35th IVTC – International Vegetable Training Course
From Seed to Table and Beyond
5 September – 25 November 2016

# Linking Nutrition with Agriculture- Nutrition Values and Interventions from Seed to Table and Beyond

**Ray-Yu Yang**
Nutritionist, World Vegetable Center, Taiwan
ray-yu.yang@worldveg.org
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## Outline

- Introduction and objectives of the day (10 min)
- Part 1: Nutrition values from seed to table and beyond
  - Lectures (50 min)
    - Food and nutrition
    - Nutrition values from seed to table and beyond
    - Case studies
  - Group discussion and presentation (120 min)
- Part 2: Nutrition interventions from seed to table and beyond
  - Lectures (60 min):
    - Public health nutrition
    - Linking nutrition with agriculture
    - Case studies
  - Group discussion and presentation (120 min)

## Introduction

- Interventions for improved nutrition and health of rural and urban consumers through increased awareness, access and consumption of nutritious, diverse and safe vegetables
- **Objectives**:

  By the end of the day, participants should be able to
  - Describe nutritional properties of vegetables from seed to table
  - Consider nutritional traits in vegetable research and development
  - Recognize the complexity and conceptual pathway between agriculture and nutrition
  - Identify potential interventions, partnership, and indicators for improving nutrition through agriculture



## Introduction

- Group work
  - 4 working groups
  - Topic 1:
    - Improve nutritional values and contributions of vegetables
      - Research topic, problems, objectives, approaches, partnerships, expected results
  - Topic 2:
    - Improve nutritional outcomes of urban/rural consumers through agriculture
      - Project title, problems, objectives, approaches, partnerships, expected results
  - Presentation by group

## Part 1: Nutrition values from seed to table and beyond

- Essential nutrients and phytochemicals
- Daily requirement and health benefits
- Nutrient database
- Nutrient values along the food flow
  - Nutrient content
  - Nutrient supply
  - Nutrient cost
  - Nutrient retention
  - Nutrient bioavailability
  - Nutrient intake
  - Nutrient requirement

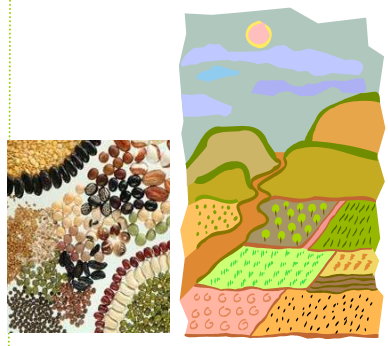


## Part 1: Nutrition values from seed to table and beyond

- Discussion:
  - Enhance Improve nutritional values of vegetables
    - Research topic, problems, objectives, approaches, partnerships, expected results

## Food flow from seed to fork, to human

Nutrition outcomes and impact




Seeds (genebank/breeding) → Field → Market → Plate → Human

Homestead Production

Gap (Seeds–Field)

Gap (Market–Homestead Production)

Gap (Plate–Market)

Gap (Human–Plate)



## Nutritional values from seed to table, to outcomes

Nutrition status

Environment | Income | Nutrition

Enabling factors

| | Germplasm | Breeding | Production | Consumption | | |
|---|---|---|---|---|---|---|
| | | | | Postharvest /processing | Market | Nutrition |
| Nutrition targets | Nutrient content | Nutrient yield | Nutrient supply | Nutrient retention | Cost of diet ? | Dietary intakes |
| Data | | | | | | |
| Content | X | X | X | X | | |
| Yield | | X | X | | | |
| Area | | | X | | | |
| Loss (?) | | | | X | | |
| Market reach/price (?) | | | | | X | |
| Consumption | | | | | | X |

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## Content

**(I) Importance of vegetables in human nutrition**

- Nutrition situation, dietary needs and consumption patterns
- Enhancing nutrient supplies from farm to table

**(II) Essential nutrients and phytochemicals**

- Classification, functionalities and health benefits
- Diversity and variation

**(III) Processing and nutrient**

- Why processing
- Nutrient loss, retention and enrichment

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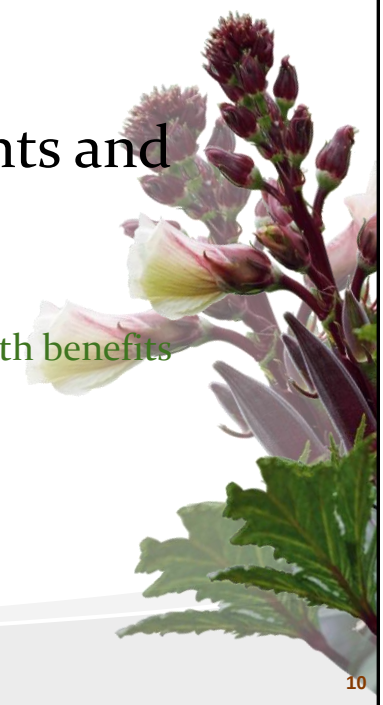
## Essential nutrients and phytochemicals



- Classification
- Functionalities and health benefits
- Diversity and variation

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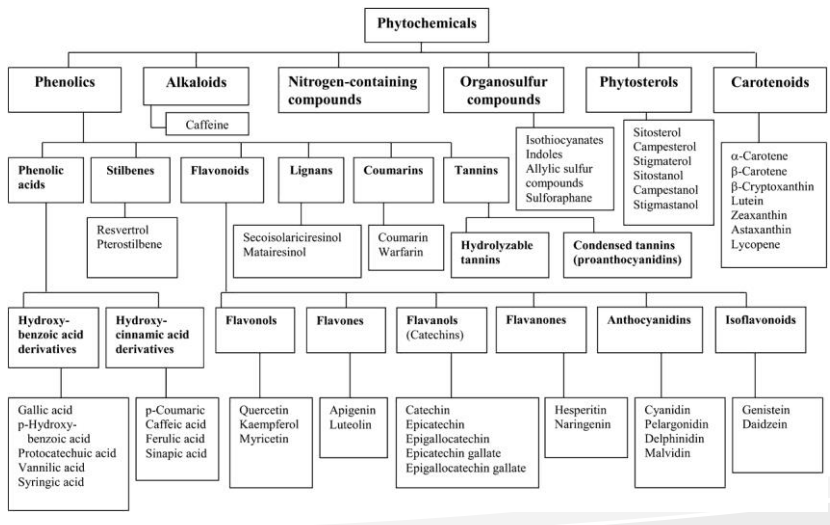
# Nutritional Components in Plants

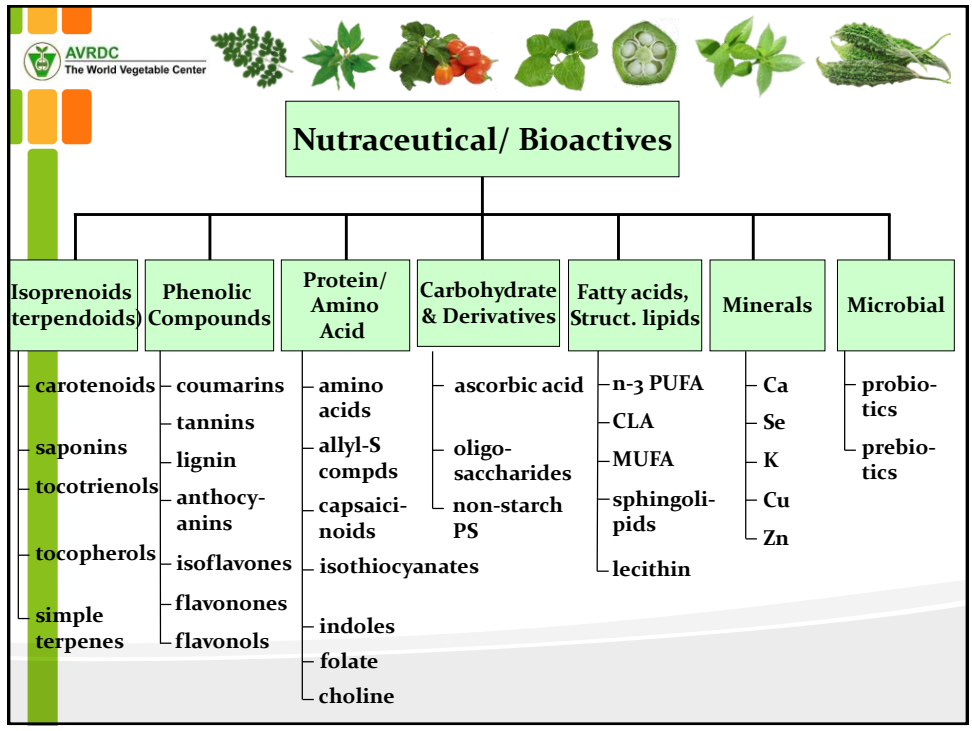
- Macronutrients (generally 90-98% dry wt)
  - Carbohydrates, Lipids, Amino Acids (few thousand compounds)
- Micronutrients (generally 1-10% dry wt)
  - Minerals: 17 essential (Fe, Zn, Ca, Na, Cu, K…)
  - Organics: 13 essential vitamins (A, B, C, D, E, K..)
- Secondary Metabolites
  - Estimated >200,000 in plants!
  - ~80,000 characterized

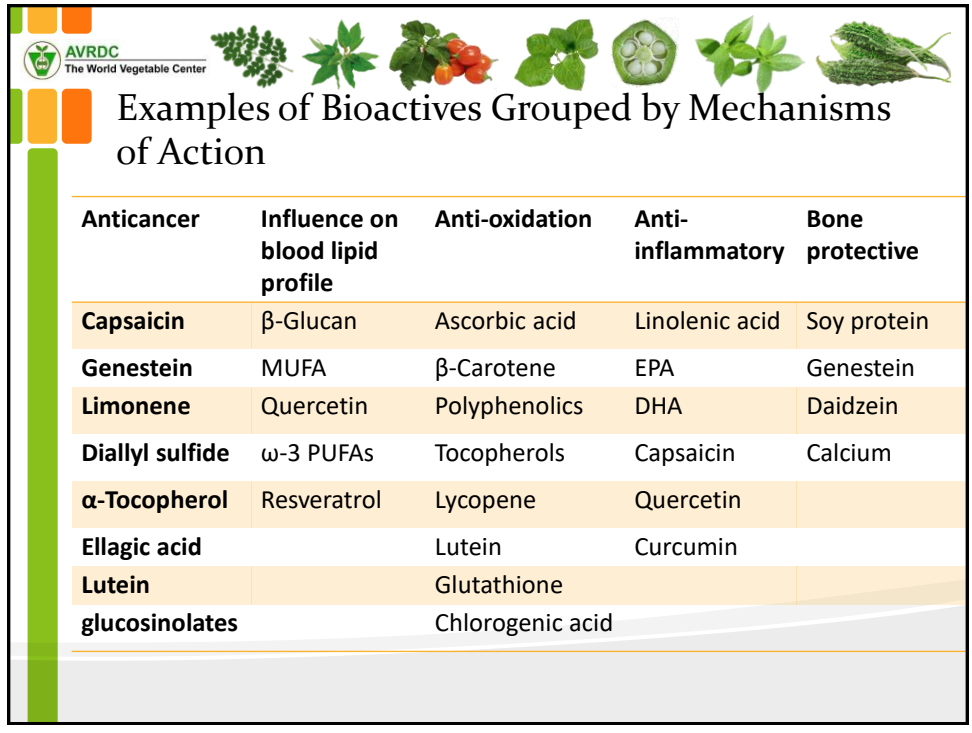
**Classification of dietary phytochemicals.**




Rui Hai Liu Adv Nutr 2013;4:384S-392S

Advances in Nutrition



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## Examples of Bioactives Grouped by Mechanisms of Action

| Anticancer | Influence on blood lipid profile | Anti-oxidation | Anti-inflammatory | Bone protective |
|---|---|---|---|---|
| **Capsaicin** | β-Glucan | Ascorbic acid | Linolenic acid | Soy protein |
| **Genestein** | MUFA | β-Carotene | EPA | Genestein |
| **Limonene** | Quercetin | Polyphenolics | DHA | Daidzein |
| **Diallyl sulfide** | ω-3 PUFAs | Tocopherols | Capsaicin | Calcium |
| **α-Tocopherol** | Resveratrol | Lycopene | Quercetin | |
| **Ellagic acid** | | Lutein | Curcumin | |
| **Lutein** | | Glutathione | | |
| **glucosinolates** | | Chlorogenic acid | | |

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## 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-inflammation
  - Anti-microbial pathogens

Source of photos: AVRDC

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## Phytonutrient Databases: examples

| Database | Domain | Phytochemicals/ compounds | Type of information | Type of database |
|---|---|---|---|---|
| **PubChem** | all organisms | >26 million unique chemicals, synthetic and natural | structures, physical properties, literature links | open access, queryable, downloadable |
| **Dr. Duke's Phytochemical and Ethnobotanical Databases** | plants | 8500 phytochemicals | occurrence in plants, content in plants, biological properties | open access, queryable |
| **Dictionary of Food Compounds** | foods | 30,000 natural food components and food additives | structures, physicochemical properties | commercial, queryable |
| **USDA Nutrient and Phytochemical databases** | foods | 63 fatty acids, vitamins, minerals, carotenoids, methylxanthines in 13,000 foods commonly eaten in the U.S.A. | content in foods | open access, queryable, downloadable |
| **EuroFIR-BASIS** | foods | 256 phytochemicals in 199 foods | content in foods, biological properties | membership, queryable |

Scalbert et al., JAFC 2011, 59, 4331: Database on food phytochemicals and their health-promoting effects

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NUTRIENT DATABASE

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African and Asian indigenous vegetables

**378 records found** (Total records:378)
Page 1 of 19 1 2 3 4 5 6 7 8 9 10 >

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20 records per page

| | ↑ Common name | Scientific name | Origin | Year | Part |
|---|---|---|---|---|---|
| Details | | Celosia argentea | Tropical Africa | 2004 | Young shoots |
| Details | African eggplant | Solanum macrocapon | Tropical Africa | 2002 | Fruit |
| Details | African nightshades | Solanum scabrum | Tropical Africa | 2006 | Young shoots |
| Details | African nightshades | Solanum villosum | Tropical Africa | 2006 | Young shoots |
| Details | African scarlet eggplant | Solanum aethiopicum | Tropical Africa | 2004 | Mature fruit |
| Details | African scarlet eggplant | Solanum aethiopicum | Tropical Africa | 2004 | Mature fruit |
| Details | African scarlet eggplant | Solanum aethiopicum | Tropical Africa | 2004 | Mature fruit |
| Details | African scarlet eggplant (3) | Solanum aethiopicum | Tropical Africa | 2004 | Mature fruit |
| Details | Aibika | Abelmoschus manihot | East Asia | 2003 | Young shoots |
| Details | Ailanthus prickly ash | Zanthoxylum ailanthoides | East Asia | 2002 | Young leaves |
| Details | Ailanthus prickly ash | Zanthoxylum ailanthoides | East Asia | 2004 | Young shoots |
| Details | Aromatic turmeric | Curcuma aromatica | India | 2002 | Stem |
| Details | Ashitaba | Angelica keiskei | East Asia | 2003 | Young leaves |
| Details | Ashitaba | Angelica keiskei | East Asia | 2004 | Young shoots |

http://avrdcnutrition.gtdtestsite.comoj.com/nutrition/

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## Indigenous vegetable garden at AVRDC, Taiwan

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

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## Laboratory analysis

- **Macro-constituents**
  - Dry matter
  - Protein
  - Crude fiber
  - Oil (total, n-3 & n-6)
- **Micro-constituents**
  - Antioxidant vitamins
    - A (carotenoids)
    - C (ascorbate)
    - E (tocopherols)
  - Minerals
    - Ca, Fe, Zn

- **Bioactives (selected)**
  - Flavonoids
  - Carotenoids
  - Glucosinolates
  - Total phenolics
  - Antioxidant activity
- **LCMS profiles**

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## Micronutrient contents of commonly consumed and indigenous vegetable

| | Ranges | Tomato | Cabbage | Moringa | Amaranth | Aibika | Sweet potato leaf |
|---|---|---|---|---|---|---|---|
| β-Carotene,mg | 0.0 - 22 | 0.40 | 0.00 | 15.28 | 9.23 | 5.11 | 6.82 |
| Vit C, mg | 1.1 - 353 | 19 | 22 | 459 | 113 | 82 | 81 |
| Vit E, mg | 0.0 - 71 | 1.16 | 0.05 | 25.25 | 3.44 | 4.51 | 4.69 |
| Iron, mg | 0.2 – 26 | 0.54 | 0.30 | 10.09 | 5.54 | 1.40 | 1.88 |
| Folates, µg | 2.8 – 175 | 5 | ND | 93 | 78 | 177 | 39 |
| Antioxidant activity, TE | 0.6 - 82,000 | 323 | 496 | 2858 | 394 | 560 | 870 |

Data source: AVRDC Nutrition Lab
Ranges: including >100 vegetable species

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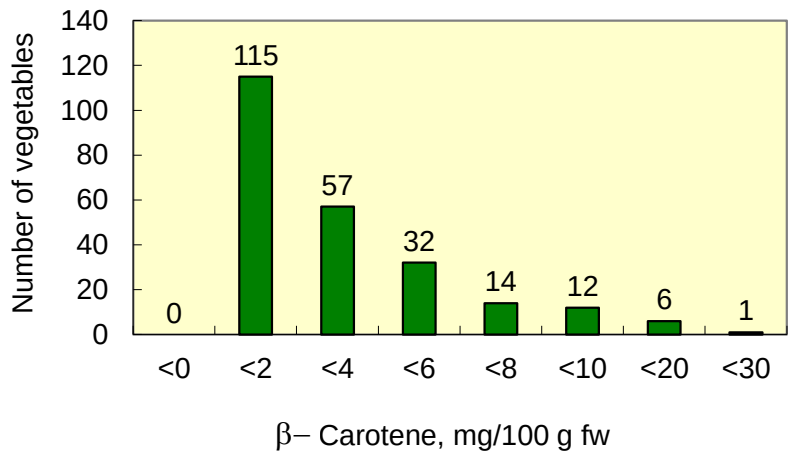
## Nutrient content ranges

| *In 100 g fw* | *N* | *Min* | *Max* | *Mean* | *SD* |
|---|---|---|---|---|---|
| Protein, g | 243 | 0.2 | 10 | 3 | 1.6 |
| β-carotene, mg | 241 | 0.0 | 22 | 3.1 | 3.3 |
| Vit. C, mg | 243 | 1.1 | 353 | 70 | 77 |
| Vit. E, mg | 243 | 0.0 | 71 | 2.6 | 5.6 |
| Folates, µg | 90 | 2.8 | 175 | 51 | 40 |
| Ca, mg | 243 | 2 | 744 | 121 | 136 |
| Fe, mg | 243 | 0.2 | 26 | 2.1 | 2.6 |
| Zn, mg | 27 | 0.17 | 1.24 | 0.49 | 0.24 |
| Total phenol, mg | 241 | 17 | 12,070 | 444 | 940 |
| AOA, TE | 243 | 0.63 | 82,170 | 1383 | 5648 |

Specie no.: ~120

## Vegetable germplasm distribution for β-carotene content




130 vegetable species

Slide 22 (2015/11/16)

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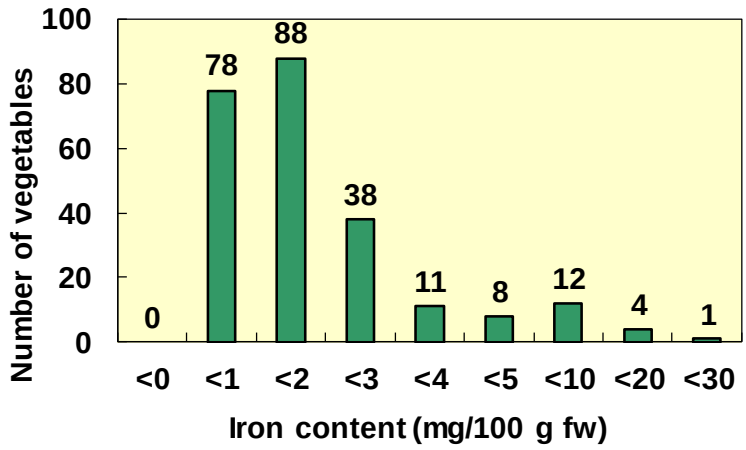
## Vegetable germplasm distribution for iron content




130 vegetable species

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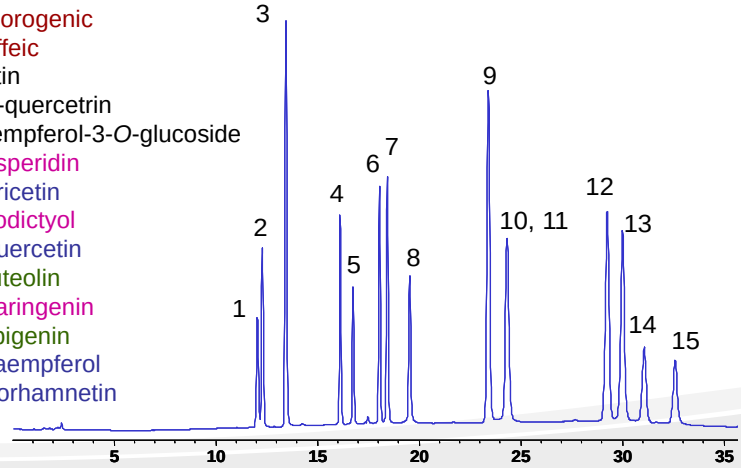
## HPLC chromatography of standard mixtures

1) Catechin
2) Chlorogenic
3) Caffeic
4) Rutin
5) Iso-quercetrin
6) kaempferol-3-*O*-glucoside
7) Hesperidin
8) Myricetin
9) Eriodictyol
10) Quercetin
11) Luteolin
12) Naringenin
13) Apigenin
14) Kaempferol
15) Isorhamnetin



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## Flavonoid content ranges of underutilized vegetables

| | Isorhamnetin | Kaempferol | Quercetin | Apigenin | Luteolin | Total |
|---|---|---|---|---|---|---|
| > 0.5 mg / 100g | | | | | | |
| Max | 9 | 111 | 224 | 72 | 95 | 256 |
| Mean | 2 | 15 | 27 | 12 | 23 | 47 |
| SD | 2 | 21 | 42 | 24 | 27 | 52 |
| *n* | 20 | 57 | 59 | 8 | 13 | 95 |
| < 0.5 mg / 100g | | | | | | |
| *n* | 95 | 58 | 56 | 107 | 102 | 20 |

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## Total flavonoids

明日葉
Ashitaba
*Angelica keiskei*
(256 mg/100g)

海巴戟
Indian mulberry
*Morinda citrifolia*
(254 mg/100g)

長蒴黃麻
Jute mallow
*Corchorus olitorius*
(164 mg/100g)

## Evaluation of germplasm for breeding materials



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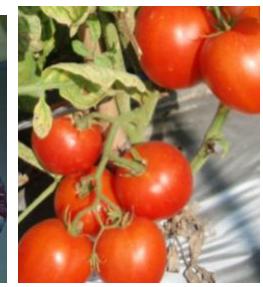
## High beta-carotene, high lycopene tomato

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



High beta-fresh, tropical type



High lycopene, disease resistant, heat tolerant , fresh type



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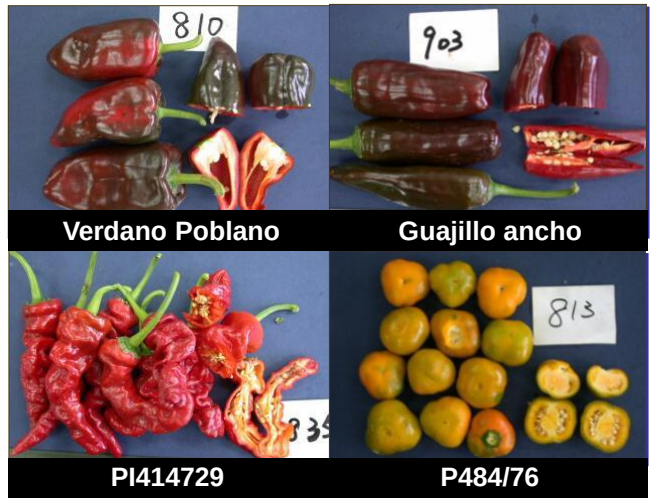
## High antioxidant Capsicum accessions




Slide 29 (11/2010)

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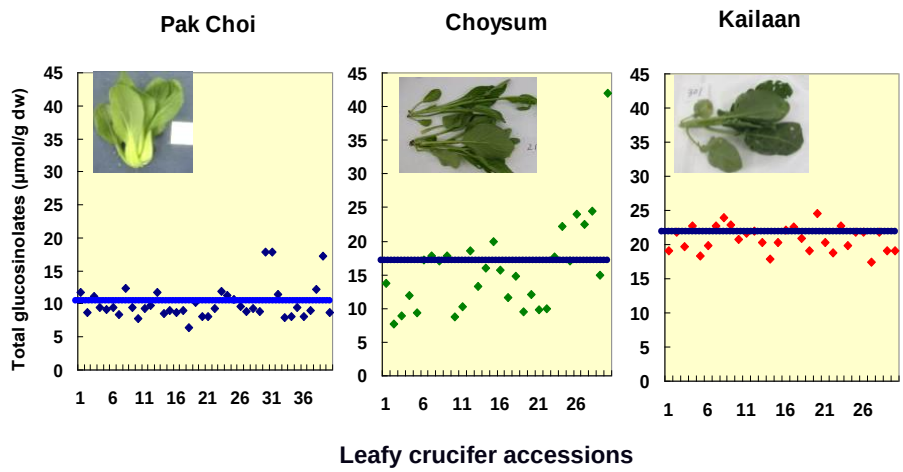
## Variation for total glucosinolates in leafy crucifer germplasm




Slide 30 (11/2010)

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## Bitter gourd accesions to be evaluated for vitamins and anti-diabetic properties


Showy


月华


NS 1020


NS 1024


NS 1026


TOT 2533


TOT 1854


TOT 4204


TOT 4234


TOT 4275


TOT 4296


TOT 4533


TOT 5793


TOT 5848


TOT 5852


Best 165 F1


Jade Dragon

Slide 31 (11/2010)

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## High density planting and pruning enable convenient and continuous harvests of young shoots

## Seasonal effects on nutritional values of mature moringa leaves

| *100 g FW* | *June (summer)* | *January (winter)* | *April (spring)* |
|---|---|---|---|
| | *Mature leaves* | | |
| Dry matter, g | 23.8 ± 0.9 a | 21.4 ± 0.7.b | 21.4 ± 1.5 b |
| Protein, g | 7.59 ± 0.35 a | 6.59 ± 0.30 b | 6.46 ± 0.89 b |
| Fiber, g | 1.83 ± 0.16 b | 1.93 ± 0.13 a | 1.47 ± 0.11 c |
| Sugars, g | 3.17 ± 0.41 a | 3.04 ± 0.22 a | 2.59 ± 0.44 b |
| Calcium, mg | 434 ± 66 b | 448 ± 48 b | 481 ± 67 a |
| Iron, mg | 6.24 ± 0.84 b | 9.73 ± 1.00 a | 4.10 ± 2.35 c |
| β-carotene | 20.1 ± 1.8 a | 7.8 ± 0.7 c | 13.8 ± 0.9 b |
| Vitamin C | 244 ± 18 b | 320 ± 28 a | 206 ± 21 c |
| Vitamin E | 18.1 ± 3.6 a | 17.4 ± 2.6 a | 14.8 ± 2.3 b |
| AOA, µmol TE | 4380 ± 862 a | 2341 ± 205 b | 4166 ± 1211 a |
| Phenolics, mg | 558 ± 70 c | 802 ± 54 a | 681 ± 51 b |

Based on 100 g fresh weight

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## Seaesonal effects on nutritional values of moringa young shoots

| *Components.* | *June (summer)* | *January (winter)* | *April (spring)* |
|---|---|---|---|
| | *Young shoots* | | |
| Dry matter, g | 17.7 ± 1.5 a | 15.4 ± 1.7 b | 12.2 ± 1.1 c |
| Protein, g | 5.33 ± 0.46 a | 4.03 ± 0.57 b | 3.48 ± 0.35 c |
| Fiber, g | 1.59 ± 0.13 a | 1.39 ± 0.16 b | 1.43 ± 0.17 b |
| Sugars, g | 2.52 ± 0.34 a | 2.19 ± 0.28 b | 1.88 ± 0.34 c |
| Calcium, mg | 88 ± 20 | 84 ± 49 | 74 ± 9 |
| Iron, mg | 2.86 ± 1.08 b | 4.22 ± 1.36 a | 1.40 ± 0.34 c |
| β-carotene, mg | 6.96 ± 1.15 a | 2.75 ± 1.00 b | 2.56 ± 0.58 b |
| Vitamin C, mg | 256 ± 25 b | 294 ± 35 a | 183 ± 21 c |
| Vitamin E, mg | 6.09 ± 1.76 a | 4.08 ± 1.60 b | 2.86 ± 0.45 c |
| TEAC, µmol TE | 3381 ± 449 a | 2223 ± 381 b | 1307 ± 219 c |
| Phenolics, mg | 552 ± 68 b | 731 ± 100 a | 461 ± 40 c |

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## Effects of variety, leaf type and season on phytonutrient contents

- Variation among 10 *M. oleifera* accessions for nutrient contents was small
  - Breeding for higher nutrient content not worthwhile.
  - Varietal selection should focus on horticultural traits.
- Mature leaves vs young shoots
  - Mature leaves more nutritious than young shoots (1-5X difference)
  - Mature leaves could be quickly dried with minimum nutrient loss;
  - Young shoots have better eating quality



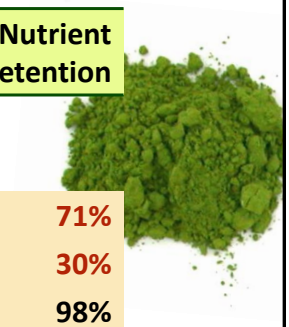


## Effects of variety, leaf type and season on nutrient and phytochemical contents (continued)

- Seasonal effects
  - 1.5 – 3X content variation for vitamin A, iron and antioxidants;
  - Higher protein, fiber, vitamin A and E in hot-wet season
  - Higher iron and vitamin C in cool-dry season

## Mild-heat drying maintained most nutrients in moringa leaves

| Phytonutrent | Freeze dry | 50˚C dry | Nutrient retention |
|---|---|---|---|
| Protein, g | 28 | 28 | |
| Fiber, g | 8 | 8 | |
| β-Carotene, mg | 154 | 110 | 71% |
| Vitamin C, mg | 582 | 157 | 30% |
| Tocopherols, mg | 169 | 165 | 98% |
| Calcium, mg | 1760 | 1670 | 95% |
| Iron, mg | 20 | 21 | 100% |
| Glucosinolates, mol | 8.6 | 9.9 | |
| AOA, mmol TE | 15.4 | 17.3 | |



Based on 100 g dry weight

Slide 37 (2015/11/16)

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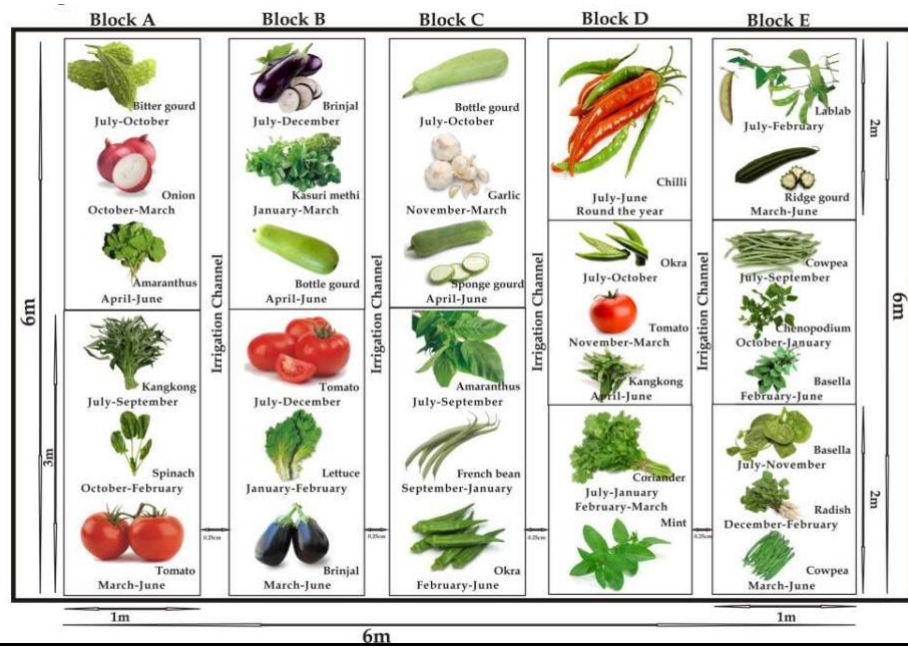
## Home garden model for Jharkhand



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## Home garden design for Jharkhand at AVRDC


Home garden demonstration at AVRDC, Hyderabad, India

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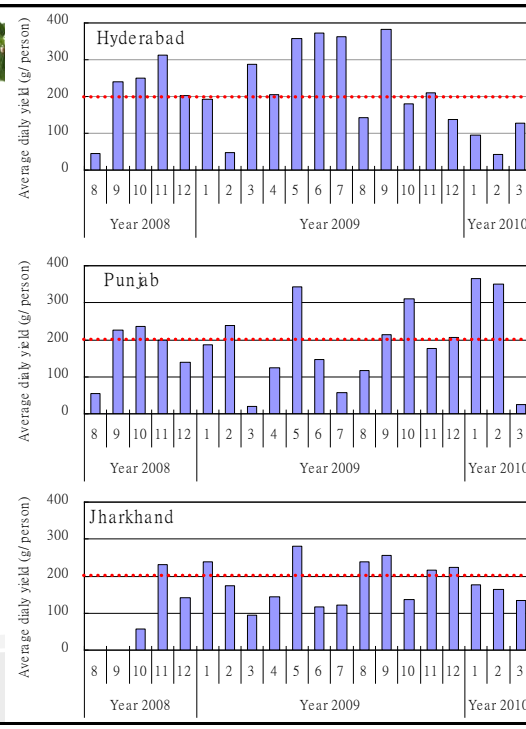
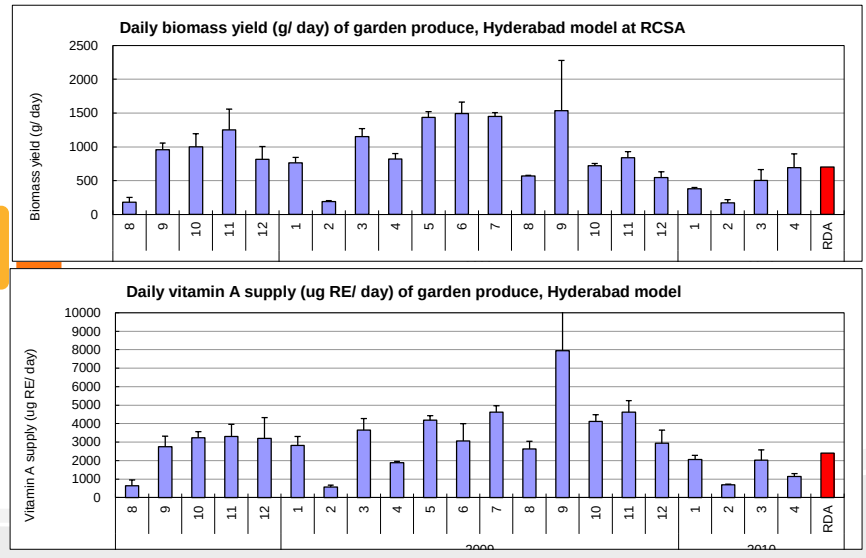
## Daily vegetable supply

- Average daily yield of vegetables harvested August 2008 – March 2010 from home garden models designed for Hyderabad, Punjab and Jharkhand.
- The line at 200 g/ person indicates recommended daily consumption level.



## Daily vegetable supply vs daily vitamin A supply (per person/day)




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

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## Daily vegetable and nutrient availability of garden produce harvested from 6x6 m² home gardens

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

- 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 7-9 year old child, and one 14-15 year-old girl. RDA data source: NIN (2010)
- Weekly harvest data provided by Easdown et al., SRTT project

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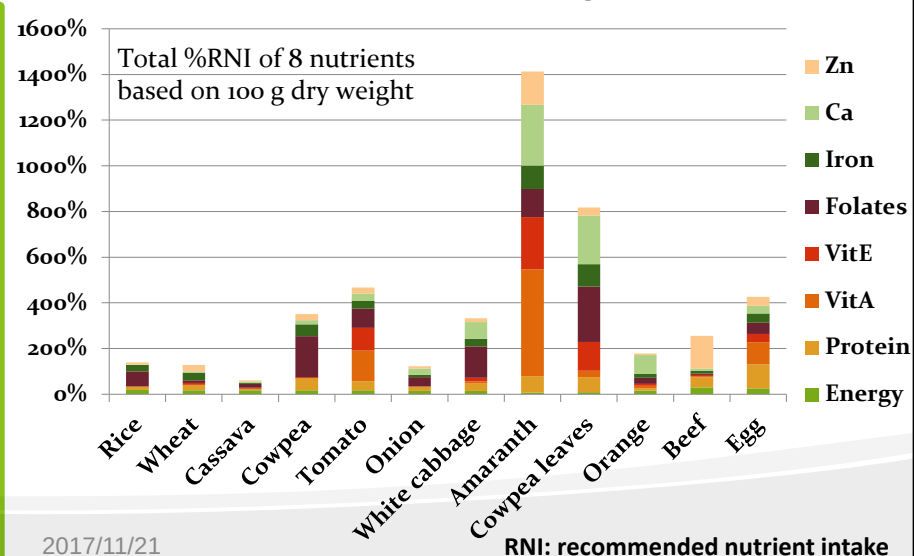
## Nutrient values of food groups




2017/11/21

RNI: recommended nutrient intake

# Processing and nutrition

- Why processing
- Nutrient loss, retention and enrichment

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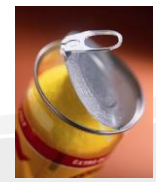
## Why are foods processed?

### Preservation

- Make them safer by killing existing bacteria and slowing bacterial growth.
- Methods: fermenting; salting; canning; pasteurising; freezing and drying.





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## Why are foods processed?

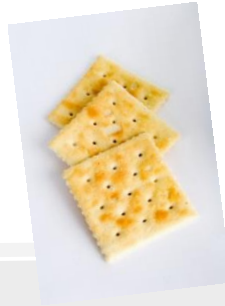
### Convenience and available year round

- Consumer demand and lifestyle choices has led to the development of a wide variety of convenience and fast food.


## Why are foods processed?

### Dietary need and health

- Health concerns within the population has led to an increased demand for healthier food choices, e.g. lower salt, fat and/or sugar
- Nutrient fortification, functional food



## Why are foods processed?

### Variety

- Processing foods provides the consumer with a wider choice.

- Processing can modify the food's:
- flavour
- texture
- smell;
- colour;
- shape.

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## Early methods of processing and preservation

### Using chemicals

- Pickling in vinegar
- Salting
- Sugar to make jam;
- Storing in alcohol
- Fermentation

### Temperature control and drying

- Cooking
- Sun drying
- Using ice blocks

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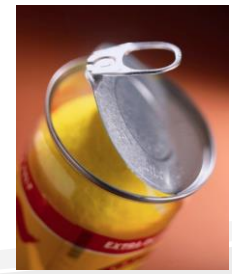
## Advances in food technology

- Some early methods of food processing and preservation are still used today.
- New technologies
  - Greater range of methods to package and store foods
  - Preservation and enhancement of nutrient values
  - Extension of food product shelf-life.
  - Greater variety and food choice



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## Effects of processing on nutritional values

### Preparation of vegetables

- Most vegetables are peeled or trimmed before cooking to remove the tough skin or outer leaves. But most nutrients, such as vitamins, tend to lie close to the skin surface, so excessive trimming can mean a huge reduction in a vegetable's nutrient value

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## Food Preservation

- All of the food preservation processes work by slowing down the activity and growth of disease causing bacteria, or by killing the bacteria all together. They also slow down or stop the action of enzymes which can degrade the quality of the food.
  - Temperature
  - Water Activity
  - pH

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## Effect of processing on nutritional values

In general:

- **Many vitamins** are sensitive and are easily destroyed when exposed to heat, air, water, or fats (cooking oils). With the exception of vitamin K and the B vitamin niacin, which are very stable in food,
- **Most minerals** are unaffected by heat. Cooked or raw, food has the same amount of calcium, phosphorus, magnesium, iron, zinc, iodine, selenium, copper, manganese, chromium, and sodium. Potassium, may escapes from foods into the cooking liquid.

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## Stable/ unstable vitamins

- Some vitamins are more stable (less affected by processing) than others. Water-soluble vitamins (B-group and C) are more unstable than fat-soluble vitamins (K, A, D and E) during food processing and storage.
- The most unstable vitamins include:
  - Folate, thiamine, vitamin C
- Vitamin A, E: sensitive to heat, pH, oxygen and light
- More stable vitamins include:
  - niacin (vitamin B3), vitamin K, vitamin D, biotin (vitamin B7), pantothenic acid (vitamin B5).

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## What Takes Nutrients Out of Food?

| Nutrient | Heat | Air | Water | Fat |
|---|---|---|---|---|
| Vitamin A | X | | | X |
| Vitamin D | | | | X |
| Vitamin E | X | X | | X |
| Vitamin C | X | X | X | |
| Thiamin | X | | X | |
| Riboflavin | | | X | |
| Vitamin B6 | X | X | X | |
| Folate | X | X | | |
| Vitamin B12 | X | | X | |
| Biotin | | | X | |
| Pantothenic acid | X | | | |
| Potassium | | | X | |

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## Processes affecting food nutrient content

- Milling
  - Ground to remove the fibrous husks
  - Loss of dietary fibre, B-group vitamins, phytochemicals and some minerals.
- Blanching
  - Heated very quickly with steam or water before canned or frozen
  - Loss water-soluble vitamins
- Canning
  - Severe heat treatment to kill any dangerous micro-organisms and extend the food's shelf life.
  - Affect the taste and texture; loss of vitamins significantly

## Processes affecting food nutrient content

- Freezing
  - Nutrient value retained when it is frozen
  - Nutrient losses due to the processing prior to freezing and the cooking once the frozen food is thawed
- Pasteurization
  - High temperature, short time treatment to destroy micro-organisms
  - Loss of some vitamins
- High pressure processing
  - Low temperature, high pressure to kill micro-organisms.
  - Less impact on the vitamin content, flavor and color

## Processes affecting food nutrient content

- Dehydrating
  - Loss of nutrients depending on temperature and drying time
  - Concentration of nutrients
  - More energy dense

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## Cooking

- Loss of nutrients depending on cooking time: vitamins B and C
- Benefits of cooking
  - making the food tastier
  - breaking down parts of vegetables that would otherwise be indigestible
  - destroying bacteria or other harmful micro-organisms
  - making phytochemicals more available, for instance, phytochemicals are more available in cooked tomatoes than in raw tomatoes
- .

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## Cumulative losses in vitamin C

***Table 2. Cumulative losses in vitamin C*** *due to fresh storage or processing and storage, followed by home cooking in all cases. Adapted from Rickman et al. (2007a).*

| Vegetable | Initial concentration (g/kg) | Refrigerated storage time before processing and cooking (days) | Loss after cooking (% wet weight) | | | Reference |
|---|---|---|---|---|---|---|
| | | | Fresh | Frozen | Canned | |
| Broccoli[a] | 1.23 | 21 | 5 | 35[b] | – | Howard et al. (1999) |
| | 1.80 | 21 | 38 | 62[b] | – | Howard et al. (1999) |
| Carrots[a] | 0.043 | 7 | 42 | 12[b] | 81[b] | Howard et al. (1999) |
| | 0.039 | 7 | +50[c] | 56[b] | 95[b] | Howard et al. (1999) |
| Green beans | 0.152 | 21 | 37 | 20[b] | – | Howard et al. (1999) |
| | 0.163[d] | 0 | 23 | 48[e] | 68[e] | Weits et al. (1970) |
| Green peas | 0.40[d] | 0 | 28 | 66[e] | 77[e] | Weits et al. (1970) |
| | 0.354 | 1–2 | 61 | 70[f] | 85[f] | Fellers and Stepat (1935) |
| Spinach | 0.28[d] | 0 | 64 | 81[e] | 67[e] | Weits et al. (1970) |

[a]*Authors repeated analysis in two consecutive years, results indicated separately.*
[b]*Stored for 12 mo prior to cooking.*
[c]*Authors reported increase in vitamin C with fresh storage.*
[d]*Authors did not provide values. Values taken from USDA (2005).*
[e]*Stored for 6 mo prior to cooking.*
[f]*Authors did not indicate storage time before cooking.*

## Effect of blanching and freezing on the retention (%) of fiber, phenolics compounds and minerals in different vegetables

| Sample | Soluble fiber | Insoluble fiber | Total dietary fiber | Pentosans | Pectins | Total Phenolics |
|---|---|---|---|---|---|---|
| Peas[a] | 149 | 106 | 107 | 108 | 84 | 79 |
| Carrots[b] | 115 | 125 | 120 | 134 | 130 | 92 |
| Cauliflower | 113 | 109 | 110 | 98 | 100 | 87 |
| Cabbage | 154 | 118 | 125 | 125 | 143 | 126 |
| Spinach | 88 | 112 | 108 | 133 | 123 | - |
| Potato | 83 | 111 | 97 | 116 | 190 | 71 |

Source: Puupponen-Pimiä *et al.* (2003).

## Effect of blanching treatment on the vitamin content of a variety of vegetables and leafy greens

| Product | Nutrient | Blanching process[a] | Loss (%) |
|---|---|---|---|
| Peas | Ascorbic Acid | W, 3 min/93°C | 33 |
| | | W, 6 min/93°C | 46 |
| | | W, 9 min/93°C | 58 |
| | Riboflavin | W, 3 min/93°C | 30 |
| | | W, 6 min/93°C | 30 |
| | | W, 9 min/93°C | 50 |
| | Thiamin | W, 3 min/93°C | 16 |
| | | W, 6 min/93°C | 16 |
| | | W, 9 min/93°C | 34 |
| | Carotene | W, 3 min/93°C | 2 |
| | | W, 6 min/93°C | 0 |
| | | W, 9 min/93°C | 0 |
| Lima beans | Niacin | W, 2 min/93°C | 32 |
| | | W, 4 min/93°C | 32 |
| | | W, 6 min/93°C | 37 |

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## Effect of blanching and freezing on the retention (%) of fiber, phenolics compounds and minerals in different vegetables

| Sample | Ca | Mg | K | P | Na | Cu | Mn | Fe | Zn |
|---|---|---|---|---|---|---|---|---|---|
| Peas[a] | 114 | 97 | 80 | 94 | 130 | 83 | 102 | 102 | 93 |
| Carrots[b] | 119 | 110 | 98 | 106 | 88 | 92 | 146 | 101 | 96 |
| Cauliflower | 100 | 89 | 84 | 87 | 87 | 115 | 75 | 94 | 70 |
| Cabbage | - | - | - | - | - | - | - | - | - |
| Spinach | 109 | 73 | 64 | 87 | 60 | 100 | 76 | 105 | 112 |
| Potato | 75 | 91 | 84 | 90 | ND | 92 | 95 | 97 | 176 |

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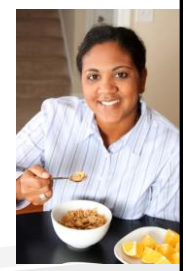
## Food processing: functional foods

- Preservation vs. enrichment of nutritional values
- Functional foods deliver additional or enhanced benefits over and above their basic nutritional value. It covers a wide range of products.

For example:
- dairy products containing probiotic bacteria;
- everyday foods fortified with a nutrient that would not usually be present e.g. folic acid fortified bread or breakfast cereals.



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## Food processing to enhance nutrient values

- Micro-encapsulation coats small particles such as B vitamins, vitamin C, iron, omega-3 fatty acids with a thin, tasteless, edible film masking any bitter taste and off odour. Products are enhanced without changing the desired flavour.
- High Pressure Processing is a cold pasteurisation technique. Food, previously sealed in flexible and water-resistant packaging, is subjected to a high level of hydrostatic pressure (pressure transmitted by water) for a few seconds to a few minutes.

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## Effect of minimum processing on nutritional values

| | Vit C | T/F | Vit A | Vit E | Minerals | Phytochem |
|---|---|---|---|---|---|---|
| Washed | | | | | | |
| Peeled | + | + | + | + | | + |
| Sliced | + | + | | | | + |
| Juiced | + | + | + | + | | + |
| Frozen | + | + | | | | |
| Oven dried | ++ | ++ | + | + | | ++ |
| Sun dried | +++ | +++ | +++ | +++ | | +++ |

T/F: thiamin and folate

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## Effects of More highly processing on nutritional values

| | Vit C | T/F | Vit A | Vit E | Minerals | Phyto-chem |
|---|---|---|---|---|---|---|
| Baked | ++ | + | ++ | ++ | | ++ |
| Fried | ++ | ++ | + | + | | |
| Pickled | +++ | +++ | +++ | +++ | + | +++ |
| Salted | +++ | +++ | +++ | +++ | + | +++ |
| Fermented | +++ | +++ | +++ | +++ | + | +++ |
| Pasteurized | +++ | +++ | ++ | ++ | | ++ |
| HPP | + | + | | | | |
| Fortification | +++ | +++ | +++ | +++ | +++ | +++ |

T/F: thiamin and folate

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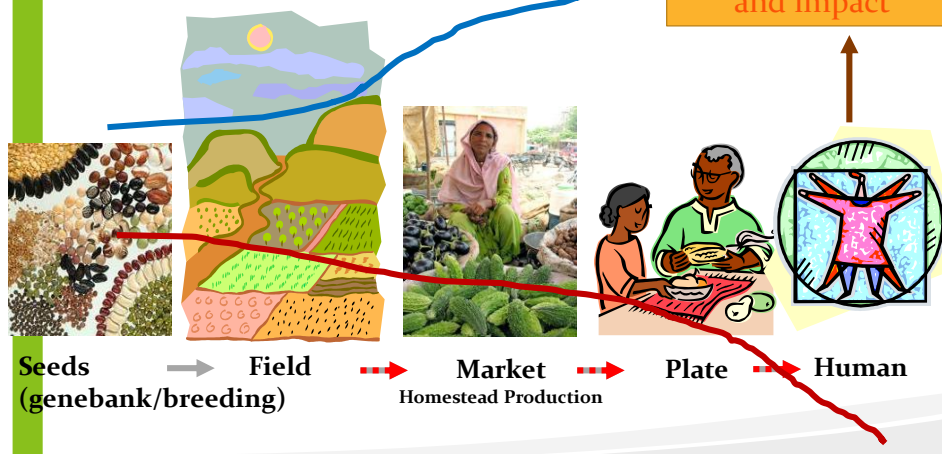
## Nutritional Value Chain



# Bioavailability

- Definition
- Measurement
- Extrinsic and intrinsic factors
- Anti-nutrient factors

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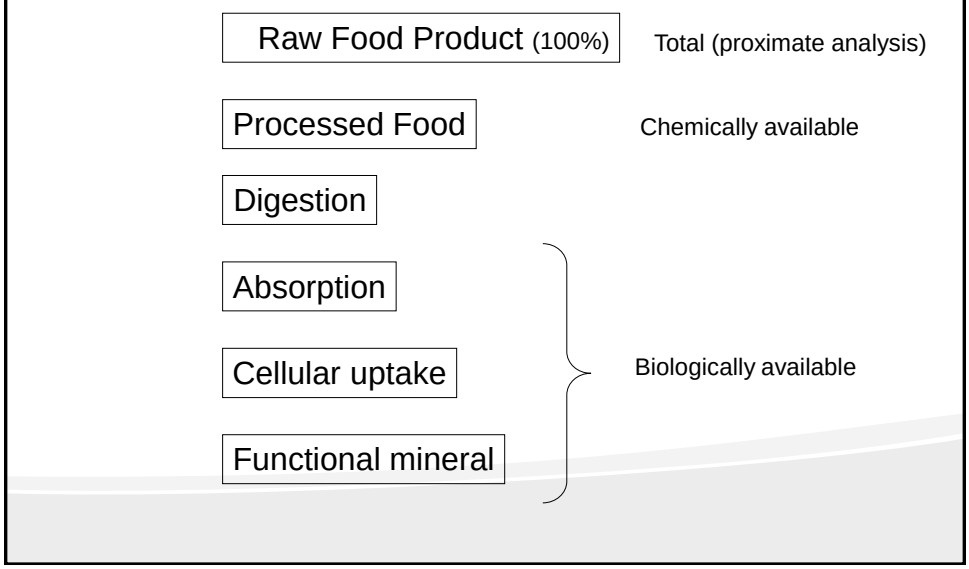
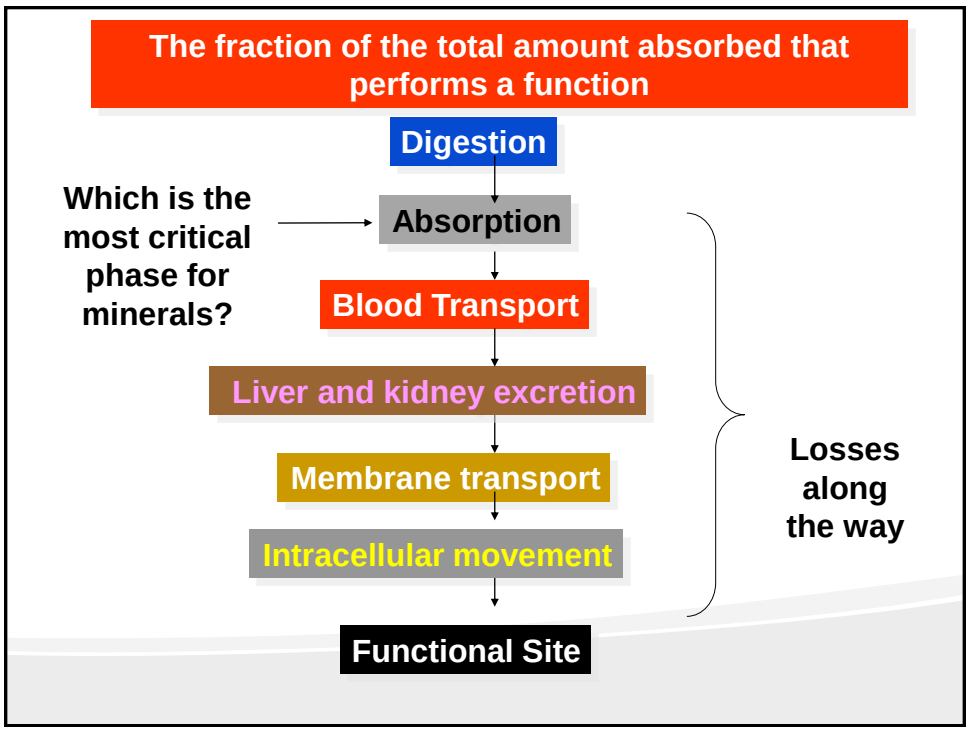
*Nutritional Definition*

Bioavailability is a post-absorption assessment of how much of a nutrient that has been absorbed becomes functional to the system

## Bioavailability *in toto*



**The amount that gets absorbed depends on:**

Extrinsic Factors

Digestibility of the food source
Solubility of the mineral
Elements in the food source that hinder or facilitate absorption

**With a focus on the organism, bioavailability depends on:**

Intrinsic Factors

Age
Health
Nutritional state
Physiological state
Genetic predisposition
Gender
Developmental stage
Species

**Biological Functions and Anti-nutritional Effects of Phytochemicals in Living System**

| Types | Biological Function of Flavonoids | Anti-Nutritional | In pants |
|---|---|---|---|
| Phytate | • Anti-cancer of phytic acid<br>• Reduce blood glucose and possesses health benefits | Excessive amounts of phytic acid in the diet will form insoluble complexes with multi-charged metals such as $Ca^{2+}$/ $Cu^{2+}$ /$Fe^{3+}$ /$Zn^{2+}$ | Nuts, Seeds, and Grains |
| Oxalate | • Chelate many toxic metals such as mercury and lead | Oxalic acid combines with divalent metallic cations such as Ca2+ / Fe2+ to become crystal | Leafy vegetable s |

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Source: C. Egbuna, J.C Ifemeje ,2015 ,Biological Functions and Anti-nutritional Effects of Phytochemicals in Living System , IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS) 10 (2), 10-19

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## Biological Functions and Anti-nutritional Effects of Phytochemicals in Living System

| Types | Biological Function of Flavonoids | Anti-Nutritional | In pants |
|---|---|---|---|
| Tannins | • Antiviral, antibacterial antiparasitic effects<br>• Inhibit HIV replication selectivity<br>• Ripening of fruit and aging of wine. | • Intake: reduce intake of forage legumes by deceasing palatability or by negatively affecting digestion.<br>• Growth: rate of gain for growing animals reflects total intake and availability of nutrients in the diet.<br>• Digestion of fiber fraction: reduce cell wall digestibility | Tea , wine, Legumes( red-colored bean) |
| Phenols | • Antitumour, antiviral, antimicrobial activities, hypotensive effects, anti-oxidant | Respiratory and cardiovascular effect<br>Reduced mineral absorption | Herbs, spices, nuts, vegetables |



## Biological Functions and Anti-nutritional Effects of Phytochemicals in Living System

| Types of Phytochemicals | Biological Function of Flavonoids | Anti-Nutritional | In pants |
|---|---|---|---|
| **Cardiac Glycosides** | • Found as secondary metabolites in several plants<br>• Inhibiting the $Na^+/K^+$ pump | Highly **toxic** effect on the vertebrate heart | Ouabain, Digoxin |
| **Alkaloids** | • Available in leaves, bark, roots or seeds of plants with diverse biological functions<br>• Stimulate the nervous system | High level of alkaloid exerts toxicity and adverse effects of humans, especially in physiological and neurological activities | Solanacea and many others |

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Source: C. Egbuna, J.C Ifemeje ,2015 ,Biological Functions and Anti-nutritional Effects of Phytochemicals in Living System , IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS) 10 (2), 10-19

## Biological Functions and Anti-nutritional Effects of Phytochemicals in Living System

| Types of Phytochemicals | Biological Function of Flavonoids | Anti-Nutritional | In pants |
|---|---|---|---|
| **Hemagglutinin (Lectin)** | • Agglutinate certain animal cells and/ or precipitate in a part of glycoprotein or glycolipid | Adverse effects may include nutritional deficiencies and immune (allergic) reactions | Legumes, cereal grains, seed nuts, potatoes |
| **Saponins** | • Biological benefits: anti-inflammatory, anti-diabetic, anti-HIV, anti-atherosclerotic<br>• Protective function: gastro-protective, hepatoprotective and hypolipidemic | • Dietary saponins are highly toxic to cold-blooded animals.<br>• Reduce nutrient utilization and conversion efficiency in ruminants | Vascular plants |



## Part 1: Nutrition values from seed to table and beyond

- Discussion:
  - Increase nutritional values of vegetables
    - Research topic, problems, objectives, approaches, partnerships, expected results

# Break!!