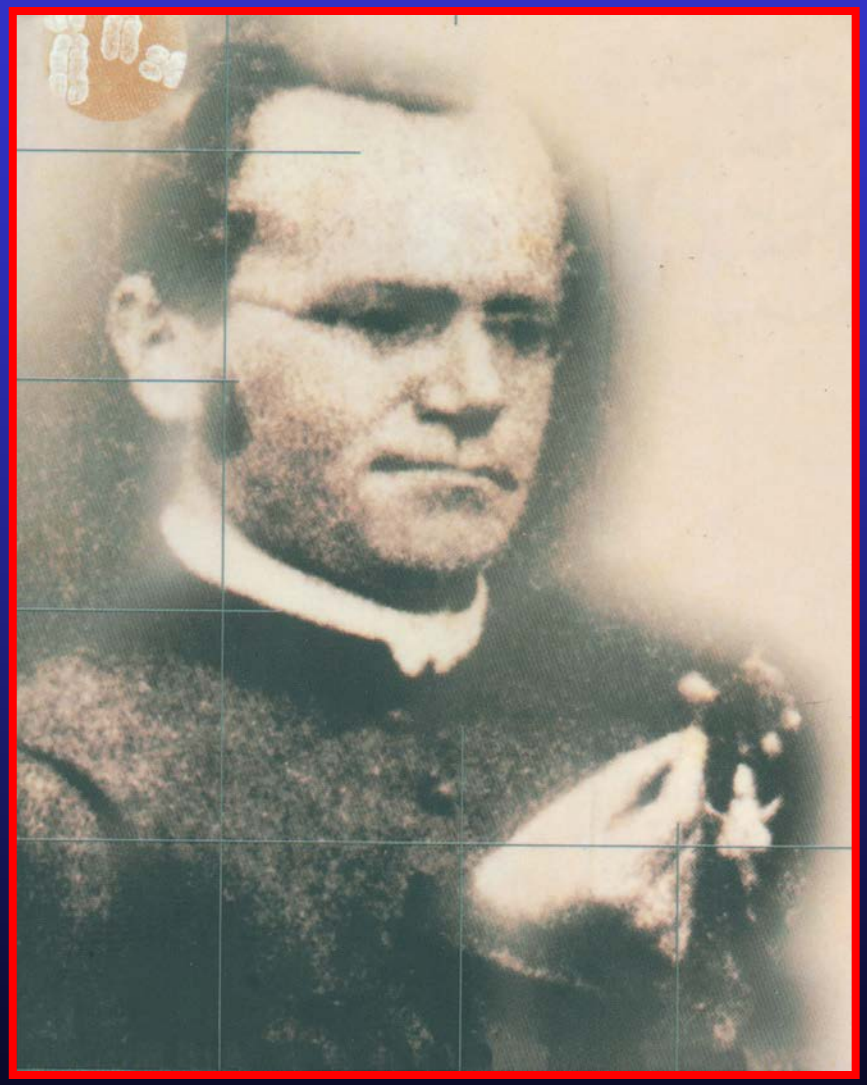
FIDAF-ROMA 23- 02-2018

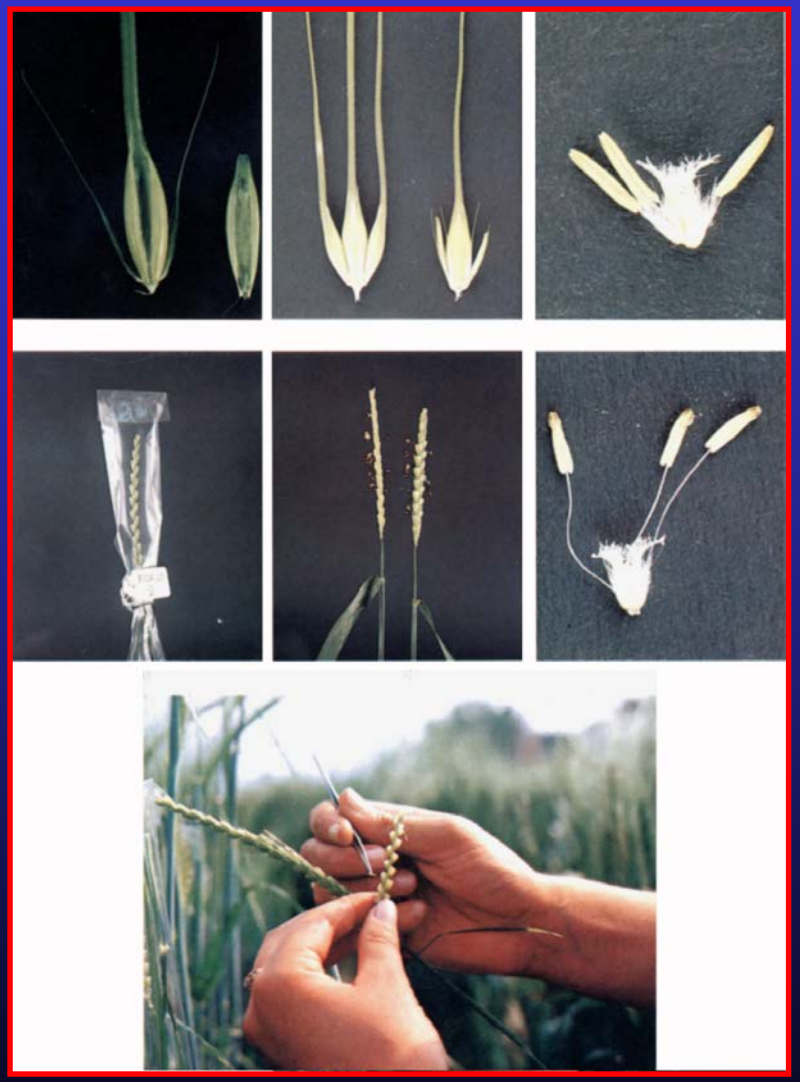
Sviluppo di Alimenti Funzionali per Migliorare la Salute Umana nel Terzo Millennio

Michele Stanca

- U N A S A – CREA GPG- Accademia dei Georgofili -

I.S.C. Fiorenzuola





CRA
CONSIGLIO PER LA RICERCA
E LA SPERIMENTAZIONE
IN AGRICOLTURA

Che cosa sono i composti funzionali?

Sono sostanze che,aggiunte agli alimenti, favoriscono lo stato di salute mediante un'azione specifica, non riconducibile al semplice apporto di nutrienti.

Transcription Factors

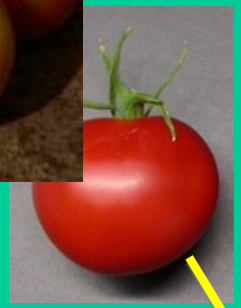
ripening inhibitor

non-ripening

Colorless non-ripening

Uniform ripenin

ction C



Green-ripe

(Nr)

high-pigment 1

(hp-1)

Never-ripe 2

ripening

DD

ylene

nsitive

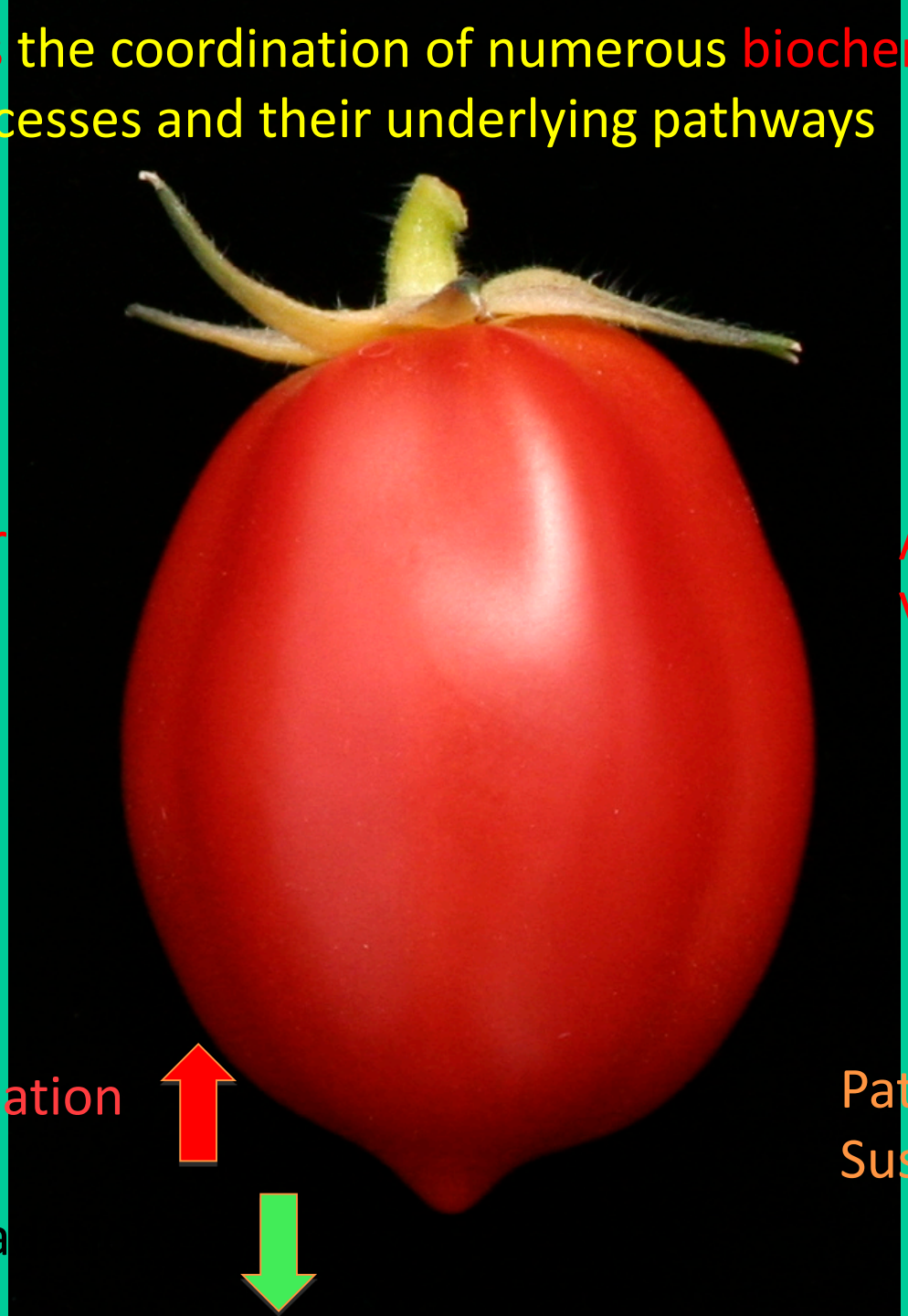
ne)

EIN2

1

Plastid Develo

Ripening is the coordination of numerous biochemical processes and their underlying pathways



Starch

Sugar

Aroma Volatiles

Texture

Pigment accumulation

Pathogen Susceptibility

Chlorophyll degra

La Cicoria di Galatina

- Valorisation and Traceability of made in Italy Products:
- Transcriptome Assembly and Marker Develpment of “Puntarelle” Chicory stems

La Cicoria di Galatina

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- Donato Giannino : donato.giannino@ibba.cnr.it

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ARKIVE
www.arkive.org
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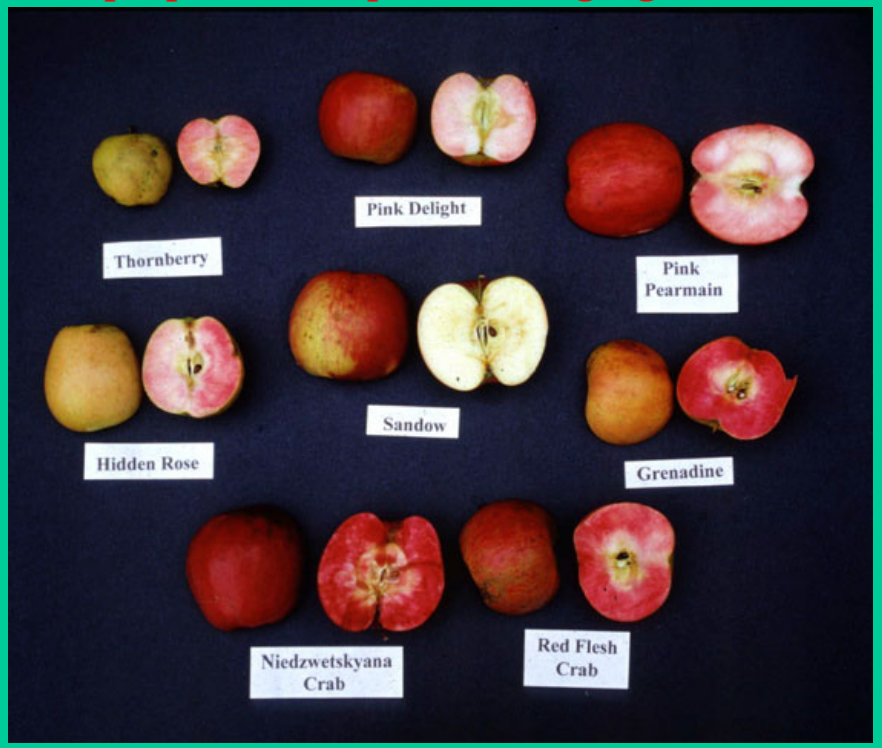
Qualità: componenti salutistiche
Mele a polpa rossa e pesche sanguigne



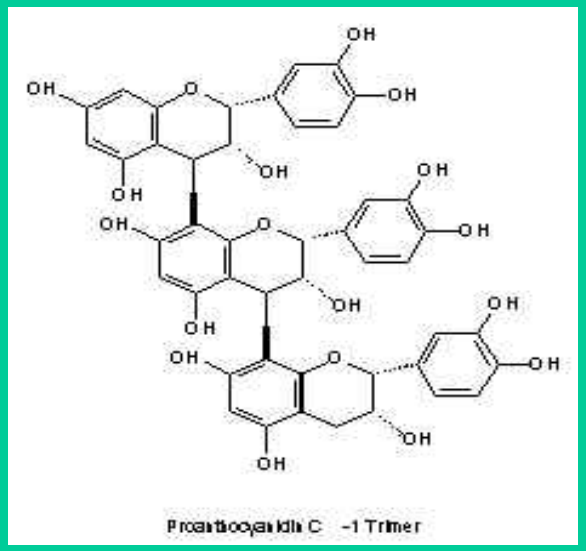
compagnia olandese Next Fruit Generation
http://www.nextfruitgeneration.nl/products/red_flesh_apple/

Red Passion (selezione UNITUS)

Mela Pelingo (Acqualagna)-Università di Urbino

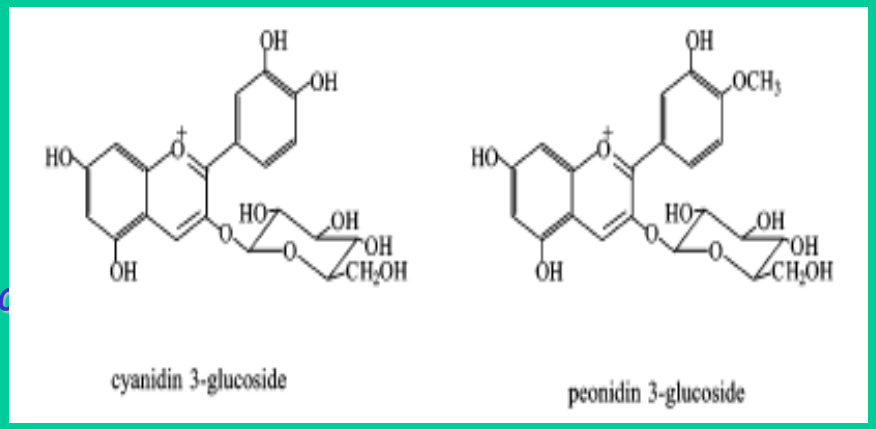
Colored rice, a niche market with healty aspects

Proanthocyanidins



Finocchiaro et al., Mol. Nutr. Food Res., 51: 1006-1019 (2007)

Anthocyanins

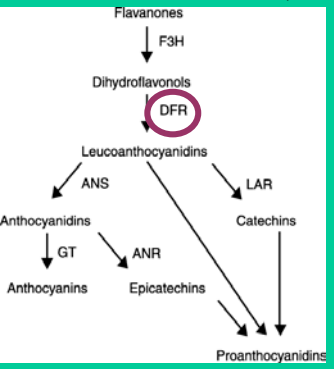


Hu et al., J. Agric. Food Chem, 51: 5271-5277 (20

Investigation on genes involved in Proanthocyanidins biosynthesis in black rices

- *Rc* encodes a regulatory protein (Basic Helix-Loop-Helix Protein) that allows the accumulation of proanthocyanidins (Sweeney M. et al., Plant Cell, 2006)

- *Rd* encodes the enzyme DFR (dehydroflavonolreductase), which is involved in anthocyanin and proanthocyanidins pathway (Furukawa et al., Plant Journal, 2006)



Rc gene in the two black rices

Artemide

Venere

Colored rice selection: quality criteria for market

- colored pericarp

-

  - Degree of pericarp coloration

  -

  -

  -

  -

  - Chewing criteria

Avenanthramides

Unique to oats
ca 30 different compounds

Antioxidative

p

Anti-inflammatory

Anti-atherosclerotic

f

Tranilast
look alike

c

Cooling sensation

Phytoalexin/Antifungal

AveQ

Phenotypic Plasticity in *Vitis vinifera*

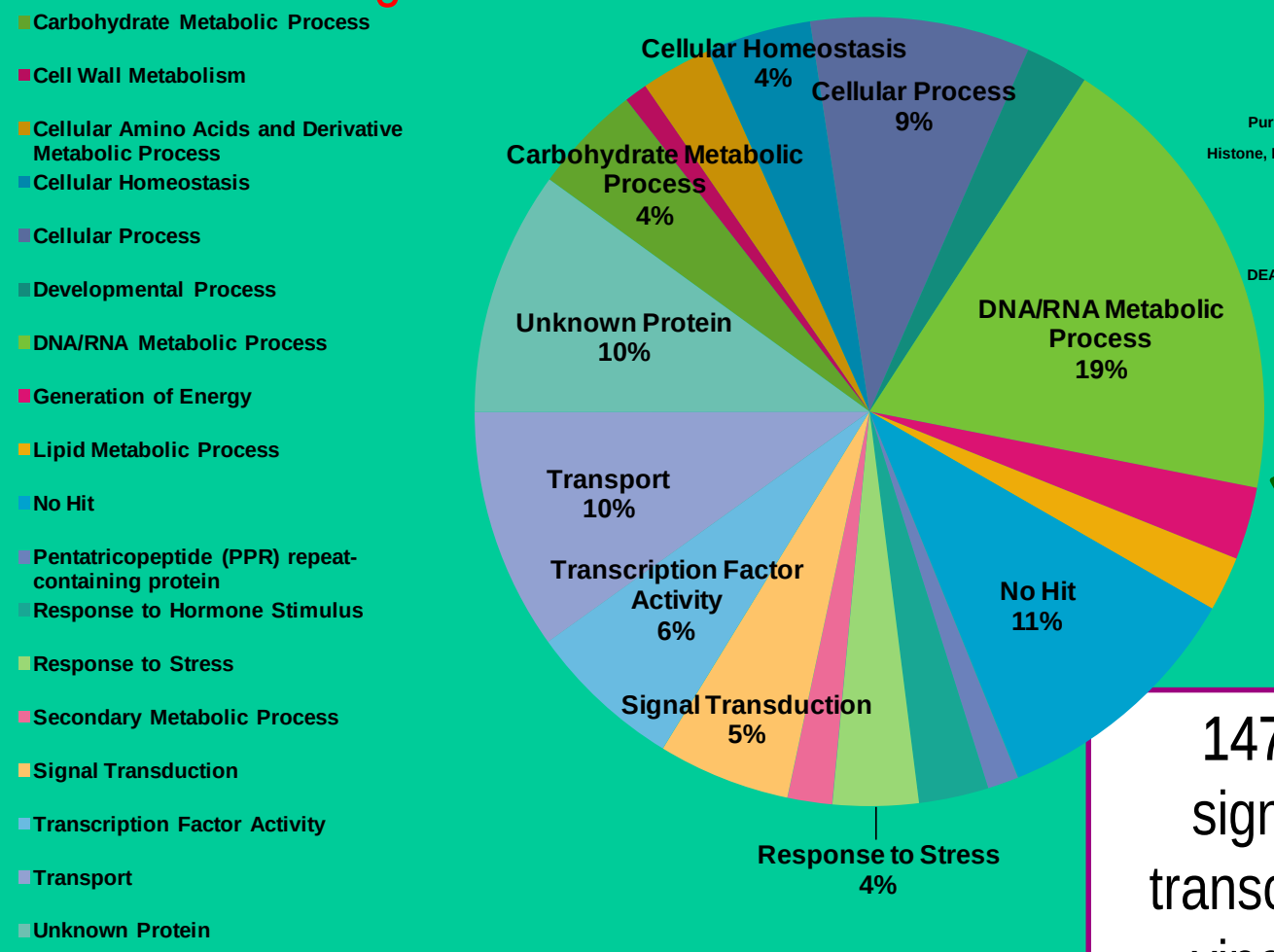
Vitis vinifera spp is one of the most plastic plants known: a single genotype is able to produce berries with different quality, thus different wine qualities, depending on the micro-environment where it is cultivated.

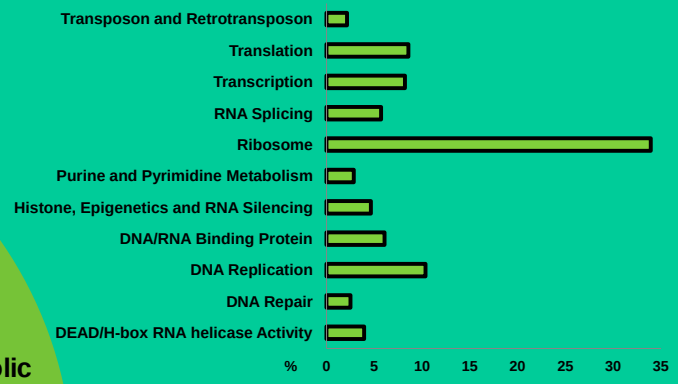
Berry plasticity is very high

Individual berries

Transcriptome Plasticity during Berry Development

Samples from 2008 harvested in 11 Vineyards in 3 developmental stages





1478 genes showed a significant difference in transcription among the 11 vineyards, during berry development

Synsepalum dulcificum

Miracle Fruit

Proteina: *MIRACULINA*

Limone dolce: Alessio Aprile

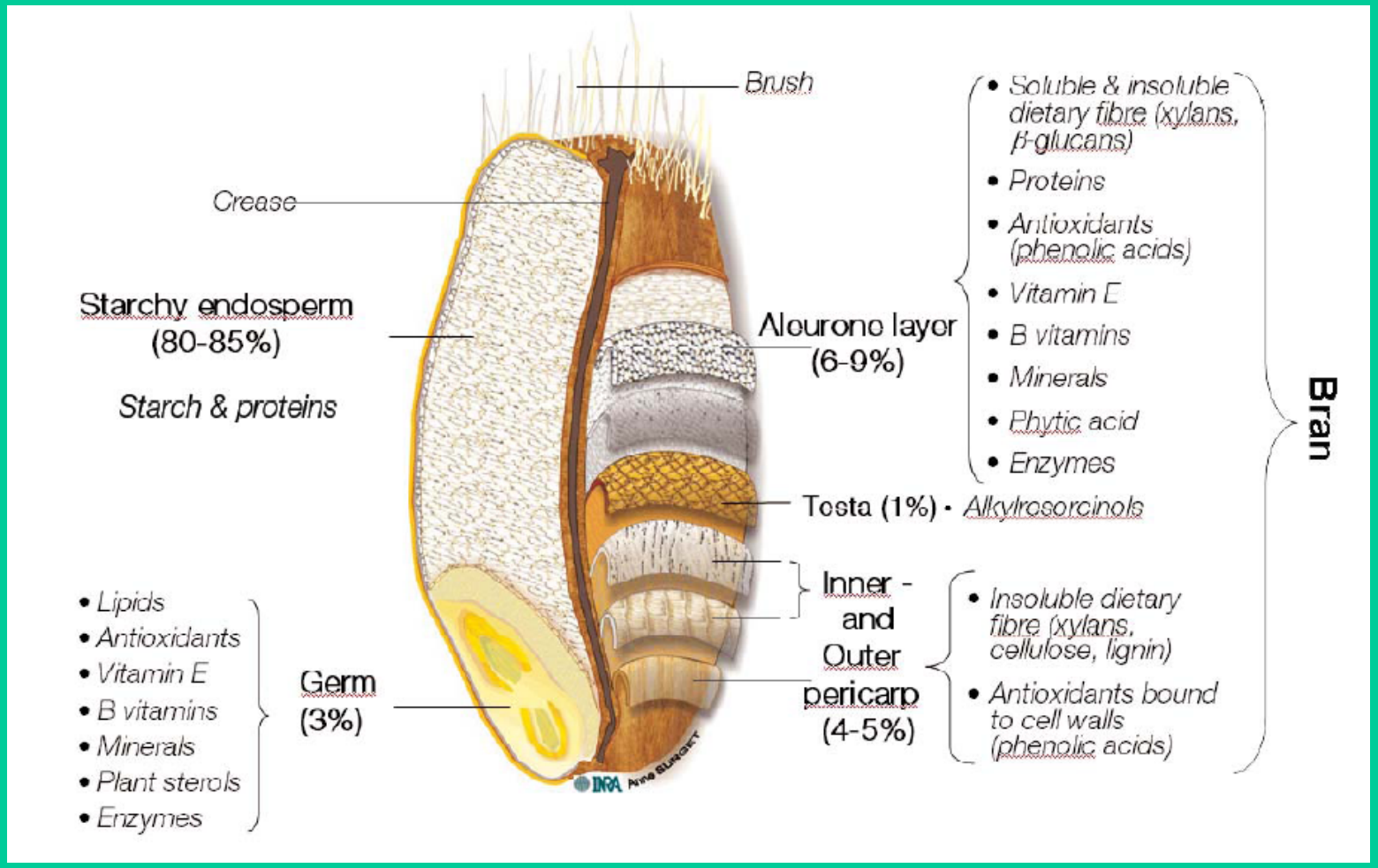
Unisalento

Miracle Fruit

Miraculina

Synsepalum dulcifi

La cariosside di frumento

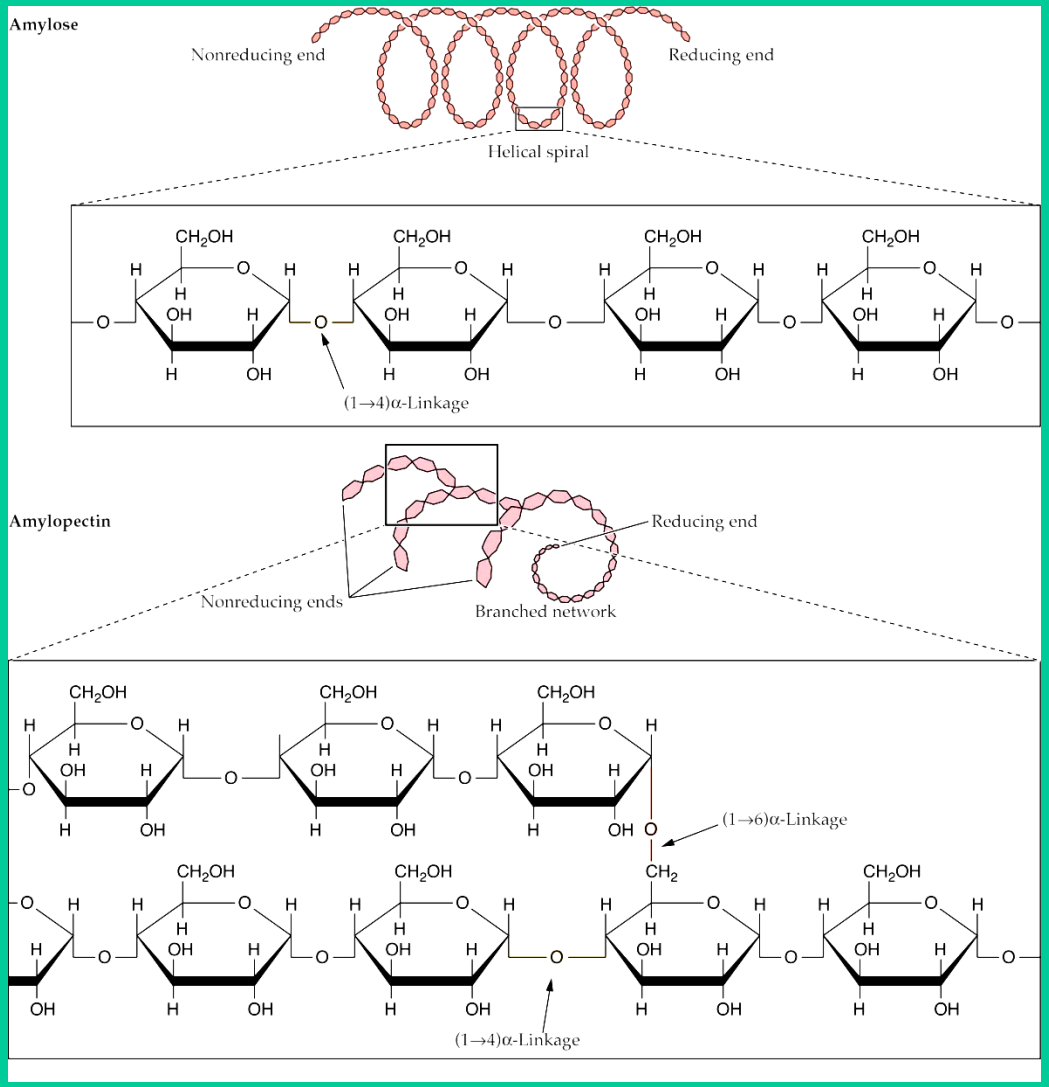


Amido

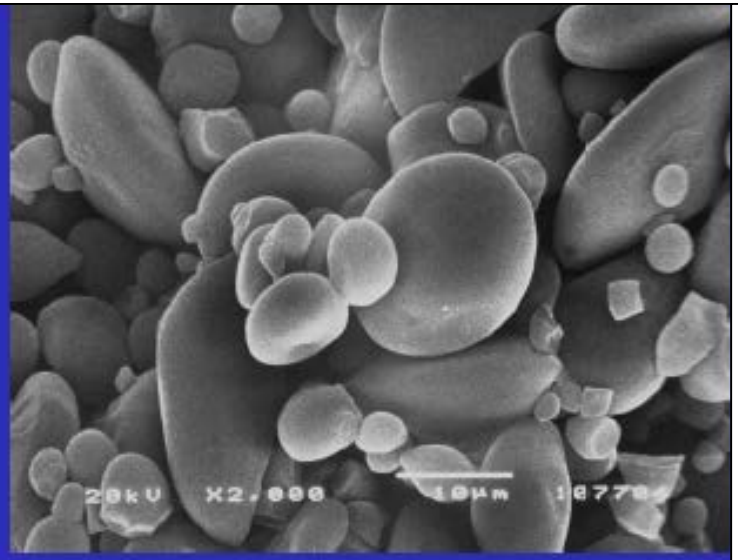
-AMILOSIO 25% (catene lineari) -

-AMILOPECTINA 75%

-(catene ramificate)



Amido e salute



L’amido ricco di amilosio è più resistente alla digestione

FRUMENTI WAXY?
IBRIDI?
Pane e Pasta Funzionali?

FRUMENTI WAXY

	Amilosio	Amilopectina
Amido norm	25%	75%
Amido waxy	0-5%	95%

-maggiore assorbimento di H_2O

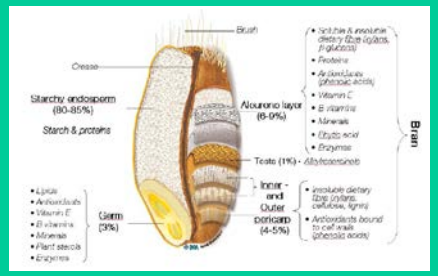
-stabilità dell'amido

-migliore consistenza dei prodotti da forno

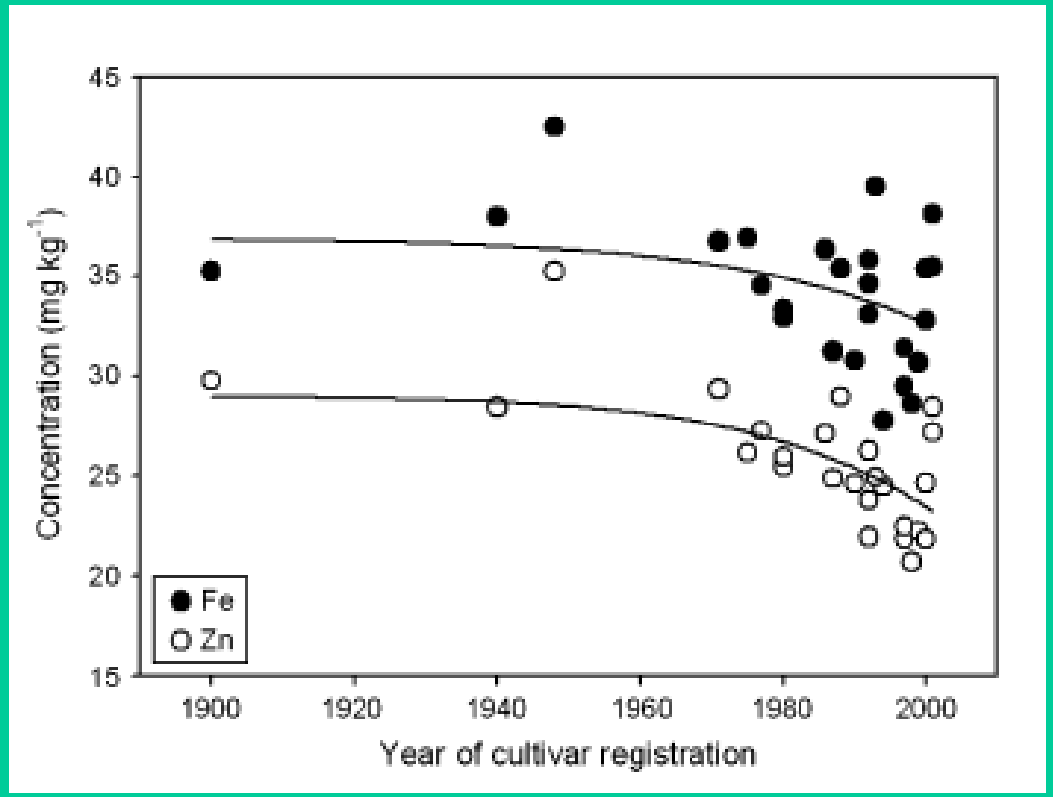
-ridotto uso dei grassi negli impasti

-stabilità del gusto e dell'aroma

-produzione di cibi surgelati:più resistenti ai cicli di congelazione e decongelazione



Biodiversità per microelementi in varietà di frumenti.



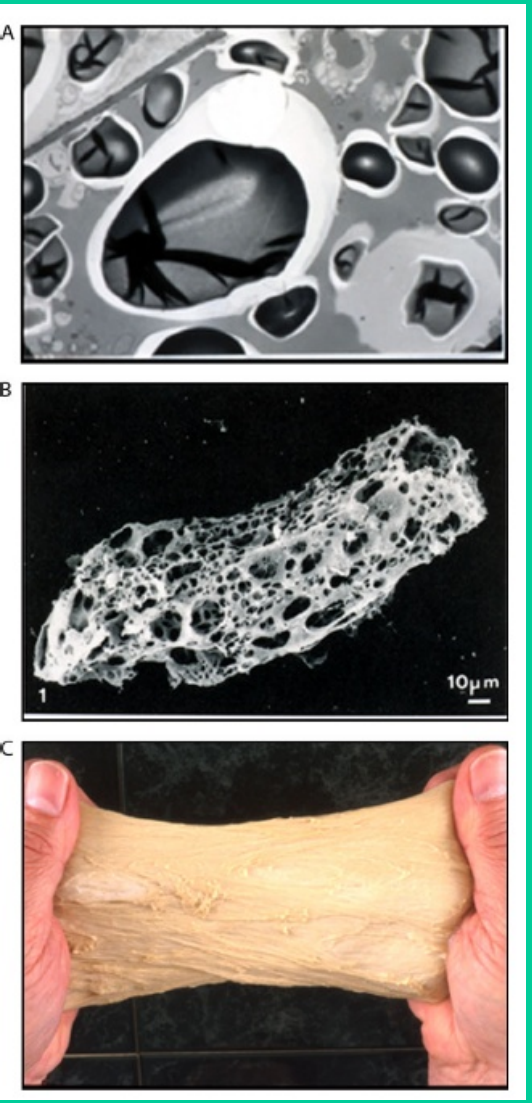
Ferro
Zinco
Selenio

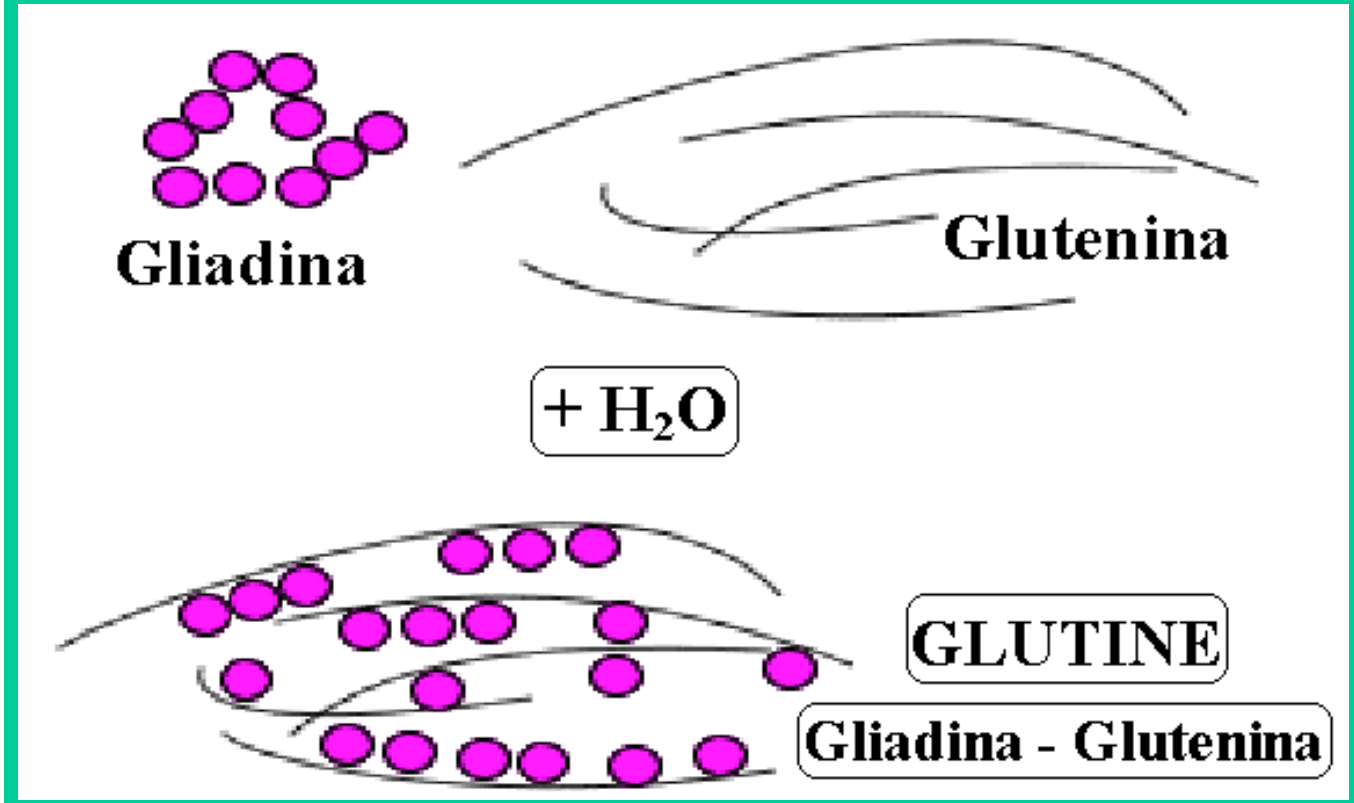
Le proteine della cariosside sono le maggiori componenti del GLUTINE

- Il glutine si forma miscelando farina ed acqua

- Il glutine è responsabile delle caratteristiche visco-elastiche dell'impasto e quindi delle caratteristiche del prodotto finale (es. pane)

Gliadine, Glutenine e Glutine





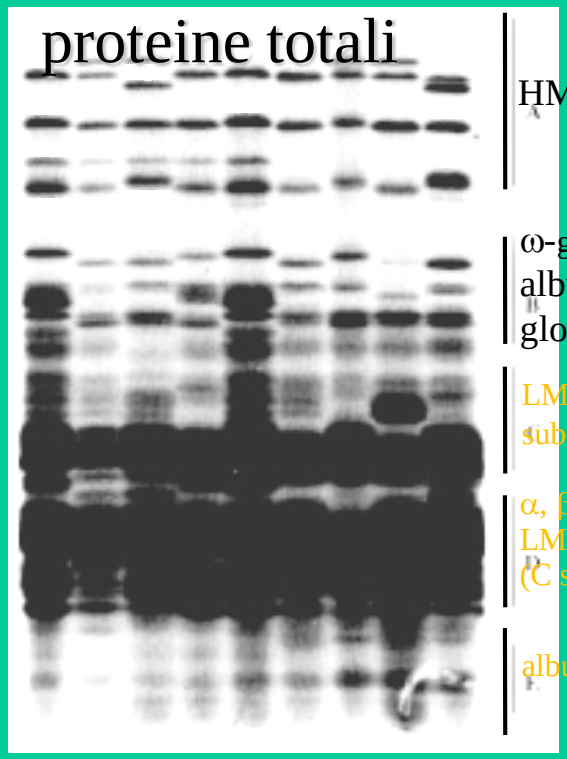
-**Glutenins**, large proteins, contribute to the elastic component

-

-**Gliadins**, small proteins, contribute the viscous component

La biodiversità delle proteine che formano il glutine

Separazione in elettroforesi di proteine totali



Glutenine

e proteine polimeriche

Insolubili in alcool

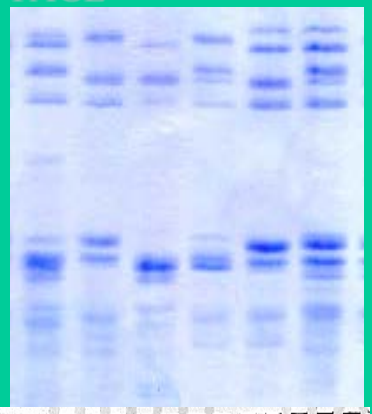
Monomeri e gliadine

alcool solubili

SDS-PAGE

HMW subunits

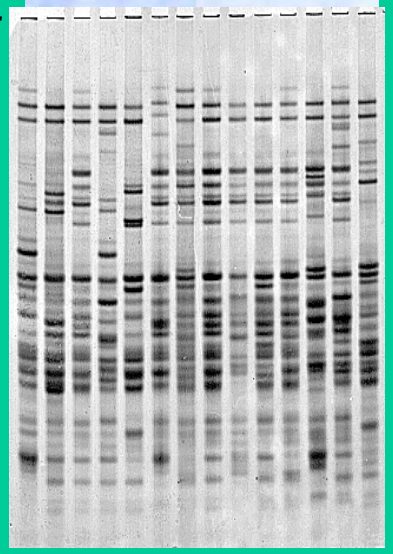
LMW subunits



ω-gliadins

γ-type gliadin

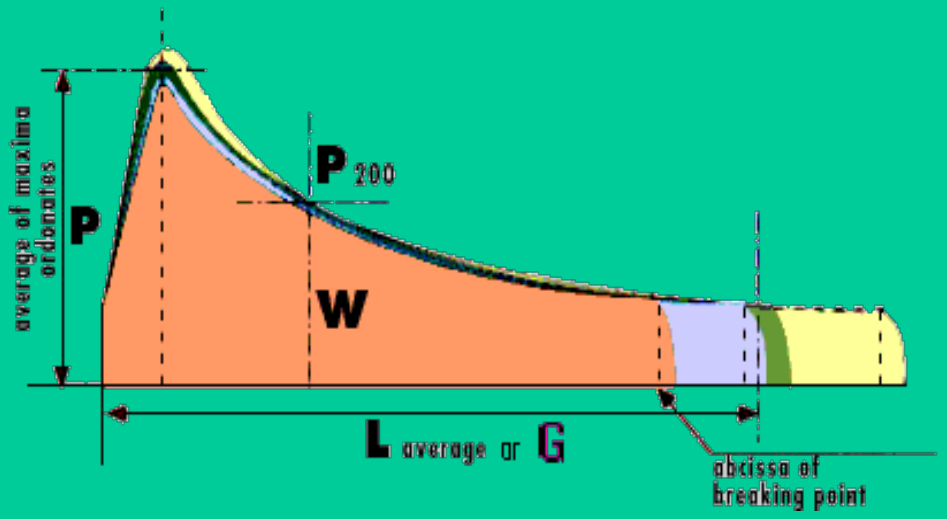
α-type gliadins



A-PAGE

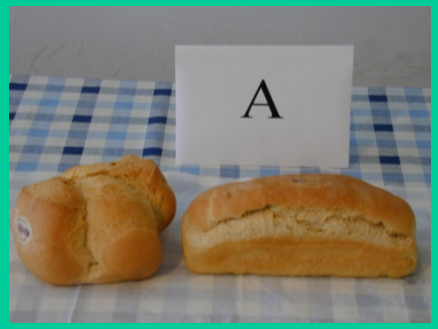
Parametri tecnologici nei frumenti

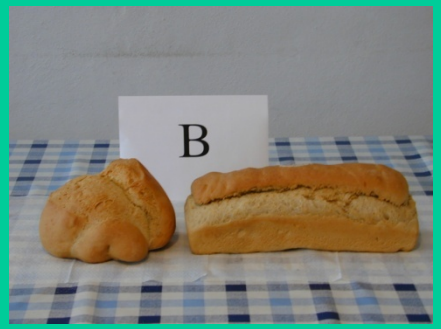
- PESO 1000 SEMI E PESO ETTOLITRICO
- GLUTEN INDEX 0-100
- CONTENUTO IN CENERI
- CONTENUTO IN PROTEINE
- P=tenacità dell'impasto; L= Estensibilità dell'impasto
- ALVEOGRAFO (W; P/L)

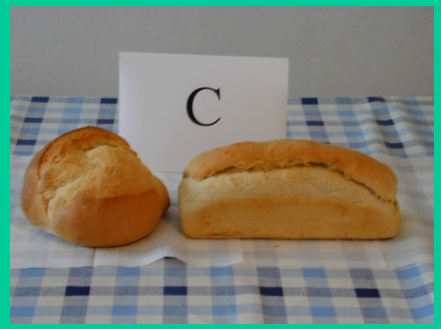


Biodiversità del glutine e diversità del pane

Analisi sensoriale: panel test







C.R.A. - Istituto Sperimentale per la Cerealicoltura - Sezione di Fiorenzuola d'Arda
"Pane di frumenti antichi"

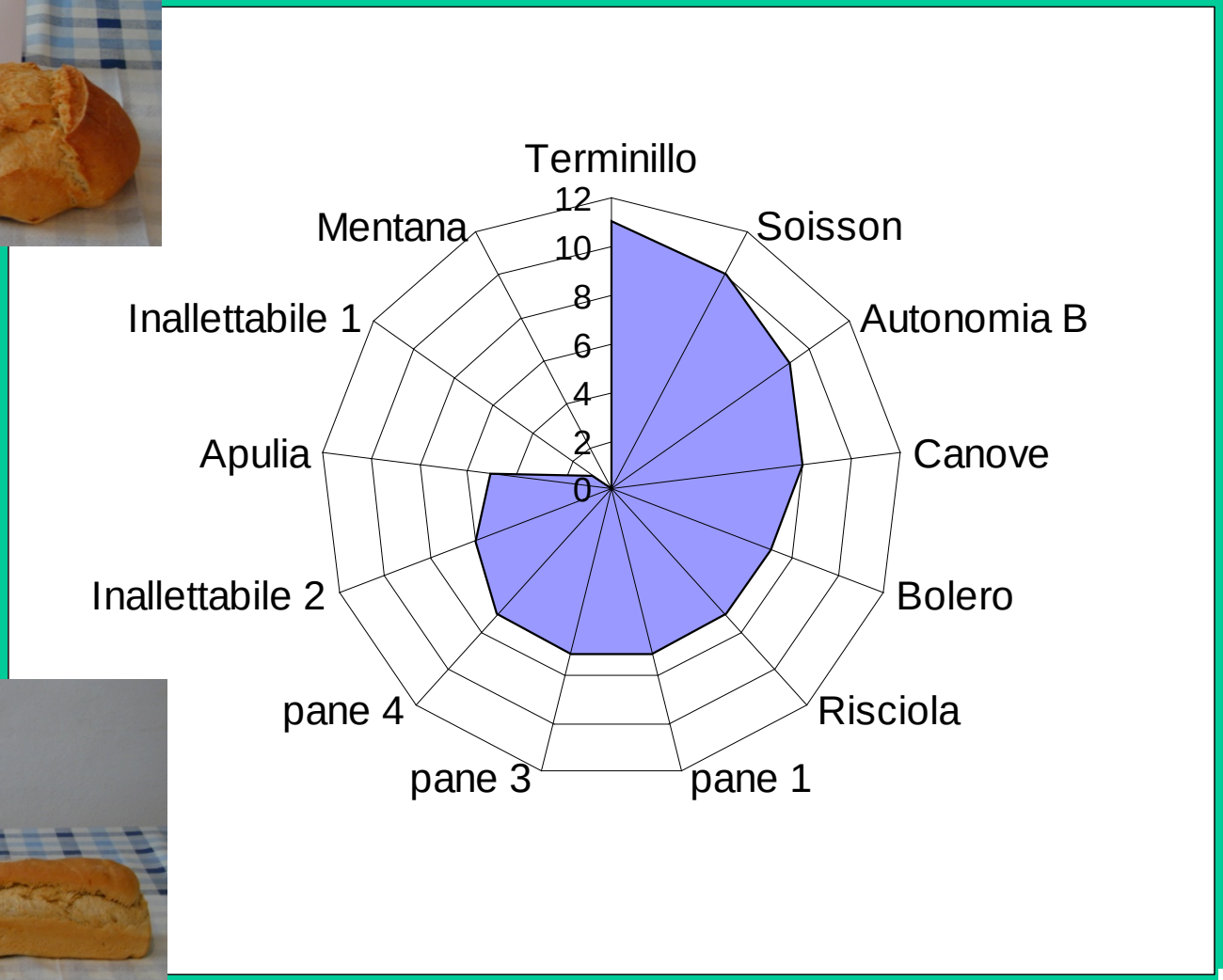
Data: .....

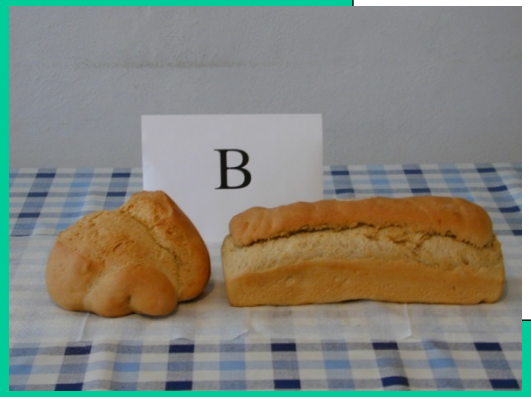
Valutazione sensoriale prodotto di panificazione ..... *(tipo o sigla)*

Parametro *(considerare nell'ordine elencato)*	**Punteggio sensoriale** (minimo 1 - massimo 5)	**Difetti** *(nel caso il punteggio sia 2 o inferiore, segnare il difetto tra quelli riportati)*
Formato *(volume e forma soddisfacenti)*	.....	☐ troppo piccolo ☐ troppo grosso
Colore esterno *(piacevolezza)*	.....	☐ colore non uniforme ☐ colore macchiato ☐ troppo scuro ☐ troppo pallido
Colore mollica *(piacevolezza)*	.....	☐ troppo scura ☐ troppo pallida ☐ non uniforme
Aroma *(gradevolezza)*	.....	☐ forte ☐ estraneo ☐ di muffa
Crosta *(croccantezza/sofficità al morso)*	.....	☐ dura ☐ gommosa ☐ umida ☐ secca ☐ abbrustolita
Alveolatura *(dimensione e uniformità)*	.....	☐ non uniforme ☐ buchi
Tessitura *(consistenza al tatto e alla masticazione)*	.....	☐ troppo compatta ☐ gommosa ☐ troppo morbida ☐ sbriciolosa ☐ che raspa ☐ non uniforme
Sapore *(appagamento)*	.....	☐ piatto ☐ estraneo ☐ acido ☐ troppo forte ☐ salato ☐ di abbrustolito
Retrogusto *(sapore residuo dopo la deglutizione)*	.....	☐ sgradevole ☐ acido ☐ bicarbonato
Rusticità *(capacità di richiamare un'impressione di prodotto tradizionale)*	.....	☐ prodotto di serie ☐ impressione di grossolanità
~~Durevolezza~~ *~~(resistenza al raffermimento)~~*	.....	~~☐ raffermo~~ ~~☐ secco~~
Giudizio sintetico *(valutazione complessiva del prodotto)*	.....	
Note		

- Colore esterno
- Formato
- Colore mollica
- Aroma
- Crosta
- Alveolatura
- Tessitura
- Sapore
- Retrogusto
- Rusticità
- Giudizio globale

Panel test – diverse varietà





CRA
CONSIGLIO PER LA RICERCA
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IN AGRICOLTURA

Biodiversità e aroma: chimica dei composti volatili

GC-MS
Naso elettronico

CLASSI QUALITATIVE

- FF= Frumenti di Forza:w > 300-P/L 0,7
- FPS=Frumenti panificabili superiori
- w220-300,P/L 0,8
- FP=Frumenti Panificabili:w140-200,P/L0,8
- FB=Frumenti Biscotti:w<140,P/L0,5
- FAU=Frumenti Altri Usi

FW= Frumenti Waxy

PROLAMINE

- Gliadine+Glutenine =Glutine- Ordeine- Secaline
- Alto contenuto di prolina e glutammina
- Contengono molti residui di prolina e questo le rende particolarmente resistenti alla digestione da parte degli enzimi gastrici , pancreatici e intestinali
- Il risultato di questa parziale digestione porta alla formazione di peptidi(8-33 amminoacidi)alcuni dei quali sono tossici e immunogenici per la mucosa celiaca
- Sequenze di DNA ripetute sui tre genomi ABD
- Difficoltà di correggere attraverso la genetica classica
- Genome Editing?
- *Gazza 2015*

2011

Sensibilità al glutine non celiaca

Non Celiac Gluten Sensitivity, NCGS

Cereali a basso indice di glutine: T. Monococcum, presenta glutine debole completamente digerito dai nostri enzimi

Ipotesi: presenza –assenza di omega gliadine

Esiste Variabilità genetica?

Gazza, 2015; Iacomino ,…, Gazza,….Mamone 2016

Altre Proteine Tossiche o Allergeniche

- INIBITORI delle alfa amilasi:Proteine a basso peso molecolare presenti nella granella di tenero e duro
- Esplicano un’azione di difesa verso l’attacco di insetti
- Nell’uomo esercitano un’azione tossica o allergenica quando inalate o ingerite
- Una famiglia di queste proteine è codificata da geni presenti sul cromosoma 6 D e 6 B .Riconosciute come allergeni coinvolti nell’asma dei panettieri.
- Resistono all’azione delle proteasi e stimolano le cellule del nostro sistema immunitario a produrre molecole infiammatorie scatenando reazioni immunitarie in pazienti affetti da celiachia
- *Gazza 2015*

Do we need to worry about eating Wheat?

Shewry and Hey 2016 Nutrition Bullettin

Immunochemical determination of Gluten in Malts and beers

Dostalek et al. 2006 Food Additives and contaminants

Differences in gluten protein composition between old and modern durum wheat genotipes inrelation to 20° century breeding in Italy

De Santis et al 2017 European Journal of Agronomy

New Insights into Wheat Toxicity : Breeding did not seem to contribute to a prevalence of potential celiac disease’s immunostmulatory epitopes

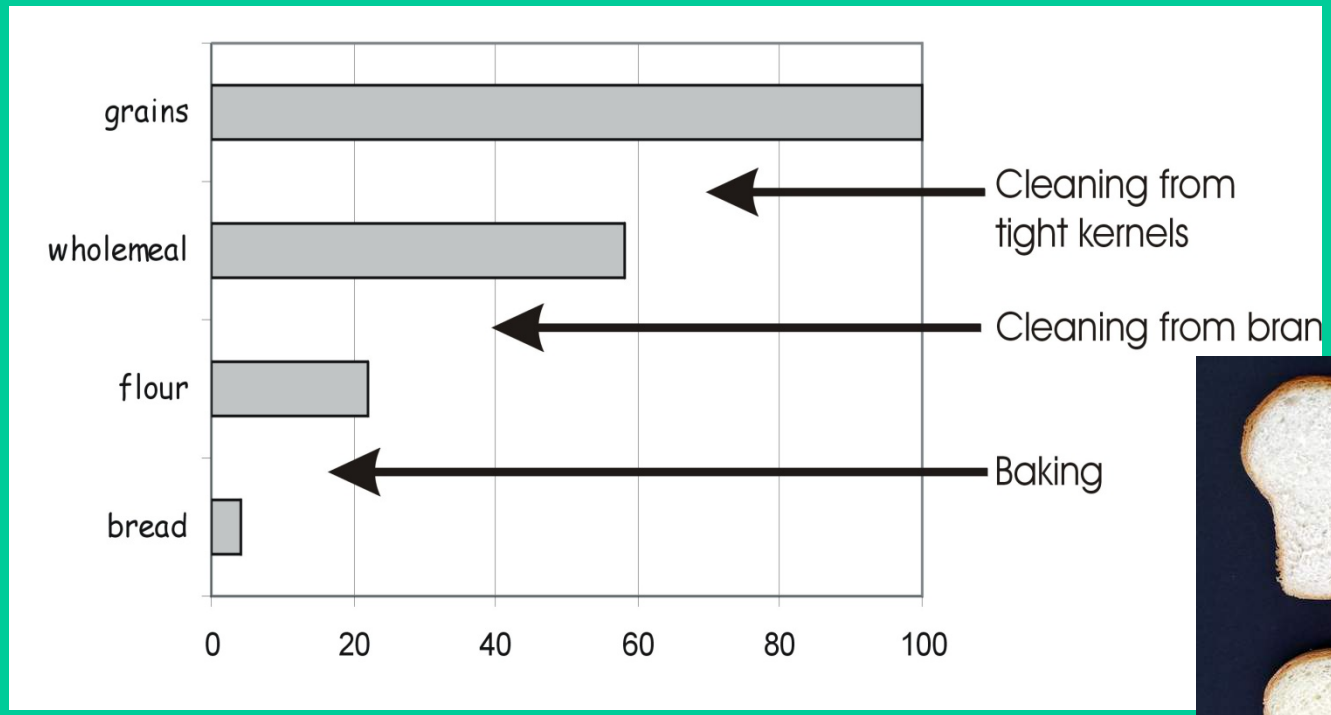
Miguel Ribeiro et al. 2016 Food Chemistry

Fusariosi della Spiga

La “fusariosi della spiga” (FHB) ha un impatto fortemente negativo sulle produzioni dei cereali a paglia e particolarmente di frumento.

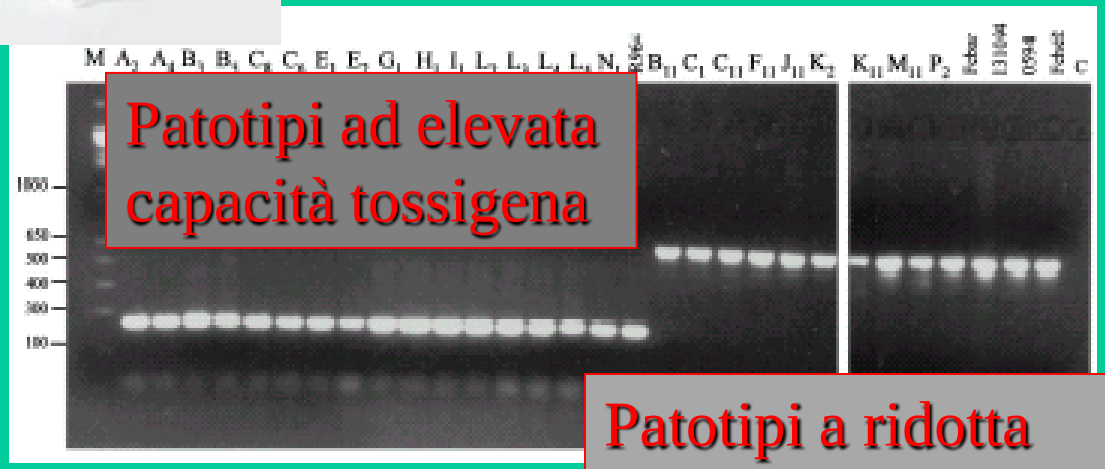
- ✓ resa in granella
- ✓ qualità della granella
- ✓ contaminazione delle cariossidi con micotossine

PRESENZA E PERSISTENZA DELLA CONTAMINAZIONE DA *FUSARIA* DURANTE LA CATENA DI PRODUZIONE DEL PANE



FUSARIOSI DELLA SPIGA: monitoraggio per il controllo del problema

- Rilievi fitopatologici
- Individuazione diretta delle micotossine
- Individuazione indiretta delle micotossine



Patotipi ad elevata capacità tossigena

Patotipi a ridotta capacità tossigena

Optimization of durum wheat bread from a selenium-rich cultivar fortified with bran

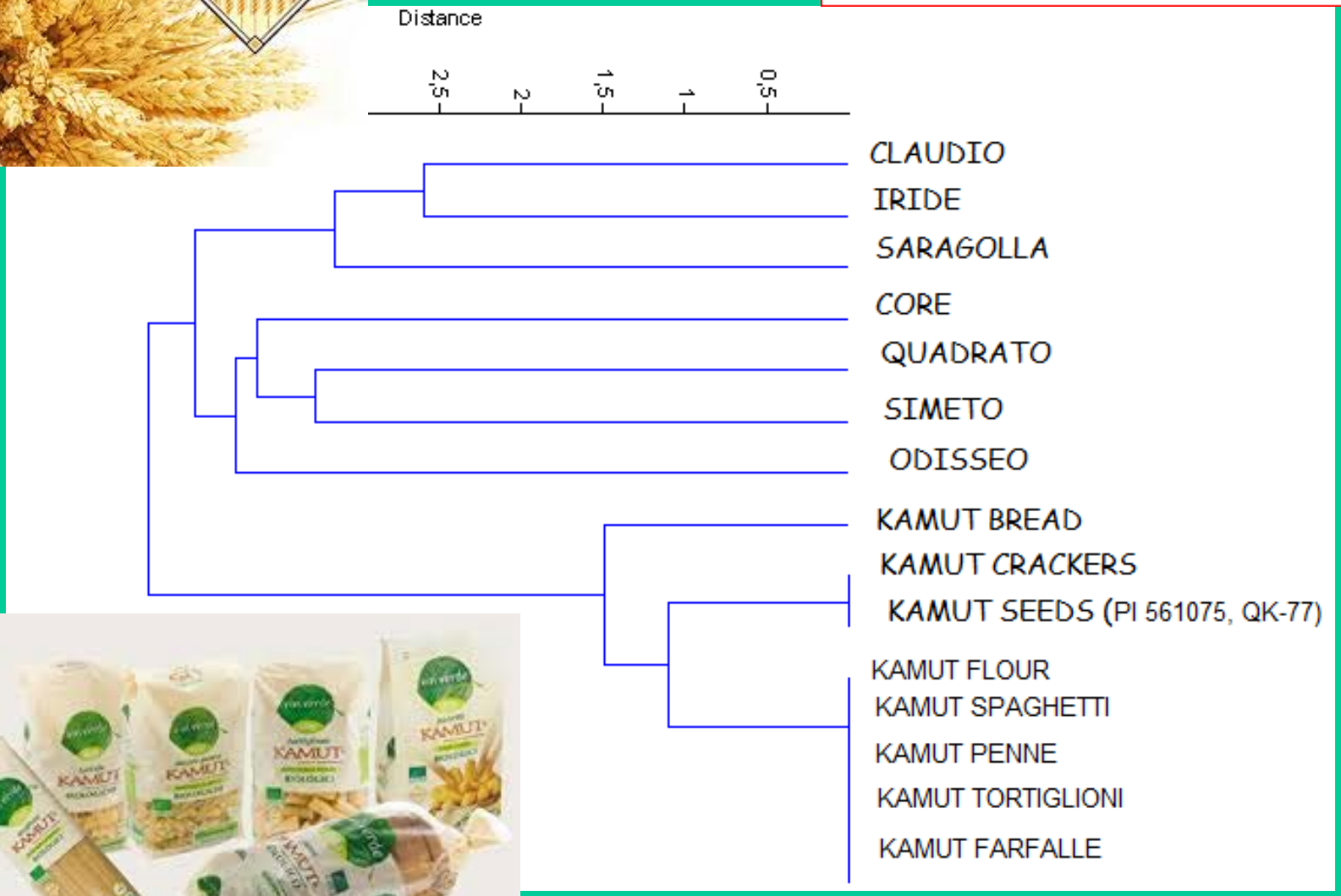
Previtali et al J:Food Sci Technol.2016

Selenium –enricheddurum wheat improves the nutritional profilesof pasta without altering its organoleptic properties.

De Vita et al Food Chemistry 2017

Use of purple durum wheat to produce naturally functional fresh and dry pasta.

Ficco et al 2016 Food Chemisty



SSR-based DNA profiling

OBIETTIVO

- **SVILUPPARE METODICA MOLECOLARE DNA-BASED per l'individuazione e quantificazione di DNA di grano tenero in semole e pasta**

- **VALIDAZIONE METODICA ANALITICA**

METODOLOGIA

Consolidare tecnica qPCR (basandoci su lavori di Alary et al. (2002) e Terzi et al. (2003))

Dossier di validazione

Organizzazione di un ring test che coinvolga laboratori di biologia molecolare

Calcolare incertezza del metodo

CO2
normale

Alta CO2

I.S.C. Fiorenzuola

Barley

is the main cereal grain for the development of Functional Foods

WHY?

It contains two classes of compounds:

Tocols

β-glucans (Dietary Fiber)

I.S.C. Fiorenzuola

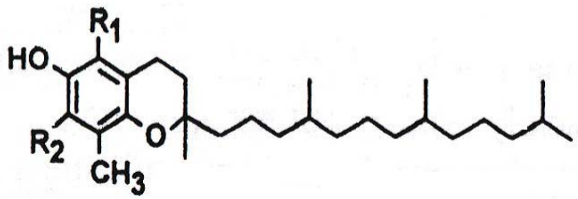
Where are

tocols and b-glucans

accumulated

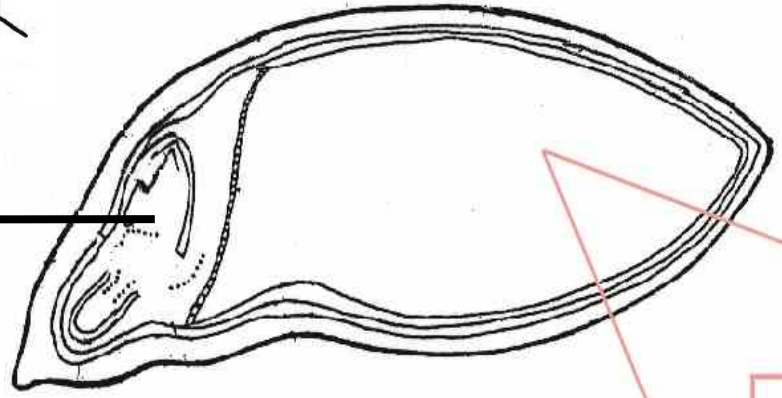
in the barley grain?

Barley grain

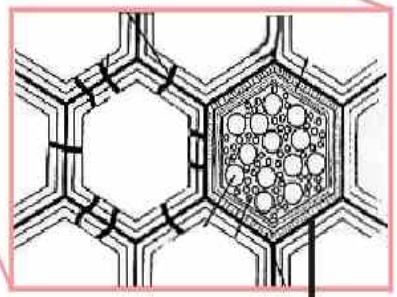


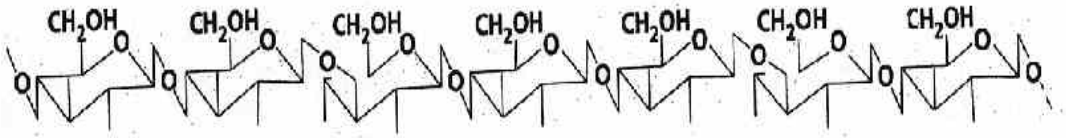
Tocols

Germ



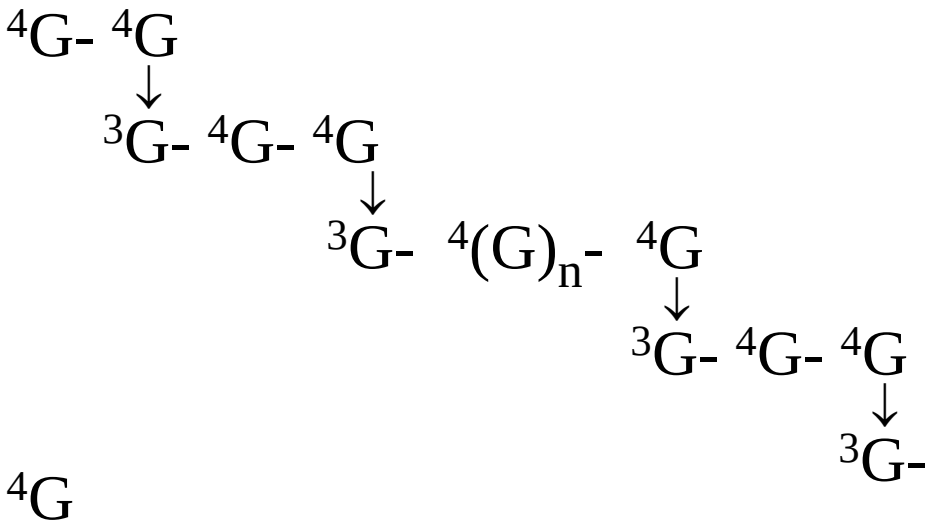
Endosperm cells





β-glucans

β-Glucans



4-8% dm

(1→3),(1→4)-β-D-Glucans

Physio-chemical carachteristics

Molecular Weight: 10^4-10^6 D

Polimarisation degree: 50-5000

Solubility: Viscous solution gel-like structured

reology: pseudoplastic behaviour

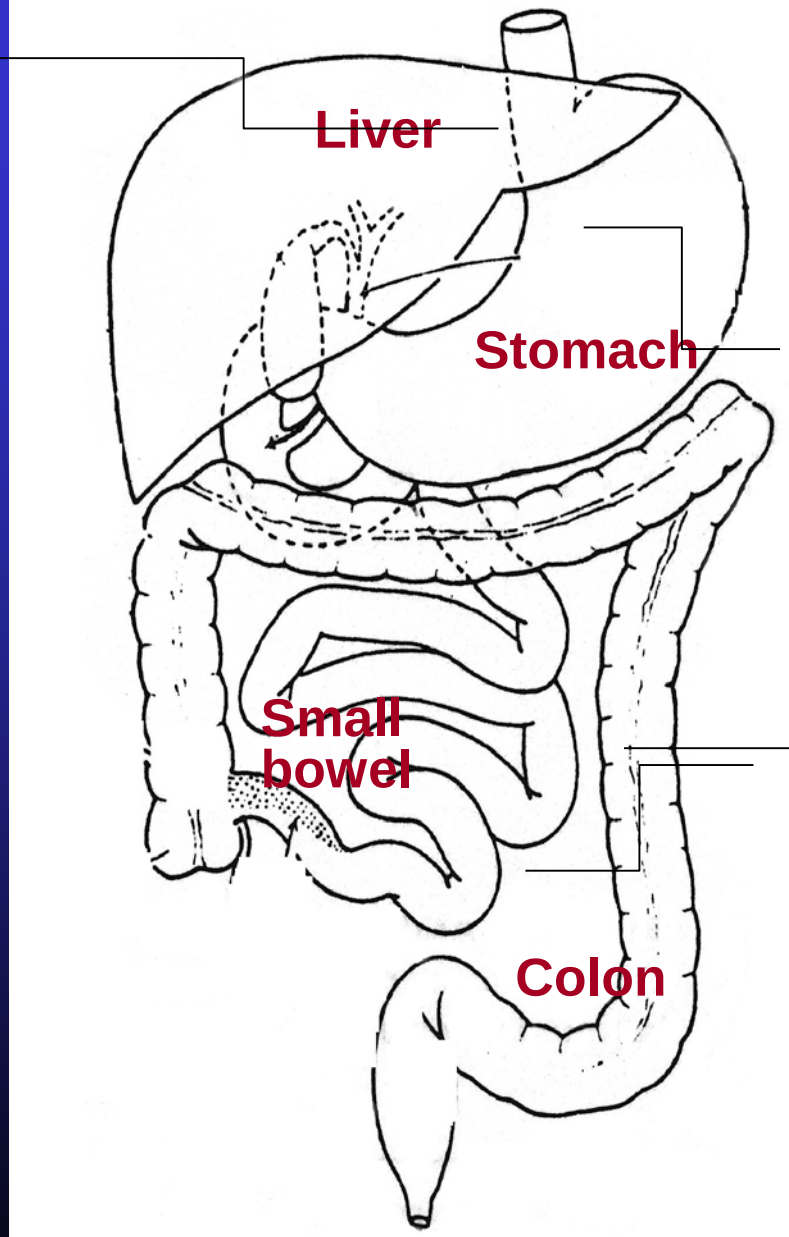
Jadhav (1998)

I.S.C. Fiorenzuola

Why b-glucans improve human health?

I.S.C. Fiorenzuola

How do tocols work in the human body?



Tocols

Hmg-CoA reductase inhibition

β-Glucans

↑ gastric emptying time

↓ carbohydrates absorption

↑ Intestinal motility

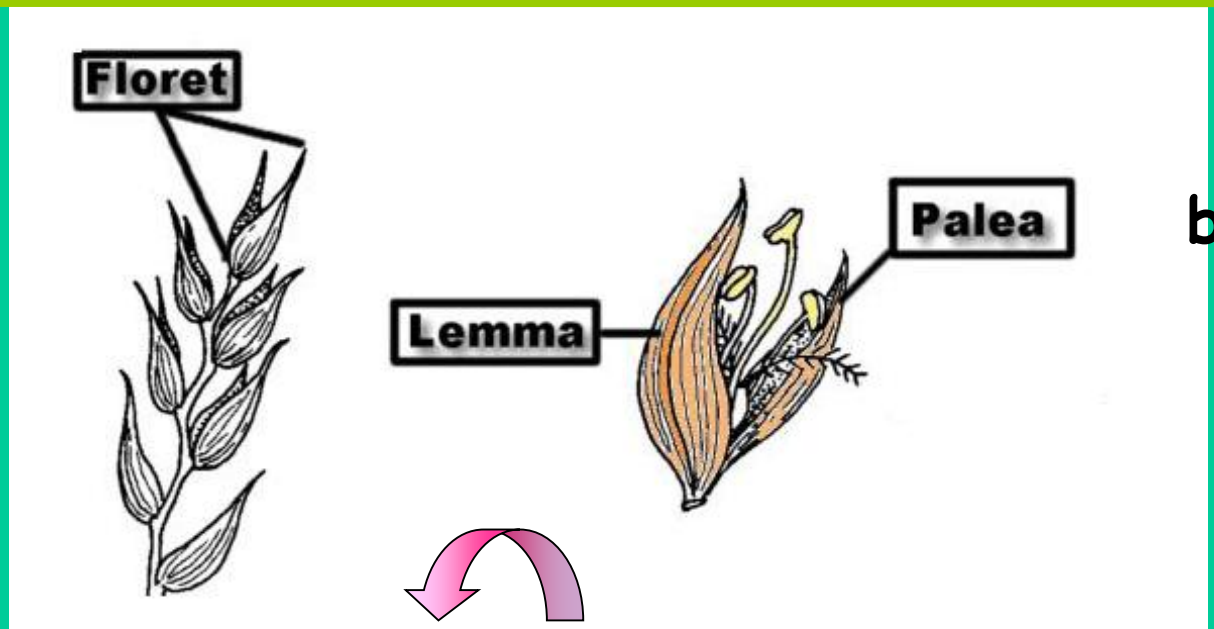
↓ reabsorption of Bile Acids

↑ SCFA

Hypoglycemic effect

Hypocholesterolemic effect

NAKED vs HULLED BARLEY (*Hordeum vulgare* L.)



Domesticated barley is classified into two major categories according to kernel type.

In **HULLED BARLEY** the husks adhere completely to the grain.

NAKED BARLEY has a caryopsis with easily separable husks upon threshing.

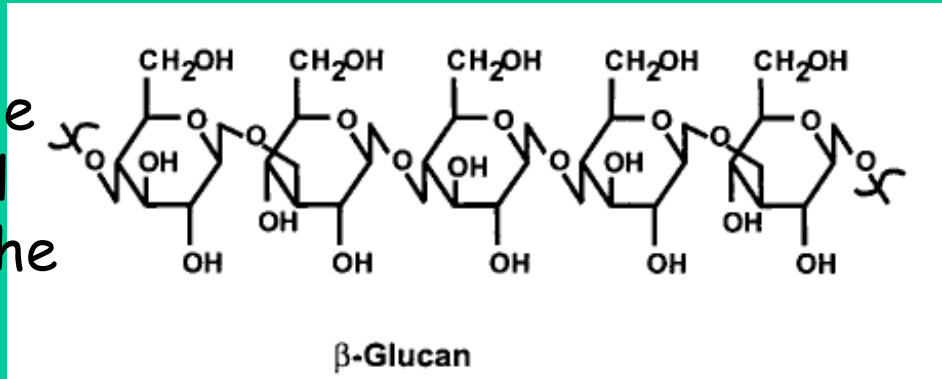
Colered (Bl)
Colorless (bl)

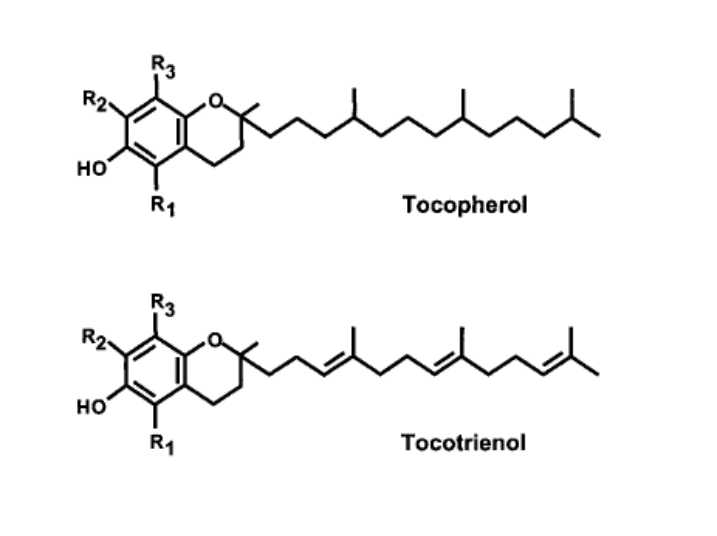
NAKED BARLEY as FUNCTIONAL FOOD

Hulled barley is mainly used for animal feed and brewing malts, while the naked one can be used as human food, in particular as HEALTHY FOOD.

BETA-GLUCANS:

principals components of soluble fiber. They reduce blood total cholesterol concentration and the rate of glucose absorption, leading to a lower glycemic





TOCOTRIENOLS and TOCOPHEROLS:

are two subgroups of the vitamin E family. They are present in the outer parts of the grain and they are natural strong antioxidants. They protect membrane lipids from peroxidation.

EMPLOYMENTS of NAKED BARLEY

Barley coffee

Barley soup, Pearled

Barley decoctions

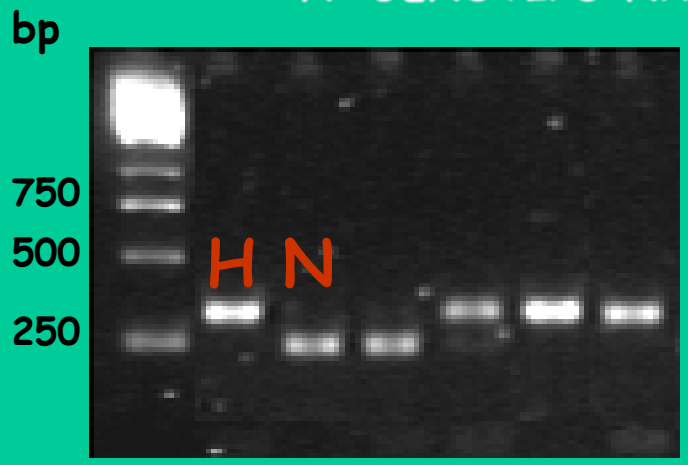
Barley flour

(bread, biscuits,

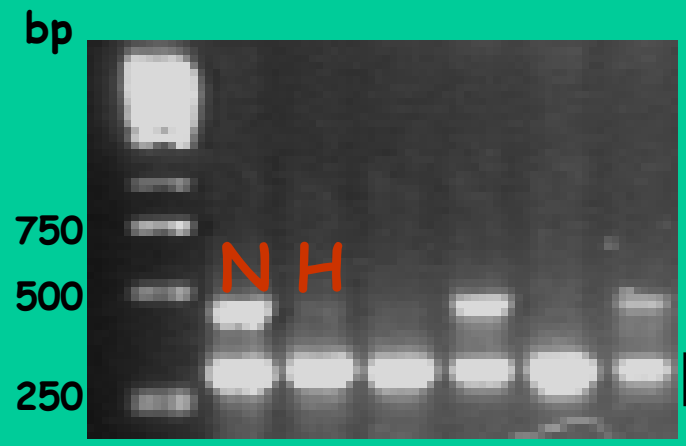
dietary food items)

MARCATORI MAPPATI VICINO AL GENE NUDO (*nud*)

N: GENOTIPO NAKED H: GENOTIPO HULLED (vestito)

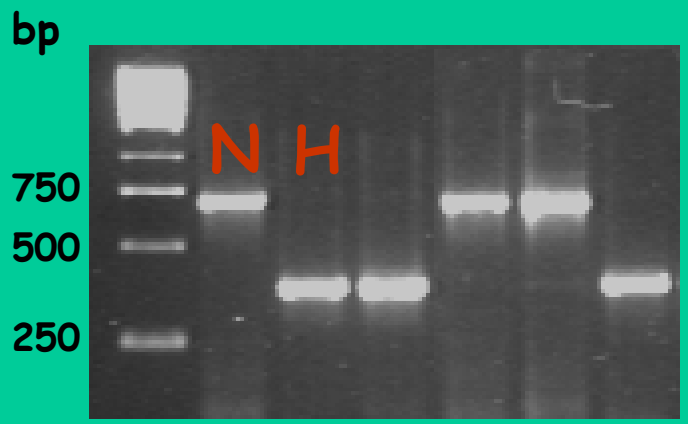


sKT2 (0.9cM da *nud*)

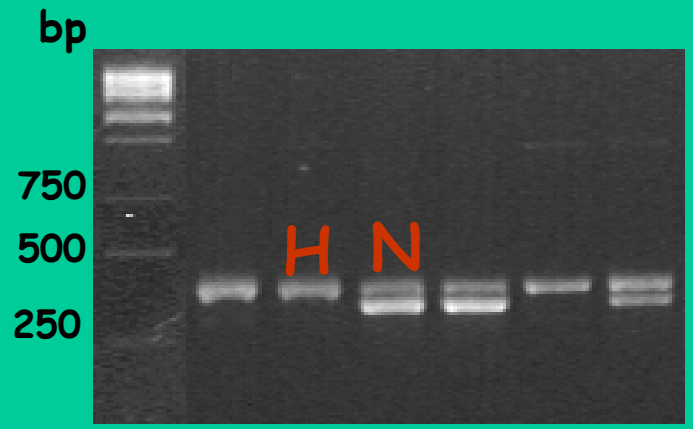


sKT7 (comappa con *nud*)

Controllo positivo ICE1



sKT3 (0.9cM da *nud*)

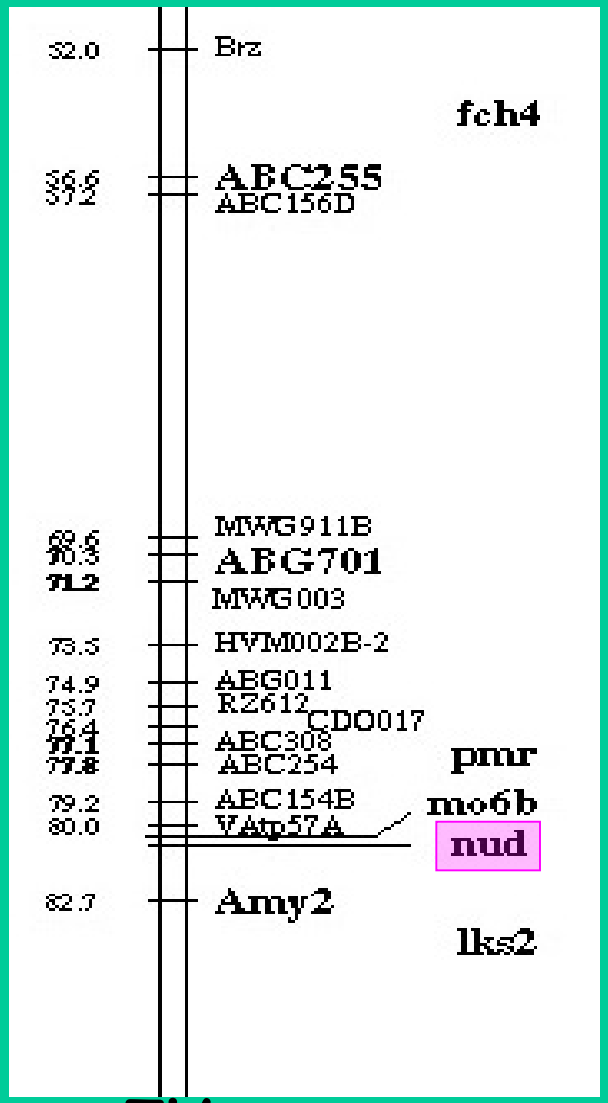


sJ14 (2.7cM da *nud*)

The NAKED GENE

The naked caryopsis character in barley is controlled by a single recessive gene *nud*, located on chromosome 1 (7H).

It has been hypothesized that the naked gene controls the production of an "undefined cementing substance" in the pericarp epidermis, responsible for adhesion of glumelets to kernel teguments.
(Gaines et al. 1985)



7H

According NABGMP

HAPLOTYPE STRUCTURE AROUND THE NUD LOCUS IN BARLEY AND ITS ASSOCIATION WITH RESISTANCE TO LEAF STRIPE (PYRENOPHORA GRAMINEA)

Barabaschi D., L. Campani, E. Francia, H. Toubia-Rahme, G.P. Valè, A. Gianinetti, G. Delogu, A.M. Stanca, N. Pecchioni

Plant Breeding, 126: 24-29, 2007

PNAS

4062–4067 | PNAS | March 11, 2008 | vol. 105 | no. 10

Barley grain with adhering hulls is controlled by an ERF family transcription factor gene regulating a lipid biosynthesis pathway

Shin Taketa*†, Satoko Amano*, Yasuhiro Tsujino*, Tomohiko Sato*, Daisuke Saisho‡, Katsuyuki Kakeda§, Mika Nomura*, Toshisada Suzuki*, Takashi Matsumoto¶, Kazuhiro Sato‡, Hiroyuki Kanamori‖, Shinji Kawasaki¶, and Kazuyoshi Takeda‡

*Faculty of Agriculture, Kagawa University, Kagawa 761-0795, Japan; ‡Research Institute for Bioresources, Okayama University, Kurashiki 710-0046, Japan; §Graduate School of Bioresources, Mie University, Tsu 514-8507, Japan; ¶National Institute for Agrobiological Sciences, Tsukuba 305-8602, Japan; and ‖Institute of Society for Techno-Innovation of Agriculture, Forestry, and Fisheries, Tsukuba 305-0854, Japan

NEW TECHNOLOGIES to INCREASE BETA-GLUCAN CONTENT in the BARLEY FLOUR

Barley micronization 2x

I Air Classification (valve = 220)

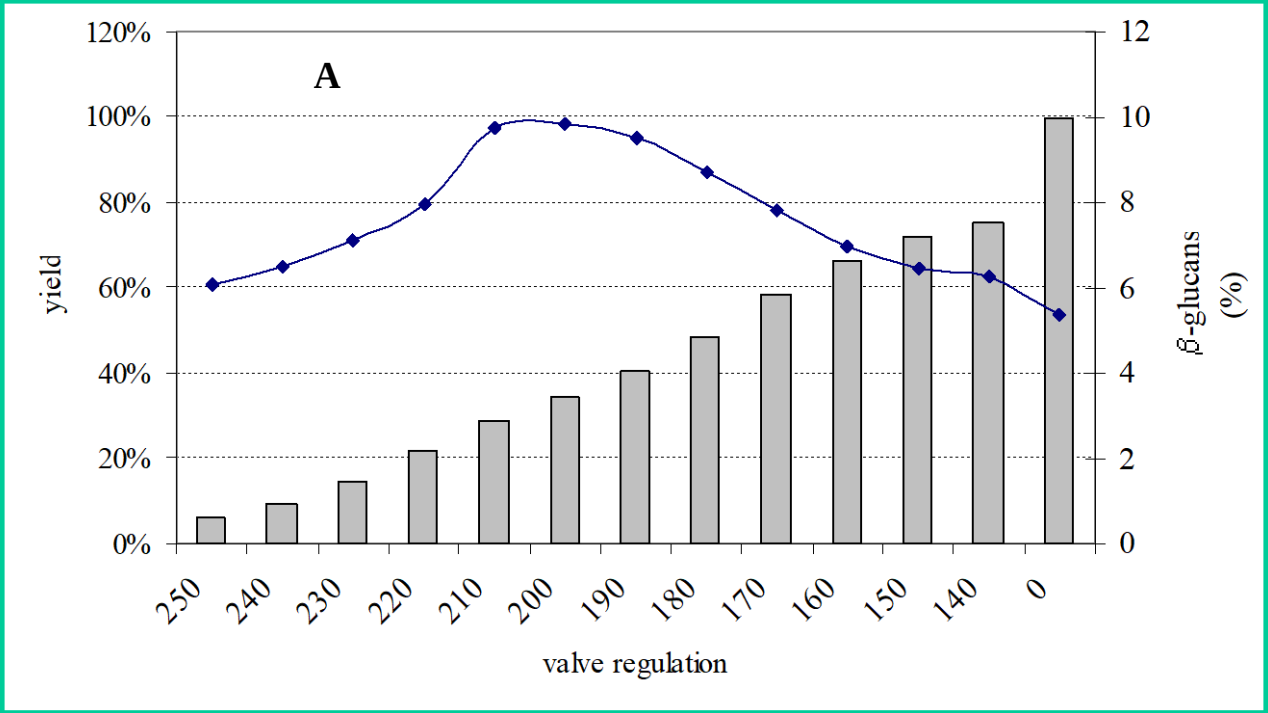
Coarse Fraction (CF1)

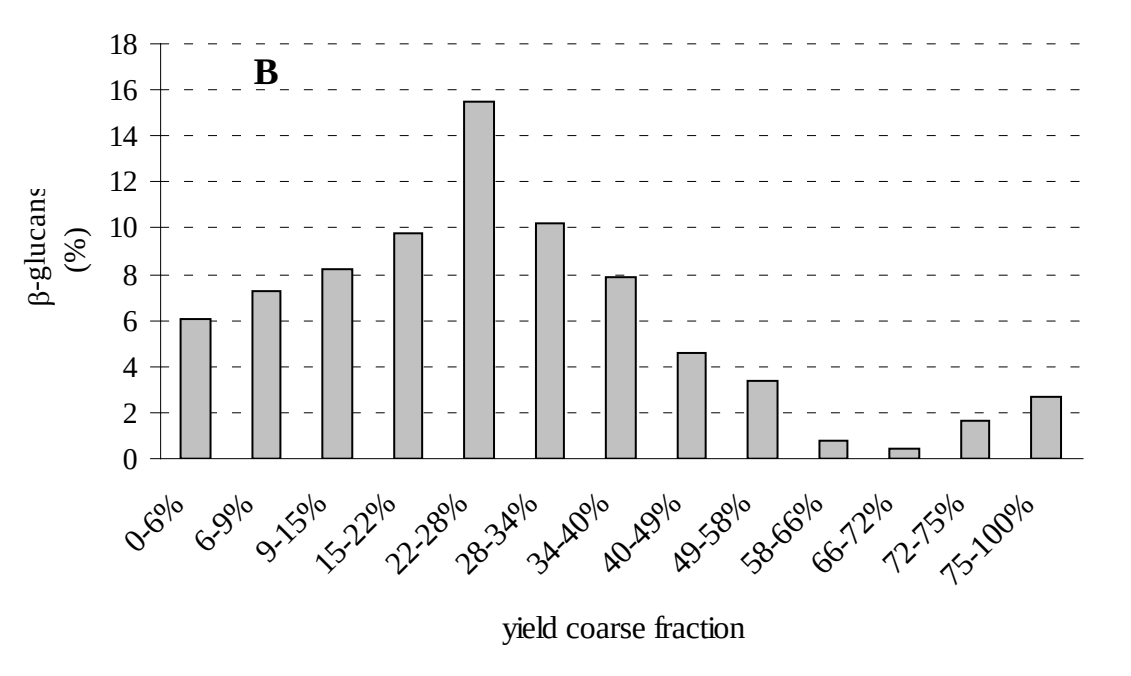
Fine Fraction (FF1)

II Air Classification (valve = 190)

Coarse Fraction (CF2)

Fine Fraction (FF2)

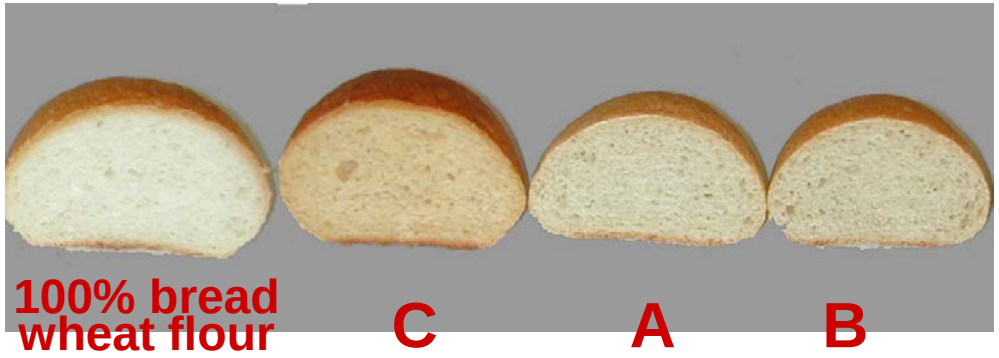

A
120%
100%
80%
60%
40%
20%
0%
yield
12
10
8
6
4
2
0
β-glucans (%)
250
240
230
220
210
200
190
180
170
160
150
140
0
valve regulation


B
18
16
14
12
10
8
6
4
2
0
β-glucans (%)
0-6%
6-9%
9-15%
15-22%
22-28%
28-34%
34-40%
40-49%
49-58%
58-66%
66-72%
72-75%
75-100%
yield coarse fraction

Flour Components after Air Classification

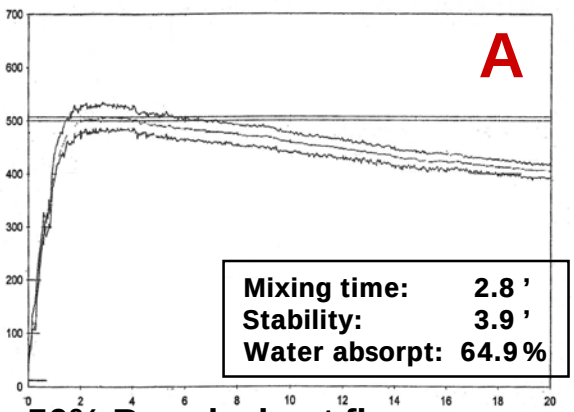
Genotypes	Flour fraction	Yields %	β-glucans %	Proteins %	Starch %	TDF %
CDC Alamo	Micronized		7,8	12,6	53,2	12,8
	CF1	10,4	11,1	14	42,8	25,5
	CF2	**28,4**	**15,6**	**13,6**	**43,5**	**25,5**
	FF2	61,2	2,3	12,6	61,2	3,8
Priora	Micronized		5,4	13,7	55,3	11,5
	CF1	16,5	8,1	15,6	51,1	23,4
	CF2	**29,8**	**11,2**	**14,4**	**46,4**	**21,8**
	FF2	53,7	3	12,4	66,7	3,3

Breads composition and sensory properties

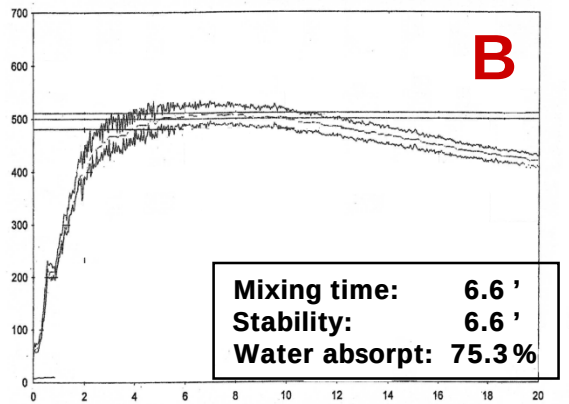


Evaluation Parameter	100% bread wheat flour	Bread "A" (50%barley flour)	Bread "B" (50% Sieved fraction)	Bread "C" (20% WE Fraction)
Proteins	17,3 %	16,1 %	17,1 %	17,3 %
Lipids	5,3 %	5,4 %	6,1 %	4,1 %
Ash	0,5 %	3,0 %	3,6 %	4,3 %
Dietary Fibre	5,0 %	7,5 %	10,2 %	10,6 %
Total β-glucans	0,1 %	2,4 %	4,2 %	6,3 %
Soluble β-glucans	0,1 %	2,0 %	2,8 %	5,7 %
crumb Color	7,5	5,8	6,1	7,2
Texture	8,1	6,2	5,8	7,0
Flavor	6,3	6,0	6,2	6,8
Acceptability	7,5	6,0	5,9	7,2

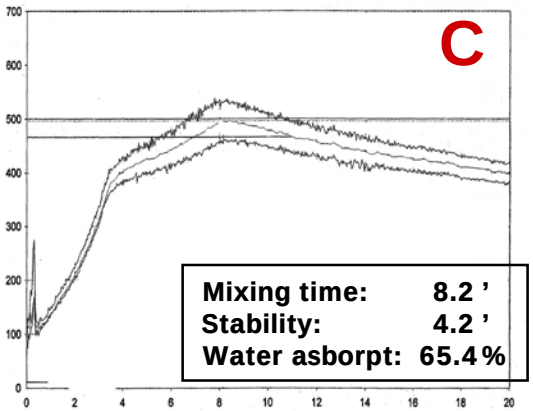
Bread Evaluation



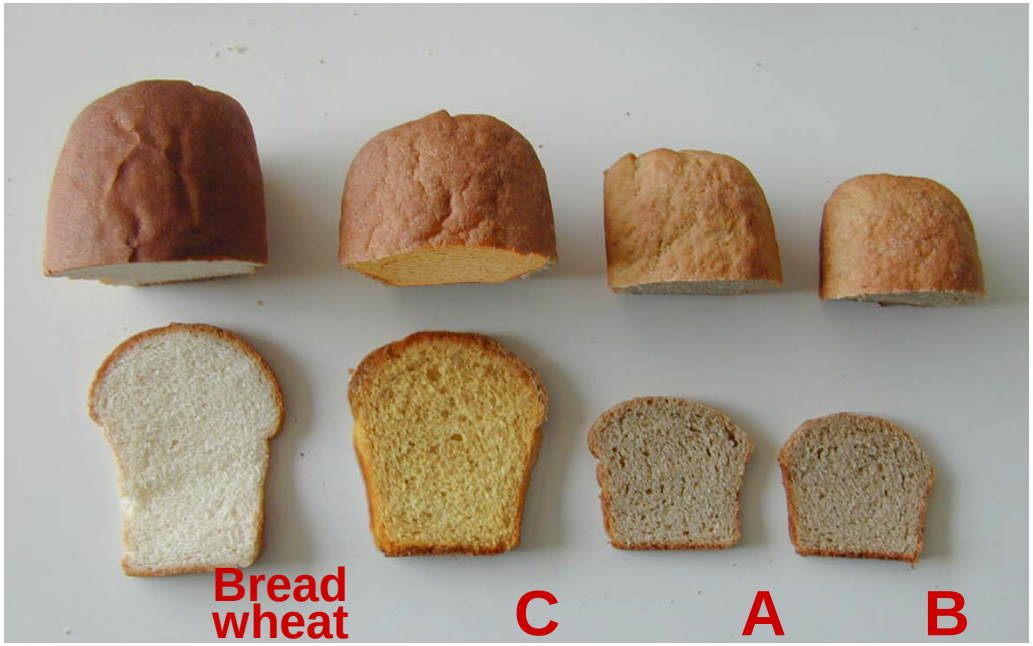
50% Bread wheat flour
50% barley flour



50% Bread wheat flour
50% Sieved fraction



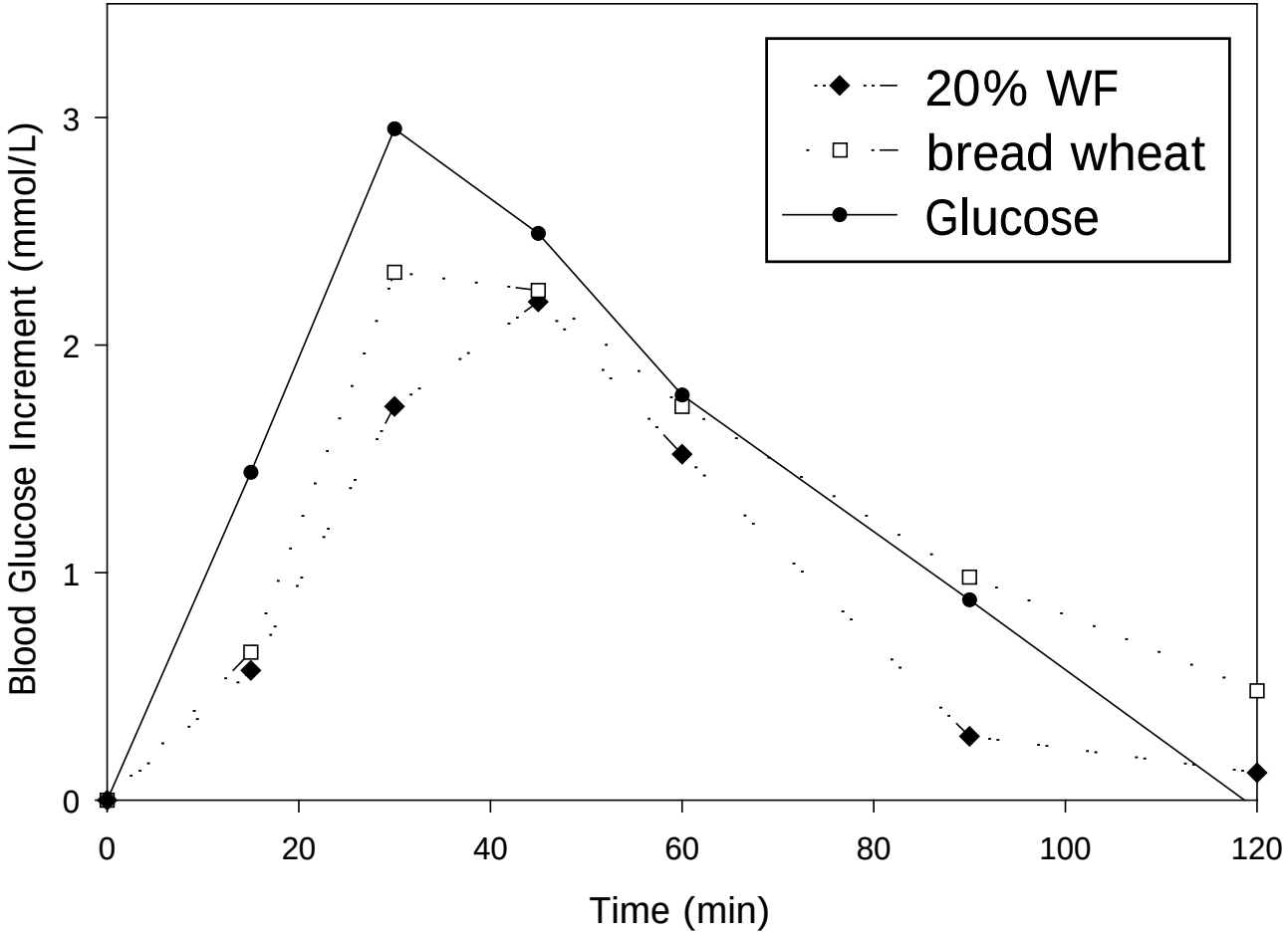
80% Bread wheat flour
20% Water-extracted fraction



Campione	β-Glucani
Pane Frumento	0.1%
A	2.4%
B	4.3%
C	6.4%

Glycemic Index of breads

The 20% WF bread had a 28% lower glycemic index than the bread wheat



GI = 91.27 – 3.68 TBG (r^2 = 0.96

~5% GI Reduction
every g of β-glucan

FRISELLE di ORZO

Barley Pasta

β-glucan content and cooking value of spaghetti made with durum wheat semolina and a mixture of durum semolina-barley flour (85:15, 70:30)

	β-glucan content	Cooking value (%)
Spaghetti barley 15%	1.3%	90-92
Spaghetti barley 30%	2.5%	75-80
Spaghetti semolina	0.5%	100

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CONSIGLIO PER LA RICERCA
E LA SPERIMENTAZIONE
IN AGRICOLTURA

PENNE RIGATE

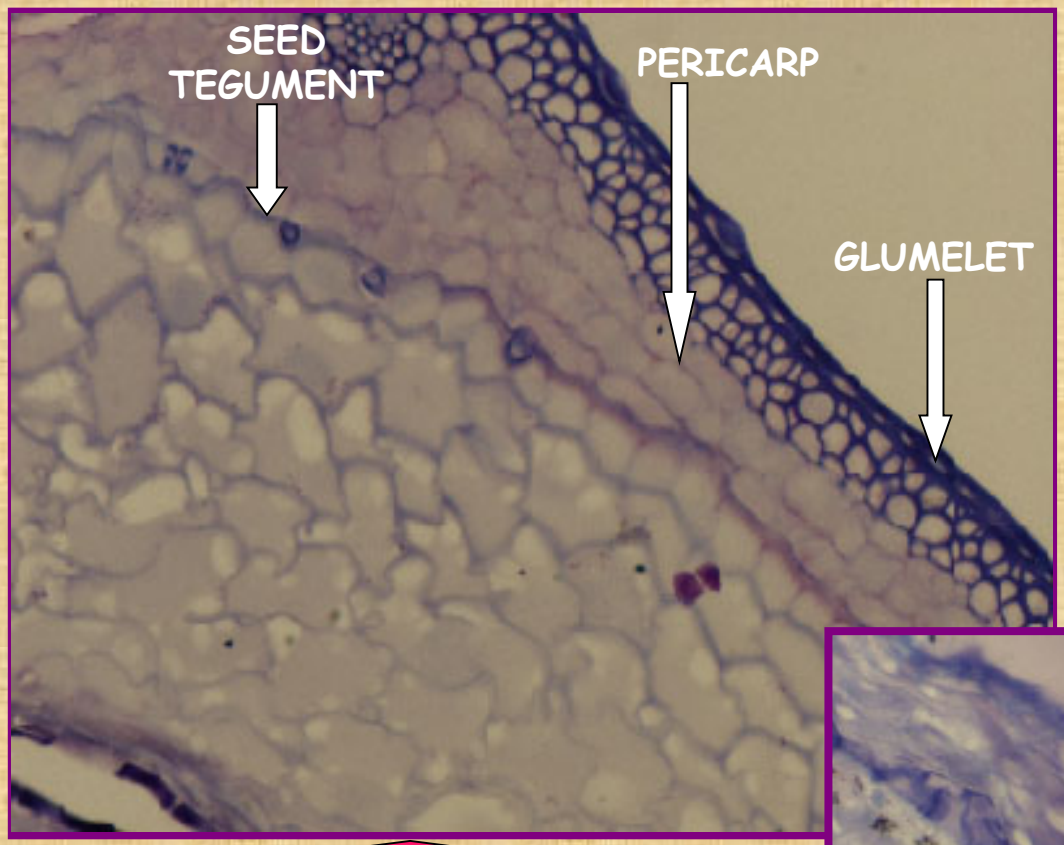
I.S.C. Fiorenzuola

Barley Coffee

Key parameters for defining Barley quality for coffee production:

- Barley protein content (influence on foam?)
- β-glucan content and coffee viscosity (influence on beverage mouthfeel)
- Mineral content (es:K) and composition (effect on thirst?)

MILKY - RIPE STAGE

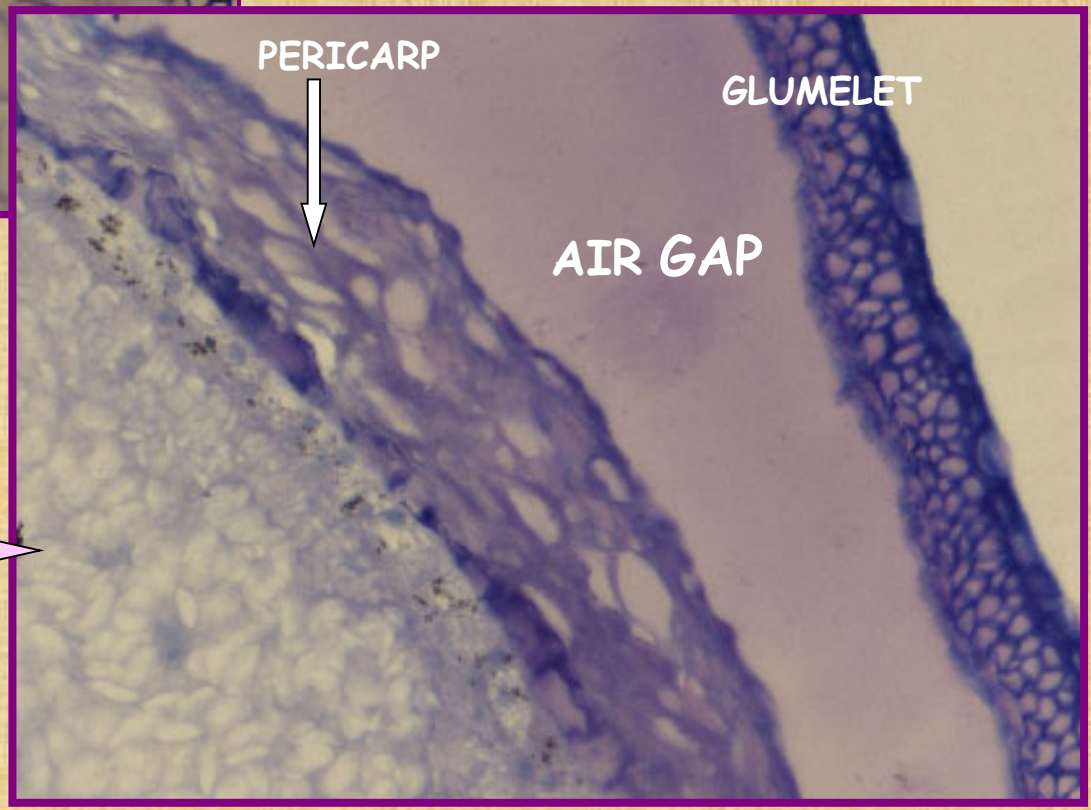


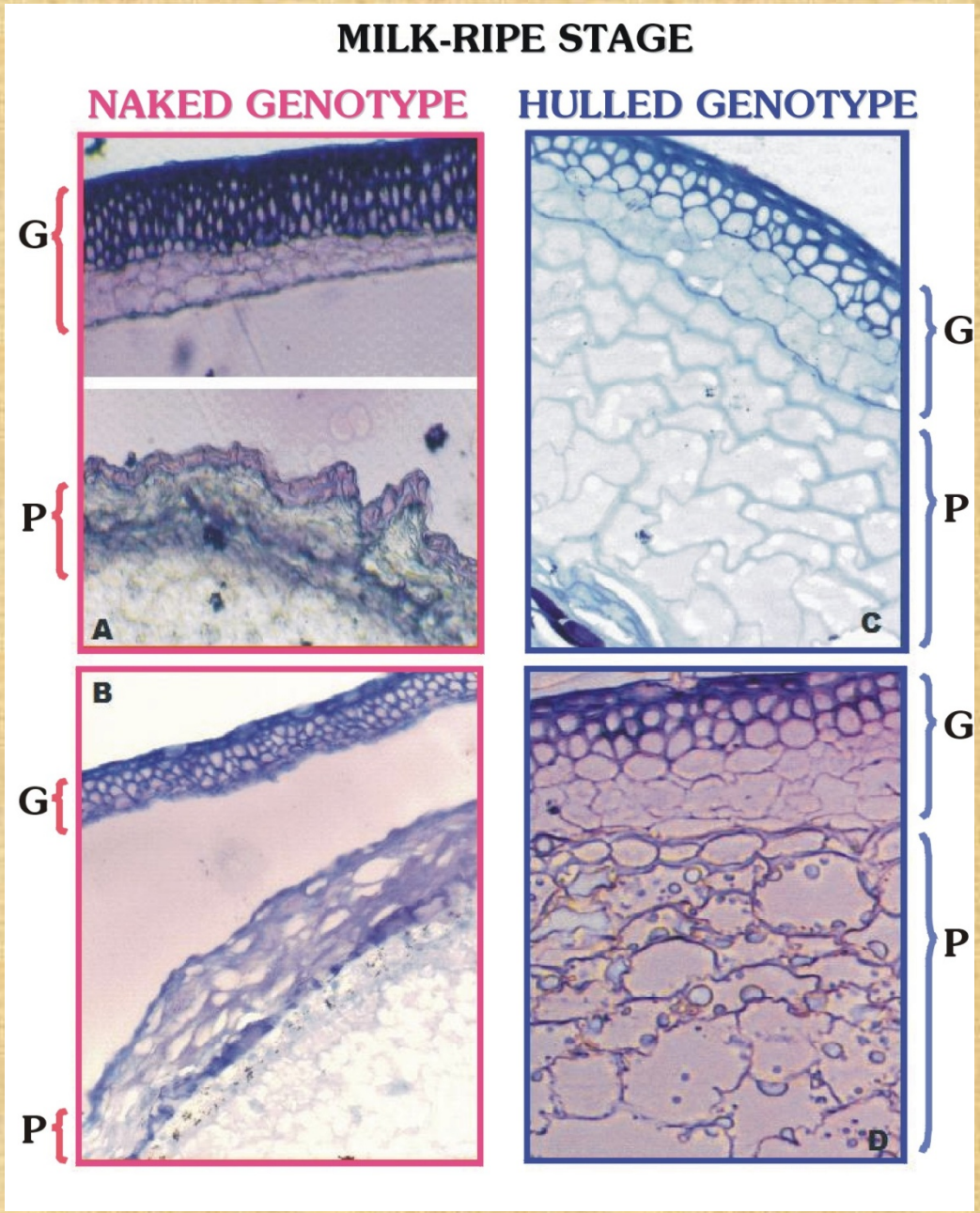
HULLED CARIOPSYS

COMPLETE ADHESION
of the GLUMELET

NAKED CARIOPSYS

AIR GAP between
PERICARP and GLUMELET





G: GLUME P: PERICARP

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CONSIGLIO PER LA RICERCA E LA SPERIMENTAZIONE IN AGRICOLTURA

NEW GENOTYPES NAKED HULLED waxy and nonwaxySTARCH

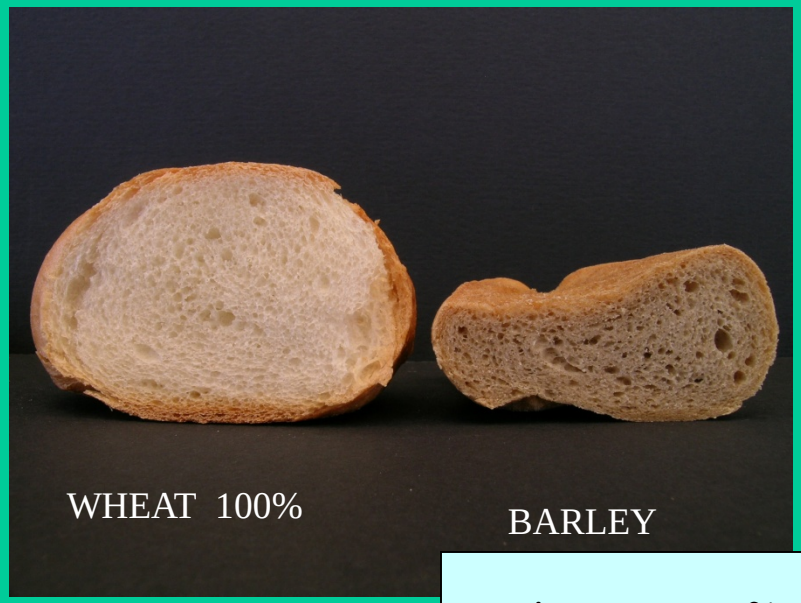
Waxy hull-less genotypes	β-glucan %
CDC Alamo	8
CDC Fibar	9,4
CDC Rattan	7,9
CDC Candle	6,5

BARLEY GENOTYPE		Yield (t/ha)	β-glucans (%)
Rondo	Hull-less	2.5	5
Priora	Hull-less	3.5	6.3
CDC Alamo	Hull-less, waxy	3.3	8.3
Tidone	Hulled	4.5	4.1
DMS		0.3	1.0

Rheological and Bread-making Evaluation

Genotype	Farinograph				Baking test		
	Absorption	Development	Stability	Falling	Volume	Height	Weight
	(%)	(min)	(min)	(U.B.)	(mL)	(g)	(mm)
CDC Alamo (30%)	78.0	4.3	5.3	102	385	169.0	79
CDC Alamo (50%)	78.2	4.9	17.7	0	185	173.3	63
Priora (30%)	68.2	2.6	4	81	400	159.2	70
Priora (50%)	73.6	4.7	4.6	98	270	164.5	65
Wheat 100%	58.7	7.3	17.5	20	900	139.5	121

BREAD VOLUME



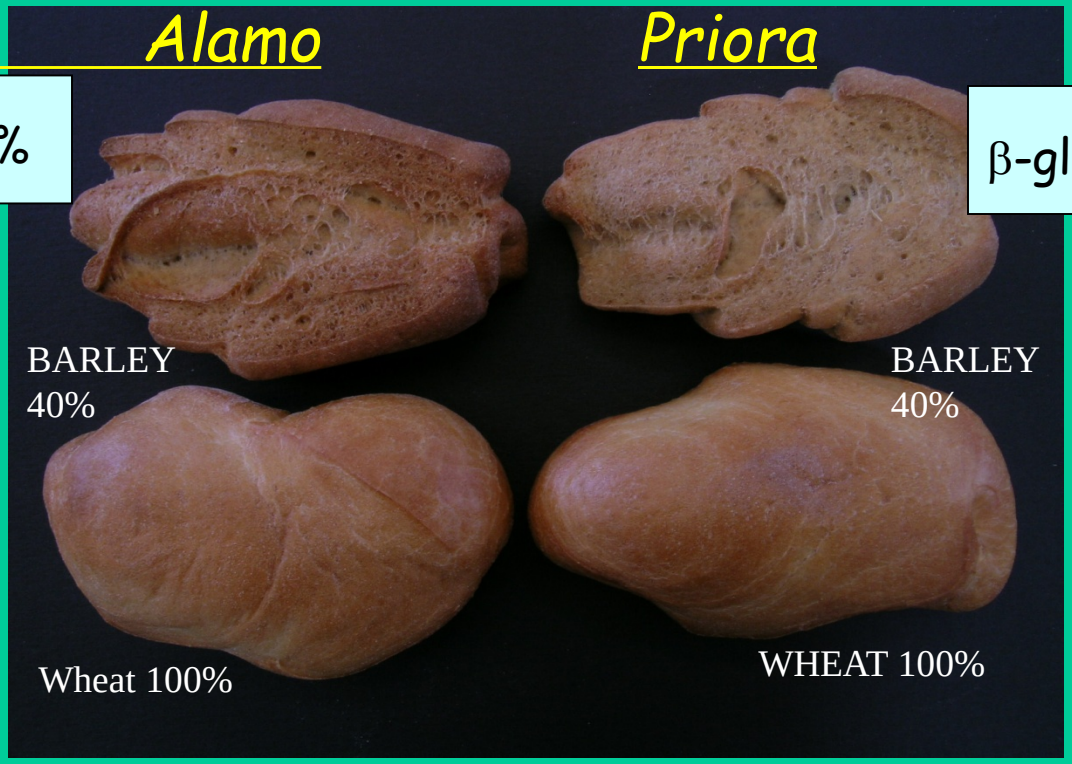
β-glucan: 5.8%

β-glucan: 6.2%

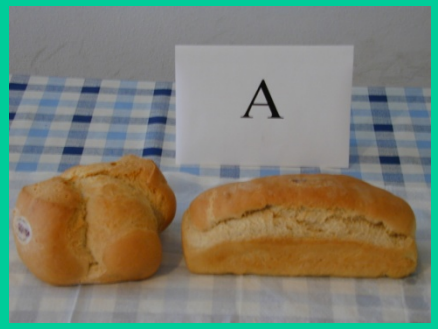
BREAD for PANEL TEST and GI

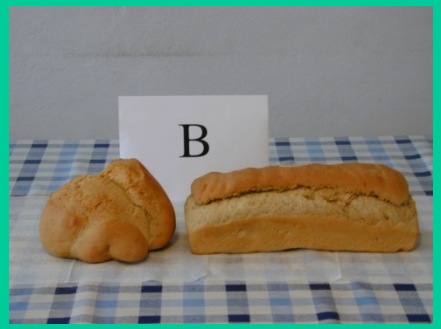
β-glucan: 6.2%

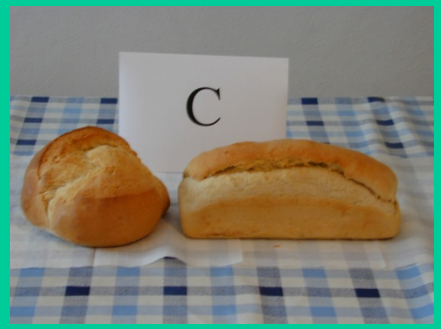
β-glucan: 5.2%



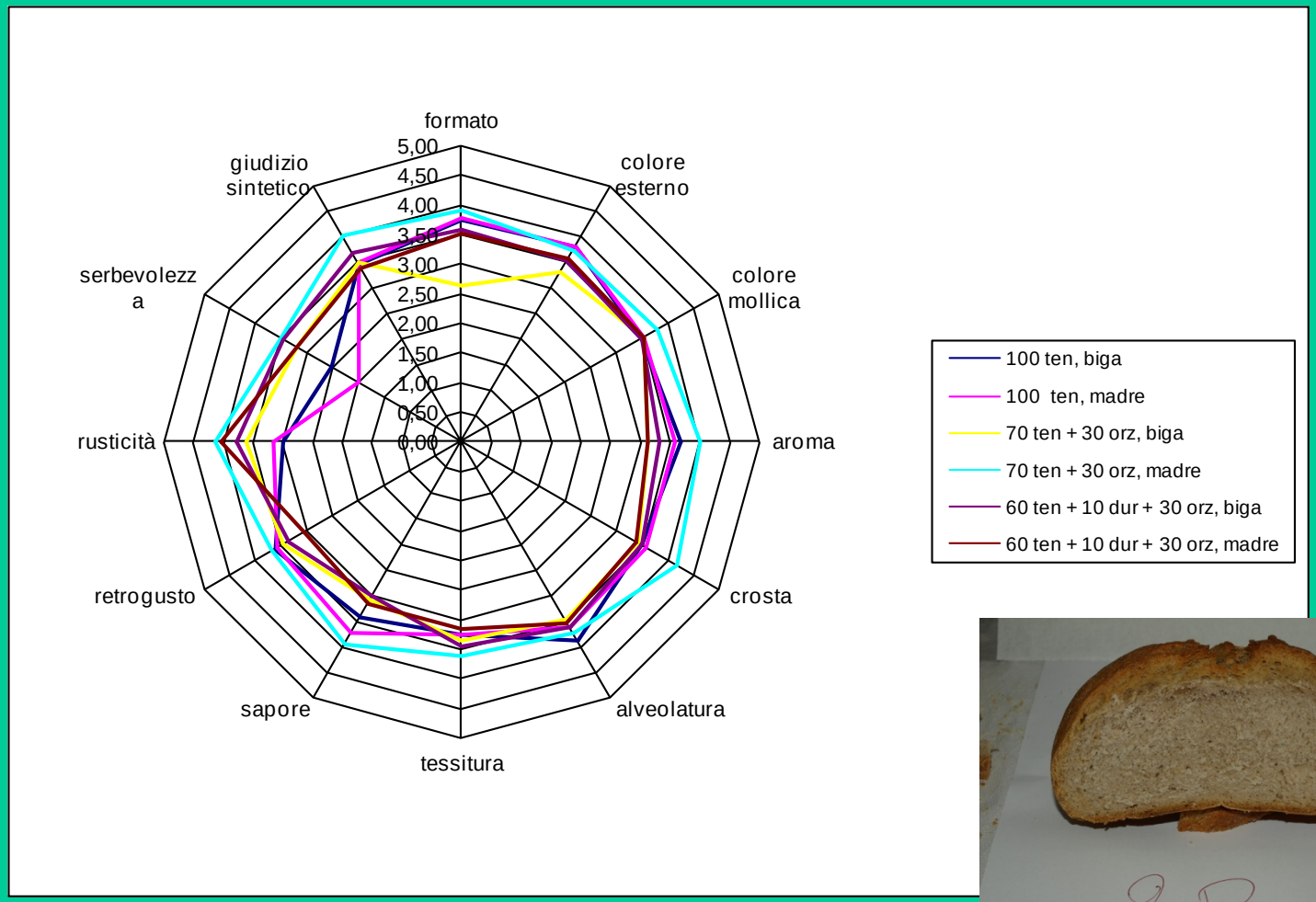
Analisi sensoriale: panel test







Panel test



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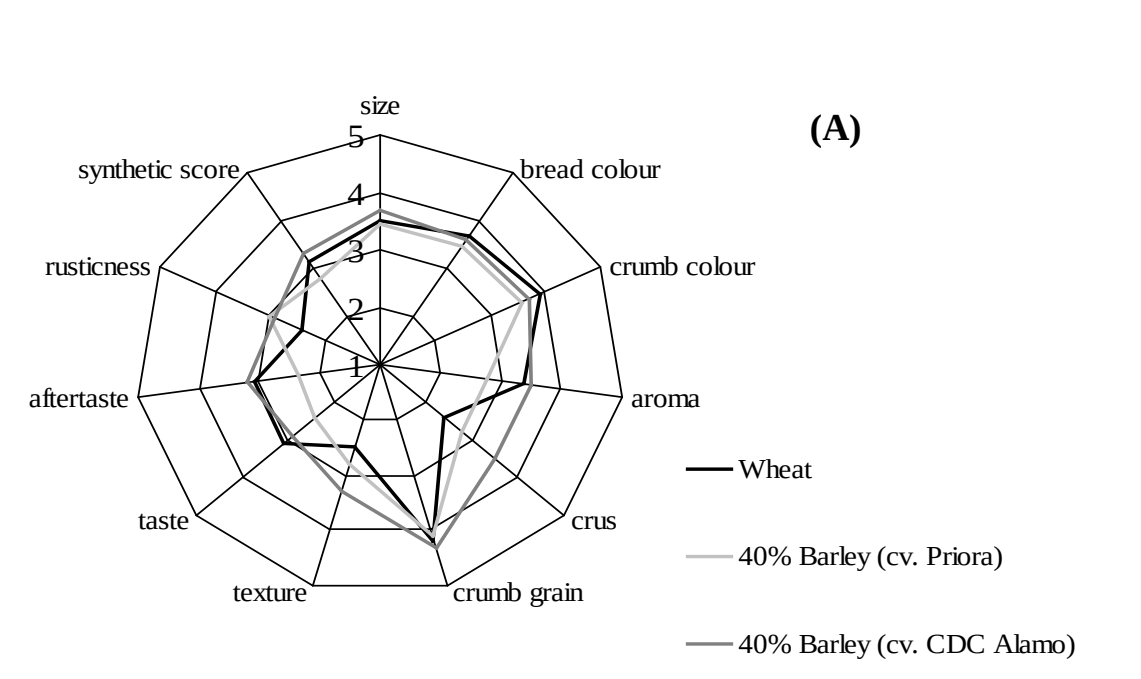
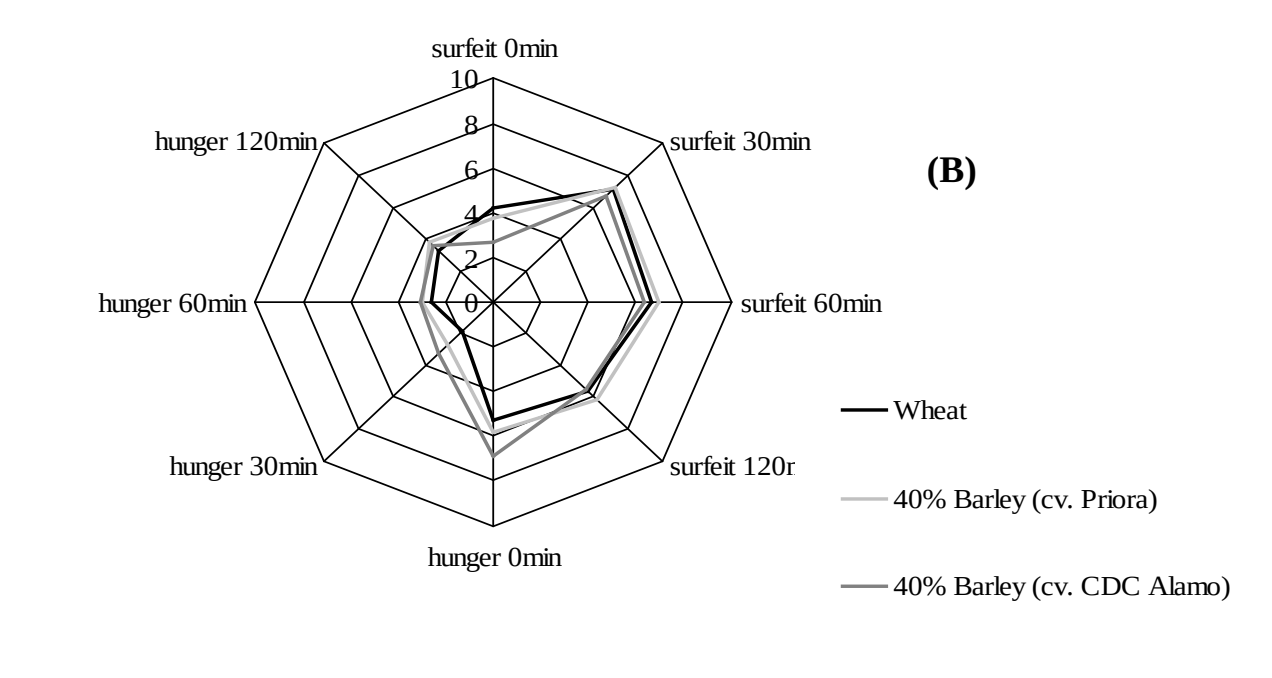
ß-glucan content in flour blend an bread. GI: glycemic index

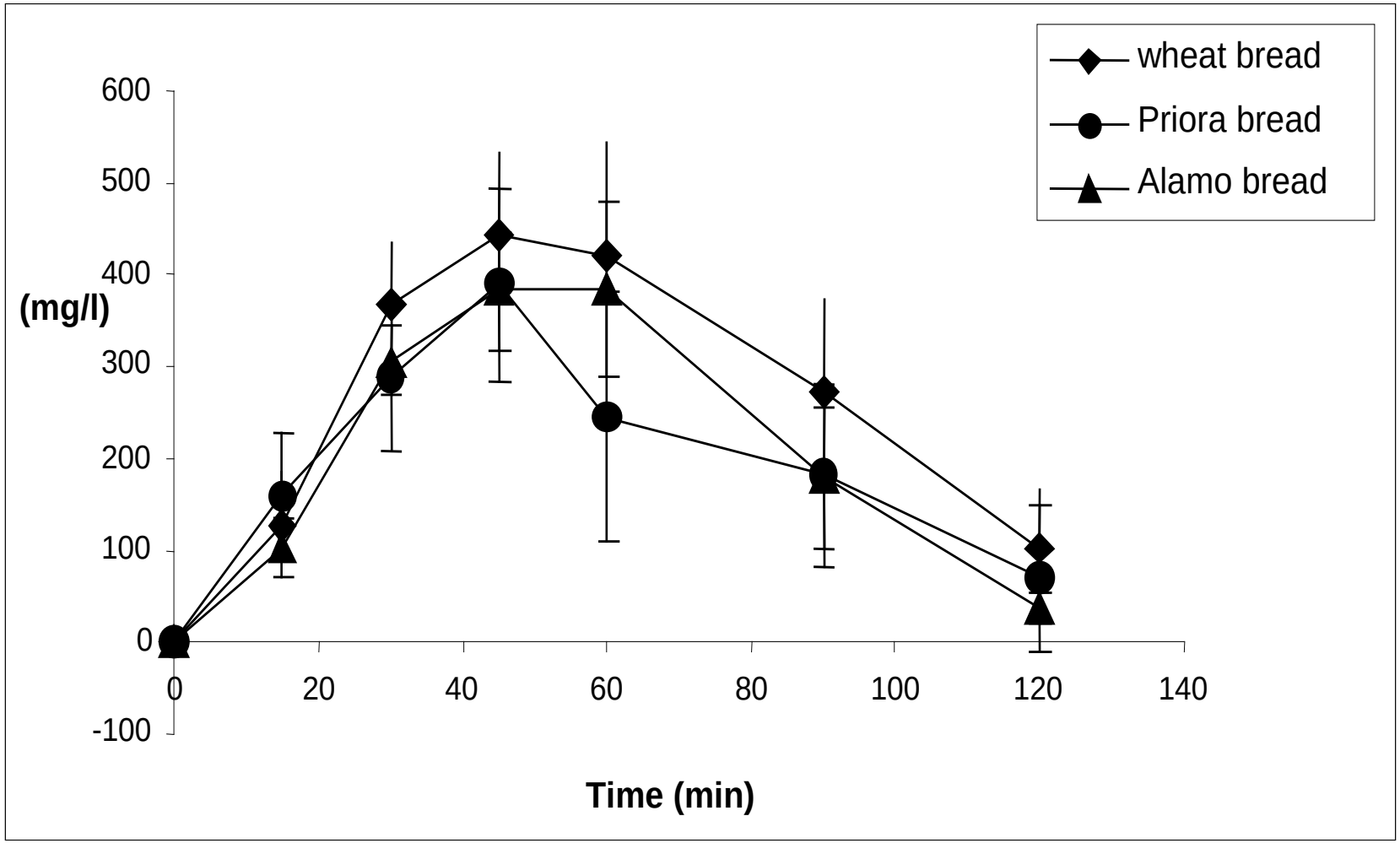
		b-glucans (%)	GI
CDC Alamo (40%)	Flour blend	6.6 (± 0.2)	
	Bread	6.2 (± 0.2)	70.1 (±9.1)
Priora (40%)	Flour blend	6.0 (± 0.3)	
	Bread	5.7 (± 0.1)	57.2 (±7.9)
Wheat (100%)	Flour	0.2 (± 0)	
	Bread	0.2 (± 0)	82.8 (±7.2)

Alamo and Priora Bread Sensorial evaluation

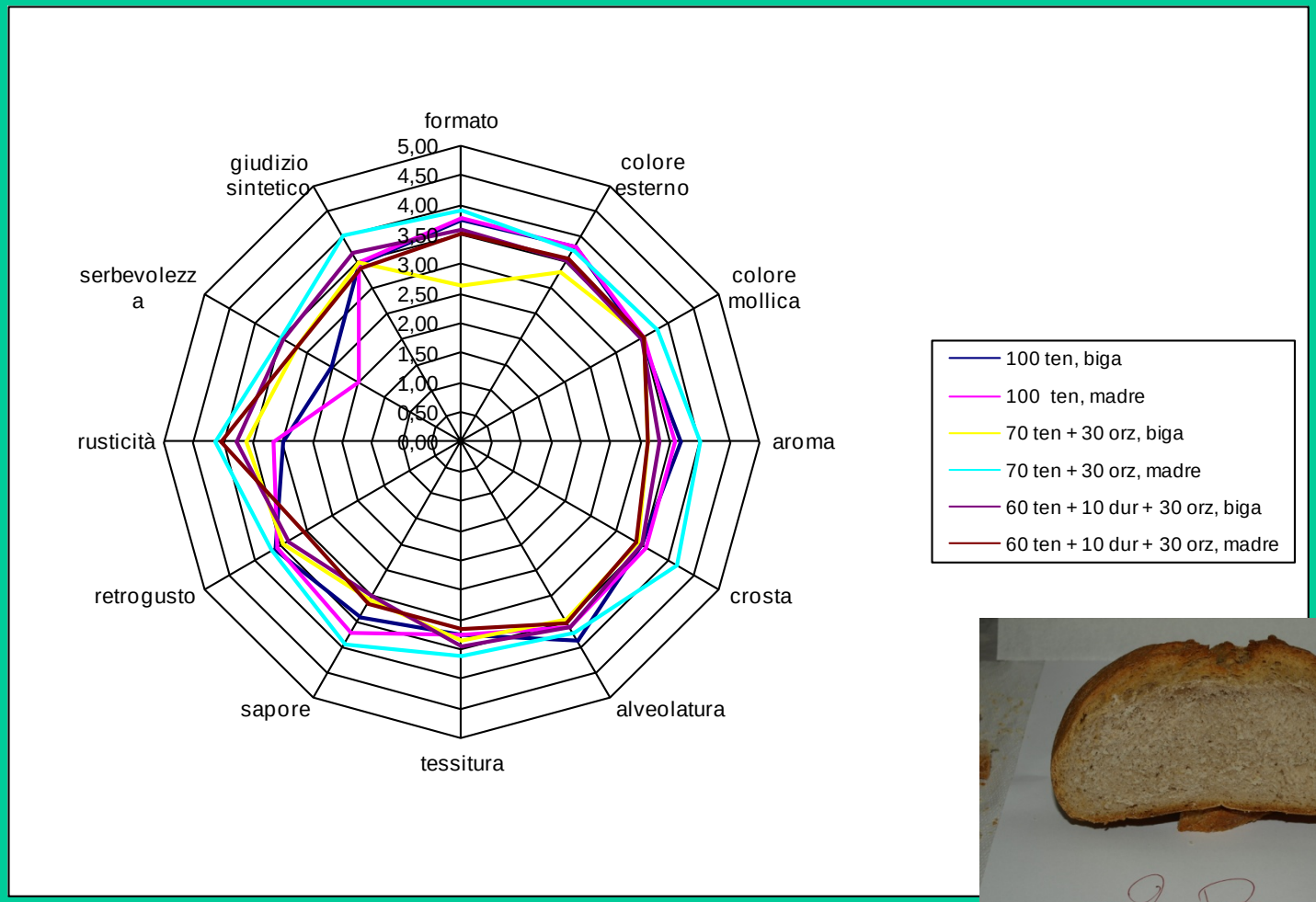




Glycemic Index



Panel test



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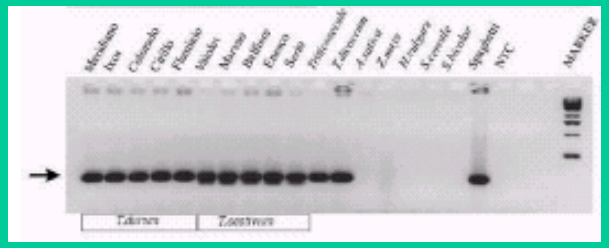
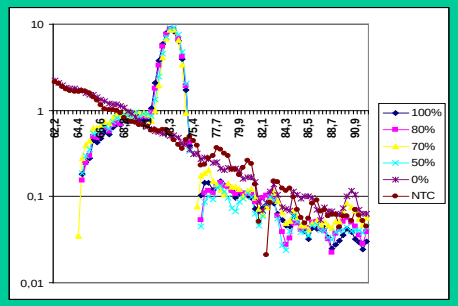
CONSIGLIO PER LA RICERCA E LA SPERIMENTAZIONE IN AGRICOLTURA

Biodiversità e aroma: chimica dei composti volatili

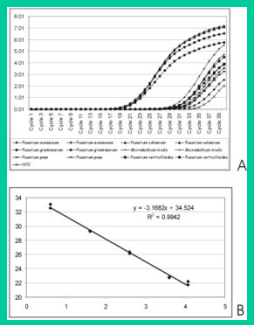
GC-MS
Naso elettronico

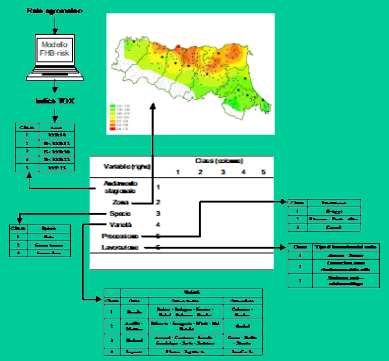
Sistemi analitici molecolari per la tracciabilità di specie vegetali, animali, microbiche

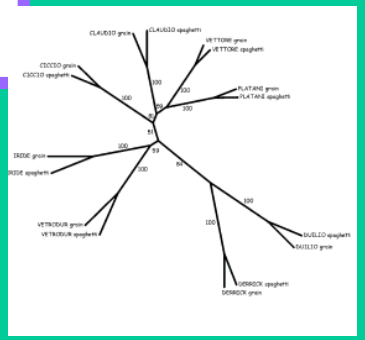


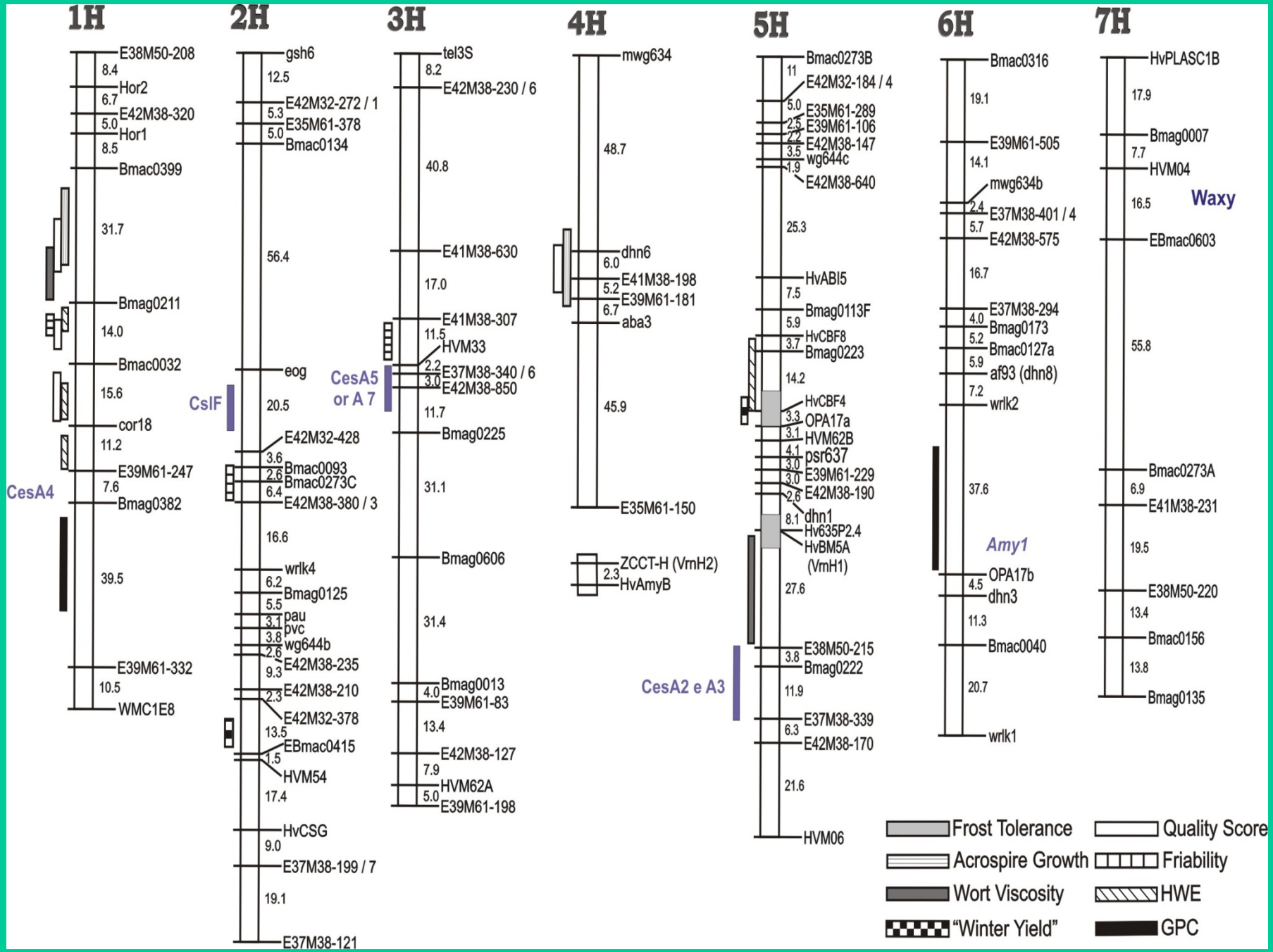


Certificazione dell'autenticità








1H
E38M50-208
8.4
Hor2
6.7
E42M38-320
5.0
Hor1
8.5
Bmac0399
31.7
Bmag0211
14.0
Bmac0032
15.6
cor18
11.2
E39M61-247
7.6
Bmag0382
39.5
E39M61-332
10.5
WMC1E8
CesA4
2H
gsh6
12.5
E42M32-272 / 1
5.3
E35M61-378
5.0
Bmac0134
56.4
eog
20.5
CslF
E42M32-428
3.6
Bmac0093
2.6
Bmac0273C
6.4
E42M38-380 / 3
16.6
wrlk4
6.2
Bmag0125
5.5
pau
3.1
pvc
3.8
wg644b
2.6
E42M38-235
9.3
E42M38-210
2.3
E42M32-378
13.5
EBmac0415
1.5
HVM54
17.4
HvCSG
9.0
E37M38-199 / 7
19.1
E37M38-121
3H
tel3S
8.2
E42M38-230 / 6
40.8
E41M38-630
17.0
E41M38-307
11.5
HVM33
2.2
E37M38-340 / 6
3.0
E42M38-850
CesA5 or A 7
11.7
Bmag0225
31.1
Bmag0606
31.4
Bmag0013
4.0
E39M61-83
13.4
E42M38-127
7.9
HVM62A
5.0
E39M61-198
4H
mwg634
48.7
dhn6
6.0
E41M38-198
5.2
E39M61-181
6.7
aba3
45.9
E35M61-150
ZCCT-H (VrnH2)
2.3
HvAmyB
5H
Bmac0273B
11
E42M32-184 / 4
5.0
E35M61-289
2.5
E39M61-106
2.2
E42M38-147
3.5
wg644c
1.9
E42M38-640
25.3
HvABI5
7.5
Bmag0113F
5.9
HvCBF8
3.7
Bmag0223
14.2
HvCBF4
3.3
OPA17a
3.1
HVM62B
4.1
psr637
3.0
E39M61-229
3.0
E42M38-190
2.6
dhn1
8.1
Hv635P2.4
HvBM5A (VrnH1)
27.6
E38M50-215
3.8
Bmag0222
11.9
CesA2 e A3
E37M38-339
6.3
E42M38-170
21.6
HVM06
6H
Bmac0316
19.1
E39M61-505
14.1
mwg634b
2.4
E37M38-401 / 4
5.7
E42M38-575
16.7
E37M38-294
4.0
Bmag0173
5.2
Bmac0127a
5.9
af93 (dhn8)
7.2
wrlk2
37.6
Amy1
OPA17b
4.5
dhn3
11.3
Bmac0040
20.7
wrlk1
7H
HvPLASC1B
17.9
Bmag0007
7.7
HVM04
16.5
Waxy
EBmac0603
55.8
Bmac0273A
6.9
E41M38-231
19.5
E38M50-220
13.4
Bmac0156
13.8
Bmag0135
Frost Tolerance
Acrospire Growth
Wort Viscosity
"Winter Yield"
Quality Score
Friability
HWE
GPC

CEREALI per il FOOD

Nuovi Formulati di Pasta,
Pane e Biscotti
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di tipo Funzionale
ben caratterizzati per le molecole
in essi contenuti e
pronti per conquistare nuovi mercati

CONCLUSION

- SMALL FOOD FACTORIES ARE PRODUCING BREAD and SPAGHETTI WITH HIGH BETA-GLUCAN CONTENT;
- The CONSUMERS LOVE THEM.

BREEDING

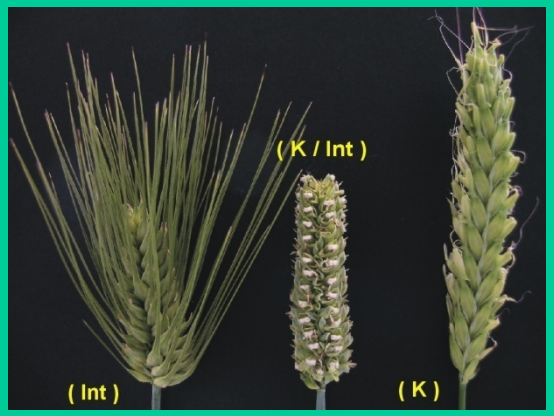
- By using modern high yielding hulled varieties and the waxy ALAMO ,FIBAR and RATTAN as parents, a Breeding Program has been developed with the final aim to get new varieties characterized by high grain yield and beta-glucan (waxy and non-waxy starch,naked or hulled grain).

- F4 are under field trial evaluation.

- Interestingly, recombinant genotypes with high beta-glucan content and non-waxy starch have been selected.

Nome varieta'	PRODUZIONE t/ha	B-glucani %
ATOMO	7,3	3,2
IDRA	6,9	4,7
COMETA	6,5	4,7
FIO 7341	6,0	4,8
FIO 13116	5,9	8,0
FI 13128A	5,7	7,8
FIO 13668	5,6	8,5
FIO 13667	5,5	8,9
ASTARTIS	5,5	4,6
FIO 13121	5,4	9,3
FIO 11610	5,4	8,5
FIO 13671	5,3	8,1
BETA	5,2	7,1
FIO 13673	5,1	8,8
FIO 13651	5,0	9,0
FIO 13650	4,8	8,2
FIO 13674	4,5	8,5
FIBAR	4,4	7,6
FIO 13676	4,2	7,9
FIO 13665	4,1	8,3
FIO 13649	4,1	8,6
MEDIA	5,4	7,4

Alberto Gianinetti
Francesca Finocchiaro
Marina Baronchelli
Valeria Terzi
Giorgio Tumino
Renzo Alberici
Roberta Ghizzoni
Caterina Morcia
Nadia Faccini



Barley Genetic Stocks

16 semi SH

22 maggio 2009