	2.02
Amaranth	12.87	6.27	8.20	5.00	2.40	0.86	2.85	0.98	5.59	1.61
Eth. must.	11.64	8.05	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	11.64	8.05
Nightshade	3.85	0.79	n.a.	n.a.	n.a.	n.a.	3.69	0.46	3.83	0.69
Okra	2.59	1.47	.863	0.19	6.61	1.78	7.95	5.36	5.92	1.40
Pumpkin	n.a.	n.a.	296	0.12	1.99	0.60	1.06	1.06	1.05	0.31

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 220 plots

Table 5.10. Share of different cost items

	Share in variable cost					Variable cost
Vegetable	Labor	Inputs	Marketing	Rent	Total	in total cost
Sweet potato	36.0	0.0	64.0	0.0	100	2.0
Cowpea	20.9	69.5	9.6	0.0	100	6.2
African eggplant	7.8	74.4	17.0	0.8	100	30.6
Amaranth	48.5	48.4	2.9	0.2	100	24.5
Ethiopian mustard	1.4	89.1	8.5	1.0	100	13.3
Nightshade	9.1	88.7	2.3	0.0	100	20.0
Okra	12.3	34.1	52.8	0.8	100	3.8
Pumpkin	69.6	30.4	0.0	0.0	100	0.4
Total	22.8	59.4	17.4	0.3	100	11.8

Note: Labor cost in variable cost is hired labor, valued at actual wage rate. Total cost includes family labor, valued at 200 TSH per hour, and total variable cost. Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 281 farmers

Since only a share of all production is usually sold on the market (see Chapter 5.5), we attribute an opportunity cost based on market values[4] to all harvested product. On a net return per ha basis this value is highest for Ethiopian mustard and African eggplant, followed by sweet potato and okra, and is much lower for pumpkin and cowpea. Considering labor use, African eggplant is the most valuable production, at approximately 2.0 US$ per hour, followed by Ethiopian mustard at 1.1 US$ per hour. Considering value per yield output, there is less variation; it is highest for cowpea at 0.38 US$ and lowest for African eggplant at 0.12 US$, but with less variation than the other two indicators (Table 5.11).

Table 5.11. Value of IV production (in TSH)

Vegetable	Total variable cost/ha	Net value/ ha	Net value/ labor hour	Net value/ kg yield
Ethiopian mustard	159585	1487430	1125	268
African eggplant	146970	1447851	1976	118
Sweet potato	8825	851711	258	238
Okra	31499	810745	723	134
Amaranth	409052	662710	411	233
Nightshade	116672	447298	450	169
Pumpkin	2190	247196	185	266
Cowpea	3458	109178	278	384
Total	111040	596390	599	241

Note: 1000 Tanzanian Shilling (TSH) are equal to approximately 1US$. Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 232 plots

In Table 5.12 we show the value of production both of non-marketed IV production, and of marketed and non-marketed vegetable production taken together a share of total household income.[5] Indigenous vegetables provide an important contribution to overall household income. The product that is not sold, but consumed at home, on average has the value of an additional 6% to total annual household income, ranging from 8.3% in Kongwa to 1.8% in Muheza, where the least

[4] Calculated as average regional prices.

[5] Households provided us with an estimate of their monthly total household income. On this, we added the monetarized value for non-marketed indigenous vegetables, which is retained at the household level for consumption. The share of non-marketed indigenous vegetables in total household income is thus the ratio between sum of household income and value of non-marketed crop and household income. The share of all indigenous vegetables in total household income considers that part of this income is monetary, and part of it is non-monetary; thus it is the ratio of the monetarized value of all IV crops (whether marketed or not) and total household income calculated as the sum of monthly household income and value of non-marketed IV crops.

Table 5.12. Share of marketed and non-marketed IVs in overall household income

District	% nonmarket IV in total income	% all IV in total income
Arumeru	3.8	12.6
Kongwa	8.3	9.2
Singida	7.8	18.5
Muheza	1.8	10.0
Total	6.0	12.9

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 281 farmers

area is allocated to indigenous vegetables. The share of both marketed and non-marketed indigenous vegetables in total household income is, on average, nearly 13%, and highest in Singida, where nearly one-fifth of all household income are related to IV production and lowest in Kongwa, where approximately one-tenth of all household income is derived through production of IVs. Indigenous vegetables thus contribute significantly to overall household incomes, both considering the share that is not marketed but consumed and used at household level, and the share that is sold at markets.

5.5 Marketing of crops

Market integration of producers of fruits and vegetables is usually higher than that of staple crop producers (Minot et al., forthcoming). The same holds true for this survey. Of farmers engaged in the production of the respective crop, 88% market indigenous vegetables, 98% market exotic vegetables, and 100% market fruit; whereas only 49% of farmers market their cereal production. Yet, the degree of commercialization is very different for the different crops (Table 5.13). It is highest for African eggplant (82% of all produce is sold), followed by nightshade, okra, amaranth and Ethiopian mustard (63–67% of the produce are sold). Of all IV crops produced, nearly half reach the market; the rest is being used for home consumption or given away as a gift. The share is highest in Arumeru and Muheza (67% and 66%, respectively), followed by Singida (50%), and lowest in Kongwa (16%).

The overwhelming majority of product (97%) is sold fresh. A prominent form of sale, particularly in Arumeru and Singida district is selling "in the field" to middlemen and -women. These persons organize the harvest of the product themselves and will then sell the product on

Table 5.13. Share of produce sold on the market

Crop	Mean (%)	N
African eggplant	82.2	24
Nightshade	66.6	30
Okra	65.1	58
Amaranth	64.8	50
Ethiopian mustard	62.6	11
Sweet potato	37.6	12
Pumpkin	32.1	21
Cowpea	11.4	86
Wild cucumber	4.0	5
Jute mallow	0.0	1
Total	46.3	298

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 298 plots

the market. They perform an important role in bridging a gap between isolated small-scale farmers and distributing wholesalers in urban areas (Keller, 2004). Such collecting middlemen can contribute to the efficiency of the marketing system. Their absence in Kongwa and Muheza may explain why the degree of commercialization is lower in these two districts. About two-thirds of the product are sold either in the field or at farm gate. Farmers themselves sell only one-third of the product at markets. The largest share, 47%, is sold to consumers; 39% are sold to middlemen; while approximately 13% are sold to retailers. One farmer reported selling to a hotel.

The peak of market sales takes place from May to August. In focus groups, farmers complained that when crops are available in abun-

Table 5.14. Place of sale

	District (no. of farmers)				Total	
Place of sale	Arumeru	Kongwa	Singida	Muheza	N	Percent
Field	47	6	25	4	82	44.3%
Farm gate	3	9	12	14	38	20.5%
Local market	11	3	16	8	38	20.5%
Market in town	4	1	8	6	19	10.3%
Farm gate and local market	2	n.a.	2	n.a.	4	2.2%
Field and market in town	n.a.	n.a.	3	1	4	2.2%
Total	67	19	66	33	185	100.0%

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 185 plots dance, it is difficult to market them, especially when they can be collected from the wild at the same time (Keller, 2004). This indicates the problem of missing market channels and bringing fresh produce into big urban markets. However, this appears not to always be a problem, and Keller (2004) reports of farmers who stated that they could not fulfill all local demand for amaranth. Most farmers in focus groups stated that market opportunities for IVs are good.

The profitability of the different crops varies widely, as Table 5.15 shows. Of all crops, amaranth requires the highest input level. Sweet potato and pumpkin require the lowest input level. Of all crops, the net return by hectare is the highest for African eggplant and Ethiopian mustard, and this is nearly double as compared to sweet potato, and approximately 2.5 the value for okra and amaranth, which generate returns per ha at about 730 US$ to 450 US$ per ha. Returns on per ha basis are lowest for cowpea. While the returns on per ha basis are somewhat similar for most of the crops, the returns per labor hour vary widely. They are highest for African eggplant at approximately 1.6 US$ per hour, and lowest for pumpkin at 5 cents per hour. Thus the cultivation of African eggplant and Ethiopian mustard is most attractive for market production.

Table 5.15. Economic indicators of IV production (in TSH)

Vegetable	Total variable cost/ha	Net return/ ha	Net return/ labor hour	Net return/ kg yield
African eggplant	148791	1331176	1591	103
Ethiopian mustard	159585	1290704	1046	229
Sweet potato	10296	734453	220	180
Okra	33322	576930	495	103
Amaranth	463996	455127	349	185
Nightshade	118366	395757	403	141
Pumpkin	1324	143053	53	210
Cowpea	48361	105455	124	674
Total	165009	601721	554	191

Note: 1000 Tanzanian Shilling (TSH) are equal to approximately 1US$. Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 156 plots

5.6 Constraints in production

Insect pests and diseases appear to be the greatest constraints in the production of IVs. In focus group discussions, between 36 and 42% of villages considered the occurrence of pests and diseases among IV crops as a production constraint (Keller, 2004). Hence, the resistance against pests and diseases is an important quality trait for different IV crops.

In general, farmers appear to be content with their seeds (91%). This may be in part explained by the seed source: 69.4% were farmer's seed. Another 4.5% were purchased on the local market, with unknown origin. About 20% are purchased either from the local seed dealer or from stores in town. The remaining seeds were appropriated from farmer's associations, NGOs and extension workers. However, while the share of seed purchased in the market appears low, these figures are still higher than for staple crops, and indicate that the market penetration of certified seeds for IV crops is already higher than currently assumed.[6]

While in the individual interviews farmers appeared to be content with their seeds, in the focus groups seed availability was identified as a major production constraint. In 24% of villages in Kongwa, 22% of villages in Arumeru, 21% of villages in Singida, and 11% of villages in Muheza, availability of seeds was identified as a production constraint (Keller, 2004). In particular, storage problems and purity of seeds was mentioned as a constraint. Thus, improving availability of quality seeds for IV crops will remain a challenge for the future, and stronger en-

Table 5.16. Sources for IV crop seeds

Source	Frequency	Percent
Farmer's own seeds/seedlings	170	48.2
Neighbor	75	21.2
Purchased in town	54	15.3
Local seed dealer	21	5.9
Local market	16	4.5
NGO	12	3.4
Other	5	1.4
Total	353	100.0

Source: Survey conducted by AVRDC in cooperation with HORTI-TENGERU, 2003. N = 353 plots

[6] Patrick Ngwediagi, Head of National Vegetable Seed Program in Tanzania estimates that approximately 15% of all IV seeds are certified seed (personal communication).

gagement in channels for improved seed, such as the Quality Declared Seeds (QDS) Program, should be considered. However, channeling more efforts into the training of farmers regarding the production of quality seed should also be considered.

For the future, farmers responded that they are most interested in obtaining improved varieties of African eggplant, amaranth and vegetable cowpea. Farmers appear to be least interested in improved varieties of jute mallow, hyacinth bean and moringa, which, incidentally, are also those crops least cultivated.

5.7 Traits demanded by producers

The following section is a summary of information provided in Keller (2004), who discussed positive and negative traits of various IV species and varieties with focus groups. While both positive and negative traits were discussed, only the positive traits are presented here, since negative traits usually presented the opposite of the positive trait.

The discussions were open to all important traits and respondents were not urged to group them according to predefined criteria. Traits were originally identified by vegetable varieties, and interested readers are urged to refer to Keller (2004) for more details.

All traits mentioned related to production and consumption aspects. Marketing appeared not to be an issue. It is striking that most of the desirable traits are in fact very similar across vegetable species. Several of them relate to the production cycle. In general, farmers desire crops that show early maturity (i.e. can be harvested three weeks after sowing), with a long production cycle that can be harvested repeatedly. Large leaves or big fruits are also considered as advantageous, since this increases yields. Finally, farmers prefer varieties that show a low susceptibility to diseases, and that grow with few inputs and in low fertility soils, and, for the case of jute mallow, are rain tolerant. For the consumption side, an important trait that was mentioned for all crops except for African eggplant is short cooking time.

Table 5.17. Positive traits identified by farmers

Vegetable	Production	Consumption
Amaranth	Early maturity Long production cycle Repeated harvesting Little input required High yield (large leaves) Low susceptibility	Short cooking time Good taste Micronutrient content Low water content Can be dried
Vegetable cowpea	Early maturity Long production cycle Repeated harvesting Grows in low fertility soils High yield (large pods)	Short cooking time Good taste
Okra	Early maturity Long production cycle Repeated harvesting High yield (large fruit)	Short cooking time No spines/ hairs Avg mucilaginous material
Jute mallow	Early maturing Long production cycle High yield Rain tolerant	Short cooking time Soft Good taste Storage
African nightshade	Early maturity Long production cycle Easy harvesting Little input required Low susceptibility	Short cooking time Nutritious
African eggplant	Early maturity Long production cycle High yield (large fruits) Low susceptibility	Good taste

Source: compiled from various tables in Keller, 2004.

5.8 Discussion of results

The analysis of production aspects of IV crops has shown that production of IVs is an important activity particularly for farmers with small plots of land. Placing more emphasis on research for these crops as opposed to exotic vegetables will thus benefit the relatively poorer farmers. On average, the production of IV crops contributes to approximately 13% of all household income, valuing both marketed and non-marketed crop.

The production of IVs is particularly important for small-scale farmers because the production involves little monetary cost and relies strongly on family labor. On average, only 10% of all costs in the production of IVs are cash costs, the remaining 90% is family labor valued at the average wage rate. Few other purchased inputs are required. Indigenous vegetables are also important because they allow for an extended harvest period, thus contributing to the food security of the household over a longer period than exotic vegetables, which are usually harvested within a few harvests. Another advantage of IVs is their adaptation to abiotic constraints, in particular, droughts.

While not all IVs are carried to the market, several of them are highly commercialized, and further expansion of their production will contribute to a further development of markets and commercialization of the rural economy. However, for small-scale farmers in remote areas to benefit from such a development, improved infrastructure and market access would be required. Since small-scale farmers rely strongly on the production of IVs for the livelihood, it is expected that further expansion of commercialization activities would particularly benefit the small farmers. The IV crops that are most important for sale on markets are African eggplant, nightshade, okra, amaranth and Ethiopian mustard.

A main constraint for further expansion appears to be availability of high quality seed with resistance to a variety of pests and diseases, and related information on best cultivation practices. The latter will be difficult to develop since cultivation of IV crops is highly location specific, and much more so than for exotic vegetables.

6 Seed Sector

Improved seed is an important input in all crop-based farming systems and a key factor in determining the upper limit of yields (Maredia et al., 1999). Thus, in order to improve the productivity of IVs it will be essential that good quality seed be made available to farmers through a functioning seed supply system. Less than 10% of the seed planted in Africa is purchased from the formal market each year (Rohrbach et al., 2003). Most farmers still do not have access to commercially processed seed at a nearby retail outlet.

The private seed sector in Tanzania is relatively young and has evolved only since 1990, when the seed sector was liberalized. Before, the parastatal Tanzania Seed Company Limited (TANSEED), founded in 1973, had monopoly rights to produce, process, and distribute or market the seed of most crops. But TANSEED never met more than 10% of national seed requirements, and faced particular difficulty trying to commercially distribute seed beyond a few urban areas. Due to the deficiencies of TANSEED and in recognition of the relatively large untapped market for improved seed, the government liberalized the seed sector in 1990. Today, at least 14 companies are registered to sell seed in the country (Rohrbach et al., 2002), mostly concentrating on importing seed of horticultural crops.

Although still not ranking very high in importance, IV seed is produced both as certified and as semi-formal ‘quality declared seed’ (QDS). The total share of all certified and quality declared seed might be as high as 20%, although the results of our farm survey suggest that it is even higher. In the following we will discuss constraints and opportunities to marketing of IV crop seeds.

Three companies (East African Seed, Alpha Seed and KIBO Seed) produce and sell indigenous vegetable seed in Tanzania. We interviewed representatives of all three with a checklist of questions for this study. In total, interviews with five seed companies, all based in Arusha, were conducted. Only one of them—Alpha Seed—is truly local. Two others, KIBO Seed and the East African Seed Company, are regional, with headquarters in Kenya, while yet two others, Q-SEM and Pop Vriend, have headquarters in Europe.

6.1 Seed company profiles

Alpha Seed

Alpha Seed is a family-owned local seed company that was founded in 1993. Alpha Seed only deals with vegetable seed, all of them HORTI-Tengeru or AVRDC varieties. The overwhelming majority of sales, 90%, are tomato seeds; the remaining 10% are IV seed. The company has dealt with IV crops from the very beginning. The IV crops sold are African eggplant, amaranth, Ethiopian mustard, and nightshade. Seed is produced both by farmers and by researchers of HORTI-Tengeru. Eight farmers are involved in the seed production of IV crops. Total seed production in 2004 was on 50–60 ha; 12.5 ha of this are under IV crops.

KIBO Seed

KIBO Seed was originally founded in Kenya in 1956 as Kenya Seed Company. It established its offices in Tanzania in 1997. In 2002, the Tanzania subsidiary switched its name to KIBO Seed, in order to distance itself from the Kenyan mother company. The company has 12 permanent staff. KIBO mainly deals with imported European pasture, maize and wheat, as well as horticultural crops (bean, tomato, sunflower, pumpkin, sweet pepper and chili pepper). In 2004 it has taken up seed production from base seed provided through AVRDC. This production includes 2 ha of tomato and 0.4 ha each of amaranth, nightshade, African eggplant and okra. The seeds are being produced on rented land. The company has been selling seeds of amaranth, nightshade and okra since 1997, from seed provided by the Kenyan mother company.

East African Seed Company

This company was originally founded in Kenya in 1965. The Tanzania outlet was opened in 1994. The company has 37 permanent staff. It deals with both production and marketing of seeds. Major crops are maize, sorghum and beans; its principal vegetable crops are cabbage, tomato and onion. The East African Seed Company also deals with production and marketing of local tomato and amaranth, the latter being exported to the Netherlands. Seed production for amaranth takes place on 2.0–2.4 ha and is outsourced to farmers.

Q-SEM

Q-SEM is a joint venture between a local company and a Dutch mother company. The company is very young; it was established only two years ago. It has 60 permanent staff (including laborers) and operates a greenhouse of 1 ha size. Its main activity is the production of hybrid seeds of tomato, pepper, sweet melon, eggplant, cucumber, gherkin and carrot for the Dutch mother company. It was the first company in Tanzania to produce hybrid vegetable seed. Since Q-SEM is a contractor for the mother company in the Netherlands, the local company cannot choose the seeds to be produced. However, IV crops would not be an option. Total investment into the greenhouse has been 1 million Euro, and annual turnover has to be 300,000 Euro in order for the investment to be profitable. This can only be achieved by growing hybrid seed, which generates an income of approximately 5000 Euro per kg of seed. Also, the disease pressure upon IV crops is considered too large.

Pop Vriend

Pop Vriend is a foreign/ domestic joint venture, with 27–30 permanent staff (without laborers). Their main activities are breeding and dealing with seed. Major crops are onion, tomato, carrot and watermelon, which are produced in Tanzania and exported; the seeds of other crops are imported and sold here. The company was founded in 1961. The company does not deal with IV crops, because they perceive there is insufficient demand. However, if IV crops were to be included, then these would certainly be the leafy spinach types such as amaranth. For these, demand is considered to be more local and European types have difficulties to adapt to the local climate.

6.2 Production of IV seed

Production of IV seed takes place both under the auspices of seed companies, as well as under the QDS Program. While seed sold through seed companies has to be certified by the Tanzania Official Seed Certifying Agency (TOSCA), QDS is a community-based seed production scheme. Although the same criteria as under the TOSCA apply, only 10% of all seed produced are actually controlled. The important difference between the two approaches is the place of sale: QDS may only be sold in the village where it was produced or the surrounding villages. Table 6.1 shows the area under QDS production for different IV crops.

Approximately 15% of all IV seed are probably certified,[6] which is produced by East African Seed company, Alpha Seed and KIBO Seed (Table 6.2), as well as imported from neighboring countries, in par-

[6]Personal communication with Patrick Ngwediagi (2004).

Table 6.1. Production of Quality Declared Seed in 2004

IV crop	Farmers (no.)	Area (ha)
Amaranth (grain and white)	21	1.4
Okra (Pusa Sawani)	18	1.3
African eggplant	26	1.6
Nightshade	18	0.9
Total	83	5.3

Source: Courtesy of Patrick Ngwediagi, Head of National Vegetable Seed Program

ticular Kenya. Considering that 15% of all IV seed are certified and produced on 16.2 ha, and another 5.3 ha are under QDS production, about 20% of all seed are either locally certified or quality declared seed. Among our sample farmers, 25% of all seed were obtained on local markets or from local seed dealers or from town; thus these results seem reliable. The difference of 5% may be explained by regional imports, i.e. from Kenya.

Table 6.2. Production of certified IV seed in 2004

	Land in production (ha)			
IV crop	Alpha	KIBO	East African	Total
African eggplant	3.0	0.4	0.0	3.4
Amaranth	0.5	0.4	2.0	2.9
Ethiopian mustard	7.0	0.0	0.0	7.0
Nightshade	2.0	0.4	0.0	2.4
Okra	0	0.4	0.0	0.4
Total	12.5	1.6	2.0	16.1

Source: Courtesy of seed companies

6.3 Potential and constraints of the market

Most seed companies regard the seed market for several IV crops as promising. There is a good potential for the marketing of seeds especially of amaranth and nightshade, because farmers harvest continuously and thus cannot keep seed, and of okra and African eggplant, because the fruits are being eaten. Thus, seed dealers consider that the market for certified seed will increase for these crops if consumers demand IV crops. Also, European seed is relatively more expensive, thus local seeds have a price advantage over imported seeds. In addition, these are fast growing crops that need little other investment, thus putting only little financial strain on farmers. Seed dealers also perceive that the demand for IV seed is rising and may be rising even further since IV crops are nowadays being sold in supermarkets.

However, while seed dealers perceive a good growth rate, they are also aware of the problem that there is a big parallel market of farmers' seed where farmers obtain their seed at no cost. Also, some of the crops such as amaranth and nightshade are not so easy to grow, so farmers may become discouraged. Another constraint for the seed market as a whole is the missing support by the government for the seed market. Crops that the dealers perceive to hold good potential for the future are cowpea and cassava leaves.

6.4 Discussion of results

Among the seed companies interviewed, the share of IV seeds sold is small, probably no more than 10% of their seed sales. In total, around 15 ha in Tanzania appears to be under production of IV seed. The IV crops that have been domesticated are: amaranth, African eggplant, Ethiopian mustard, black nightshade and okra; amaranth and African eggplant are most prominent. Approximately 15% of all IV seed used are probably certified seed, while another 8–10% are quality declared seed. Indigenous vegetable crops cannot compare with exotic vegetable crops such as tomato and onion, because the latter are more readily marketed and farmers are more accustomed to buying the seed of these crops.

7 Collections of Indigenous Vegetable Germplasm

It is outside the scope of this study to perform a full economic assessment on the value of conservation of IVs. As the preceding chapters have shown, demand for IVs exists both at the consumer and the producer levels. It will thus be crucial to enhance the productivity of IVs. As such, further assessment of species for identification of promising lines will be required.

Indigenous knowledge on how to collect, cultivate and prepare IVs is in the process of getting lost in Tanzania (Keller, 2004). Thus, activities are required for maintaining genetic diversity. One such activity is the collection of IV germplasm. In Tanzania, ex-situ conservation of genetic resources is under the responsibility of the National Herbarium and the National Genebank, both located in Arusha. Both institutions hold collections of IVs (see Table 7.1). The number of accessions is particularly large for the more commonly domesticated vegetables, vegetable cowpea, amaranth species, and pumpkins. Several indirect use values have been recorded for several of them and are presented in the table.

Table 7.1. Numbers of accessions

Scientific name	Common name	Accessions GB	Accessions NH	Value
Lablab purpureus	Hyacinth bean	12	6	Not recorded
Vigna unguiculata	Vegetable cowpea	85	4	Drought resistance; treat skin problems; used as mullocide; treat skin problems
Solanum aethiopicum	African eggplant	5	12	Not recorded
Amaranthus spp.	Amaranth	50	34	Inhibit bean seed germination; plant ashes used as salt substitute
Corchorus olitorius	Jute mallow	4	5	Treat abdominal pain; treat menstrual and pregnancy problems and treats gonorrhea
Brassica carinata	Ethiopian mustard	2	1	Seed oil used in birth control; rich in protein
Moringa oleifera	Moringa	0	2	Not recorded
Solanum spp.	Nightshades	6	22	Increases soil fertility when rotated in field
Abelmoschus esculentus	Okra	8	0	Seeds substitute for coffee; mucilage from root and stem used for clarification of sugar cane juice
Cucurbita moschata, C. pepo	Pumpkin	140	0	Drought resistance; used to suppress weed *Cyprus rotundas*
Cleome gynandra	Spiderflower plant	12	4	Used to treat toothache, ear and oral problems, and worms

Note: GB = National Gene Bank, NH = National Herbarium. Source: Courtesy of Ana H. Makundi and National Herbarium, Arusha

8 Conclusion

Indigenous vegetables are important both for consumption and production, and in both cases, poor households rely more on these vegetables than more wealthy households. However, in comparison to older literature, the importance of IVs for consumption appears to have declined over the years. For poor households, the value of IV consumption is approximately 11% of the value of all food consumption, compared to 2% for the wealthiest households. Indigenous vegetables contribute significantly to the consumption of micronutrients, particularly of poor households, where approximately half of vitamin A and one-third of iron requirements are consumed through IVs.

Approximately 40% of farmers who cultivate small plots of land are engaged in the cultivation of IVs, while only 25% of relatively large-scale farmers are engaged in the cultivation of IVs. The share of both marketed and non-marketed indigenous vegetables in total household income is, on average, nearly 13%. Indigenous vegetables thus contribute significantly to overall household incomes.

It would be wrong to believe, though, that IVs are a purely subsistence crop. Several IVs are highly commercialized, and some of them can nowadays be found in supermarkets and convenience stores. Thus it appears that there is a good market potential for these crops, both in the high-price segment, as well as in the low-price segment. A willingness-to-pay analysis among urban consumers indicated there is considerable scope for price increases. On average, consumers were willing to pay an additional 34% for amaranth to 23% for African eggplant. Commercial seed companies are also recognizing this potential and are entering—albeit cautiously—the market of IV crop seeds.

In order to tap this potential while also ensuring that small and resource poor farmers can benefit, it will be essential that future research incorporates the needs of small farmers into the agenda.

In particular this relates to the selection of improved varieties with traits that are important for small-scale farmers. Indigenous vegetables enjoy the advantage of being produced with relatively small inputs and thus with low capital risk and it is unlikely that farmers would change this production pattern. Thus, selecting varieties that require an intensive input regime will probably be less attractive to farmers. Furthermore, farmers are interested in early maturing varieties that allow for multiple harvesting over a long production cycle.

Currently, approximately 25% of IV seed are either certified or quality declared seed. To contribute to the enhanced availability of quality seed, it is recommended to provide farmers with training on how to produce quality seed. Collaboration with existing “Quality Declared Seed” initiatives should also be considered. In addition, to foster seed companies and increase their share in the production and market of indigenous vegetable seed, it will be desirable for agricultural research institutions to provide seed companies with bigger quantities of base seed and to provide training of employees of seed companies.

The success of promoting neglected indigenous vegetable crops for nutritional health in Eastern and Southern Africa will also depend on strong promotional activities. Production related information, such as varietal information, yields and cultivation practices, should be packaged and made available to extension personnel and seed companies who may have a greater outreach to farmers. Consumption related information such as medicinal and nutritional properties should also be packaged and made available in an easily digestible form. Opportunities for distributing this information through schools, in supermarkets, or through media such as the radio should be explored. Consumers often believe that indigenous vegetables are healthier than exotic ones, because of lower pesticide and fertilizer use. Thus, consumers are well aware of the low input regimen used for production of IVs, and are also aware of health hazards related to injudicious use of pesticides. It may be advantageous for an educational campaign to highlight this aspect in the production of IVs.

A main constraint for further expansion appears to be high quality seed and related information on best cultivation practices. The latter will be difficult to develop, since cultivation of IV crops is highly location specific, and much more so than for exotic vegetables. A major problem that any priority setting exercise within such a diverse range of crops is confronted with is the extreme variation in preferences. As such the companion project has already achieved a formidable task in selecting twelve crops for further research. In order to come to quantifiable output, however, it may be best to focus on a smaller group of crops. Amaranth appears to offer the best opportunities across all study areas. Okra and African eggplant also offer good market potential, however with some more location specificity. African eggplant and okra both offer relatively attractive returns on per hectare and per labor hour basis. The importance of nightshade, for instance, is more location specific and may offer fewer opportunities for market expansion. Ethiopian mustard, while highly attractive in economic terms, is much less demanded by consumers across all four regions and would require intensive promotion activities to increase demand.

In conclusion, this study reveals the importance of IVs in resource poor communities; thus, preserving biodiversity and indigenous knowledge on production and consumption while improving varieties and cultivation practices of IVs in Tanzania will contribute to the well-being of thousands of poor farmers by enabling them to participate in markets.

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Annex-1 Iron, zinc and ß-carotene contents of other identified indigenous vegetables in Kongwa district (mg/100 g)

Name of vegetable						
Local	Swahili	English	Scientific	Fe	Zn	β–carotene
Safye	Majani ya kunde	Cowpea leaves	*Vigna unguiculata* (L.)	17.90	0.304	4.45
Mzimwe/ mgagani	Mgagani	Spider-flower plant	*Cleome gynandra* (L.)	49.95	0.407	2.10
Mhuza	Majani ya maboga	Pumpkin leaves	*Cucurbita pepo* (L.)	26.65	0.196	5.34
Suunga	Mchunga	Bitter lettuce	*Launaea cornuta*	44.60	0.262	2.69
Mhanga-lale	Kishon-anguo	Black jack	*Bidens pilosa* (L.)	6.10	0.288	1.14
Mhilile	n.a.	n.a.	*Cleome hirta* (Klotzsch)	17.50	0.315	0.95
Ikui/ ikuhwi	Majani ya mbuyu	Baobab leaves	*Adansonia digitata* (L.)	7.90	0.263	2.63
Matembele	Majani ya viazi	Sweet potato leaves	*Ipomea batatas* (L.)	8.35	0.198	1.93
Mtulu/ mturu	n.a.	n.a.	*Opilia amentacea*	3.30	0.344	4.15
Mkomba-dole/ kombadole	n.a.	n.a.	n.a.	11.85	0.215	2.88
Matanga-matango	Matango pori	n.a.	n.a.	32.10	0.449	3.69
Yambu-yambu	n.a.	n.a.	n.a.	9.75	0.410	1.63
Kisamvu	Kisamvu-Muhogo	Cassava leaves	*Manihot esculenta*	3.65	0.445	5.13
Pumbwiji	Mlenda	n.a.	*Talinum portulacifolium*	36.45	0.302	1.52
Mbigili/ Mbigiri	Mbigiri	Puncture vine	*Oxygonum sinuatum*	12.10	0.627	0.34

Annex-2 Iron, zinc and ß-carotene contents of other identified indigenous vegetables in Singida district (mg/100 g)

Name of vegetable						
Local	Swahili	English	Scientific	Fe	Zn	β–carotene
Majani ya kunde	Majani ya kunde	Cowpea leaves	*Vigna unguiculata* (L.)	6.60	0.255	0.66
Mgagani	Mgagani	Spider-flower plant	*Cleome gynandra* (L.)	24.75	0.380	0.42
Majani ya maboga	Majani ya maboga	Pumpkin leaves	*Cucurbita pepo* (L.)	18.05	0.272	2.52
Usunga	Mchunga	Bitter lettuce	*Launaea cornuta*	21.80	0.369	1.33
Mkukuu	n.a.	n.a.	n.a.	12.45	0.264	0.36
Marambate	n.a.	n.a.	n.a.	6.80	0.332	0.72
Nkonda/ mlenda	Mlenda	Jute mallow	*Corchorus trilocularis* (L.)	4.05	0.385	1.91
Matembele	Majani ya viazi	Sweet potato leaves	*Ipomea batatas* (L.)	11.10	0.218	2.39
Kirinti	n.a.	n.a.	n.a.	5.50	0.167	1.58
Maimbe	n.a.	n.a.	*Cucumis anguria* (L.)	18.55	0.335	0.66
Muganji	n.a.	n.a.	n.a.	31.60	0.182	1.71
Mtee	n.a.	n.a.	n.a.	2.31	0.310	0.85
Kisamvu	Kisamvu-muhogo	Cassava leaves	*Manihot esculenta*	8.35	0.517	3.64
Mdunta	n.a.	n.a.	n.a.	15.95	0.301	0.71
Itindimbui	n.a.	n.a.	n.a.	5.55	0.366	1.51
Ndelo-aghwara	n.a.	n.a.	n.a.	19.00	0.289	0.58
Gahunga	n.a.	n.a.	n.a.	10.45	0.313	2.48
Kasipa	n.a.	n.a.	n.a.	24.15	0.261	0.25
Mang'-ang'aa	n.a.	n.a.	n.a.	9.55	0.397	0.39
Kituntu/ Makanja	n.a.	n.a.	n.a.	19.85	0.346	n.a.
Kabuhi	n.a.	n.a.	n.a.	19.20	0.250	0.39

Annex-3 Iron, zinc and ß-carotene contents of other identified indigenous vegetables in Muheza district (mg/100 g)

Name of vegetable						
Local	Swahili	English	Scientific	Fe	Zn	β–carotene
Safa	Majani ya kunde	Cowpea leaves	*Vigna unguiculata* (L.)	7.75	0.399	4.29
Mgagani	Mgagani	Spider-flower plant	*Cleome gynandra* (L.)	3.00	0.208	10.05
Majani ya maboga	Majani ya maboga	Pumpkin leaves	*Cucurbita pepo* (L.)	8.80	0.297	3.71
Msunga	Mchunga	Bitter lettuce	*Launaea cornuta*	9.90	0.579	6.80
Kisamang-uo/ mbembwe	Kishonanguo	Black jack	*Bidens pilosa* (L.)	12.05	0.484	2.32
Taata/ taaja	Mtembele ya maji	n.a.	*Ipomea pes-caprae*	7.60	0.215	2.44
Kibwando mlenda	Mlenda	Jute mallow	*Corchorus trilocularis* (L.), *C. fascicularis*, *C. tridens*	4.20	0.196	6.31
Matembele	Majani ya viazi	Sweet po-tato leaves	*Ipomea batatas* (L.)	8.05	0.230	3.24
Zuma	n.a.	Cape myrtle	*Myrsine africana*	16.85	0.807	4.85
Mnkoswe/ Mkoswe	n.a.	n.a.	n.a.	5.65	0.530	2.97
Mnyembe-uwe	n.a.	n.a.	*Erythrococca kirkii*	6.40	0.190	5.36
Kiumbu	Mlenda wa unga	n.a.	n.a.	10.20	0.221	4.38
Kisamvu	Kisamvu-muhogo	Cassava leaves	*Manihot esculenta*	4.40	0.651	4.50
Kisamvu	Kisamvu-mpira	Cassava leaves	*Manihot glaziovii*	7.60	0.490	5.43
Kisogo	Msogo	n.a.	*Rourea orientalis*	3.50	0.249	4.63
Tako ja hasani	Tako la hasani	n.a.	*Portulaca oleracea*	3.25	0.226	1.10
Limi ja ng'ombe	n.a.	n.a.	*Emilia coccinea*	19.40	0.591	2.32
Longwe/ ongwe	n.a.	n.a.	n.a.	7.20	0.266	2.53
Tikini	n.a.	n.a.	*Asystasia gangetica*, *A. mysorensis*	4.20	0.409	4.90
Mpilipili	Majani ya mpili pili	Chili pepper leaves	*Capsicum* sp.	7.90	0.302	5.55

Annex-4 Iron, zinc and ß-carotene contents of other identified indigenous vegetables in Arumeru district (mg/100 g)

Name of vegetable						
Local	Swahili	English	Scientific	Fe	Zn	β–carotene
Sikono	Majani ya kunde	Cowpea leaves	*Vigna unguiculata* (L.)	18.70	0.547	7.18
Mgagani/njewe	Mgagani	Spider-flower plant	*Cleome gynandra* (L.)	10.65	0.515	3.24
Mbeneko-lokoku	Majani ya maboga	Pumpkin leaves	*Cucurbita pepo* (L.)	6.15	1.631	4.16
Omchunga	Mchunga	Bitter lettuce	*Launaea cornuta*	7.85	0.542	2.38
Olamburi	Majani ya sungura	Gallant soldier	*Galinsoga parviflora*	11.45	0.331	1.31
Ngomba	Ngoomba	n.a.	*Brassica* sp.	8.95	0.348	2.22
Matembele meusi	n.a.	n.a.	n.a.	5.90	0.335	4.38
Matembele	Majani ya viazi	Sweet potato leaves	*Ipomea batatas* (L.)	7.60	0.646	2.67
Endere-venyu	n.a.	n.a.	n.a.	5.95	0.542	2.01
Mkombi-takata	n.a.	n.a.	n.a.	10.70	0.768	3.08
Saro	n.a.	n.a.	n.a.	12.65	0.615	1.91
Majani ya magimbi	Majani ya magimbi	n.a.	*Colocasia* sp.	6.60	0.600	1.65
Engisamvu	Kisamvu-muhogo	Cassava leaves	*Manihot esculenta*	6.95	0.825	16.13
Muhogo-mpira	Kisamvu-mpira	Cassava leaves	*Manihot glaziovii*	3.05	0.852	9.95
Mbigiri	Mbigiri	Puncture vine	*Oxygonum sinuatum*	8.25	1.418	10.79
Mpilipili	Majani ya mpili pili	Chili pepper leaves	*Capsicum* sp.	6.30	0.310	7.05

Annex-5 Cluster analysis: preferred traits in amaranth

	TYPE I	TYPE II	TYPE III
Leaf color			
Light green	0.095	0.000	0.071
Green***	0.095	**1.000**	0.107
Dark green***	**0.810**	0.000	**0.821**
Leaf shape			
Narrow***	**0.789**	**0.568**	0.037
Broad***	0.211	**0.432**	**0.963**
Leaf size			
Little***	**0.333**	0.114	0.033
Average***	**0.429**	**0.795**	**0.533**
Big***	0.238	0.091	**0.433**
Leaf texture			
Soft texture***	**0.826**	0.114	0.065
Fibrous texture***	0.174	**0.886**	**0.935**
Cooking time			
Cooks within 10 min*	**0.583**	0.535	0.323
Cooks within 20 min	0.375	0.419	0.548
Cooks within 30 min	0.042	0.047	0.129
Flavor			
Very bitter	0.000	0.000	0.067
A little bitter	0.105	0.023	0.133
A little sweet	0.105	0.068	0.100
Aroma			
Some aroma***	0.059	**0.810**	**0.897**
No aroma***	**0.941**	0.190	0.103
Sliminess			
Not slimy**	**0.842**	**1.000**	**0.833**
A little slimy**	0.158	0.000	0.167

*, **, *** Significance at 0.05, 0.01, or 0.001 levels, respectively. Bold numbers indicate the most representative output for each type, for example, Type I amaranth is dark green, narrow leaved, with little or average leaf size, soft textured, cooks within 10 minutes, has no distinct flavor, no aroma, and is not slimy after cooking. Survey in cooperation between Sokoine University and AVRDC, 2003, N=287

Annex-6 Cluster analysis: preferred traits in nightshade

	TYPE I	TYPE II	TYPE III
Leaf color			
Light green	0.097	0.000	0.095
Green***	**0.839**	0.176	0.286
Dark green***	0.065	**0.765**	**0.619**
Leaf shape			
Narrow***	0.000	0.294	**1.000**
Broad***	**1.000**	**0.706**	0.000
Leaf size			
Little***	0.032	0.000	**0.667**
Average**	**0.548**	**0.706**	0.286
Big**	**0.419**	0.294	0.048
Leaf texture			
Soft texture***	0.129	**0.588**	0.238
Fibrous texture***	**0.871**	0.412	**0.762**
Cooking time			
Cooks within 10 min	0.323	0.118	0.190
Cooks within 20 min	0.484	0.412	0.714
Cooks within 30 min*	0.194	**0.471**	0.095
Flavor			
Very bitter***	0.032	0.000	**0.381**
A little bitter***	**0.903**	**1.000**	**0.476**
Neutral	0.065	0.000	0.048
A little sweet	0.000	0.000	0.048
Aroma			
Some aroma	0.613	0.882	0.714
No aroma	0.387	0.118	0.286
Sliminess			
Not slimy**	**0.968**	**0.706**	**0.857**
A little slimy**	0.032	0.294	0.143

*, **, *** Significance at 0.05, 0.01, or 0.001 levels, respectively. Bold numbers indicate the most representative output for each type, for example, Type I nightshade is green, broad leaved, with average or big leaf size, fibrous, does not have a particular cooking time, is a little bitter tasting, has no consistent aroma or lack thereof, and is not slimy after cooking. Survey in cooperation between Sokoine University and AVRDC, 2003, N=287

Annex-7 Cluster analysis: preferred traits in African eggplant

	TYPE I	TYPE II	TYPE III
Fruit color			
Light green**	**0.375**	0.188	0.116
Dark green***	0.250	**0.500**	0.070
Milk white***	0.083	0.250	**0.605**
Yellow	**0.292**	0.063	0.209
Fruit shape			
Round***	**1.000**	0.000	0.048
Egg shaped***	0.000	0.000	**0.929**
Long***	0.000	**1.000**	0.024
Fruit size			
Small	0.087	0.125	0.045
Average***	**0.870**	**0.688**	**0.455**
Big***	0.043	0.188	0.500
Seediness			
No seeds	0.391	0.200	0.250
Seeds	**0.609**	**0.800**	**0.750**
Cooking time			
Cooks within 10 min	**0.522**	**0.500**	0.302
Cooks within 20 min	0.304	**0.438**	**0.558**
Cooks within 30 min	0.174	0.063	0.140
Flavor			
Very bitter	0.333	0.125	0.136
Little bitter***	0.250	**0.750**	**0.705**
Neutral	0.250	0.125	0.159
Little sweet**	0.125	0.000	0.000
Very sweet	0.042	0.000	0.000
Aroma			
No aroma**	**0.467**	0.267	0.150
Weak aroma**	0.000	0.267	0.050
Medium aroma***	0.267	0.200	**0.775**
Strong aroma**	0.267	0.267	0.025

*, **, *** Significance at 0.05, 0.01, or 0.001 levels, respectively. Bold numbers indicate the most representative output for each type, for example, Type I African eggplant is light green or yellow in color, round in shape, average sized, has seeds, cooks in 10 min or less, has no consistent flavor, and no aroma. Survey in cooperation between Sokoine University and AVRDC, 2003, N=287

Annex-8 Variable definition and sample statistics

Variable definition	Name	Mean	SD	Min	Max
WTP an additional %	WTP	2.24	1.144	1	4
1 = none		0.29			
2 = up to 25%		0.25			
3 = up to 50%		0.22			
4 = more than 50%		0.24			
Location					
1 = Arusha; 0 otherwise	ARUSHA	0.12	0.316	0	1
1 = Morogoro; 0 otherwise	MOROGORO	0.52	0.501	0	1
1 = Dar es Salaam; 0 otherwise	DAR ES SALAAM	0.12	0.487	0	1
Crop					
1 = Amaranth; 0 otherwise	AMARANTH	0.40	0.446	0	1
1 = Nightshade; 0 otherwise	NIGHTSHADE	0.27	0.470	0	1
1 = African eggplant; 0 otherwise	EGGPLANT	0.33	0.446	0	1
Market Type					
1 = Local market; 0 otherwise	LOCAL	0.65	0.028	0	1
1 = Wholesale market; 0 otherwise	WHOLE	0.09	0.017	0	1
1 = Supermarket; 0 otherwise	SUPER	0.26	0.026	0	1
Knowledge of IVs					
1 = can give examples for indigenous vegetables; 0 otherwise	KNOW	0.74	0.391	0	1
Highest completed education level					
1 = up to primary; 0 otherwise	PRIMARY	0.45	0.501	0	1
1 = up to secondary; 0 otherwise	SECONDARY	0.21	0.418	0	1
1 = up to high school; 0 otherwise	HIGHSCHOOL	0.09	0.266	0	1
1 = college and beyond; 0 otherwise	COLLEGE	0.25	0.412	0	1
Respondent's sex					
1 = Male; 2 = female	SEX	1.58	0.494	1	2
Respondent's age in years	AGE	35.01	8.954	19	71
Average weekly per capita expenditure	PC_EX	15.79	10.044	250	33333
Share vegetable in total food expenditure	SHARE	4407.86	3451.151	2	50