6° Annual IAOM Eurasia District Conference and Expo

Florence, September 10-14, 2011

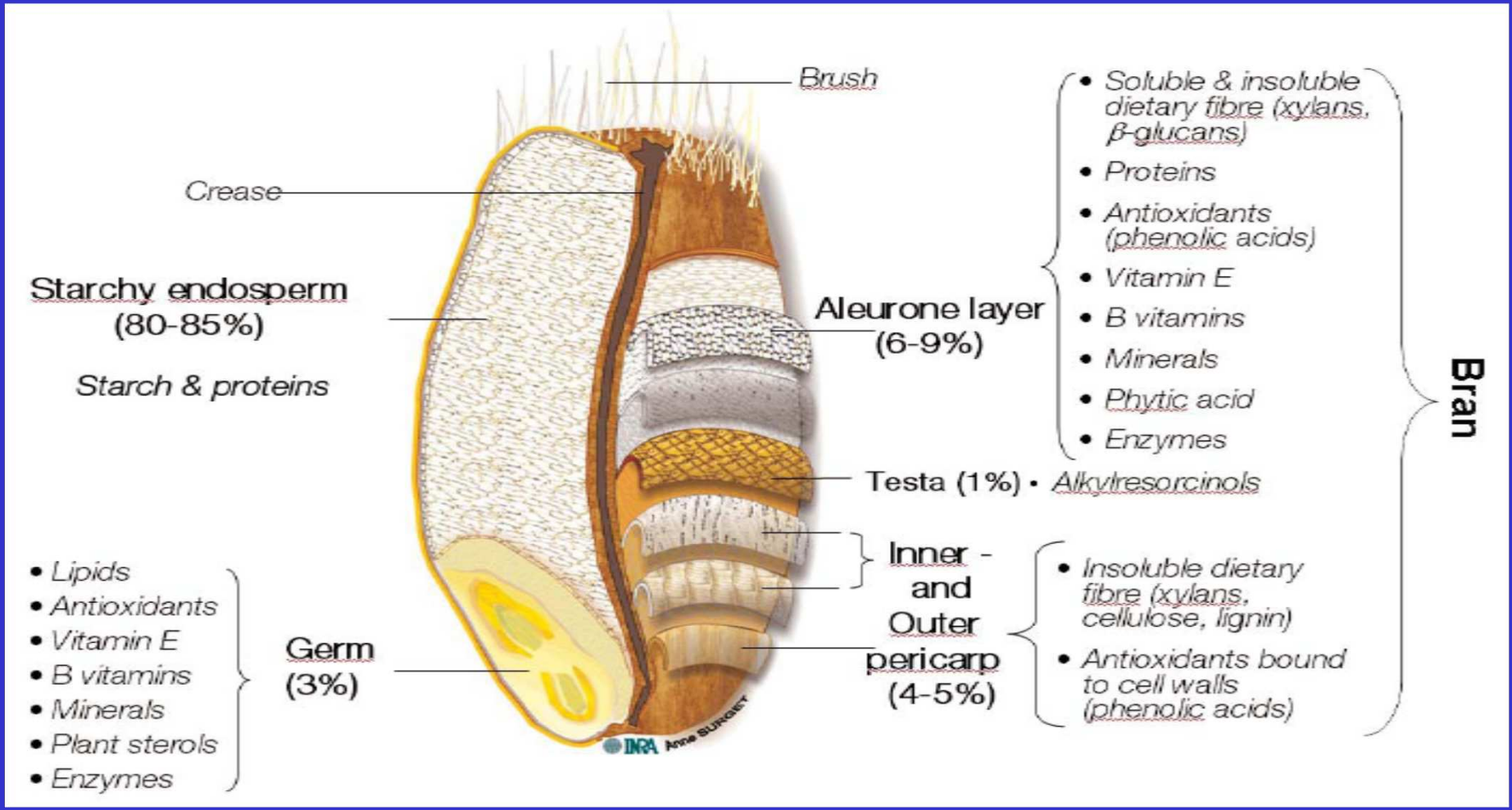
Nutritional quality and functionality of wholemeal wheat

Qualità nutrizionale e funzionalità del grano integrale

Marina Carcea

National Research Institute on Food and Nutrition (INRAN), Rome, Italy

Distribution of bioactive molecules in cereal grains



From Report "Progress in Healthgrain 2008" within the Healthgrain project

1) Phenolic Acids

They belong to the cinnamate family and consist simply of a single hydroxyl group borne by a benzene ring. Phenolic acids of wheat and other cereals are in the free, esterified and insoluble bound forms and are present particularly in the pericarp and aleurone layers.

The antioxidant activity of phenolic acids and their esters depends on the number of hydroxy groups in the molecule

Ferulic acid is the most abundant phenolic acid in the cell walls of cereal grains. Free ferulic acid is a good antioxidant since it forms a resonance-stabilized phenoxy radical, inhibits chemically induced carcinogenesis in animal models and protects against the formation of nitroso compounds.

1) Phenolic acids

Phenolic acid content in cereal grains (μg/g d.m.) *

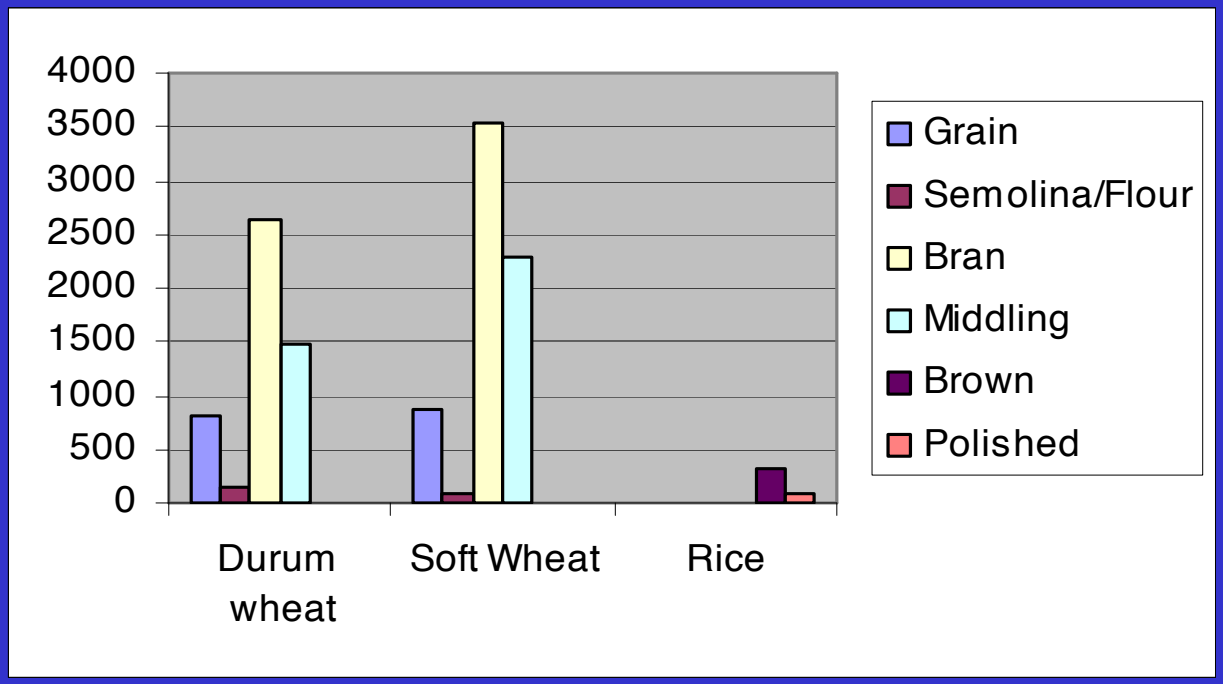
Grains	Phenolic Acid Fractions		
	Insoluble bound	Soluble Esterified	Soluble Free
Durum Wheat	806.00 116.00	54.00 20.00	3.60 1.00
Soft Wheat	880.00 123.00	57.00 17.00	5.00 1.00
Rice	328.00 26.00	47.00 5.00	4.20 0.20
Emmer	455.00 62.00	57.70 34.10	7.10 3.50
Maize	2416.00 330.0	198.90 60.00	15.00 8.50

*Data are reported as the mean of 3 independent determinations and standard deviation (SD).

1) Phenolic acids

Effects of processing

Average content of <u>insoluble bound</u> ferulic acid in cereal grains and milling products (p.p.m. on d.m.)* .

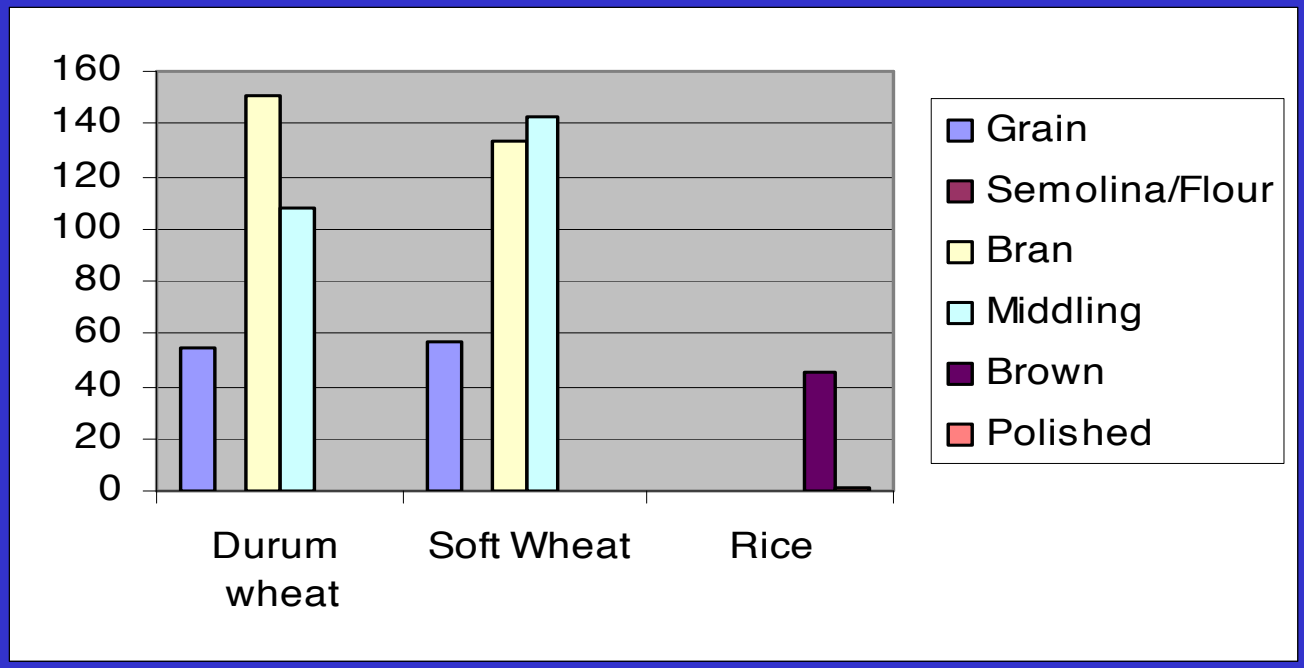


***Mean of duplicate determinations on 3 cultivars for each species**

1) Phenolic acids

Effects of processing

Average content of soluble esterified phenolic acids in cereal grains and milling products (p.p.m. on d.m.)*



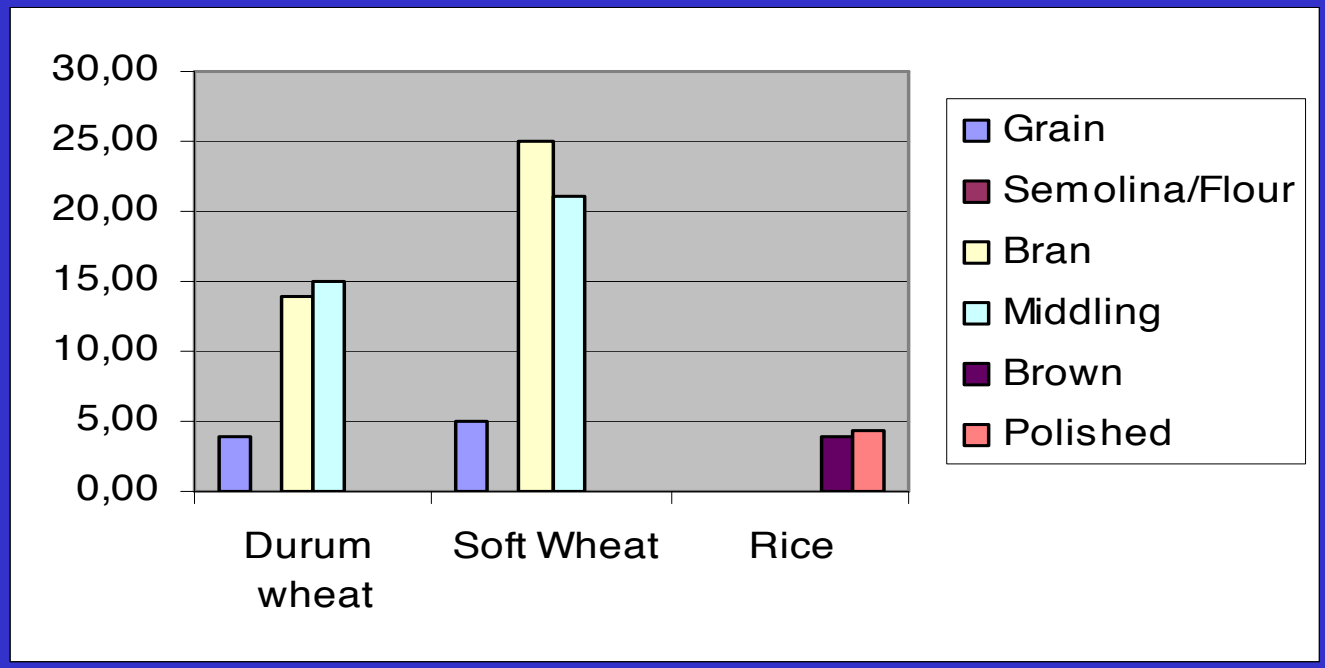
*Mean of duplicate determinations on 3 cultivars for each species

Sinapic, ferulic , caffeic, p-coumaric, vanillic and syringic acid were identified.

1)Phenolic acids

Effects of processing

Average content of soluble free phenolic acids in cereal grains and milling products (p.p.m. on d.m.)*



***Mean of duplicate determinations on 3 cultivars for each species**

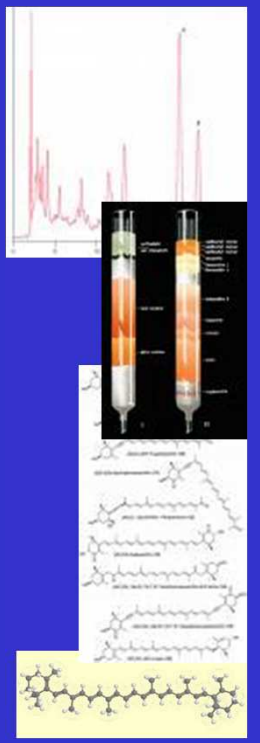
Sinapic, ferulic , caffeic, p-coumaric, vanillic and syringic acid were identified.

2) Carotenoids

Carotenoids are a widespread group of naturally occurring fat-soluble pigments, representing one of the major food micronutrients in the human diet with many physiological functions.

Carotenoids also potentially play an important role in human health by acting as biological antioxidants, protecting cells and tissues from the damaging effects of free radicals and singlet oxygen.

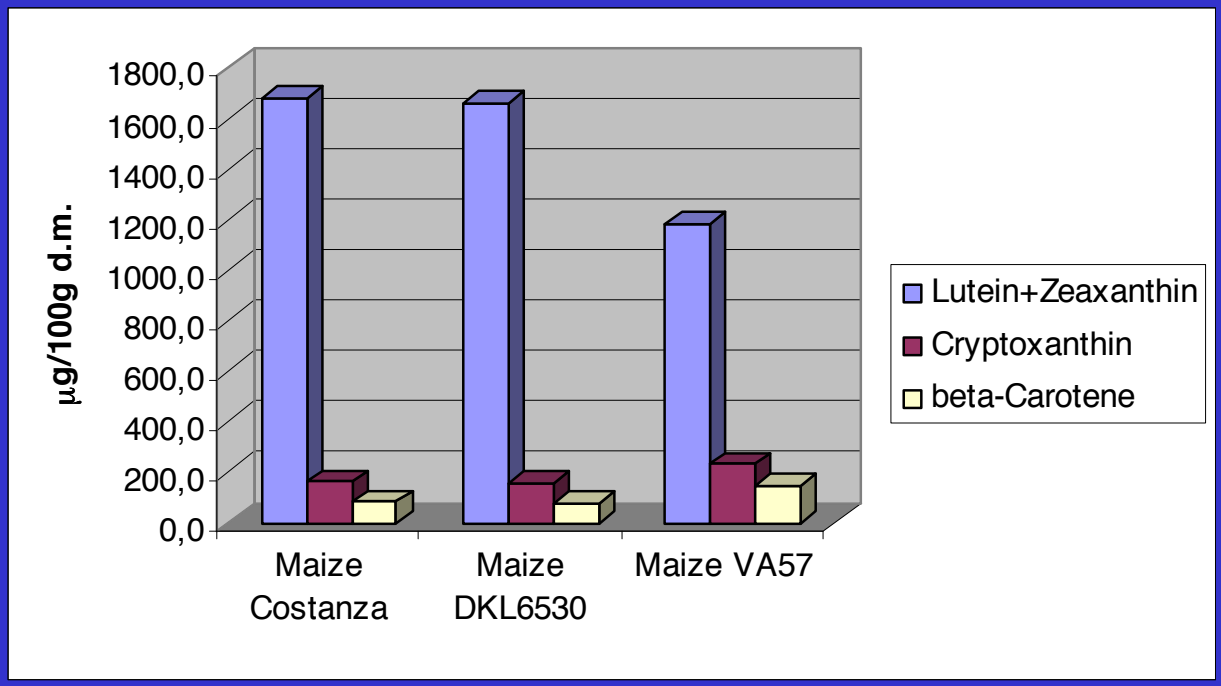
Other health benefits of carotenoids, that may be related to their antioxidative potential, include enhancement of immune system function, protection from sunburn and inhibition of the development of certain types of cancers.



2) Carotenoids

Content in grains

Carotenoids in maize cultivars (*µ*g/100g d.m.)

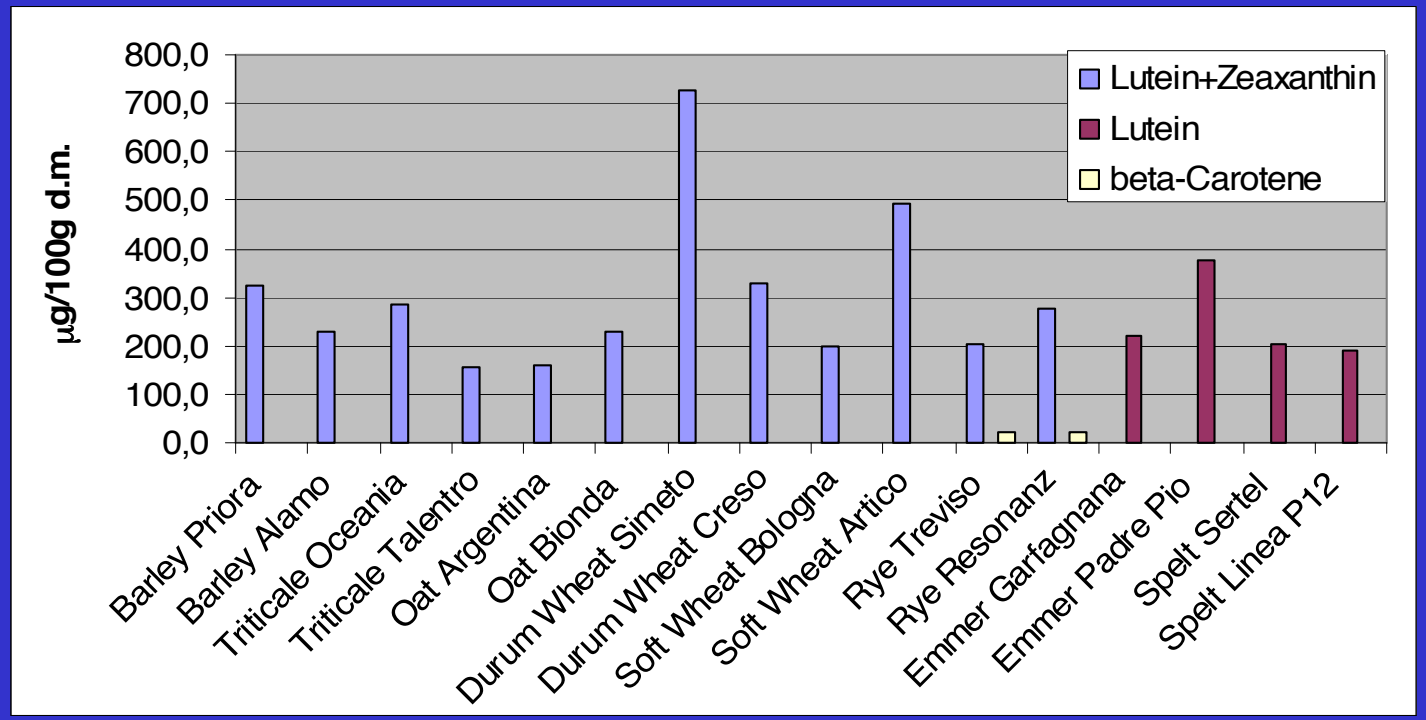


* data are reported as the mean of 3 independent determinations.

2) Carotenoids

Content in grains

Carotenoid contents in barley, triticale, oat, durum and soft wheat, emmer, spelt and rye (*µ*g/100g d.m.)



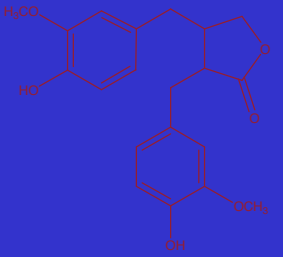
***data are reported as the mean of 3 independent determinations.**

3) Lignans

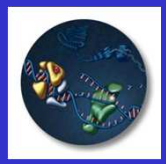
Lignans (a form of phytoestrogens) are a class of secondary metabolites obtained by oxidative dimerization of two phenylpropanoids units.

Several epidemiological studies have shown a potential protective effect of their metabolites, the mammalian lignans enterolactone and enterodiol, against hormone-dependent cancers, especially breast and prostate cancer and against cardiovascular diseases.

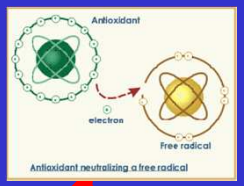
Matairesinol



Secoisolariciresinol



Anticarcinogenic activity



Antioxidant activity

LIGNANS

Estrogenic and antiestrogenic activity

3) Lignans

Content in grains

Lignans in Italian cereal grains (*μ*g/100g d.m.)

Sample	Iso	Lari	Seco	Pino	Mat	Total Lignans
Durum Wheat *Creso*	n.i.	95.11±34.34	n.i.	n.i.	n.i.	95.11
Durum Wheat *Simeto*	n.i.	57.00 30.55	n.i.	n.i.	n.i.	57.00
Soft Wheat *Artico*	n.i.	48.53 18.05	n.i.	n.i.	n.i.	48.54
Soft Wheat *Bologna*	n.i.	66.59 6.10	n.i.	n.i.	n.i.	66.59

*Single determination or average ±S.D; n.i. = not identifiable due to interference with other substances .

3) Lignans

Content in grains

Lignans in Italian cereal grains (*μ*g/100g d.m.)

Sample	Iso	Lari	Seco	Pino	Mat	Total Lignans
Emmer *Garfagnana*	n.i.	105.80 3.70	26.86 0.33	n.i.	n.i.	132.67
Emmer *Padre Pio*	n.i.	102.38 0.54	30.32 0.37	n.i.	n.i.	132.70
Spelt *Sertel*	n.i	39.88 2.15	5.71 1.09	n.i.	n.i.	45.59
Spelt *Linea P12*	n.i.	125.80	46.72	n.i.	n.i.	172.52
Triticale *Oceania*	n.i.	43.66±2.79	n.i.	n.i.	n.i.	43.66
Triticale *Talentro*	n.i.	72.51 0.52	n.i.	n.i.	n.i.	72.51

*Single determination or average ±S.D; n.i. = not identifiable due to interference with other substances.

3) Lignans

Content in grains

Lignans in Italian cereal grains (*μ*g/100g d.m.)

Sample	Isol	Lari	Seco	Pino	Mat	Total Lignans
Rye *Resonanz*	n.i.	53.87 15.72	24.67 5.44	n.i.	n.i.	78.55
Rye *Treviso*	n.i.	145.99 0.81	n.i.	n.i.	n.i.	146.00
Oat *Bionda*	n.i.	86.50	n.i.	226.22	n.i.	312.72
Oat *Argentina*	n.i.	108.14 13.8	n.i.	382.07 61.06	n.i.	490.22

*Single determination or average ±S.D; n.i. = not identifiable due to interference with other substances .

3) Lignans

Content in grains

Lignans in Italian cereal grains (μg/100g d.m.)

Sample	Iso	Lari	Seco	Pino	Mat	Total Lignans
Rice *Perla*	n.i.	47.95 9.96	n.i.	17.32 9.75	n.i.	65.28
Rice *Perla Rosso*	n.i.	120.59	9.01	28.85	n.i.	158.44
Rice *Vialone Nano*	n.i.	216.87 61.1	20.76 0.61	39.46 5.39	n.i.	277.09
Maize *Costanza*	n.i.	10.78 0.78	13.40 1.23	0.00	n.i.	24.19
Maize *DKL6530*	n.i.	8.52 0.75	11.14 0.23	0.00	n.i.	19.66
Maize *VA57*	n.i.	14.25 0.64	n.i.	0.00	n.i.	14.25

*Single determination or average ±S.D; n.i. = not identifiable due to interference with other substances .

3) Lignans

Effects of processing

Contents of lignans in wheat grains and their milling products (*μ*g/100g d.m.)*

Sample	Iso	Lari	Seco	Pino	Mat
Soft wheat					
cv Bologna					
Grain	n. i.	138.90 9.75	62.46 3.87	48.08 6.98	n. i.
Flour	n. i.	n. i.	n. i.	n. i.	n. i.
Middling	n. i.	162.71 42.79	100.53 19.18	n. i.	n. i.
Bran	n. i.	459.23 181.40	370.45 159.31	386.17 50.25	n. i.
Durum wheat					
cv Creso					
Grain	n. i.	96.77 16.72	n. i.	n. i.	n. i.
Semolina	n. i.	14.72 2.83	n. i.	n. i.	n. i.
Flour	n.i.	26.68 14.07	n. i.	20.11 7.35	n. i.
Middling	n. i.	160.81 17.69	n. i.	142.48 11.39	n. i.
Bran	n. i.	316.90 45.40	n. i.	184.38 18.22	n. i.

* average ± S.D.

3) Lignans

Effects of processing

Contents of lignans in cereal based foods consumed at breakfast (*μ*g/100g d.m.)*

Sample		Iso	Lari	Seco	Pino	Mat	Total Lignans
Breakfast cereals	Type 1	n.i.	78.53 5.07	6.51 0.60	68.54 8.15	n.i.	153.57
	Type 2	n.i.	96.95 6.43	19.97 2.72	130.74 17.20	n.i.	247.66
	Type 3	n.i.	99.38 11.96	n.i.	186.83 20.61	n.i.	286.20
Wholegrain biscuits		n.i.	25.22 5.66	27.75 5.46	23.16 1.50	n.i.	76.13
Compressed puffed rice		n.i.	81.86 18.70	23.06 3.26	22.18 1.73	n.i.	127.09
Puffed barley		n.i.	142.92 48.54	25.78 5.25	47.97 20.79	n.i.	216.67

* average ± S.D.

3) Lignans

Effects of processing

Contents of lignans in semolina and semolina/20% oat flour pasta (μg/100g d.m.)*

Sample	Iso	Lari		Seco		Pino		Mat	Total Lignans
Semolina Pasta	n.i.	26.01	18.84	22.46	18.04	27.45	28.00	n.i.	75.93
Semolina/20% Oat flour Pasta	n.i.	33.11	23.10	22.08	10.31	86.64	59.65	n.i.	141.83

*Average ± S.D.

3) Lignans

Bioavailability and functionality of lignans in vivo

In vivo study

Effects of consumption of whole grain foods high in lignans in healthy postmenopausal women with moderate serum cholesterol.

The study aimed at investigating in a group of postmenopausal women, with moderate serum cholesterol, the effect of an experimental period of intake of whole-grain cereal based foods high in lignans as part of a habitual diet on a) the plasma and urinary excretion of enterolignans, b) the biomarkers of lipid metabolism and c) the immunological and antioxidant status.

Bioavailability and functionality of lignans in vivo

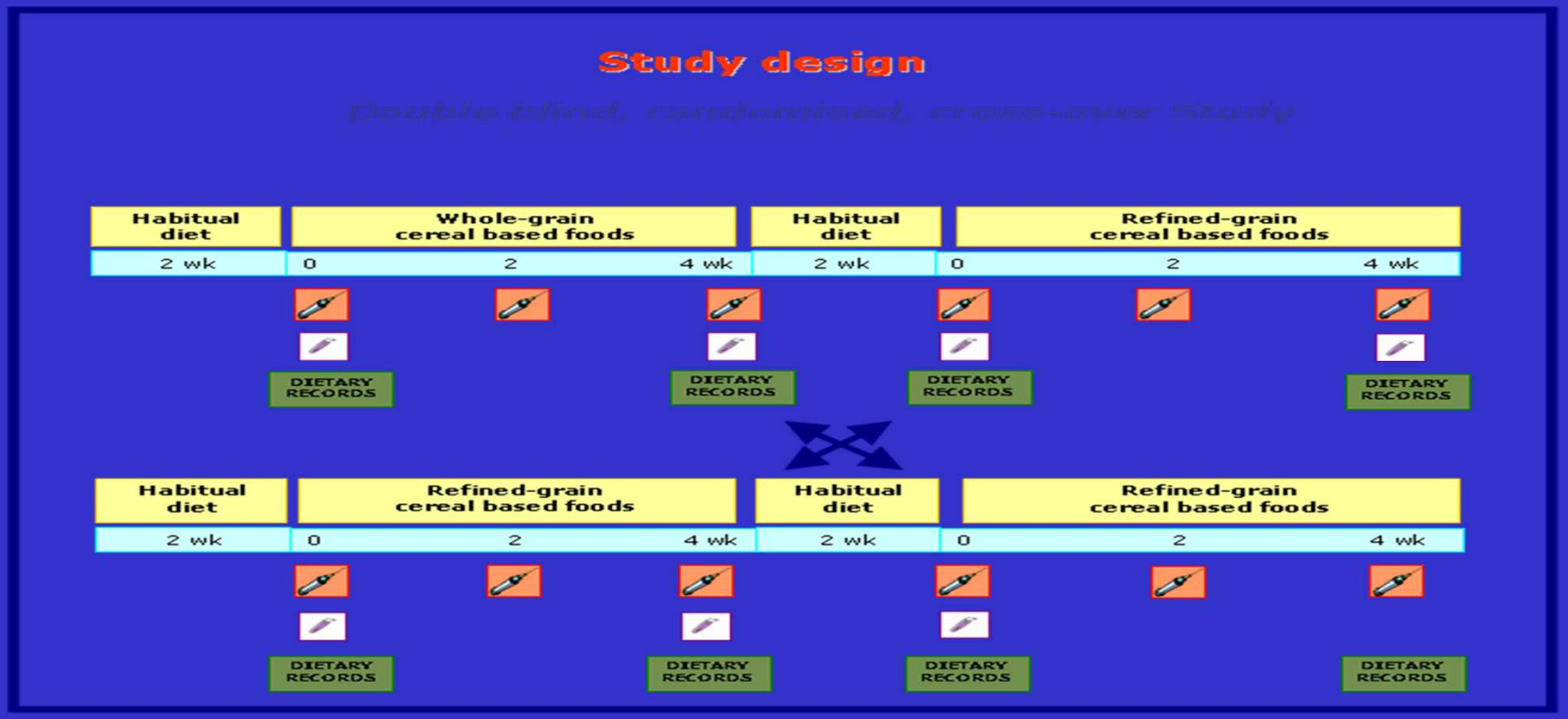
Subjects

Healthy postmenopausal women were recruited by the Asl-Roma B, Nutrition and Health Clinic. Forty-six enrolled, and, after screening, 20 participated.

The age, weight, height, BMI and waistline of subjects attending the trials were 52.8 3.7 years, 64.2 9.9 Kg, 157.1 7.9cm ,26.4 4.3Kg/m^2 and 80.9 7.5 cm respectively.

3) Lignans

Bioavailability and functionality of lignans in vivo



Bioavailability and functionality of lignans in vivo

Test foods

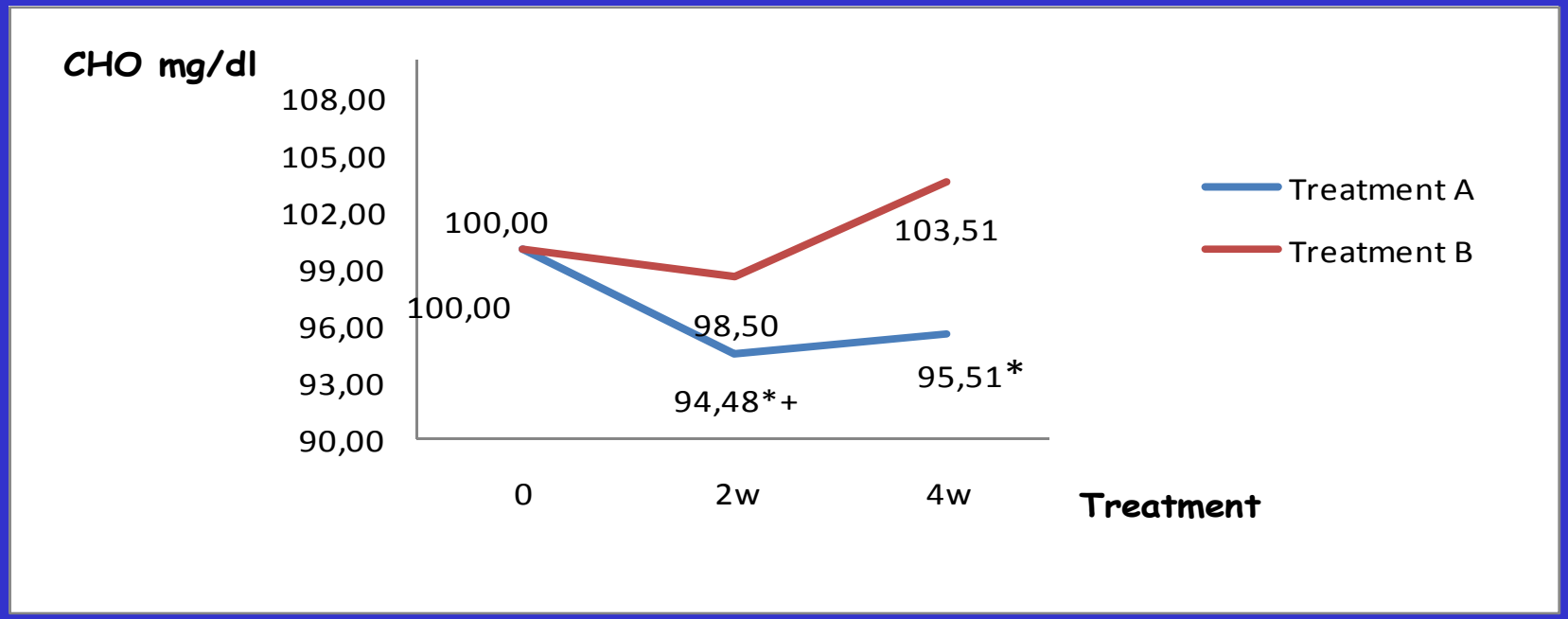
The breakfast cereals used in the whole-grain cereal based food treatment were commercial products chosen on the basis of their lignans content, whereas whole grain pasta was manufactured for this study by one of the major Italian pasta manufacturer.

Contents of lignans in the selected breakfast cereals were found in the range of 112.13-283.17 *μ*g/100g and in whole grain pasta about 8758.74 *μ*g/100g.

3) Lignans

Bioavailability and functionality of lignans in vivo

Hypocholesterolaemic effect of whole-grain products rich in lignans



*** Significant difference respect to refined-grain treatment : P<0.001**

+Significant difference from baseline : P<0.05

* Treatment A: whole-grain cereal based foods consumption
Treatment B: refined-grain cereal based foods consumption

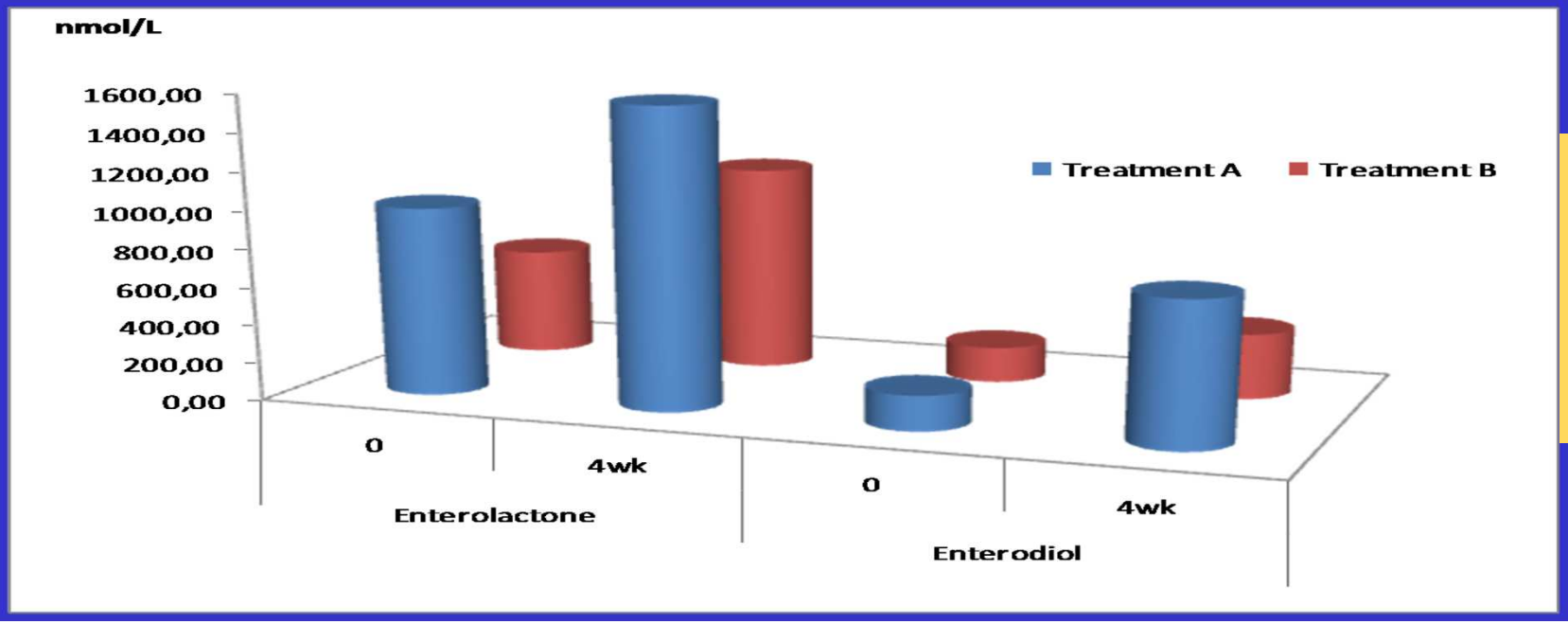
3) Lignans

Bioavailability and functionality of lignans in vivo

Enterolignans levels in plasma and urine

During both treatments, plasma enterolignans values ranged from 0 to 63.91 nmol/L and from 0 to 40.10 nmol/L for enterolactone and enterodiol respectively; furthermore interindividual differences were recordered.

As reported below, in urine excretion a significant increase of enterolignans concentrations was observed at the end of the consumption period in both treatments. In addition urinary enterolactone and enterodiol excretions increased significantly (P<0.01) during treatment A compared with the treatment B.



* Treatment A: whole-grain cereal based foods
Treatment B: refined-grain cereal based foods

Bioavailability and functionality of lignans in vivo

Conclusions

4 wks consumption of whole-grain cereal based foods high in lignans

- **had cholesterol-lowering effect;**

- increased urinary enterolactone and enterodiol excretion in healthy postmenopausal women.

ACKNOWLEDGEMENTS

These results were obtained within 2 projects, Antioxidants financed by MiPAAF (Italian Ministry for Agriculture and Forestry) and QUASICER financed by MIUR (Italian Ministry for University and Research).