Vegetables for Combating Global Nutrition Problems

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Outline

1. Global nutrition: double burden
2. Vegetable production, consumption and health benefits
3. AVRDC mission and research themes
4. Approaches to food security, diversity and value addition
   - Vegetable germplasm
   - Indigenous vegetables and nutrition properties
   - Breeding for nutrition
   - Agricultural interventions for better nutrition and health
5. Challenges: evidence base and scaling up
1. Global nutrition: double burden

Global Nutrition and Health: Double Burden
Projected main causes of death, worldwide, all ages, 2005

- 35 million people (61%) died of chronic diseases in 2005
- 23 million people (30%) died of communicable diseases and nutritional deficiencies
- 80% of chronic disease deaths occur in low & middle income countries

Source: WHO 2005
Estimated number of adults with diabetes

Under Nutrition
Anaemia as a public health problem by country: Preschool-age children

Source: WHO
Under Nutrition
Biochemical vitamin A deficiency (retinol) as a public health problem:
Preschool-age children, 2001 - 2005

2. Vegetable production, consumption and health benefits
National vegetable availability vs. health/nutrition status

Health status indicator: Children under 5 mortality rate
Nutrition status indicator: Children under 5 underweight

Iceland, Thai, Malaysia, Costa Rica, Fiji, Grenada, Columbia, Peru, Panama, Honduras, Nicaragua

Data source for the correlation test: FAOSTAT and WHO

The strength of evidence for obesity, type 2 diabetes, cardiovascular disease (CDV), and cancer

<table>
<thead>
<tr>
<th></th>
<th>Obesity</th>
<th>Type 2 diabetes</th>
<th>CVD</th>
<th>Cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>High intake of energy-dense foods</td>
<td>C ↑</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High intake of NSP (dietary fibre)</td>
<td>C ↓</td>
<td>P ↓</td>
<td>P ↓</td>
<td></td>
</tr>
<tr>
<td>Wholegrain cereals</td>
<td></td>
<td>P ↓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruits and vegetables</td>
<td>C ↓</td>
<td>P ↓</td>
<td>C ↓</td>
<td>P ↓</td>
</tr>
<tr>
<td>Whole fresh fruits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugars-sweetened soft drinks and fruit juices</td>
<td>P ↑</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight and obesity</td>
<td></td>
<td>C ↑</td>
<td>C ↑</td>
<td>C ↑</td>
</tr>
<tr>
<td>Physical activity, regular</td>
<td>C ↓</td>
<td>C ↓</td>
<td>C ↓</td>
<td>C ↓</td>
</tr>
<tr>
<td>Heavy marketing of energy-dense foods, and fast-food outlets</td>
<td>P ↑</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C ↑: Convincing increasing risk; C ↓: convincing decreasing risk; P ↑: Probable increasing risk; P ↓: Probable decreasing risk; P-NR: Probable, no relationship.
Dietary recommendation

Vegetables
3-5 servings a day
Min. 200 g per day
Min. 73 kg per year

Share of vegetable consumption in Asia
(min. 200 g/day/person)

<table>
<thead>
<tr>
<th>Region</th>
<th>Eastern Asia</th>
<th>Western Asia</th>
<th>Central Asia</th>
<th>Asia</th>
<th>SE Asia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td>715 g/day</td>
<td>423 g/day</td>
<td>422 g/day</td>
<td>171 g/day</td>
<td>144 g/day</td>
</tr>
<tr>
<td>SE Asia</td>
<td>7%</td>
<td>36%</td>
<td>29%</td>
<td>14%</td>
<td>4%</td>
</tr>
<tr>
<td>Other veg</td>
<td>8%</td>
<td>12%</td>
<td>15%</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Tomatoes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data source: FAOSTAT 2010
Vegetable consumption in sub-Saharan African countries

- Nigeria
- Kenya
- Sudan
- Tanzania
- Uganda
- Ethiopia
- Congo, D.R.
- Mozambique

Regional average: 31.5 kg/person/yr

Minimum required level = 73 kg

3 AVRDC mission and research themes
Our mission

“Alleviate poverty and malnutrition in the developing world through increased production and consumption of nutritious vegetables”

A broader crop portfolio

- Solanaceae: Tomato, Pepper
- Bulb Alliums: Onion, Garlic, Shallot
- Indigenous vegetables
- Legumes: Mungbean, Vegetable soybean
- Crucifers: Pak Choi, Broccoli
- Cucurbits: Cucumber, Pumpkin, Bitter gourd
Regional and project offices

AVRDC Research Themes

<table>
<thead>
<tr>
<th>Germplasm</th>
<th>Germplasm conservation, evaluation and gene discovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breeding</td>
<td>Genetic enhancement, varietal development and selection of indigenous lines</td>
</tr>
<tr>
<td>Production</td>
<td>Safe and sustainable vegetable and seed production systems</td>
</tr>
<tr>
<td>Consumption</td>
<td>Nutrition, socio-economic and marketing</td>
</tr>
</tbody>
</table>

Cross-cutting topics: nutrition, socio-economic and marketing
4. Approaches to food security, diversity and value addition
   - Vegetable germplasm
   - Indigenous vegetables and nutrition properties
   - Breeding for nutrition
   - Agricultural interventions for better nutrition

Strategies to address micronutrient malnutrition:

- Supplementation
- Food fortification
- Dietary modification
Contribution of vegetables to human nutrition and health

- Increased access, availability, and consumption of vegetables

- Improved nutrient and bioactive phytochemical contents

- Enhanced nutrient retention and bioavailability

= Nutrition and health outcome

- Assessing the outcomes from the consumption of vegetables on nutrition, public health and overall economic development.

Nutrition approaches

- Improve nutrition and health through food-based and agricultural interventions
- Emphasize direct access to nutritious food
- Link Agriculture – Food – Nutrition – Social science
- Develop R to D pathway
4. Approaches to food security, diversity and value addition
- Vegetable germplasm
- Indigenous vegetables and nutrition properties
- Breeding for nutrition
- Agricultural interventions for better nutrition

<table>
<thead>
<tr>
<th>Germplasm accessions conserved at AVRDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal crops</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>No. of accessions</td>
</tr>
<tr>
<td>No. of genera</td>
</tr>
<tr>
<td>No. of species</td>
</tr>
<tr>
<td>No. of countries of origin</td>
</tr>
</tbody>
</table>

[Image of vegetables]
The world’s largest* collection of vegetable germplasm: AVRDC-GRSU

Diversity

- Biodiversity
  - Germplasm collection and conservation
- Crop diversity
  - Breeding for better yield, quality and tropical adaptation
  - Improving farmer’s skills in vegetable production
- Food diversity
  - Promotion of greater consumption of vegetables including widely consumed and indigenous/ local vegetables
4. Approaches to food security, diversity and value addition
- Vegetable germplasm
- Indigenous vegetables and nutrition properties
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Indigenous vegetables

- Native to a particular region
- Long time use in diets
- Important role in biodiversity and diverse diet
- Grown locally on a small scale
- Often tolerant to environmental stress
- Most underutilized
- Limited Information on nutrient values, bioactive compounds, anti-nutrients, and potential health hazards

Indigenous vegetable species selected for promotion in southeast countries (ADB project, 2000-2006)

<table>
<thead>
<tr>
<th>No.</th>
<th>Species Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Abelmoschus esculentus</td>
<td>Okra, smooth and ridged types</td>
</tr>
<tr>
<td>2</td>
<td>Amaranthus spp.</td>
<td>Amaranth</td>
</tr>
<tr>
<td>3</td>
<td>Basella alba</td>
<td>Malabar spinach/Ceylon spinach</td>
</tr>
<tr>
<td>4</td>
<td>Benincasa hispida</td>
<td>Wax gourd</td>
</tr>
<tr>
<td>5</td>
<td>Beta vulgaris cvg bengalensis</td>
<td>Swiss chard group</td>
</tr>
<tr>
<td>6</td>
<td>Brassica oleracea cvg acephala</td>
<td>Kale group</td>
</tr>
<tr>
<td>7</td>
<td>Capsicum</td>
<td>Chilli</td>
</tr>
<tr>
<td>8</td>
<td>Coccinia grandis</td>
<td>Ivy gourd</td>
</tr>
<tr>
<td>9</td>
<td>Corchorus spp.</td>
<td>Jute</td>
</tr>
<tr>
<td>10</td>
<td>Cucurbita moschata</td>
<td>Pumpkin</td>
</tr>
<tr>
<td>11</td>
<td>Cucumis sativus</td>
<td>Cucumber</td>
</tr>
<tr>
<td>12</td>
<td>Dolichos lablab</td>
<td>Hyacinth bean/ lablab bean</td>
</tr>
<tr>
<td>13</td>
<td>Lagenaria siceraria</td>
<td>Bottle gourd</td>
</tr>
<tr>
<td>14</td>
<td>Luffa acutangula</td>
<td>Sponge gourd, ridged type</td>
</tr>
<tr>
<td>15</td>
<td>Luffa aegyptiaca</td>
<td>Sponge gourd, smooth type</td>
</tr>
<tr>
<td>16</td>
<td>Momordica charantia</td>
<td>Bittergourd</td>
</tr>
<tr>
<td>17</td>
<td>Solanum melongena</td>
<td>Eggplant</td>
</tr>
<tr>
<td>18</td>
<td>Trichosanthes cucumerina</td>
<td>Snakegourd</td>
</tr>
</tbody>
</table>

Source: LM Engle, AVRDC
Consumption of indigenous vegetables

- Thailand
- Lao PDR
- Tanzania
- Rwanda
- Uganda
- Philippines
- Average

Source: Surveys conducted by AVRDC in collaboration with NARES in respective countries

Priority indigenous vegetables promoted in Africa

- African eggplant
- Ethiopian mustard
- Amaranth
- Jute mallow
- Okra
- Leafy roselle
- African nightshade
Priority crops in Mali

- Okra
- High beta tomato
- African eggplant
- Roselle

Okra and moringa promoted in Niger

- Cameroon:
  - Okra, African Eggplant, Nightshade, Amaranth, Jute mallow
Over 5000 varieties of indigenous vegetables are maintained at AVRDC

Ivy Gourd  
*Coccinia grandis*

Tropical violet  
*Asystasia gangetica*

Jute mallow  
*Corchorus olitorius*

Okra  
*Abelmoschus esculentus*

Sweet potato vine  
*Ipomoea batatas*

Drumstick tree  
*Moringa oleifera*

AVRDC Vegetables Commercialized in Africa

Source: Takemore, AVRDC-RCA, Tanzania; Project: vBSS
Indigenous vegetable garden at AVRDC, Taiwan

Southern Taiwan: hot-wet, cool-dry tropical climates

Analytical items

- **Nutritional quality**
  - **Protein** (AOAC)
  - **Vitamins**
    - Carotenoids (HPLC)
    - Vitamin C (colorimetric)
    - Tocopherols (HPLC)
    - Folate (Microbial assay)
  - **Minerals** (AAS)
    - Calcium, iron, zinc

- **Eating quality**
  - Dry matter, crude fiber
  - Free sugars (reducing sugar)

- **Anti-nutrient factors**
  - Oxalate (HPLC)
  - Polyphenols (Folin)

- **Health promoting properties**
  - Flavonoids (HPLC)
  - Glucosinolates (enzymatic)
  - Antioxidant activities (ABTS, SOS)
  - Anti-microbial activities (diffusion)
  - Anti-inflammation (cell)
  - Anti-diabetes (cell)
**Nutrient content ranges**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Specie no.: ~120</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In 100 g fw</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Protein, g</td>
<td>243</td>
</tr>
<tr>
<td>β-carotene, mg</td>
<td>241</td>
</tr>
<tr>
<td>Vit. C, mg</td>
<td>243</td>
</tr>
<tr>
<td>Vit. E, mg</td>
<td>243</td>
</tr>
<tr>
<td>Folates, µg</td>
<td>90</td>
</tr>
<tr>
<td>Ca, mg</td>
<td>243</td>
</tr>
<tr>
<td>Fe, mg</td>
<td>243</td>
</tr>
<tr>
<td>Zn, mg</td>
<td>27</td>
</tr>
<tr>
<td>Total phenol, mg</td>
<td>241</td>
</tr>
<tr>
<td>AOA, TE</td>
<td>243</td>
</tr>
</tbody>
</table>

**Micronutrient contents of commonly consumed and indigenous vegetables**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Tomato</th>
<th>Cabbage</th>
<th>Moringa</th>
<th>Amaranth</th>
<th>Aibika</th>
<th>Sweet potato leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>β-Carotene, mg</td>
<td>0.40</td>
<td>0.00</td>
<td>15.28</td>
<td>9.23</td>
<td>5.11</td>
<td>6.82</td>
</tr>
<tr>
<td>Vit C, mg</td>
<td>19</td>
<td>22</td>
<td>459</td>
<td>113</td>
<td>82</td>
<td>81</td>
</tr>
<tr>
<td>Vit E, mg</td>
<td>1.16</td>
<td>0.05</td>
<td>25.25</td>
<td>3.44</td>
<td>4.51</td>
<td>4.69</td>
</tr>
<tr>
<td>Iron, mg</td>
<td>0.54</td>
<td>0.30</td>
<td>10.09</td>
<td>5.54</td>
<td>1.40</td>
<td>1.88</td>
</tr>
<tr>
<td>Folates, µg</td>
<td>5</td>
<td>ND</td>
<td>93</td>
<td>78</td>
<td>177</td>
<td>39</td>
</tr>
<tr>
<td>Antioxidant activity, TE</td>
<td>323</td>
<td>496</td>
<td>2858</td>
<td>394</td>
<td>560</td>
<td>870</td>
</tr>
</tbody>
</table>

Data source: AVRDC Nutrition Lab
Ranges: including >100 vegetable species
4. Approaches to food security, diversity and value addition
- Vegetable germplasm
- Indigenous vegetables and nutrition properties
- Breeding for nutrition
- Agricultural interventions for better nutrition

Breeding for better nutrition and health in the tropic (Biofortification)

- For widely consumed vegetables crops such as tomato and pepper, modest improvements in micronutrient density would benefit human health
- **Tomato**: Breeding for high beta-carotene, high lycopene, high rutin content
- **Pepper**: Breeding for high antioxidant and carotenoid paprika
- **Pumpkin**: Selection for high α- and β-carotenes
- **Bitter gourd**: Selection for antioxidant vitamins and anti-diabetic activities
- **Leafy crucifer**: selection for higher glucosinolates
- **Indigenous vegetables**: selection for high nutrient and low anti-nutrient content
Evaluation of germplasm for breeding materials

High beta-carotene, high lycopene tomato

- AVRDC high beta-carotene tomato lines in fresh market and cherry market types
- Orange color a challenge for consumer acceptance
- Piggyback with diseases resistant and heat tolerant genes
High antioxidant Capsicum accessions

Variation for total glucosinolates in leafy crucifer germplasm
Bitter gourd accessions to be evaluated for vitamins and anti-diabetic properties

Pumpkin accession for evaluation of carotenoids

Selection for high $\alpha$ - and $\beta$-carotene contents
4. Approaches to food security, diversity and value addition

- Vegetable germplasm
- Indigenous vegetables and nutrition properties
- Breeding for nutrition
- Agricultural interventions for better nutrition and health

Challenges

The complex of food and nutrition security

- All people, at all times, have access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active healthy life. (FAO)
- Food should be available, accessible, and consumed to meet nutritional needs.
Title: Improving vegetable production and consumption for sustainable rural livelihoods in Jharkhand and Punjab, India

Subproject 2: Home gardens for diet diversification and better health

- **Goal**: To contribute to increased diet diversification and improved household nutrition of rural population in India.
- **Objective**: To expand improved home garden practices in the targeted areas of Jharkhand and Punjab

### Major output (op) and operation pathway

- **Research for development**
  - OP 2: Baseline information
  - OP 3: Home garden design
  - OP 4: Food methods integration

- **Development for action**
  - OP 5: Technology transfer
  - OP 6: Capacity building

- **Dissemination to project stakeholders**

OP 7: Public dissemination through partnership
Garden layout

- 5 blocks
- 12 sub-plots
- Size:
  - 3 x 1m
  - 2 x 1m

Finalized home garden model for Jharkhand
Home garden design for Jharkhand at AVRDC

Home garden model design at AVRDC, Hyderabad, India

Home garden adopted in Jharkhand

Home garden model at research station

Home garden model in villages
### Daily vegetable and nutrient availability of garden produce harvested from 6x6 m home garden models

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>RDA*</th>
<th>Andhra Pradesh</th>
<th>Punjab</th>
<th>Jharkhand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables, g/d</td>
<td>750</td>
<td>111</td>
<td>60</td>
<td>72</td>
</tr>
<tr>
<td>Energy, kcal/d</td>
<td>8980</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Protein, g/d</td>
<td>196</td>
<td>10</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Vitamin A, ug RE/d</td>
<td>2400</td>
<td>123</td>
<td>93</td>
<td>69</td>
</tr>
<tr>
<td>Vitamin C, mg/d</td>
<td>160</td>
<td>239</td>
<td>95</td>
<td>127</td>
</tr>
<tr>
<td>Folate, ug DFE/d</td>
<td>670</td>
<td>118</td>
<td>65</td>
<td>56</td>
</tr>
<tr>
<td>Iron, mg/d</td>
<td>81</td>
<td>16</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Zinc, mg/d</td>
<td>41</td>
<td>12</td>
<td>6</td>
<td>9</td>
</tr>
</tbody>
</table>

* RDA: Values were the sum of RDA of 4 household members including one adult male and one adult female both with moderate physical work, one child of 7-9 year old, and one 14-15 year-old girl. RDA data source: NIN (2010)

* Weekly harvest data provided by Easdown et al., SRTT project

### Nutritional yields (amount per day) by month: fulfill daily nutrient requirements for a 4-person household in India

- Daily biomass yield (g/day) of garden produce, Hyderabad model at RCISA
- Daily vitamin A supply (ug RE/day) of garden produce, Hyderabad model

Weekly harvest data: provided by Easdown et al., SRTT project
Nutritional yields (amount per day) by month: failure to meet daily nutrient requirements for a 4-person household in India

- **Daily protein supply (g/day) of garden produce, Hyderabad model**

- **Daily iron supply (mg/day) of garden produce, Hyderabad model**

Weekly harvest data: provided by Easdown et al., SRTT project

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**Improved recipes for Jharkhand**

- Bottle gourd kheer
- Brinjal curry
- Kangkong mung dal curry
- Methi parantha
- Mix veg poha
- Spinach cucumber soup
- Soury bitter gourd
- Basella with buttermilk
- Fenugreek leaves with potato
- Spinach raita
- Sponge gourd in milky gravy
- Steel cut onion curry
- Tomato sauce
- Chilli carrot chutney
- Ridge gourd masha
- Fenugreek leaves with potato in yoghurt
- Baelis with buttermilk
- Paner capsicum fry
- Bean carrot fried
- Kangkong stir fry with potato
- Fried aubergine with potato fingers
- Vegetable jalfrezi
- Spinach sad
- Spinach sad in milky gravy
Women’s group in Tanzania trained by AVRDC staff for home gardening

Home harden produce for home consumption and local market

Veggie grown in home garden and sold at local market

Dried vegetable for sale
Hospital gardens in Rwanda

High adoption of improved lines of nightshade, Amaranth, celosia and African eggplant

Gikondo District Hospital, Kigali

Improved food methods, nutrient retention and accessibility; participatory recipe design and promotion
Village women group leaders, agricultural extension people and AVRDC staff

School garden in the Philippines

Gardening and physical activity

• Compare energy expenditure, nutritional and environmental effects of working in a 6 x 6 m² vegetable garden versus exercise in a wellness center

Vegetable seed kits for disaster response, rehabilitation, and nutrition relief

• To produce and make appropriate vegetable seed kits available and alleviate nutritional crises and respond to immediate rehabilitation of vegetable production in the most vulnerable farming communities in disaster-affected regions

Packet label

Seed packets

Threshing

Packing
Causes of lack of access to insulin

- Insulin is too expensive
- Not available in regional areas
- Transportation problems
- Supply is less than required
- Insulin is of very poor quality
- Preference is given to type I

Source: IDF, World Diabetes Report 2003
Bitter gourd

- A vegetable
  - Popular in India, China, the Philippines, Taiwan, and Japan
  - Consumed worldwide, particularly in Chinese and India communities

- A medicinal plant
  - Anti-hyperglycemia
  - Anti-hyperlipidemia
  - Anti-oxidation
  - Anti-inflammatory
  - Anti-microbial pathogens

BMZ-AVRDC Bitter Gourd Project

- Project title
  - A better bitter gourd: Exploiting bitter gourd (Momordica charantia L.) to increase incomes, manage type 2 diabetes, and promote health in developing countries

- Funded by BMZ
  - BMZ: Federal Ministry for Economic Cooperation and Development, Germany

- Project duration:
  - 2011.03.01 – 2014.02.28
Project goal and objectives

- **Goal**
  - Improved income and quality of life of diabetics in developing countries

- **Objectives**
  - Optimize production of anti-diabetic compounds in bitter gourd through varietal selection, postharvest practices, and preparation methods
  - Develop evidence-based dietary strategies using bitter gourd to reduce hyperglycemia (high blood sugar) in type 2 diabetic populations in Asia and Africa
Content, stability and effect of phytonutrients in bitter gourd

Germplasm

Commercial variety

Field and location

Harvest/ maturity

Postharvest

Food preparation

Animal

Human

Evidence-based agricultural and dietary strategies for the production and use of bitter gourd for anti-hyperglycemic control

Project approach

Bitter Gourd Project

www.Bitter-Gourd.org
5. Challenges

- Evidence-based interventions
  - Intervention packages, efficacy tested
  - Experimental design
  - Measuring nutritional efficacy and cost-effectiveness
- Delivery pathway and scaling up
  - Delivery strategies
  - Scaling up strategies