



***Anglo-Italian workshop  
on  
Sustainability in the Food Chain***



***FOOD QUALITY***

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**London, 29-30 November 2007**

## Which is the link between diet and health?



**Diet**



**Food**



**Human health**

- ◆ **Epidemiological studies: assessment of **nutritional status** (biochemical, anthropometry, dietary) in population groups**
- ◆ **Assessment of the relationship between dietary habits and **antioxidant status** in humans and its subsequent impact on human health:**
  - studies on **bioactive compounds**
  - studies on nutrient **bioavailability**
  - studies on ***in vivo* effects** of food ingestion



# QUALITY OF THE DIET



# HEALTH

**In particular:**

**Epidemiological studies have demonstrated that diets rich in plant food protect humans against degenerative diseases**



**OXIDATIVE  
STRESS**

**=**



**CHRONIC-DEGENERATIVE  
DISEASES**



**Poor diet**



**Healthy diet**

## ***Which factors does food quality depend on?***

- 1) Genetic factors and agricultural practices***
- 2) Technological processes***
- 3) Domestic treatments***



# **LEVEL 1**

## **Pre-harvest factors**



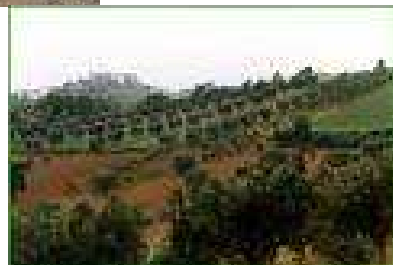
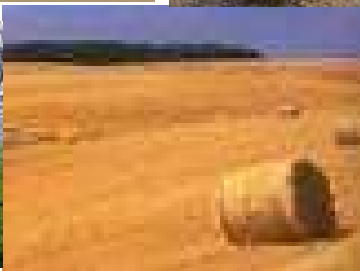
**Genetic factors**

**Cultivar  
Variety**



**Agricultural practices**

**Soil characteristics  
Sunlight exposition  
Irrigation  
Seasonal condition  
Geographical condition  
Pedo-climatic condition  
Soil fertilization  
Stage of maturity  
Time of harvest  
Methods of harvest**



# ***Post-harvest treatments***

## ***LEVEL 2***

### ***Technological processes***



***Blanching***  
***Pasteurisation***  
***Freezing***  
***Canning***  
***Milling***  
***Drying***  
***High pressure treatments***  
***Cooking***  
***Storage***

## ***LEVEL 3***

### ***Domestic treatments***

***Cooking***  
***Storage***  
***Modalities of consumption***



# ***FOOD QUALITY PROJECT***

The **overall aim** is to improve the competitiveness of the Italian typical products by identifying and evaluating food nutritional quality characteristics.

The **specific aim** is the evaluation of:

- Influence of environmental conditions, cultivar and agricultural practices on macro and micronutrient content;
- Influence of post-harvest treatments on macro and micronutrient content;
- Impact of the new technologies on food composition, shelf-life and organoleptic quality;
- Food safety;
- Bioactive compounds and their biological effects: in vivo and in vitro models;
- Consumer perception, expectations and attitudes;
- Dietary intake and lifestyle in population groups.



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# APPROACH: FOOD CHAIN FROM FARM TO FORK

## *Vertical Actions*

Fruit and vegetables  
Cereals  
Milk and dairy products  
Grapes and wine  
Meat  
Fish  
Olive and oil



## *Horizontal Actions*

Interaction between food (cause) and consumer health (effect)



Food intake  
Consumer perception  
Lifestyle and nutritional status  
Epidemiological network

## ***Pre-harvest factors***

### **Influence of cultivar on bioactive compound content**

#### **Flavone and carotenoid content of fresh celery petioles**

<b>Celery</b>	<b>Bianco di Sperlonga (Local ecotype)</b>	<b>Early Green</b>	<b>Golden Boy</b>	<b>Octavius</b>
<b><i>Carotenoids (mg/kg)</i></b>				
<b>Lutein</b>	<b>0.60 a</b>	<b>1.12 c</b>	<b>0.77 b</b>	<b>1.58 d</b>
<b>β-Carotene</b>	<b>0.26 b</b>	<b>0.37 c</b>	<b>0.20 a</b>	<b>0.71 d</b>
<b><i>Flavones (mg/kg)</i></b>				
<b>Apigenin</b>	<b>2.29 b</b>	<b>1.09 a</b>	<b>0.76 a</b>	<b>3.11 c</b>
<b>Luteolin</b>	<b>1.74 c</b>	<b>1.42 b</b>	<b>0.50 a</b>	<b>1.59 b</b>

Raffo et al, 2005

**Different letters indicate significant differences according to the Duncan test (p=0.05)**

## Influence of variety on Total Antioxidant Capacity

<i>FRAP (mmol/kg)</i>	<i>Typical</i>	<i>Commercial</i>	
<i>Chicory</i>	<b>20.4 ± 0.08</b>	<b>8.1 ± 0.03</b>	<b>60%</b>
<i>Apple</i>	<b>7.7 ± 0.46</b>	<b>3.0 ± 0.00</b>	<b>61%</b>
<i>Pear</i>	<b>2.9 ± 0.28</b>	<b>4.2 ± 0.06</b>	<b>31%</b>

## Influence of agronomic practices (biological vs conventional) on flavonoid content in tomato

	Rutin (mg/kg) fresh product			Quercetin (mg/kg) fresh product			Naringenin (mg/kg) fresh product		
	Biological	Conventional	Student T test	Biological	Conventional	Student T-test	Biological	Conventional	Student T test
<b>1*</b>	17.62±2.79	34.74±3.41	P<0.008	10.04±0.76	29.26±1.96	P<0.005	24.11±18.07	20.18±1.70	ns
<b>2*</b>	27.01±11.10	45.81±1.64	P<0.01	7.98±1.21	40.87±0.17	P<0.0005	50.07±18.14	43.33±8.02	ns
<b>3*</b>	43.02±10.19	30.50±6.44	ns	19.53±3.52	35.73±8.54	P<0.01	36.97±5.92	34.90±8.83	ns
<b>4*</b>	58.99±0.92	37.20±1.40	P<0.0003	34.10±2.63	29.72±2.41	ns	54.94±12.90	39.82±8.53	ns
<b>mean±ds</b>	<b>36.66±17.72</b>	<b>37.06±6.68</b>	<b>n.s</b>	<b>17.92±10.95</b>	<b>33.90±6.31</b>	<b>P&lt;0.0004</b>	<b>41.52±17.71</b>	<b>34.56±11.16</b>	<b>n.s</b>

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## Influence of time of harvest on bioactive compound content

### Carotenoid and $\alpha$ -tocopherol content in tomatoes harvested at different times of year.

Compound (mg/100g)	Apr	Jun	Jul	Dec	Jan	Mar	CV
carotenoids							
lycopene	8100 $\pm$ 140 b	10818 $\pm$ 78 d	7061 $\pm$ 271 a	10192 $\pm$ 233 c	8202 $\pm$ 427 b	11969 $\pm$ 218 e	20.1
$\beta$ -carotene	950 $\pm$ 24 c	1063 $\pm$ 33 d	519 $\pm$ 30 a	843 $\pm$ 127 bc	623 $\pm$ 35 a	820 $\pm$ 19 b	25.2
phytoene	733 $\pm$ 10 c	608 $\pm$ 13 b	367 $\pm$ 7 a	1215 $\pm$ 19 d	1231 $\pm$ 56 de	1284 $\pm$ 41 e	42.8
phytofluene	386 $\pm$ 17 b	412 $\pm$ 4 b	300 $\pm$ 8 a	525 $\pm$ 5 c	563 $\pm$ 25 d	846 $\pm$ 23 e	38.1
lutein	17 $\pm$ 2 a	-*	25 $\pm$ 4 b	14 $\pm$ 3 a	16 $\pm$ 6 a	20 $\pm$ 2 ab	55.0
neurosporene	29 $\pm$ 1 a	36 $\pm$ 5 a	-*	32 $\pm$ 2 a	35 $\pm$ 8 a	45 $\pm$ 3 b	52.4
$\gamma$ -carotene	35 $\pm$ 2 c	38 $\pm$ 4 c	11 $\pm$ 2 a	23 $\pm$ 4 b	15 $\pm$ 3 a	24 $\pm$ 2 b	43.9
lycopene 1,2- epoxide	134 $\pm$ 15 c	133 $\pm$ 9 c	71 $\pm$ 8 a	91 $\pm$ 18 ab	91 $\pm$ 21 ab	110 $\pm$ 9 bc	24.1
total carotenoids	10384 $\pm$ 190 b	13108 $\pm$ 116 d	8353 $\pm$ 315 a	12935 $\pm$ 400 c	10775 $\pm$ 550 b	15119 $\pm$ 340 e	20.4
$\alpha$ -tocopherol	1100 $\pm$ 20 e	1160 $\pm$ 10 f	800 $\pm$ 10 c	40 $\pm$ 10 a	1000 $\pm$ 20 d	100 $\pm$ 10 b	71.9

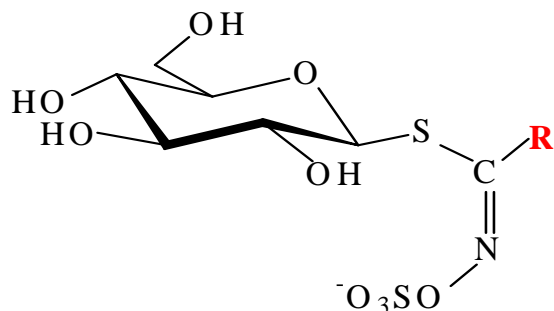
\* Below the detection limit

<sup>1</sup> Different letters indicate significant differences according to the Duncan test ( $p=0.05$ ).

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Raffo et al, 2005

## Glucosinolates (GLs) in Brassica vegetables



**R= aliphatic, aromatic and indole**

<b>Landraces harvesting (Raw vegetables)</b>	<b>Glucosinolates (<math>\mu\text{moli g}^{-1}</math> dry weight)</b>
<b>Cauliflower landraces</b>	
March	<b>27.2</b>
December	<b>11.9</b>
October	<b>6.9</b>
<b>Broccoli landraces</b>	
March	<b>11.7</b>
December	<b>8.2</b>
October	<b>15.2</b>

# Post-harvest treatments

## Effect of processing on carotenoid content

Technology	Product	Bioactive compound	Effect	Ref.
Blanching	Kintoki carrots	Lycopene	-	1
	Spinach	Lutein	-	2
	Fresh spinach	Lutein	↓ after 20'	2
Pasteurisation	Tomato puree	Lutein 9-cis	↓	3
		Lutein 13-cis	-	3
	Orange juice	Lycopene	-	4
		Lutein	-	4
	Orange-carrot juice mix	Lutein	↑	5
		Zeaxanthin	-	5
Canning	Tomato pulp	Lutein	-	6
		Zeaxanthin	↑	6
	Kale	Lycopene	↑	7
		Total cis-lutein	↑	8
	Corn, spinach and green peas	Lutein 13-cis	↑	8
		Trans-zeaxanthin	↑	8
	Corn	Lutein	-	9
		Zeaxanthin	-	9
	Sweet corn	Lutein	↓	10
		Zeaxanthin	↓	10
	Nutri red carrots	9-cis Lycopene	↑	11
Trans-Lycopene		↓	11	
Osmotic treatment	Nutri red carrots	Lycopene	↑	12
	Dried tomatoes	Lycopene	-	13
	Tomato paste	Lycopene	↓	14
	Two red pepper varieties	Carotenoids	-	15
	Korean red pepper varieties	Zeaxanthin	-	16
	Spanish pepper varieties	Zeaxanthin	↓	17
	Paprika	Zeaxanthin	↓	18
Frying	Potatoes	Lutein	↑	19
	Carrot chips	Carotenoids	↑	20
Microwave heating	Papaya	Total carotenoids	↓	21
	Spinach, green beans, broccoli	Lutein	-	22
	Broccoli	Lutein	↑	23
	Sweet potatoes leaves	Lutein	↓	24
	Broccoli florets	Total carotenoids	↓	25
	Nutri red carrots slices	Trans-lycopene	-	26
Multistep heat-treated products	Raw tomatoes + various commercial tomato products	Cis-Lycopene	-	27
		Trans-Lycopene	-	27
	Tomato paste	Trans-Lycopene	↑	28
		Cis-Lycopene	-	28
	Tomato paste	Lutein	-	28
		Lycopene	↓	29
	Brazilian Valencia orange juice	Total carotenoids	↓	30
	Cooking	Broccoli, spinach and green beans	Trans-lutein	↑
Trans-lycopene			↑	32
Tomatoes homogenates		Cis-lycopene	↑	32
		Total lycopene	-	33
Tomato juice		Cis-lycopene	↑	33
		Lycopene	↓	34
Tomato pulp		Trans-Lycopene	-	35
	Nutri red carrots	9-cis-lycopene	↑	35

- no changes    ↑ increase    ↓ decrease

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## Effect of Harvest Time and Minimal Processing on Total Antioxidant Activity (TAA) of Three Leaf Crops grown in Central Italy conditions.

'Ready-to-eat' vegetables: flourishing market of pre-packed fresh products, packaged under different conditions and with different processing to extend shelf-life.

Factor	Total antioxidant activity (TAA)		
	Chicory	Endive	Crisphead
Harvest Time (H)	***	***	***
Minimal processing (M)	***	***	***
H × M	***	***	***

\*\*\* Significant at  $p = 0.001$ .

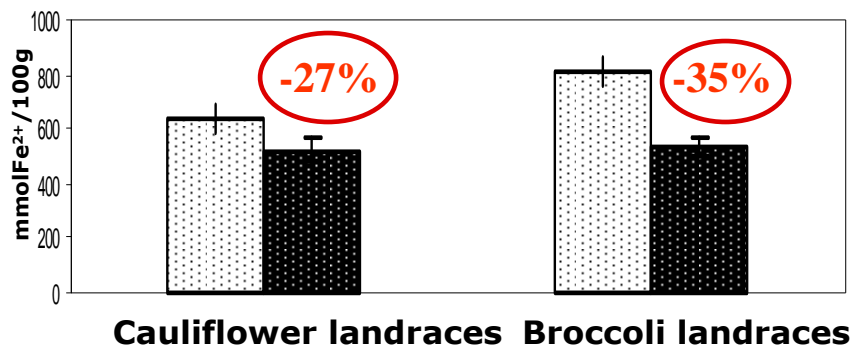
Venneria et al, 2007

## Influence of domestic cooking

Landraces harvesting (Cooked vegetables)	Glucosinolates ( $\mu\text{moli g}^{-1}$ dry weight)
<b>Cauliflower landraces</b>	
March	8.6 -68%
December	3.3 -73%
October	-
<b>Broccoli landraces</b>	
March	3.6 -69%
December	1.1 -87%
October	-

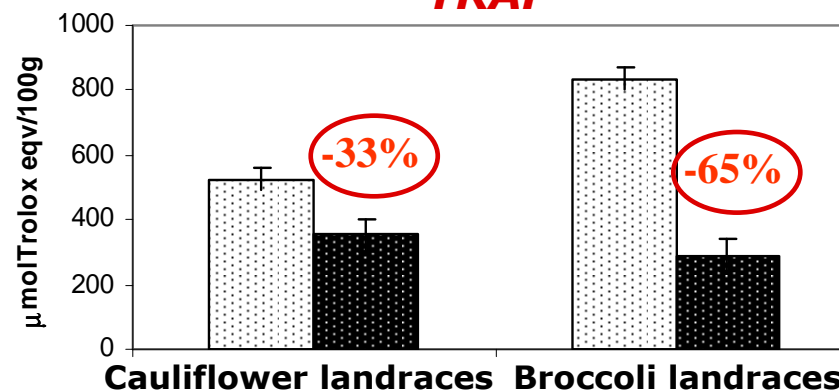
### Effect of domestic cooking on Total Antioxidant Capacity in December landraces

#### FRAP



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#### TRAP



Cauliflower landraces Broccoli landraces

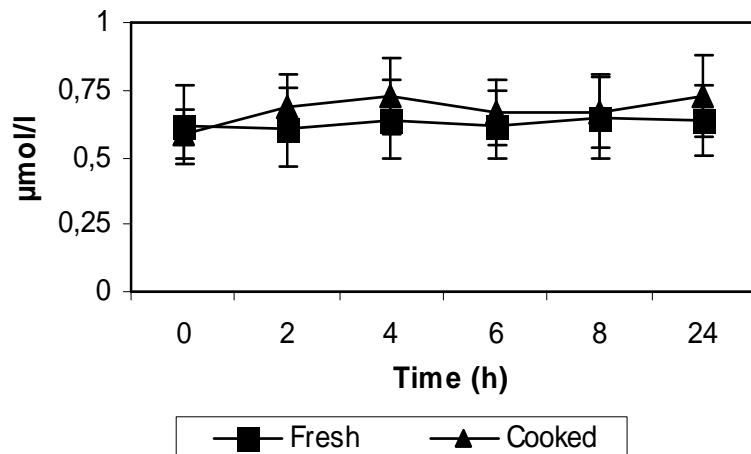
## Influence of domestic cooking on Total Antioxidant Capacity

<i>Carrot</i>	<i>Typical</i>	<i>Commercial</i>
<i>FRAP (mmol/kg)</i>		
Raw	0.9 ± 0.11	0.8 ± 0.04
Cooked	0.8 ± 0.02	0.7 ± 0.02
<i>TRAP (mmol/kg)</i>	<b>-11%</b>	<b>-12%</b>
Raw	1.9 ± 0.007	1.4 ± 0.03
Cooked	1.5 ± 0.03	1.3 ± 0.06
	<b>-21%</b>	<b>-7%</b>

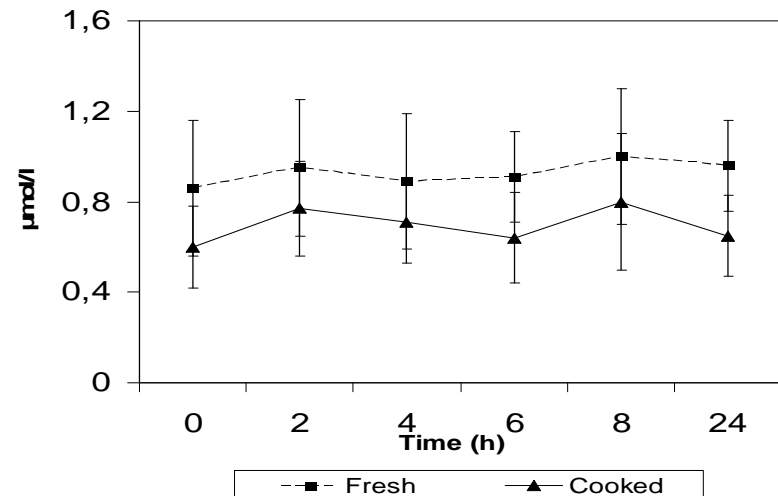
## Effect of domestic cooking on human bioavailability of plasma $\beta$ -carotene and lycopene in cherry tomatoes.

Plasma  $\beta$ -carotene and lycopene concentrations over time in subjects consuming a single portion of fresh and cooked tomato meals.

$\beta$ -carotene



Lycopene



Values are means of five subjects and bars indicate standard deviation.

Bugianesi et al., 2004

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## ***Conclusions***

**-Food quality depends on genetic factors, agricultural practices, domestic treatments and technological properties.**

**-Determinants of nutritional quality are related to both the native quantity of bioactive compounds and the post-harvest treatments. It is relevant to identify and quantify these compounds and their fate during processing.**

**-The nutritional value of raw matter can be modified (reduced) and deprived of essential elements during the processing. The derived food consequently may lose its nutritional and health effects.**

***Strategic research on:***  
***-Agriculture***  
***-Industry***



***Information to consumer***

## ***Research challenges***

- To examine the influence of agricultural practices, wild species and intra-species biodiversity, environmental factors and other factors on food quality;**
- To develop new technologies (i.e. physical methods for conservation, new packaging systems) to extend the shelf-life and to optimize the nutritional quality of the raw materials and/or processed food;**
- To develop recommendations on the benefits, risks, safety and healthiness of specific dietary choices, encouraging the consumers to choose a healthy diet; the responsibility of the dissemination of information should be committed to all the stakeholders of the food system through an appropriate educational strategy;**
- to increase the financial resources committed to innovation of national research and industry**

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