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

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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 traits 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

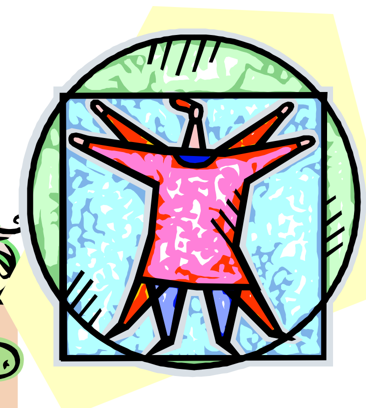
Part 1: Nutrition values from seed to table and beyond

- 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

X



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

Homestead Production

Gap

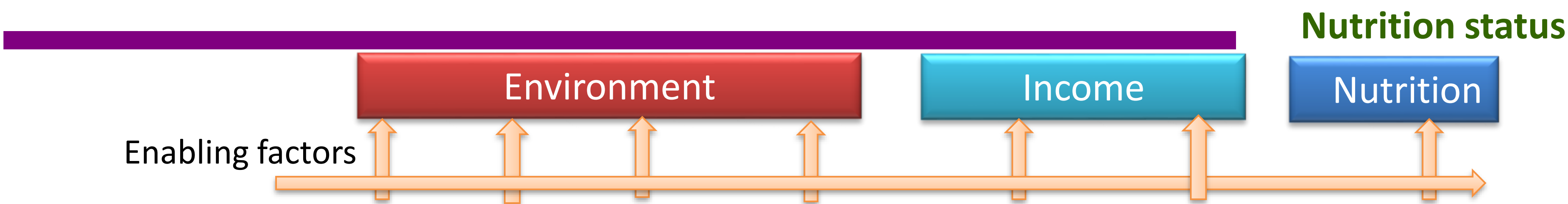
Gap

Gap

Gap

Gap

Nutritional values from seed to table, to outcomes



	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

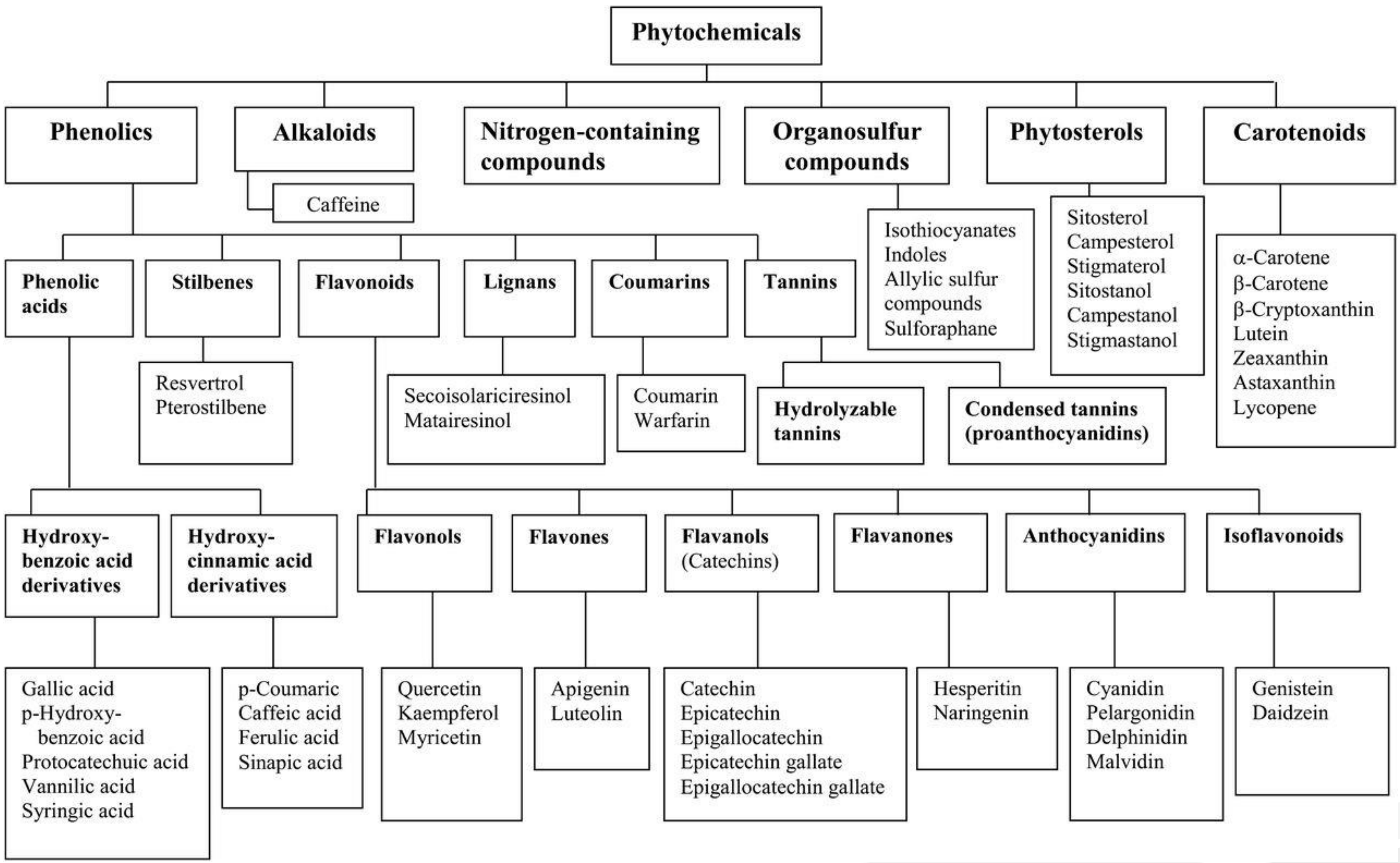
Essential nutrients and phytochemicals

- Classification
- Functionalities and health benefits
- Diversity and variation

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
AN INTERNATIONAL REVIEW JOURNAL

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Nutraceutical/ Bioactives

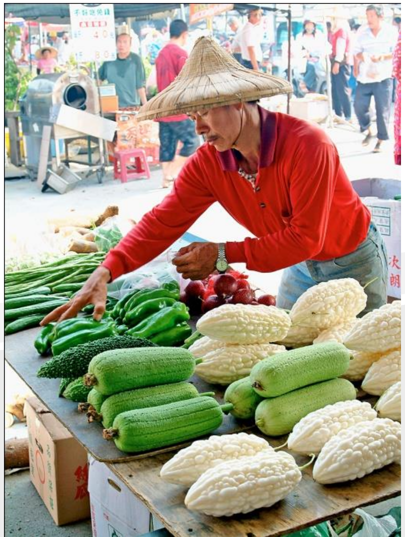
- **Isoprenoids (terpendoids)**
  - carotenoids
  - saponins
  - tocotrienols
  - tocopherols
  - simple terpenes
- **Phenolic Compounds**
  - coumarins
  - tannins
  - lignin
  - anthocy-anins
  - isoflavones
  - flavonones
  - flavonols
- **Protein/ Amino Acid**
  - amino acids
  - allyl-S compds
  - capsaici-noids
  - isothiocyanates
  - indoles
  - folate
  - choline
- **Carbohydrate & Derivatives**
  - ascorbic acid
  - oligo-saccharides
  - non-starch PS
- **Fatty acids, Struct. lipids**
  - n-3 PUFA
  - CLA
  - MUFA
  - sphingoli-pids
  - lecithin
- **Minerals**
  - Ca
  - Se
  - K
  - Cu
  - Zn
- **Microbial**
  - probio-tics
  - prebio-tics

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		

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

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 >

AVRDC Nutrition

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/

Indigenous vegetable garden at AVRDC, Taiwan

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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

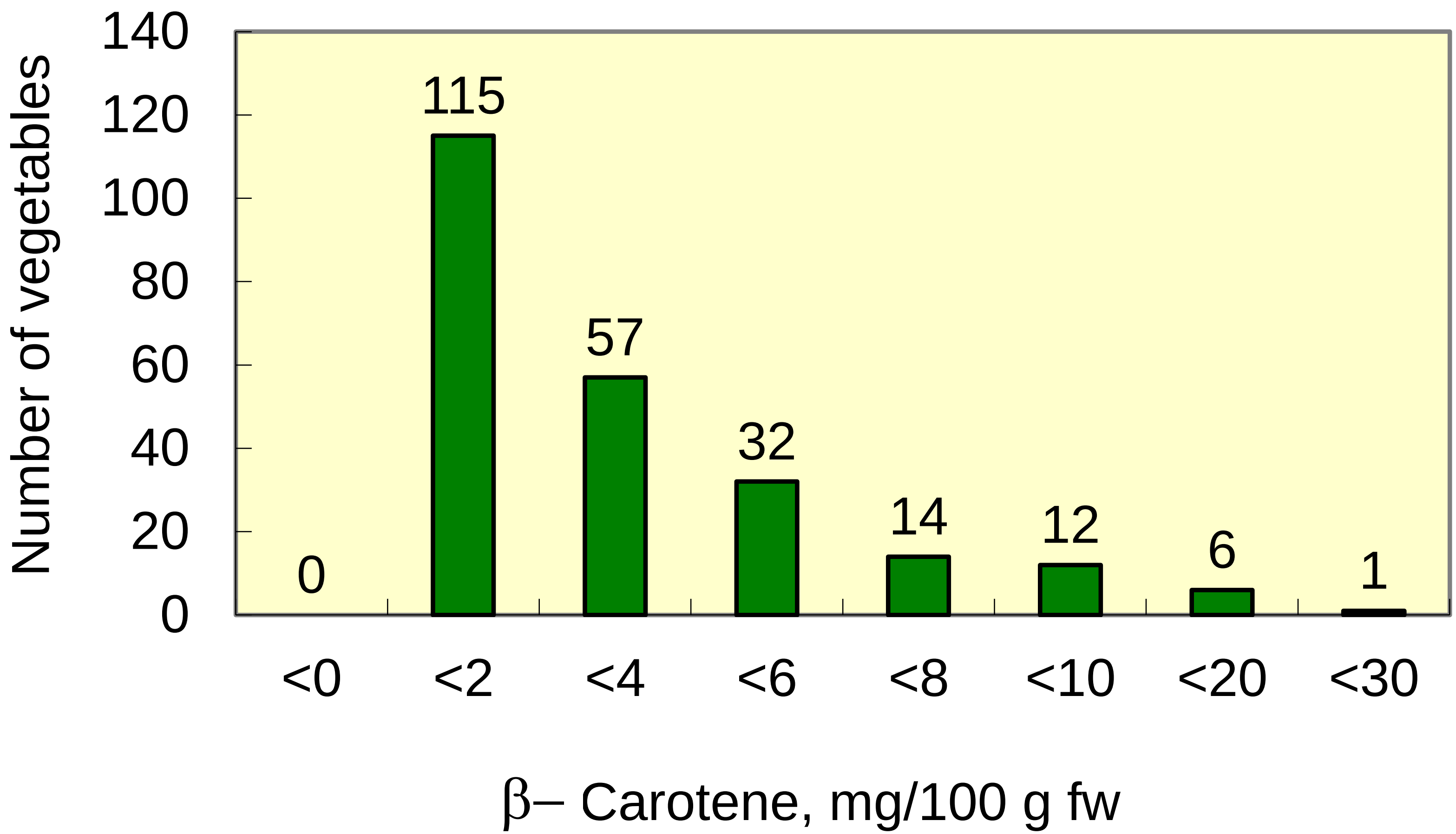
Data source: AVRDC Nutrition Lab
Ranges: including >100 vegetable species

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

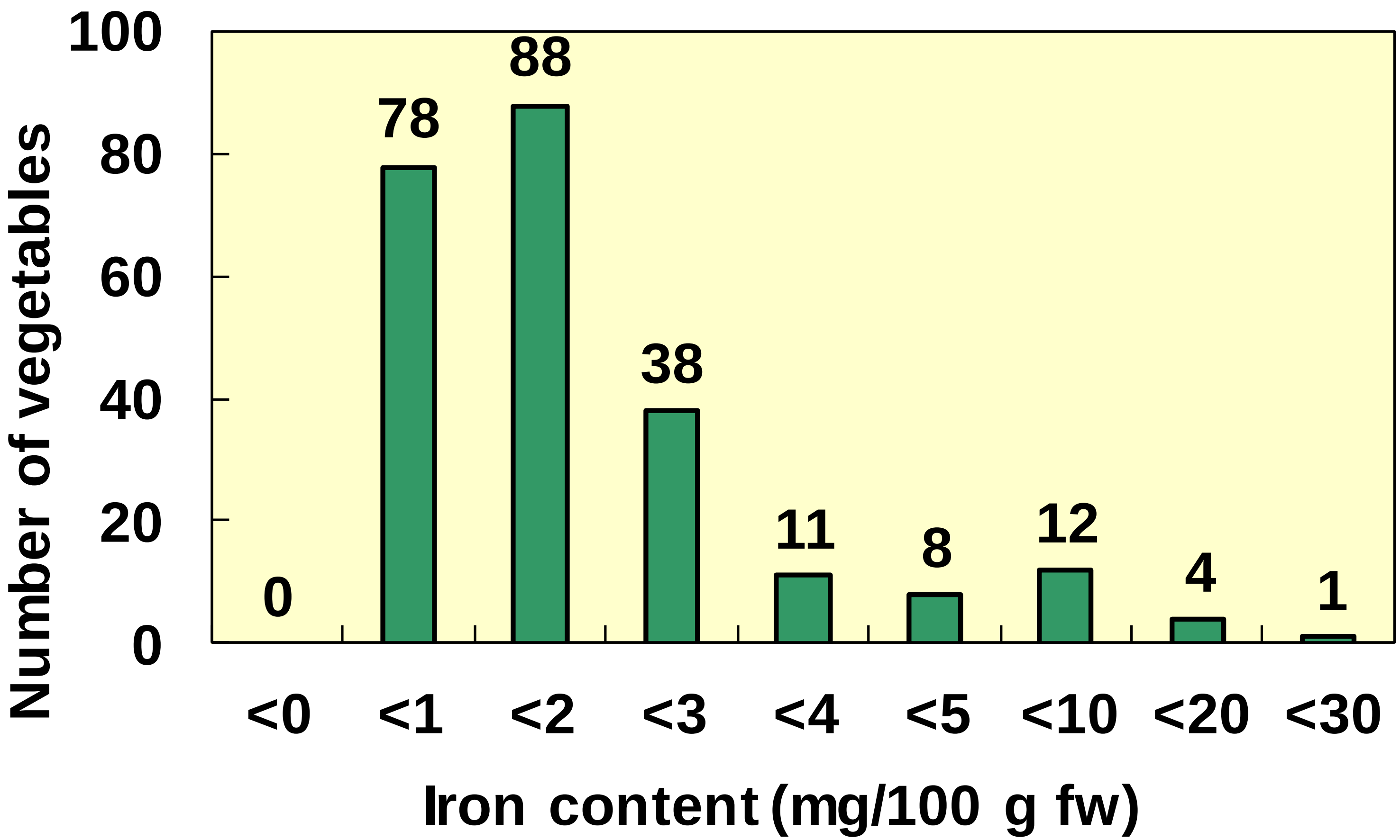
Specie no.: ~120

Vegetable germplasm distribution for β-carotene content



130 vegetable species

Vegetable germplasm distribution for iron content



130 vegetable species

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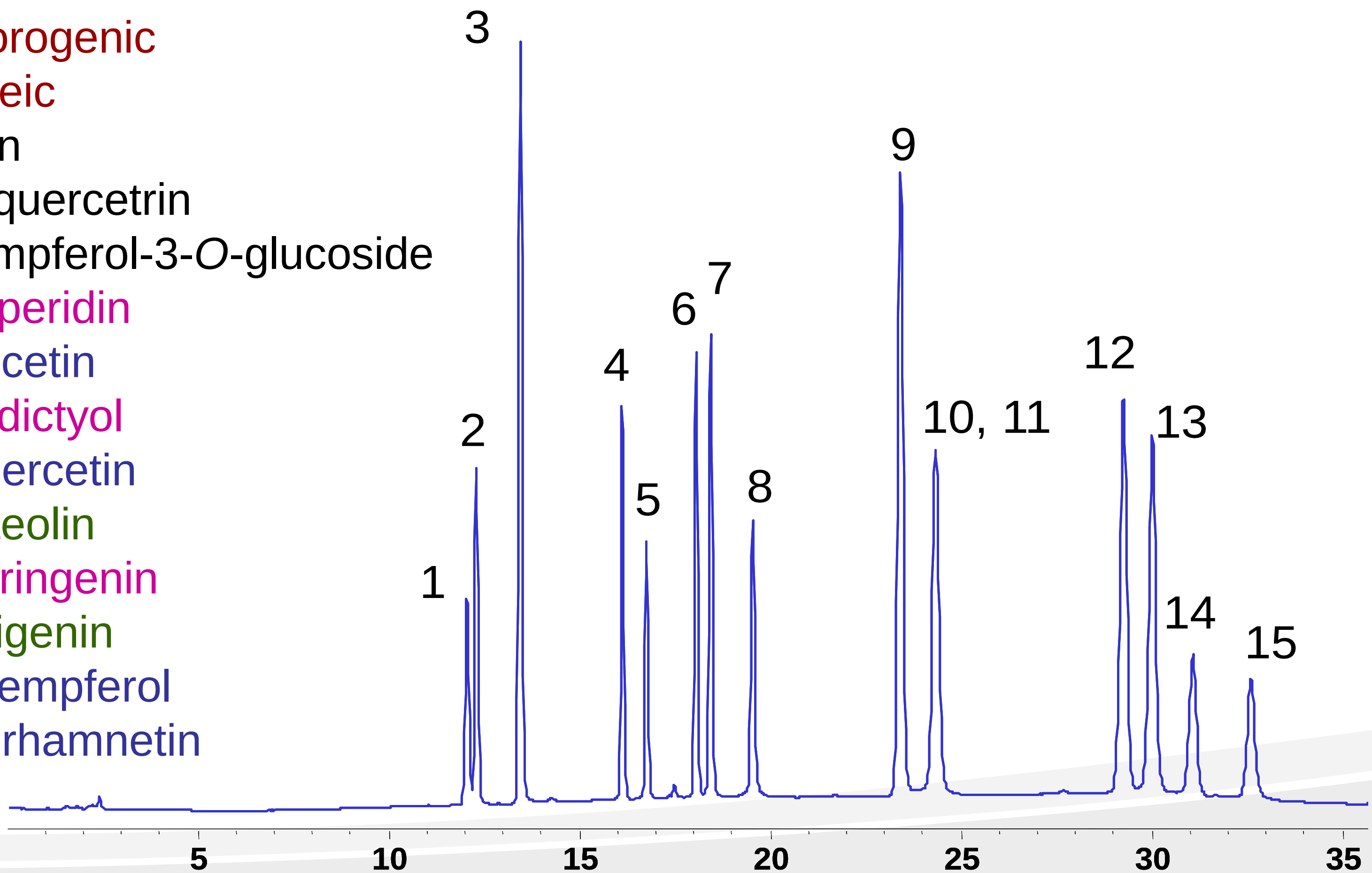
HPLC chromatography of standard mixtures

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

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

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 cherry tropical type

High beta-fresh, tropical type

High lycopene, disease resistant, heat tolerant , fresh type

High antioxidant Capsicum accessions

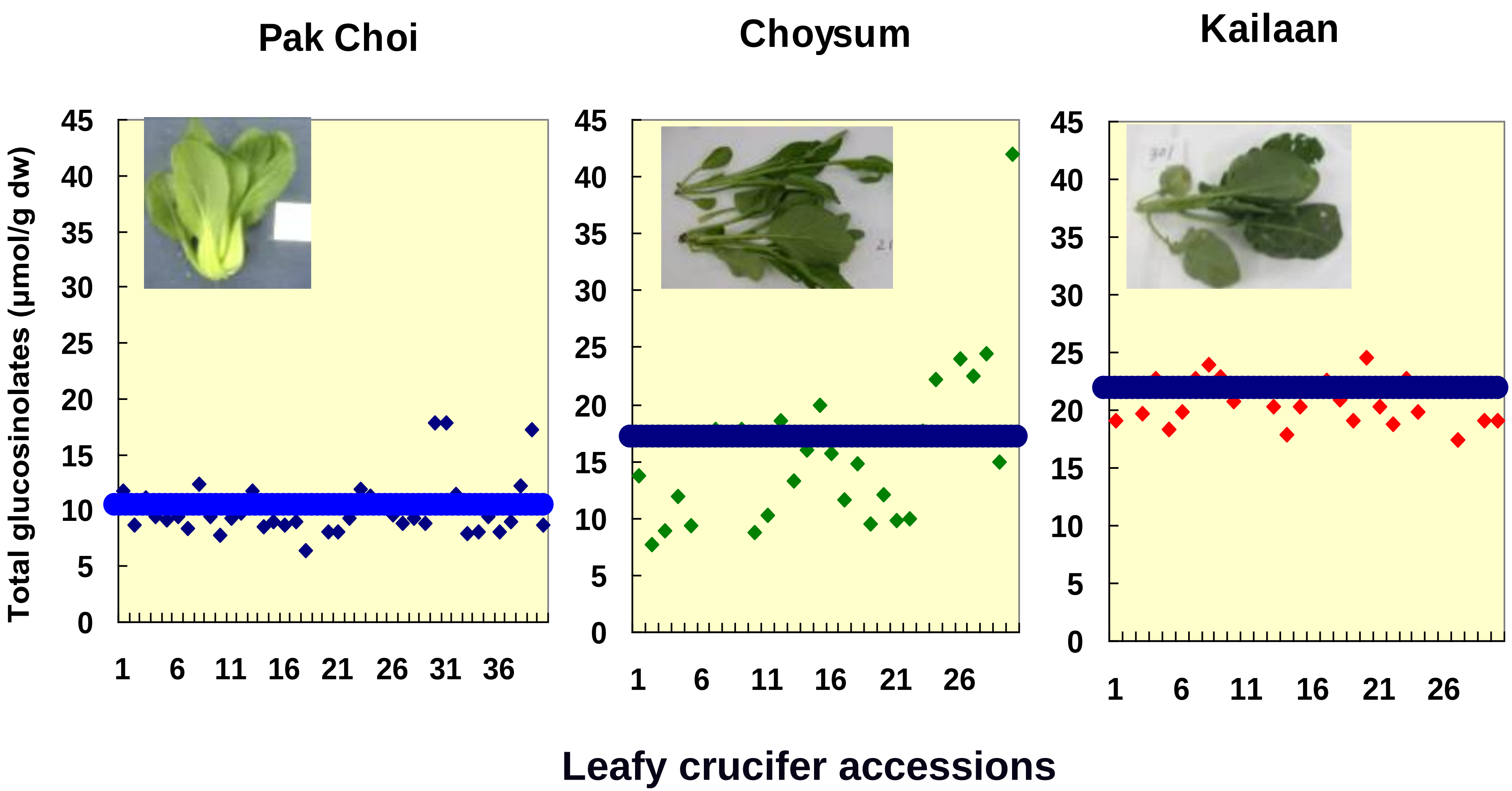
Verdano Poblano

Guajillo ancho


PI414729

P484/76

Variation for total glucosinolates in leafy crucifer germplasm



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

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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

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

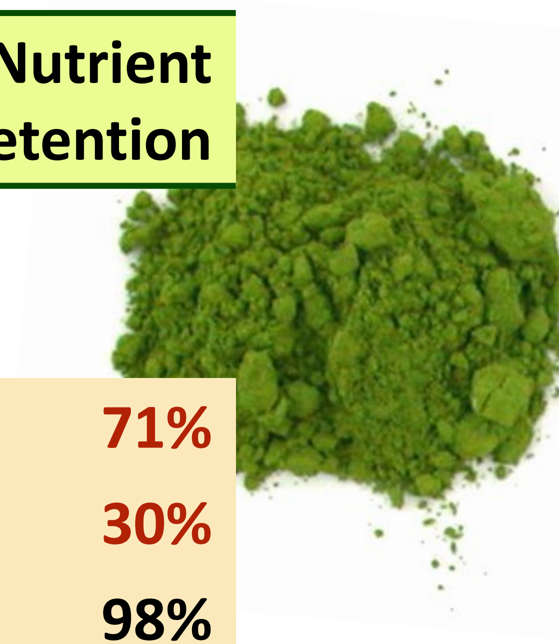
Effects of variety, leaf type and season on phytonutrient contents

- 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

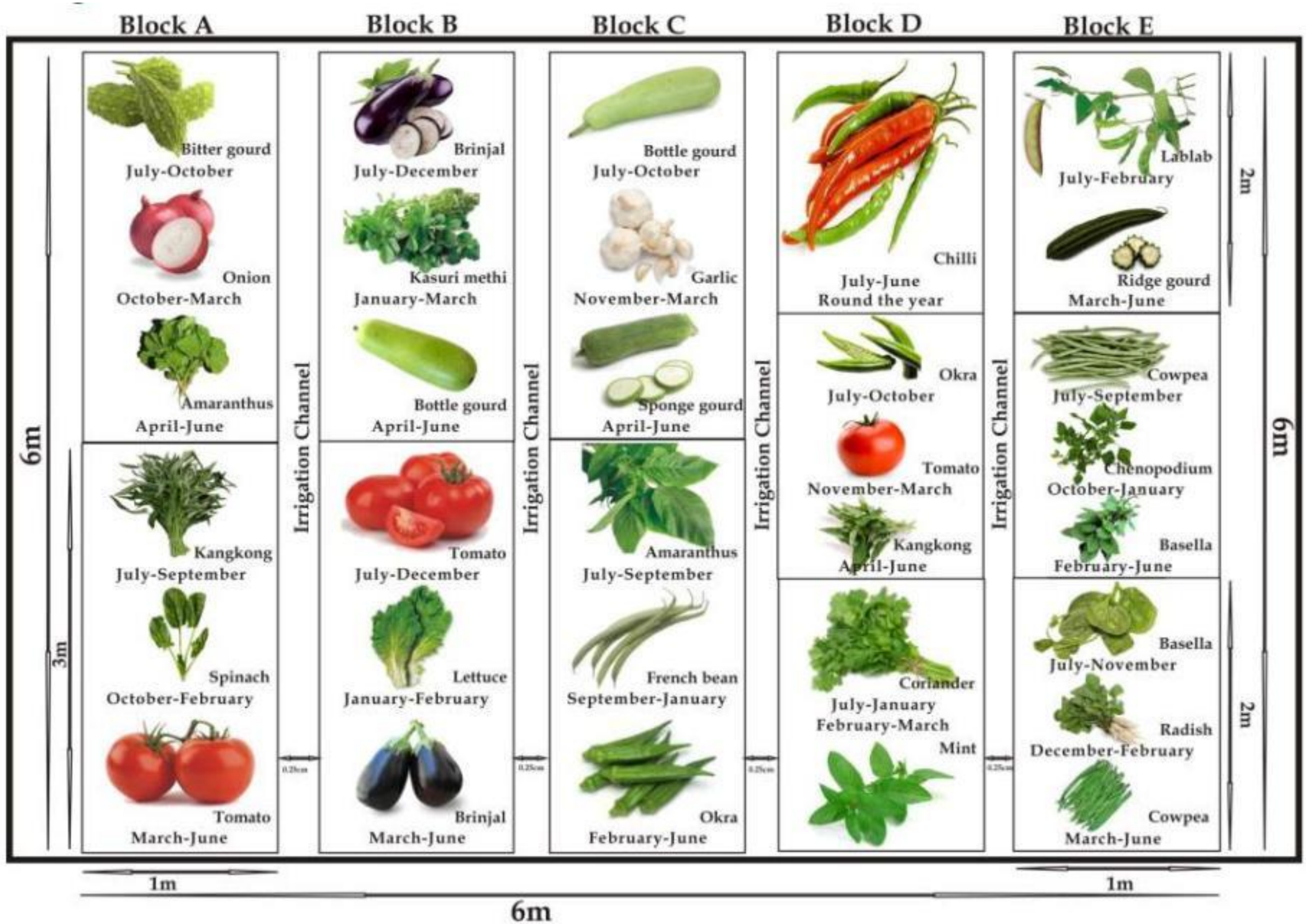
Mild-heat drying maintained most nutrients in moringa leaves



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

Home garden model for Jharkhand

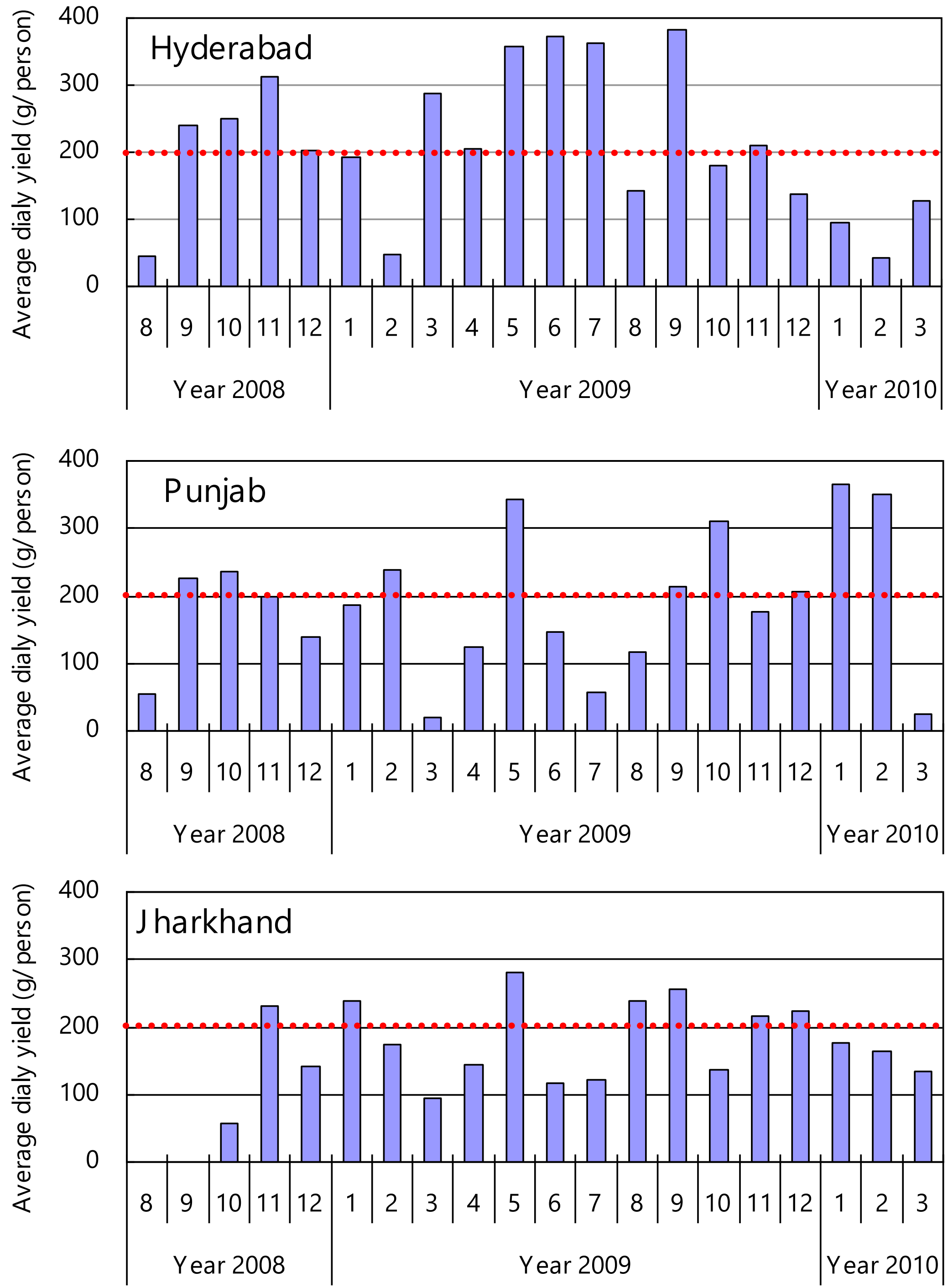


Home garden design for Jharkhand at AVRDC

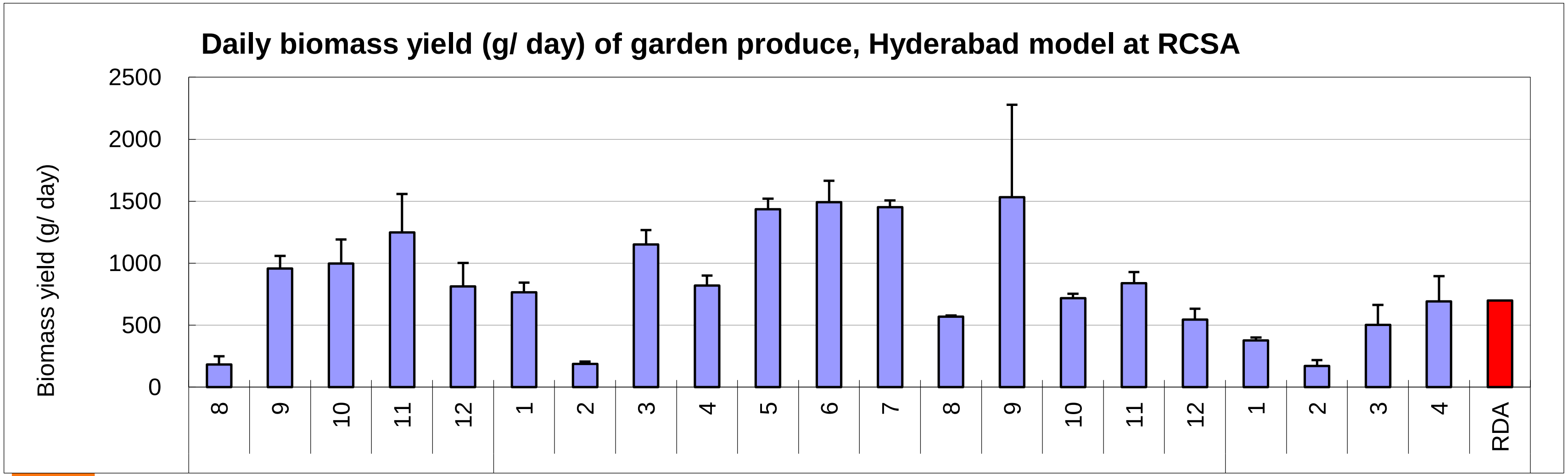
Home garden demonstration at AVRDC, Hyderabad, India

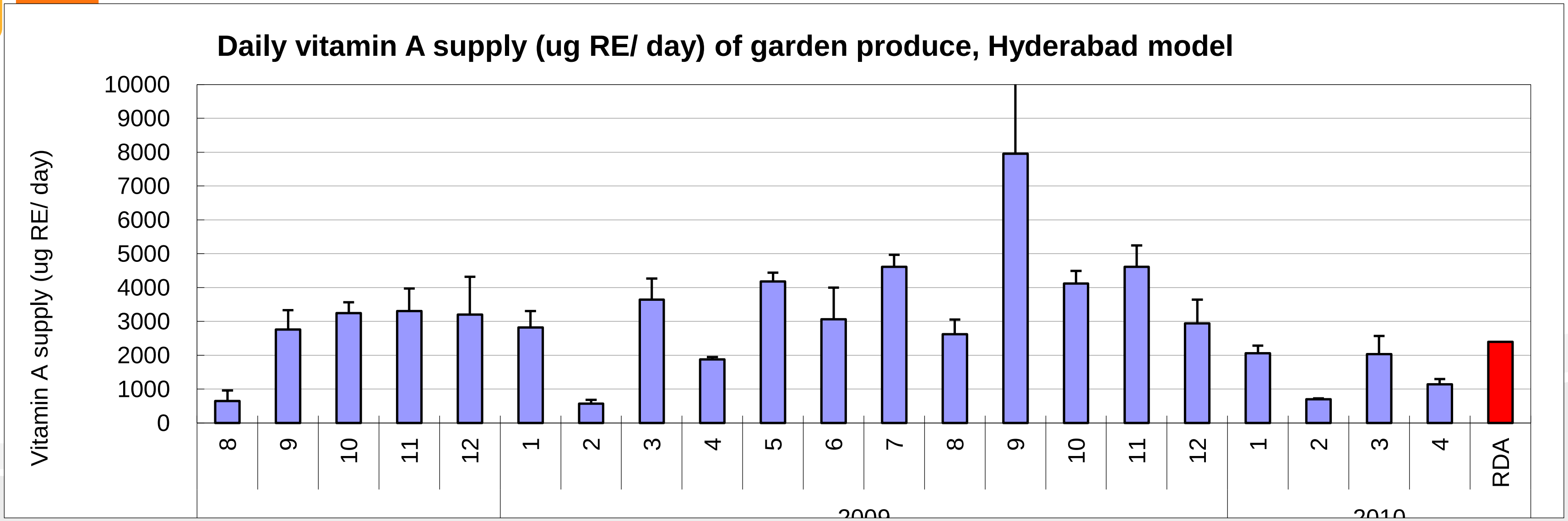
Daily vegetable supply

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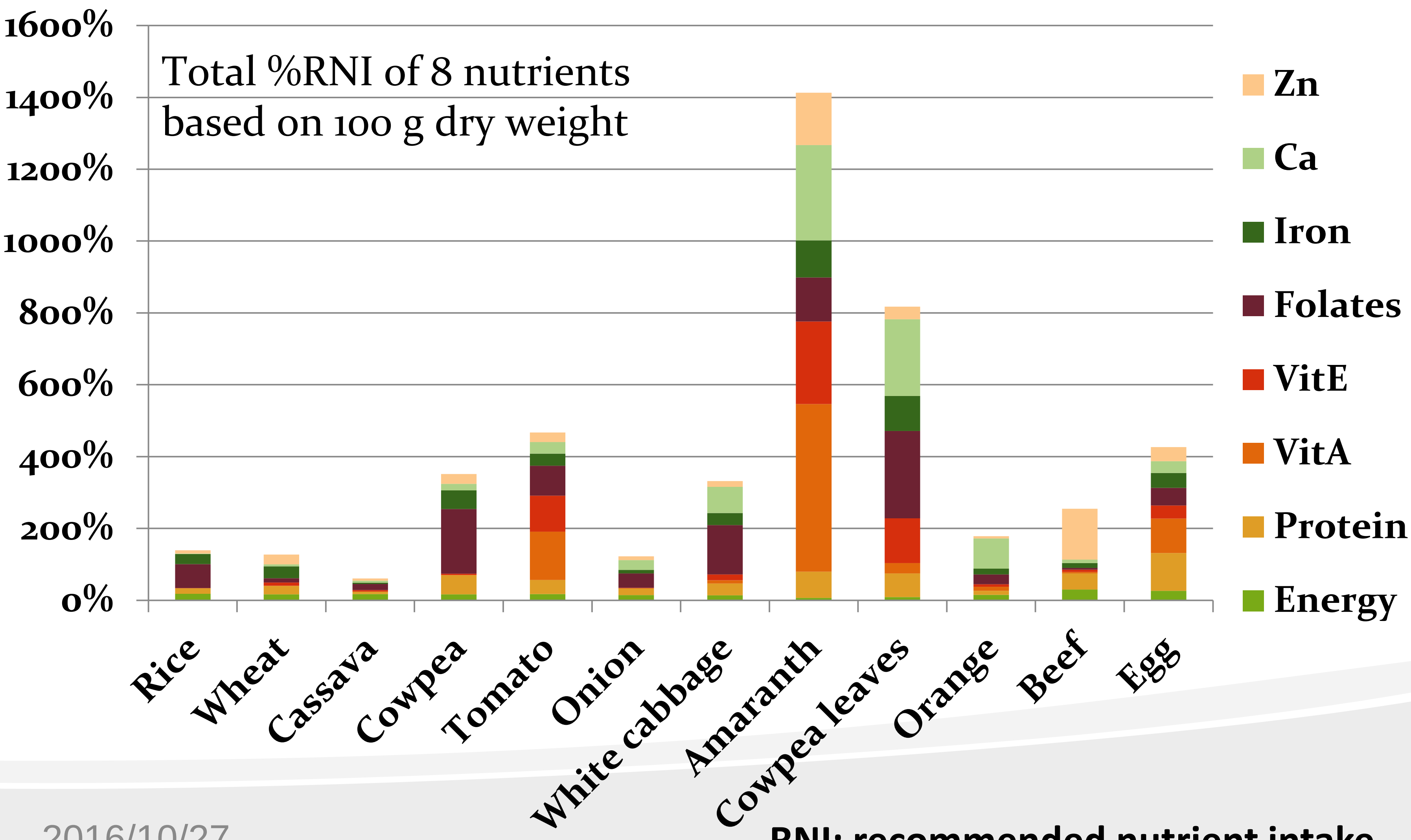
Daily vegetable and nutrient availability of garden produce harvested from 6x6 m² home gardens

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

Nutrient values of food groups



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.

Why are foods processed?

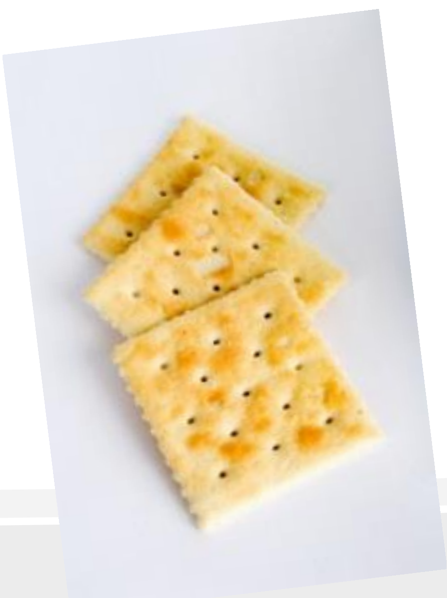
Convenience and available year round

- 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.

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

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

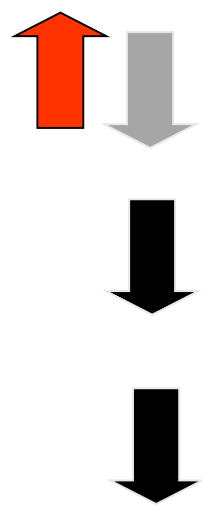
Effects of processing on nutritional values

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

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



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.

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	

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

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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

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).

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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

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

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.

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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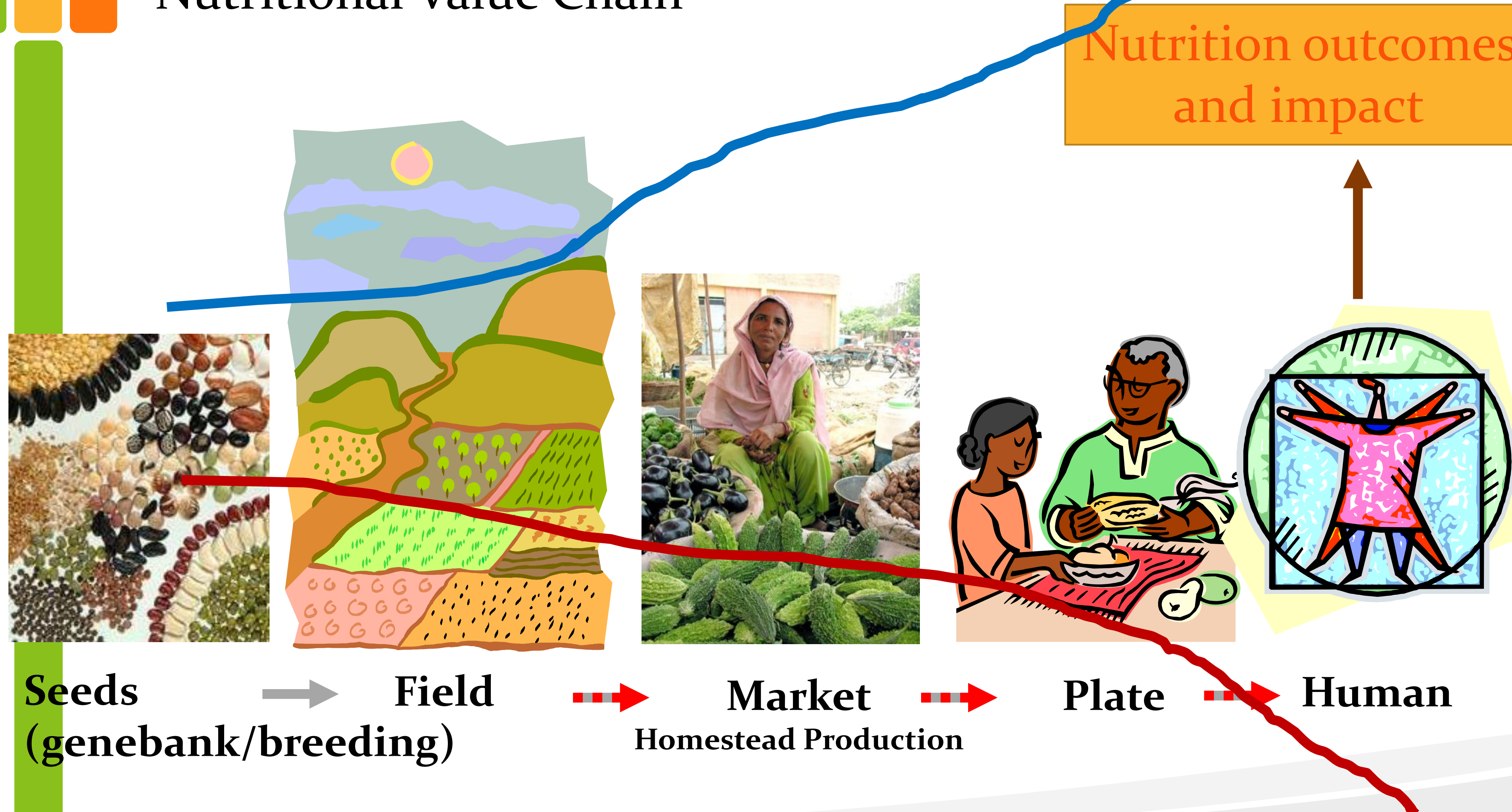
Nutritional Value Chain



Bioavailability

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

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*

Raw Food Product (100%) — Total (proximate analysis)

Processed Food — Chemically available

Digestion

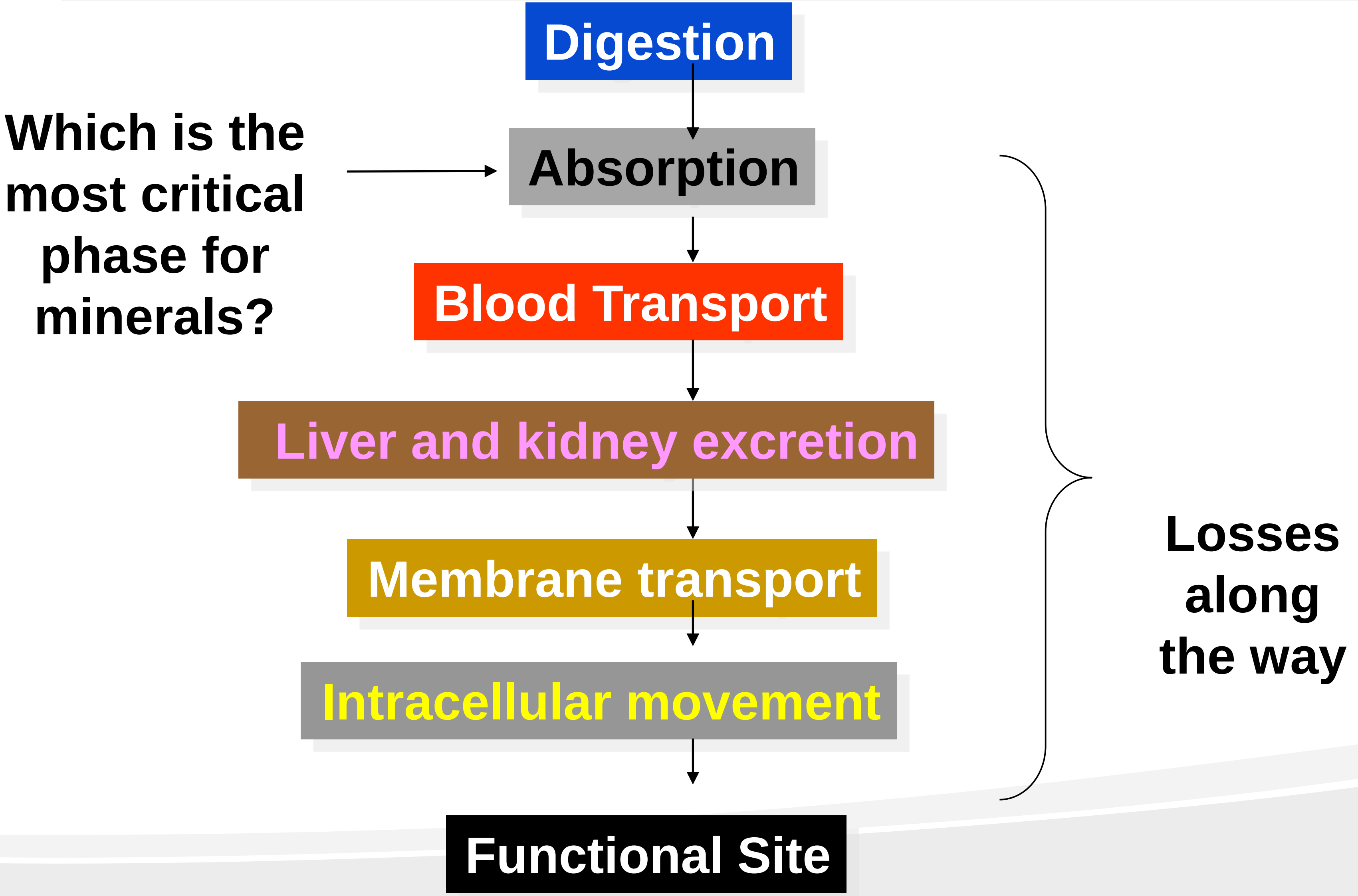
Absorption

Cellular uptake

Functional mineral

(Absorption, Cellular uptake, Functional mineral) — Biologically available

The fraction of the total amount absorbed that performs a function



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 • 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

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

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 • Protective function: gastro-protective, hepatoprotective and hypolipidemic	• Dietary saponins are highly toxic to cold-blooded animals. • 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!!