Società Italiana di Agronomia
XLV Convegno Nazionale
Sassari 20-22 settembre 2016

Università di Foggia

Thursday, September 22 **–** session "**Cropping systems and food security"**

# Assessment of Storage Protein Composition in Old and Modern Durum Wheat Genotypes

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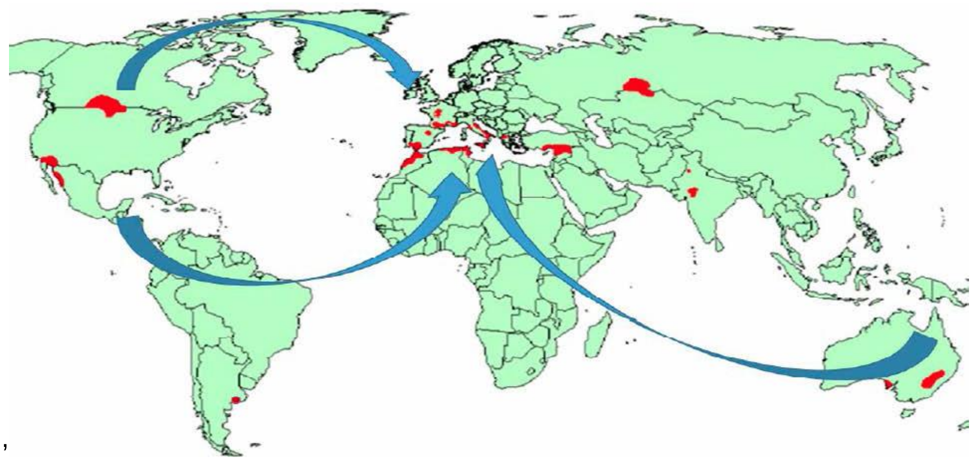
# Durum wheat production



from International Grain Council,

| Country | 2011/12 | 2012/13 | 2013/14 | 2014/15 | Variation |
|---|---|---|---|---|---|
| **EU-28** | 8.2 | 7.9 | 7.9 | 7.7 | -2.5% |
| **France** | 2.1 | 2.4 | 1.8 | 1.6 | -11.1% |
| **Greece** | 0.9 | 0.7 | 0.8 | 0.9 | 12.5% |
| **Italy** | 3.9 | 4.2 | 4.0 | 4.0 | 0% |
| **Spain** | 0.9 | 0.4 | 0.9 | 0.9 | 0% |
| **Kazakhstan** | 3.0 | 1.4 | 2.0 | 2.1 | 5.0% |
| **Canada** | 4.2 | 4.6 | 6.5 | 4.8 | -26.2% |
| **Mexico** | 2.2 | 2.1 | 2.3 | 2.3 | 0.1% |
| **USA** | 1.4 | 2.2 | 1.7 | 2.5 | 47.1% |
| **Argentina** | 0.2 | 0.2 | 0.3 | 0.3 | 0.0% |
| **Syria** | 1.7 | 1.5 | 1.5 | 1.5 | 0.0% |
| **Turkey** | 3.0 | 3.0 | 3.0 | 2.8 | -6.7% |
| **India** | 1.1 | 1.2 | 1.2 | 1.3 | 8.3% |
| **Algeria** | 2.5 | 3.0 | 2.5 | 2.5 | 0.0% |
| **Morocco** | 1.7 | 1.3 | 1.9 | 1.6 | -15.8% |
| **Tunisia** | 1.2 | 1.3 | 1.2 | 1.2 | 0.0% |
| **Australia** | 0.6 | 0.5 | 0.5 | 0.5 | 0.0% |
| **others** | 5.8 | 8.2 | 5.7 | 5.7 | 0.0% |
| **World total** | 36.7 | 35.2 | 38.0 | 36.6 | -3.7% |

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# Durum wheat

Durum wheat (*Triticum turgidum* L. spp. durum) is a tetraploid cereal (2n = 4x = 28), highly adapted to the Mediterranean environment.

from Shewry and Tatham, 2016

| Ploidy genome | Wild species | Cultivated species | |
|---|---|---|---|
| diploid | | | |
| D | *T. tauschii* | | |
| A | *T. urartu* | | |
| A | *T. monococcum* var. *boeticum* | *T. monococcum* var. *monococcum* | einkorn |
| tetraploid | | | |
| AB | *T. turgidum* var. *dicoccoides* | *T. turgidum* var. *dicoccum* | emmer |
| | | *T. turgidum* var. *durum* | durum |
| hexaploid | | | |
| ABD | | *T. aestivum* var. *aestivum* | bread wheat |
| | | *T. aestivum* var. *spelta* | spelt |

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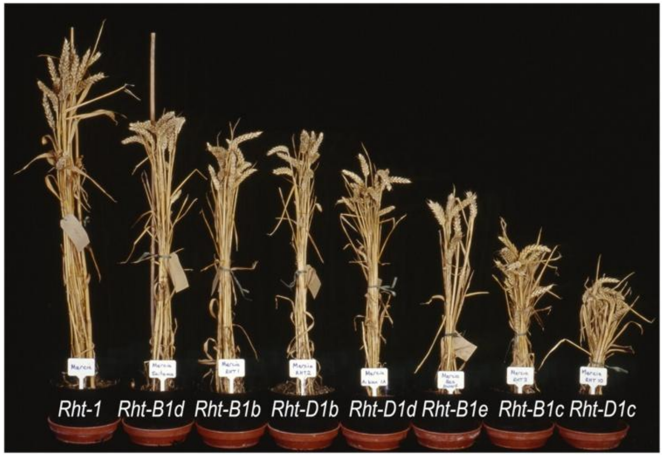
# 20th century durum wheat breeding

Durum wheat breeding, promoted by Nazareno Strampelli, resulted in the selection of genotypes associating the following traits:

- higher yield
- environmental adaptability
- earliness in the heading time (longer grain filling period)
- size reduction by introgression of the Rht genes (lodging resistance and higher harvest index)
- better technological quality traits (glu B1 and glu B3 alleles)



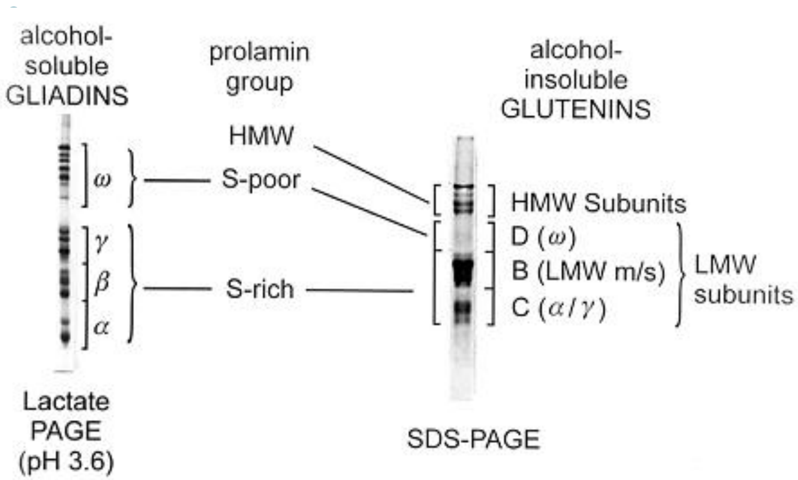
# Durum wheat technological end-use

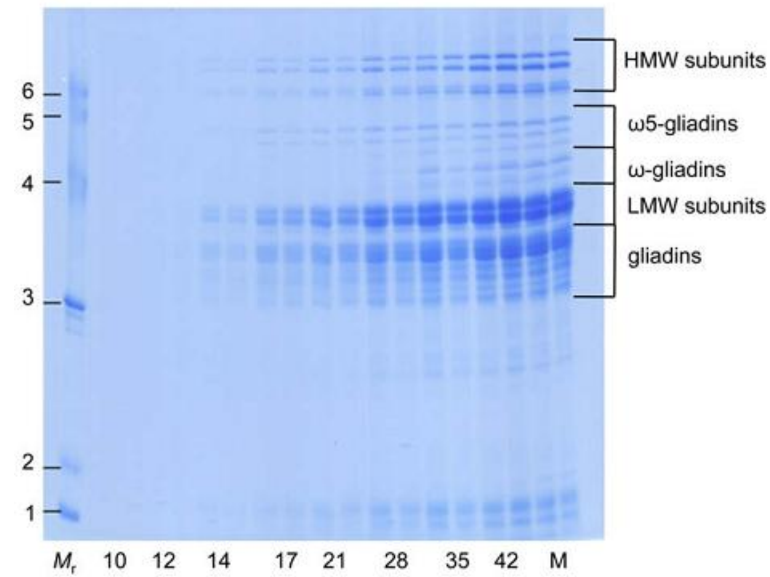
Semolina, mostly used for the production of pasta, bread and cous cous, is obtained from the milling process of the endosperm.

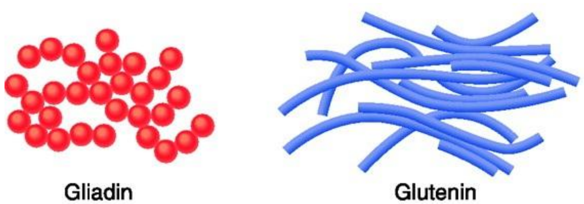
It represents the main source of carbohydrates as well as proteins and dietary fibre, in the M

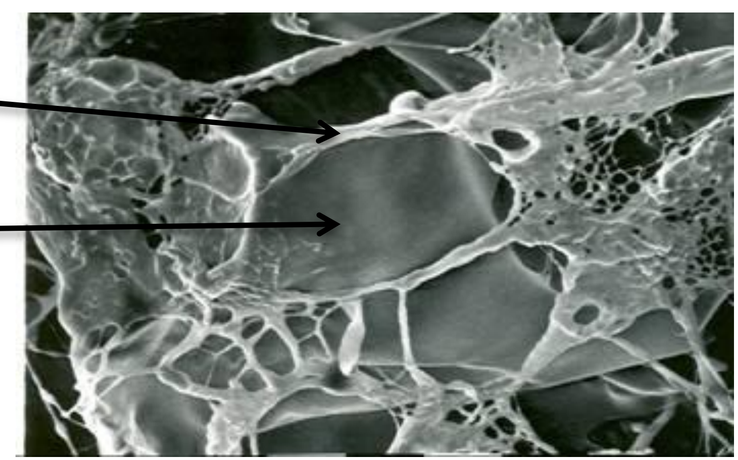
# Gluten proteins

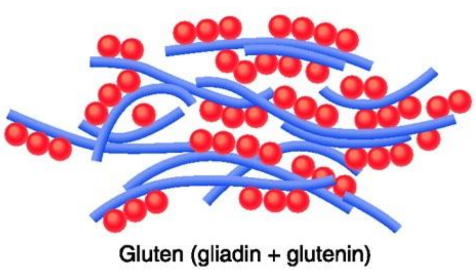
Storage proteins account for about 80% of total grain proteins (Shewry *et al*., 2009)



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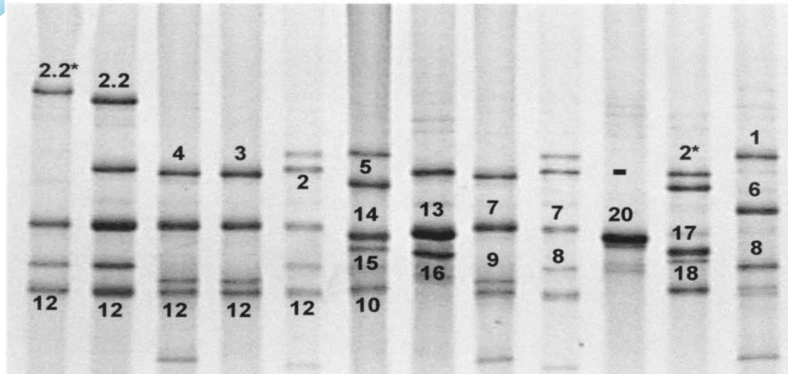
# Glutenin subunits polymorphism

## High molecular weight (HMW-GS)

Shewry et al. (2009)




## Low molecular weight (LMW-GS)

D'Ovidio and Masci (2004)

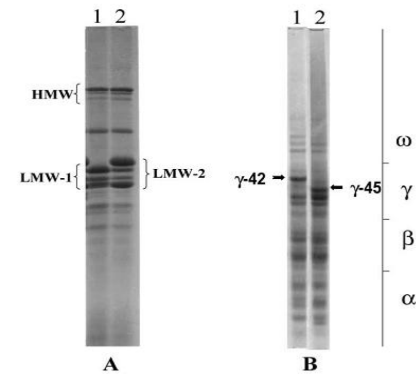
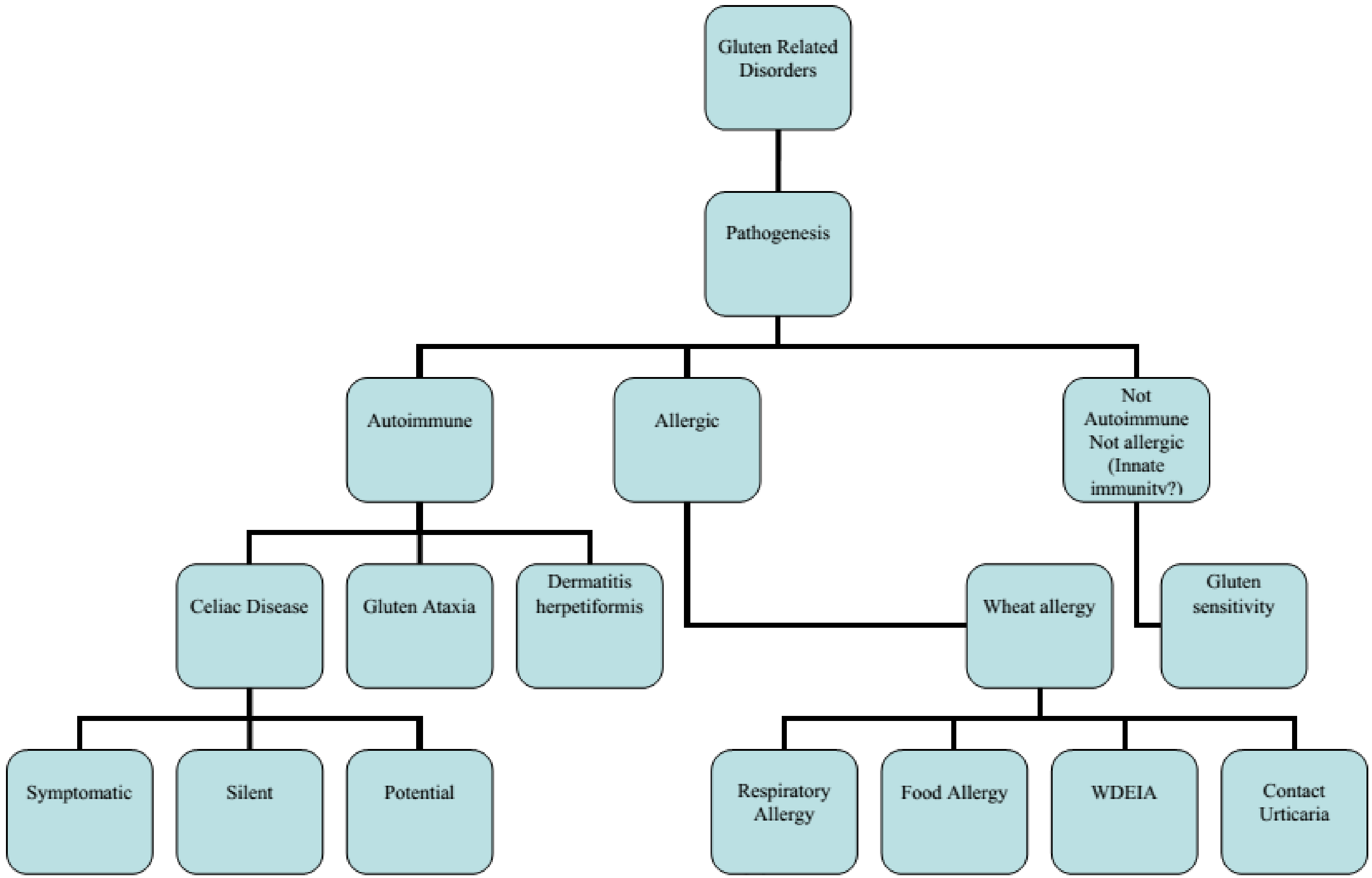



Table 4
Glutenins (*Glu*) and gliadins (*Gli*) composition evaluated for 14 durum wheat cultivars

| | Glu-A1 | Glu-B1 | Gli-A1 (ω-gli) | Gli-B1 | | | | Gli-A2 | Gli-B2 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | ω-gli | γ-gli | β-gli | LMW | α-gli | β-gli |
| Timilia | Null | 20 | 20 | 23;35 | 45;46 | – | LMW-2 | 76;78;80;82;85 | 59;60;62;65 |
| Russello S.G.7 | Null | 13 + 16 | – | 23;25; 35;38 | 45;46;51 | – | LMW-1 | 76;78;80;82;85;94 | 59;60;62;65 |
| Cappelli | Null | 20 | 20 | 23;35 | 45;51 | – | LMW-2 | 73;77;79;84;89 | 59;60;62;65 |
| Aziziah | Null | 6 + 15 | – | 25;33;35;38 | 42 | – | LMW-1 | 73;77;79;84;89 | 55;58;61;63 |
| Grifoni 235 | Null | 7 + 8 | – | 23;31;35 | 45;46 | – | LMW-2 | 76;78;80;82;85;94 | 59;60;62;65 |
| Capeiti 8 | Null | 20 | – | 35 | 45;46 | – | LMW-2 | 73;77;79;84;89 | 59;60;62;65 |
| Trinakria | Null | 20 | – | 35 | 45;46 | – | LMW-2 | 73;77;79;84;89 | 59;60;62;65 |
| Appulo | Null | 20 | 20 | 23;35 | 45;46 | – | LMW-2 | 73;77;79;84;89 | 59;60;62;65 |
| Creso | Null | 6 + 8 | 20 | 23;35 | 45;51 | – | LMW-2 | 73;77;79;84;89 | 59;60;62;65 |
| Valnova | Null | 7 + 8 | 20 | 23;35 | 45;51 | – | LMW-2 | 73;77;79;84;89 | 59;60;62;65 |
| Arcangelo | Null | 20 | 20 | 23;35 | 45;51 | – | LMW-2 | 73;77;79;84;89 | 59;60;62;65 |
| Duilio | Null | 7 + 8 | 20 | 23;35 | 45;51 | – | LMW-2 | 76;78;80;82;85;94 | 59;60;62;65 |
| Simeto | Null | 7 + 8 | 20 | 23;35 | 45;51 | – | LMW-2 | 73;77;79;84;89 | 59;60;62;65 |
| Ofanto | Null | 20 | 20 | 23;35 | 45;51 | – | LMW-2 | 73;77;79;84;89 | 59;60;62;65 |

De Vita *et al.*, 2007

# Gluten related disorders




from Sapone *et al*. (2012)

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## List of celiac disease epitopes (Shewry and Tatham, 2016)

| Epitope | Sequence |
|---|---|
| DQ2.5 restricted epitopes | |
| Wheat | |
| DQ2.5-glia-α1a | PFPQPQLPY |
| DQ2.5-glia-α1b | PYPQPQLPY |
| DQ2.5-glia-α2 | PQPQLPYPQ |
| DQ2.5-glia-α3 | FRPQQPYPQ |
| DQ2.5-glia-γ1 | PQQSFPQQQ |
| DQ2.5-glia-γ2 | IQPQQPAQL |
| DQ2.5-glia-γ3 | QQPQQPYPQ |
| DQ2.5-glia-γ4a | SQPQQQFPQ |
| DQ2.5-glia-γ4b | PQPQQQFPQ |
| DQ2.5-glia-γ4c | QQPQQPFPQ |
| DQ2.5-glia-γ4d | PQPQQPFCQ |
| DQ2.5-glia-γ5 | QQPFPQQPQ |
| DQ2.5-glia-ω1 | PFPQPQQPF |
| DQ2.5-glia-ω2 | PQPQQPFPW |
| DQ2.5-glut-L1 | PFSQQQQPV |
| DQ2.5-glut-L2 | FSQQQQSPF |
| Barley | |
| DQ2.5-hor-1 | PFPFPQQPF |
| DQ2.5-hor-2 | PQPQQPFPQ |
| DQ2.5-hor-3 | PIPQQPQPY |
| Rye | |
| DQ2.5-sec-1 | PFPQPQQPF |
| DQ2.5-sec-2 | PQPQQPFPQ |
| DQ2.2 restricted epitopes | |
| Wheat | |
| DQ2.2-glut-L1 | PFSQQQQPV |
| DQ8 restricted epitopes | |
| Wheat | |
| DQ8-glia-α1 | QGSFQPSQQ |
| DQ8-glia-γ1a | QQPQQPFPQ |
| DQ8-glia-γ1b | QQPQQPYPQ |
| DQ8-glut-H1 | QGYYPTSPQ |
| DQ8.5 restricted epitopes | |
| Wheat | |
| DQ8.5-glia-α1 | QGSFQPSQQ |
| DQ8.5-glia-γ1 | PQQSFPQQQ |
| DQ8.5-glut-H1 | QGYYPTSPQ |

## List of wheat allergens (Matsuo et al., 2015)

Wheat allergens.

| Protein name | | IUIS name | MW (kDa) |
|---|---|---|---|
| **Water/salt-soluble protein** | | | |
| Profilin | | Tri a 12 | 14 |
| Non-specific lipid transfer protein 1 | | Tri a 14 | 9 |
| α-Amylase inhibitors | | | |
| Monomeric | 0.28 | Tri a 15 | 12 |
| Dimeric | 0.19 | Tri a 28 | 13 |
| Tertameric | CM1/CM2 | Tri a 29 | 13 |
| | CM3 | Tri a 30 | 16 |
| | CM16/CM17 | – | 17 |
| Agglutinin | | Tri a 18 | 17 |
| Thioredoxin | | Tri a 25 | 13 |
| Thiol reductase homologue | | Tri a 27 | 27 |
| Triosephosphate isomerase | | Tri a 31 | 26 |
| 1-Cys-peroxiredoxin | | Tri a 32 | 24 |
| Serpin | | Tri a 33 | 40 |
| Glyceraldehyde-3-phosphate-dehydrogenase | | Tri a 34 | 40–42 |
| Dehydrin | | Tri a 35 | 12 |
| α-Purothionin | | Tri a 37 | 12 |
| Serine protease inhibitor-like protein | | Tri a 39 | 9 |
| Glutathione transferase | | – | 25 |
| Thaumatin like protein | | – | 18 |
| Peroxidase | | – | 36 |
| **Water/salt-insoluble protein** | | | |
| α/β-Gliadin | | Tri a 21 | 28–35 |
| γ-Gliadin | | Tri a 20 | 28–35 |
| ω1,2-Gliadin | | – | 40 |
| ω5-Gliadin | | Tri a 19 | 65 |
| High molecular weight glutenin subunits | | Tri a 26 | 88 |
| Low molecular weight glutenin subunits | | Tri a 36 | 32–40 |

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# Aim

While the influence of breeding on the polymorphism of durum wheat glutenin and gliadin subunits has been extensively investigated, very few studies have been reported of differences in the level of expression of the different gluten protein sub-fractions.

In order to explore the effects of breeding during the 20th century on gluten quality of durum wheat in relation to technological and health aspects, a set of old and modern Italian genotypes were compared under Mediterranean conditions

# Field trial

Trials have been conducted at Cereal Research Centre, Council for Agricultural Research and Economics,
SS 16 Km 675, Foggia (It)

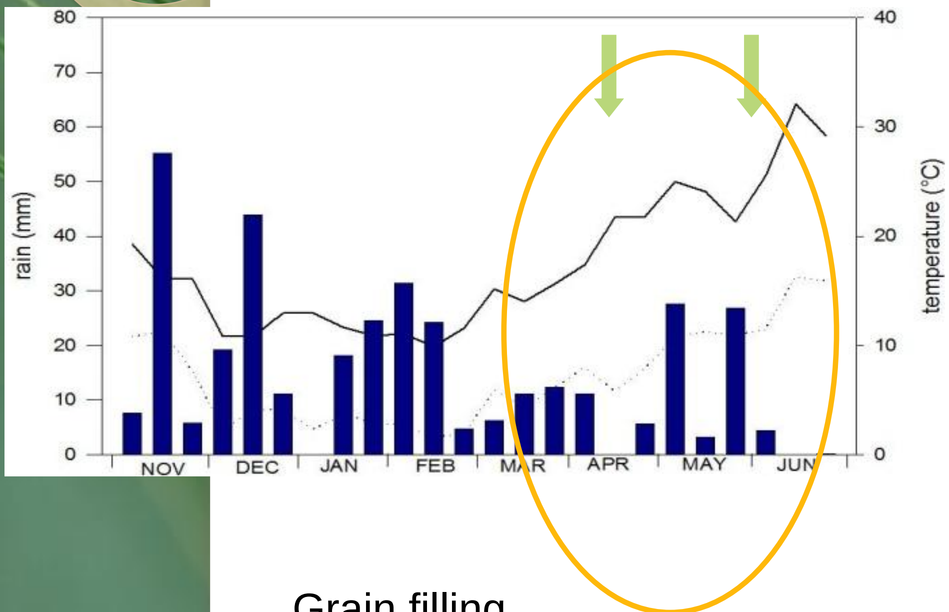
Foggia (41°28′ N, 15°32′ E and 75 m a.s.l), in southern-east Italy, on a clay-loam soil (Typic Chromoxerert).

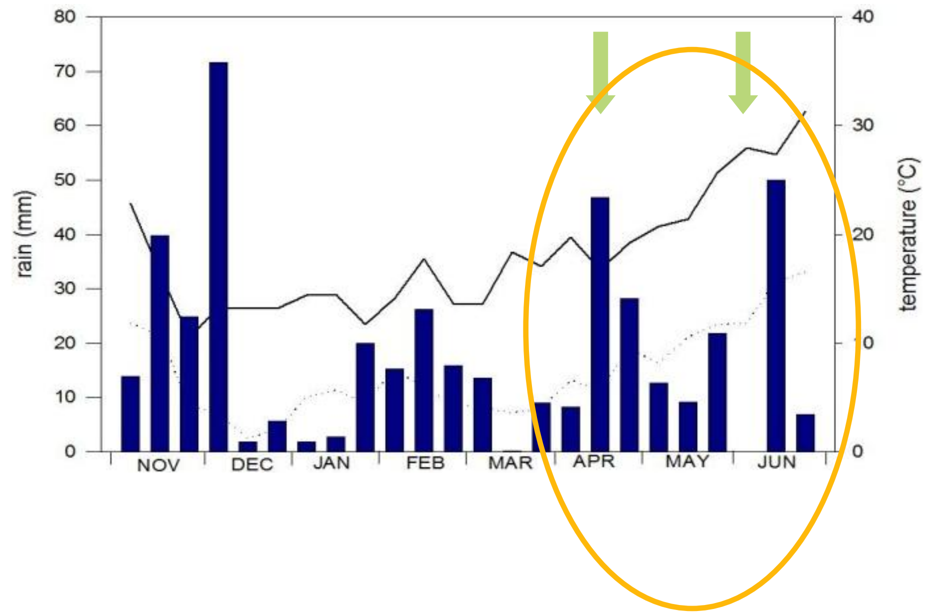
A total of 80 kg $ha^{-1}$ of N was split in two applications:
1/3 at sowing and 2/3 at tillering stage
70 kg/Ha of P at sowing

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

Each experimental unit consisted of a 10.2 $m^2$ plot (eight rows 7.5 m long with 0.17 m between rows). Seed density was 350 seeds $m^{-2}$

# Weather conditions




## Grain filling

| | T max (°C) | mean T min (°C) | mean T (°C) | evaporated (mm) | rainfall (mm) |
|---|---|---|---|---|---|
| 2013 | 24.9 | 11.1 | 18.0 | 284 | 53.8 |
| 2014 | 23.1 | 11.1 | 17.0 | 241 | 152.8 |

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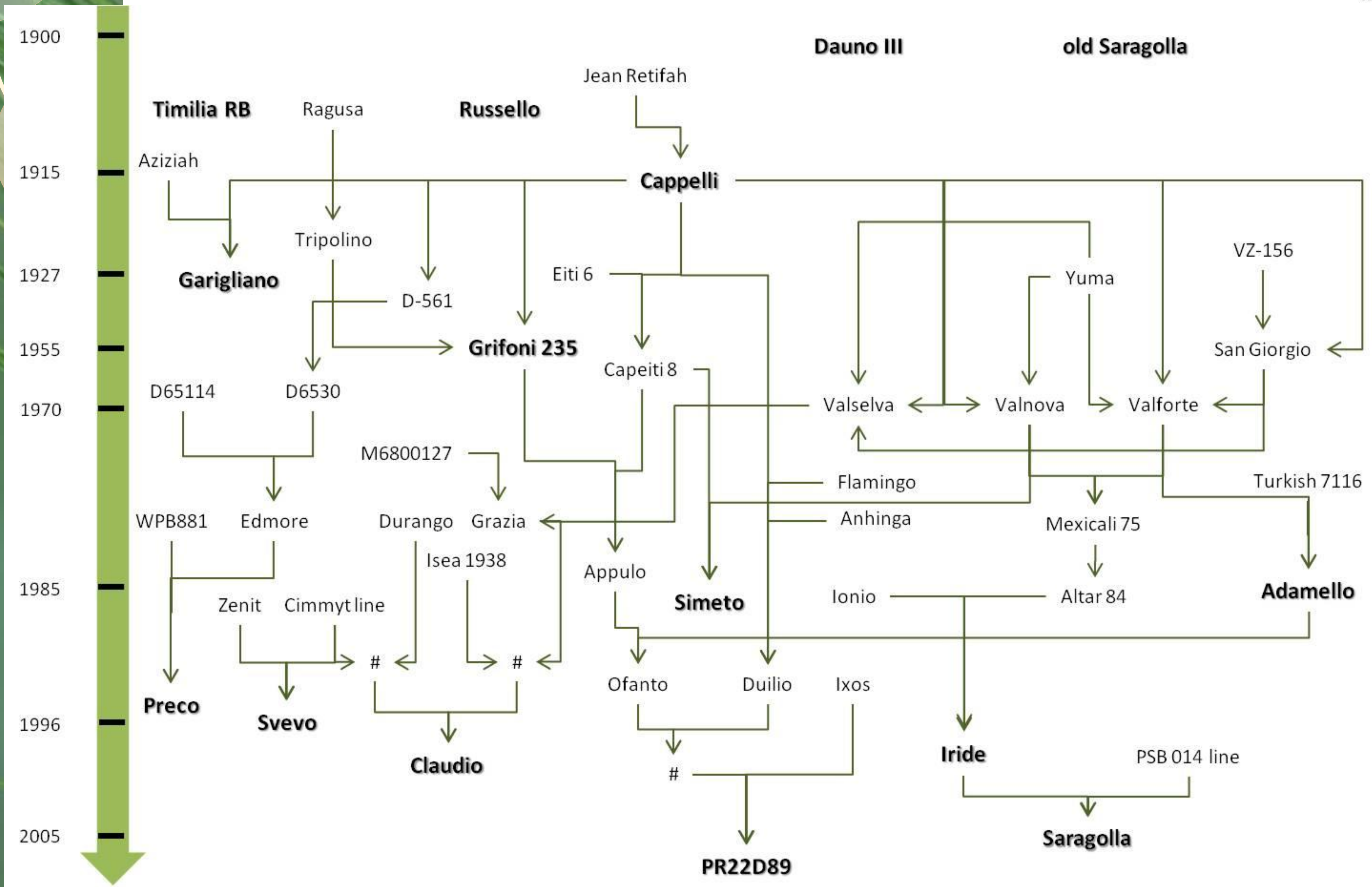
# Genotypes

| Groups | Genotypes | Pedigree | Year of release | Glutenin gene | | |
|---|---|---|---|---|---|---|
| | | | | Glu A1 | Glu B1 | Glu B3 |
| Old | Dauno III | landraces from south Italy | 1900 | 2? | 6 + 8? | LMW 1? |
| | old Saragolla | landraces from south Italy | 1900 | null | 7 | LMW 2 |
| | Russello | landraces from Sicily, Italy | 1910 | null | 13 + 16 | LMW 1 |
| | Timilia RB | landraces from Sicily, Italy | 1910 | null | 20 | LMW 2 |
| | Cappelli | selection from Tunisian population Jean Retifah | 1915 | null | 20 | LMW 2 |
| | Garigliano | Tripolino x Cappelli | 1927 | null | 7 + 8 | LMW 2 |
| | Grifoni 235 | Cappelli x Triticum aestivum | 1949 | null | 7 + 8 | LMW 2 |
| Modern | Adamello | Valforte x turkish line 7116 | 1985 | null | 7 + 8 | LMW 2 |
| | Simeto | Capeiti 8 x Valnova | 1988 | null | 7 + 8 | LMW 2 |
| | Preco | (Edmore x WPB881) x Selected line 3 | 1995 | null | 6 + 8 | LMW 2 |
| | Svevo | Cimmyt line x Zenit | 1996 | null | 7 + 8 | LMW 2 |
| | Iride | (Cimmyt selection x Durango) x (IS1938 x Grazia) | 1996 | null | 7 + 8 | LMW 2 |
| | Claudio | Altar 84 x Ionio | 1998 | null | 7 + 8 | LMW 2 |
| | Saragolla | Iride x PSB 014 line | 2004 | null | 6 + 8 | LMW 2 |
| | PR22D89 | (Ofanto x Duilio) x Ixos | 2005 | null | 7 + 8 | LMW 2 |


1900
1915
1927
1955
1970
1985
1996
2005
Dauno III
old Saragolla
Jean Retifah
Timilia RB
Ragusa
Russello
Aziziah
Cappelli
Tripolino
VZ-156
Garigliano
Eiti 6
Yuma
D-561
Grifoni 235
San Giorgio
Capeiti 8
D65114
D6530
Valselva
Valnova
Valforte
M6800127
Flamingo
Turkish 7116
WPB881
Edmore
Durango
Grazia
Anhinga
Mexicali 75
Isea 1938
Appulo
Simeto
Ionio
Altar 84
Adamello
Zenit
Cimmyt line
#
#
Ofanto
Duilio
Ixos
Preco
Svevo
Claudio
#
Iride
PSB 014 line
Saragolla
PR22D89

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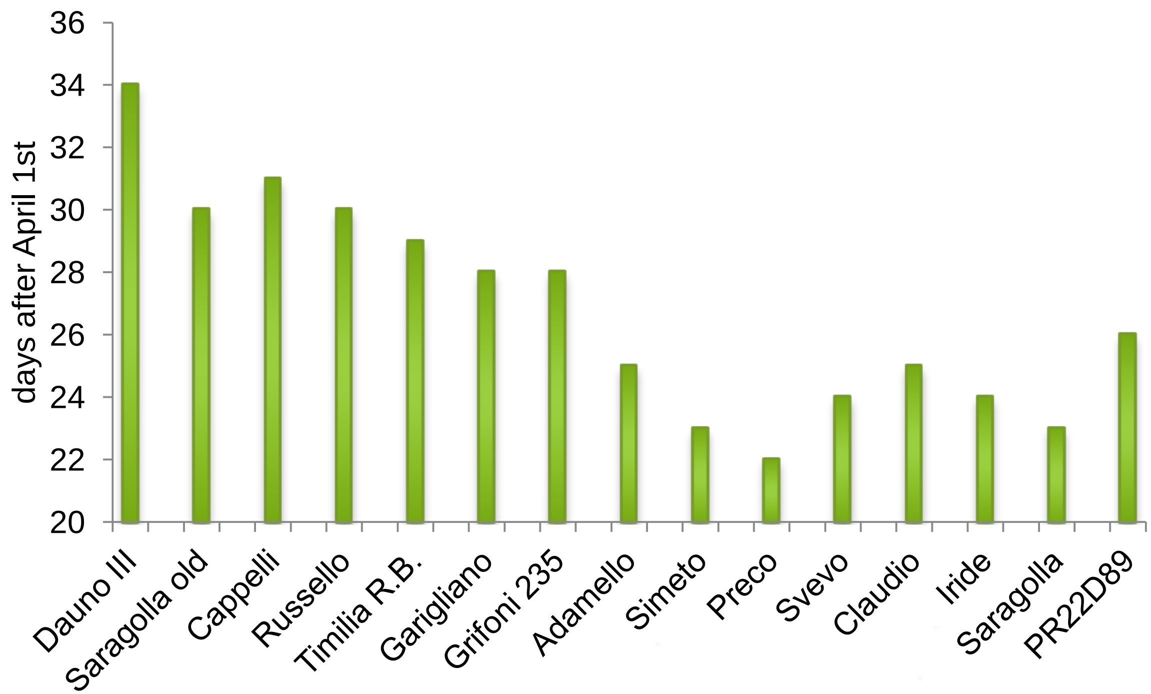
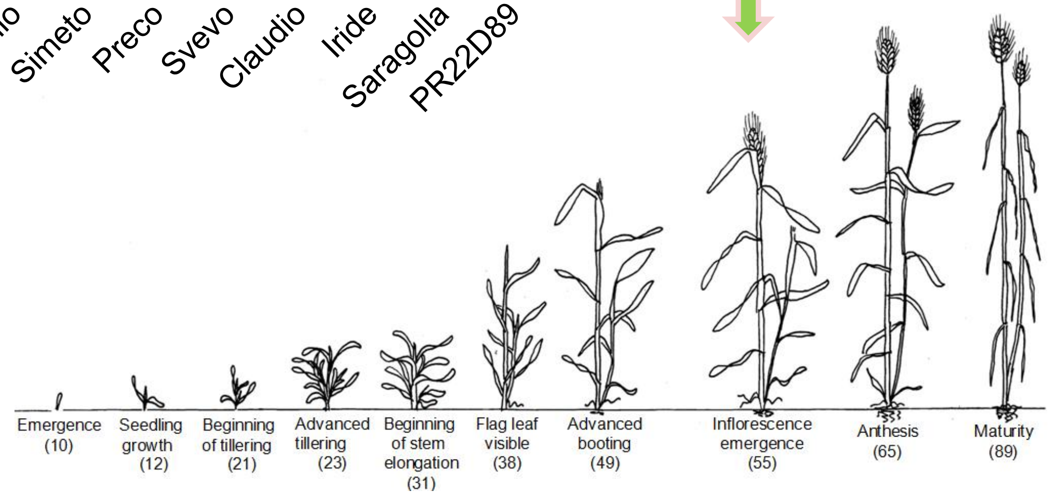
# Earliness

(expressed as number of days from April 1st of the heading date )




Zadoks et al. (1974)



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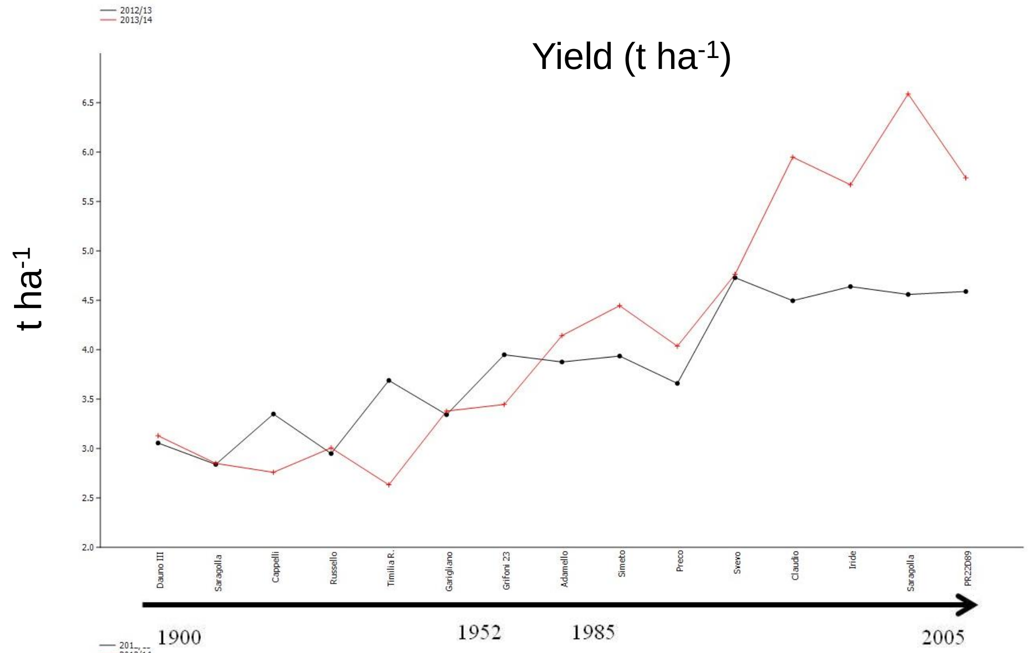


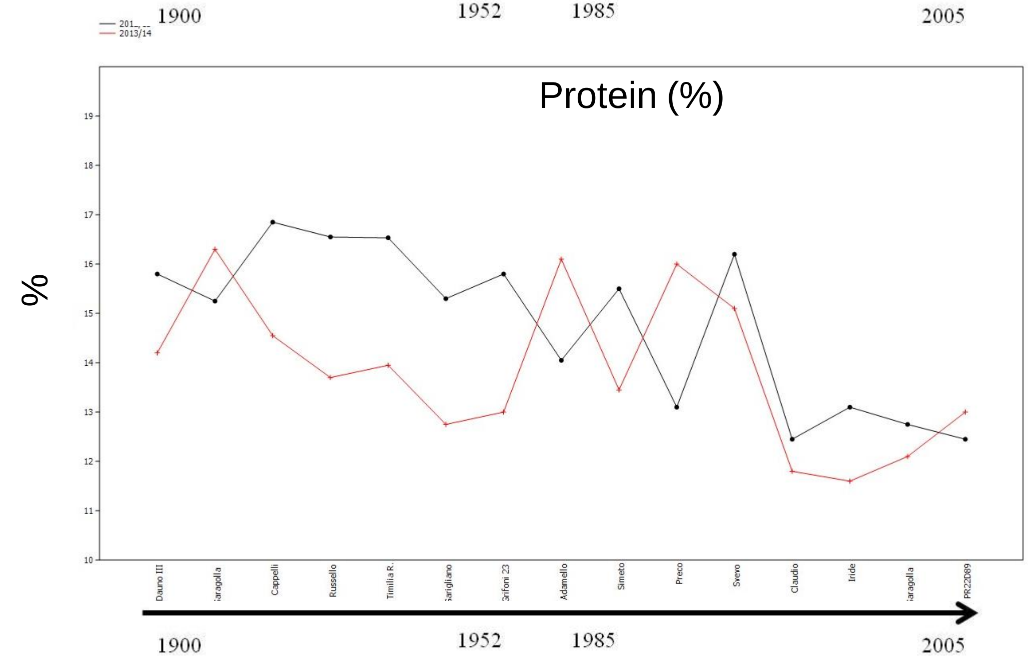

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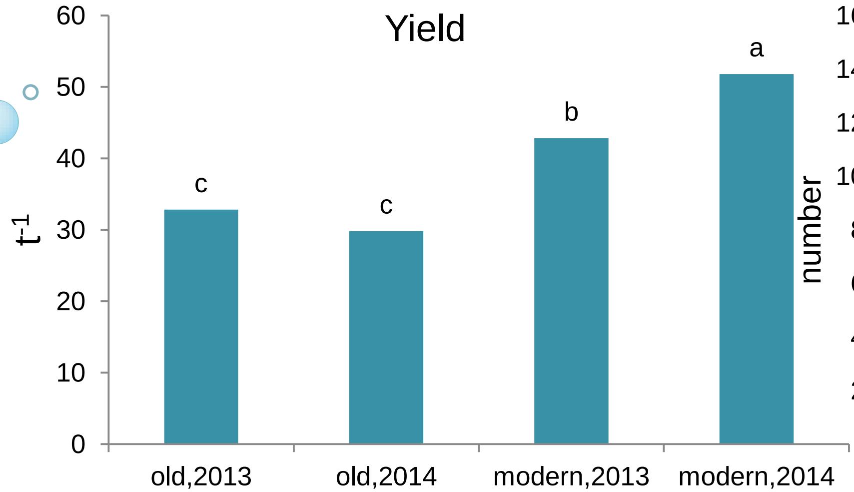


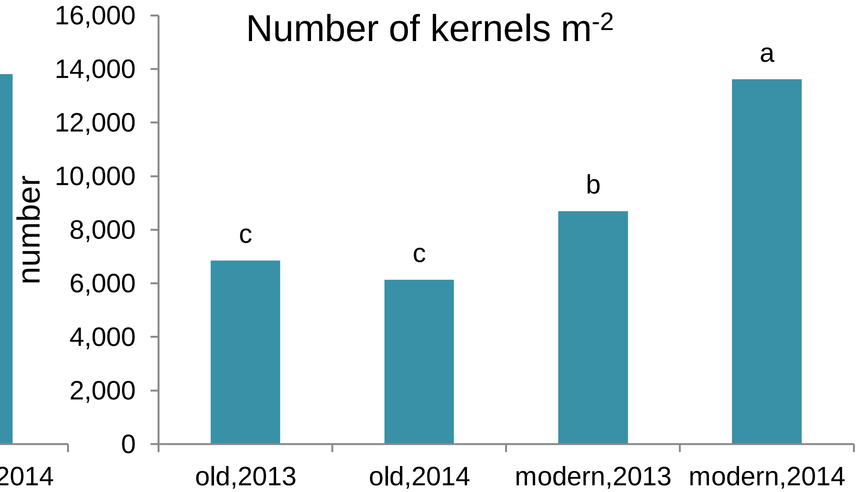


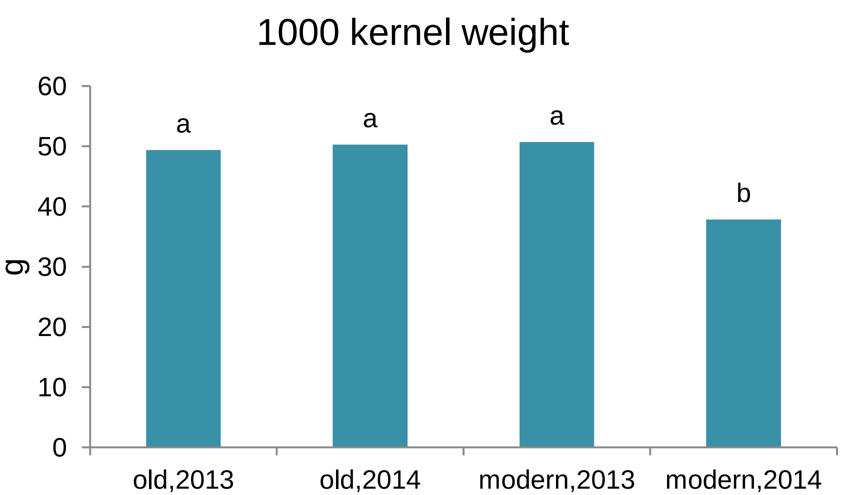


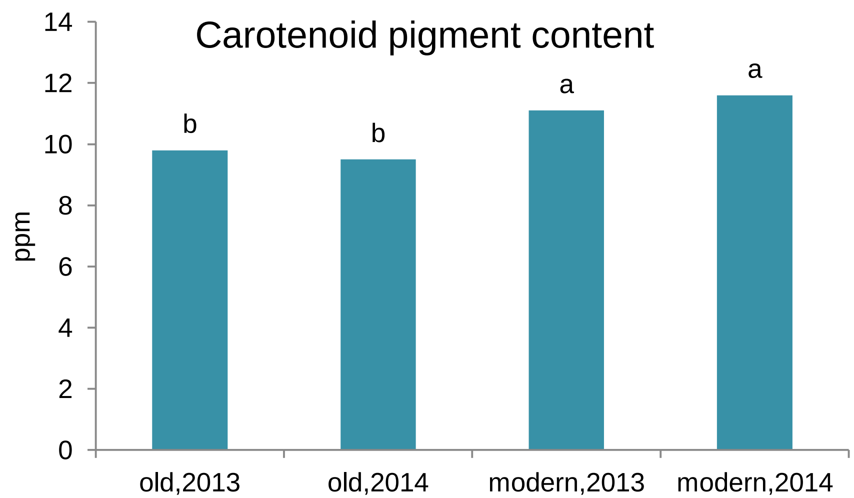

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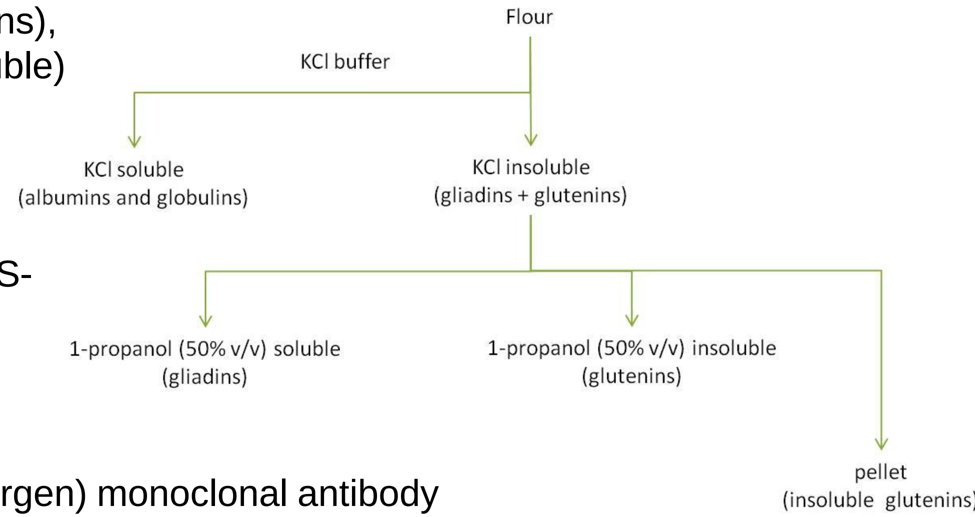
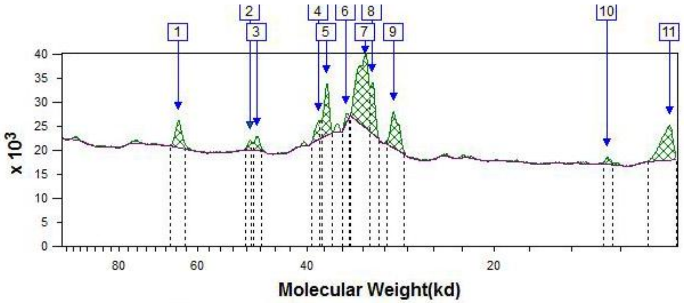
# Analysis performed

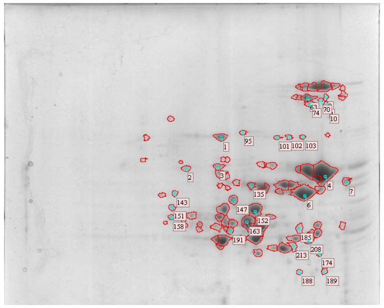
- determination of gluten index
- extraction and quantification (biuret) of metabolic proteins (albumins and globulins), gliadin and glutenins (soluble and unsoluble) from semolina
- determination of gliadin : glutenin ratio
- gliadin and glutenin composition by SDS-PAGE
- 2-DE SDS-PAGE
- western blot by ω-5 gliadin (Tri a 19 allergen) monoclonal antibody (kindly provided by prof. Peter Shewry – Rothamsted Research, Dept. of PBCS)

from Hurkman and Tanaka (2004), modified according to Singh *et al*. (1991)




ImageQuant Tl (GE-Healtcare)



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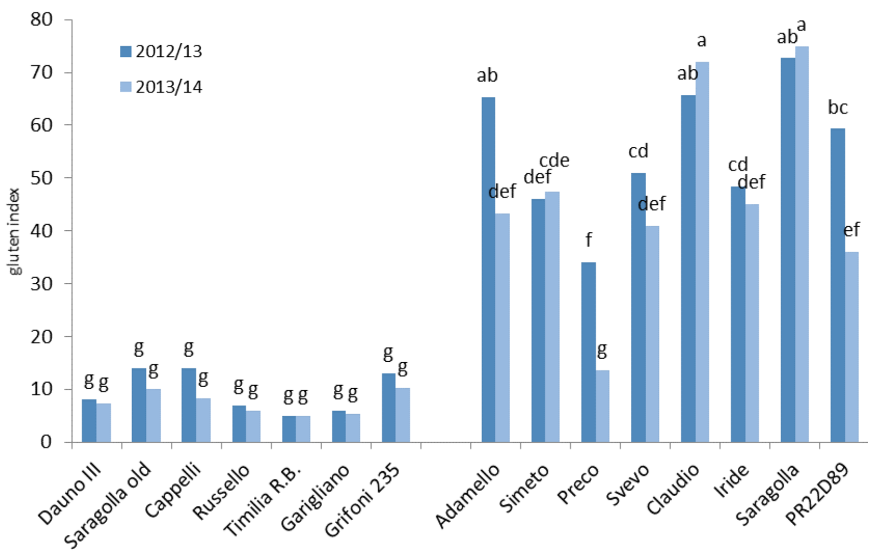
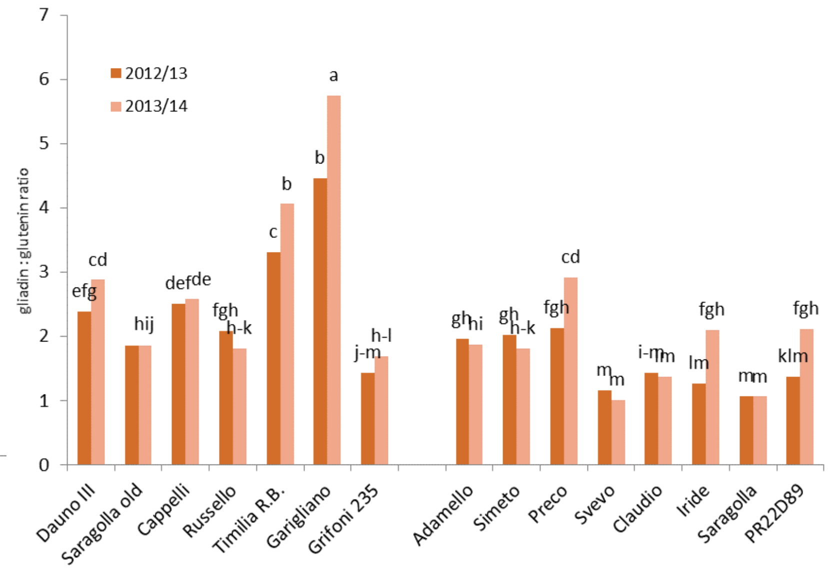
## Gluten index




## gliadin : glutenin ratio



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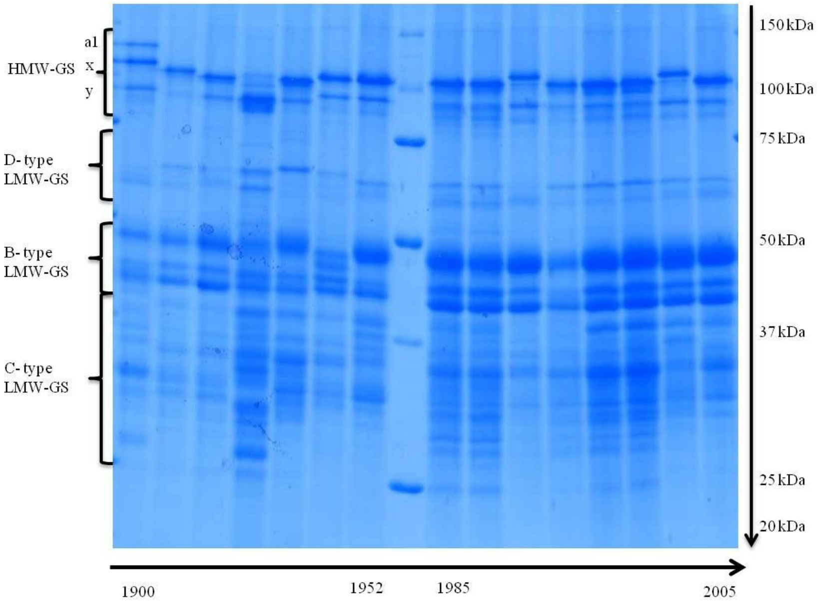
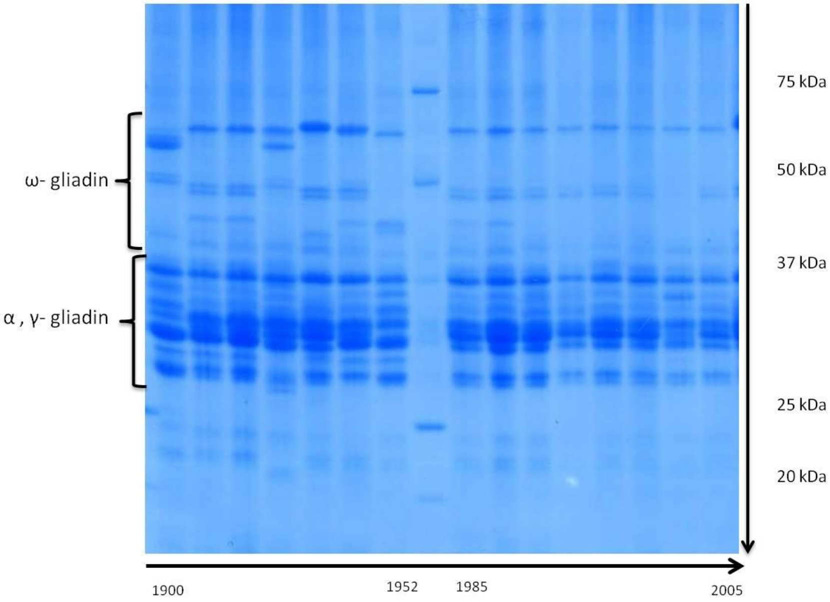
# SDS-PAGE

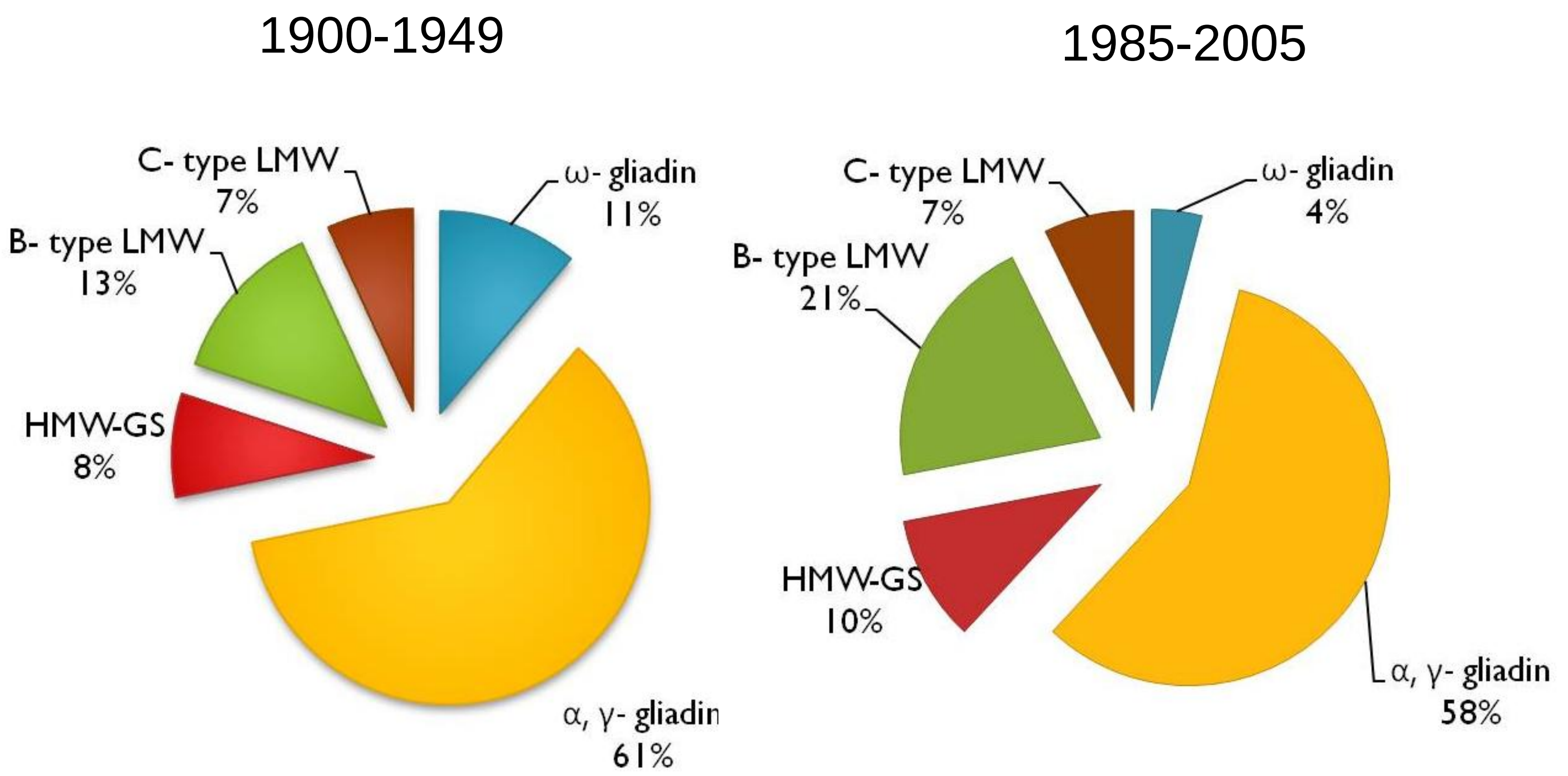
## Glutenin




## Gliadin



# Storage protein composition



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# Year effect

In 2013 (water deficit in grain filling)

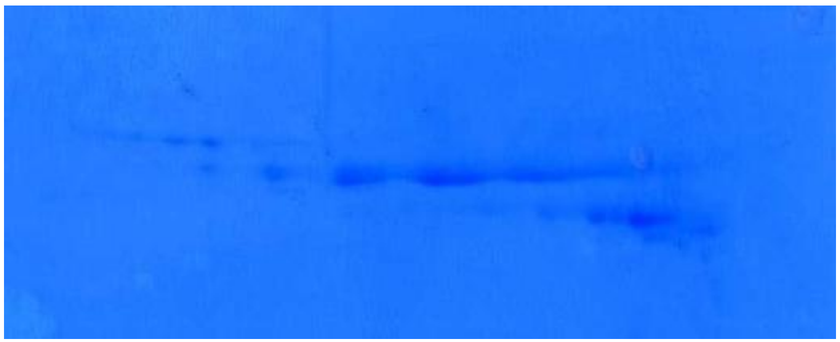
↑ Protein content

↑ HMW-GS

↑ ω-type gliadin

# HMW-GS

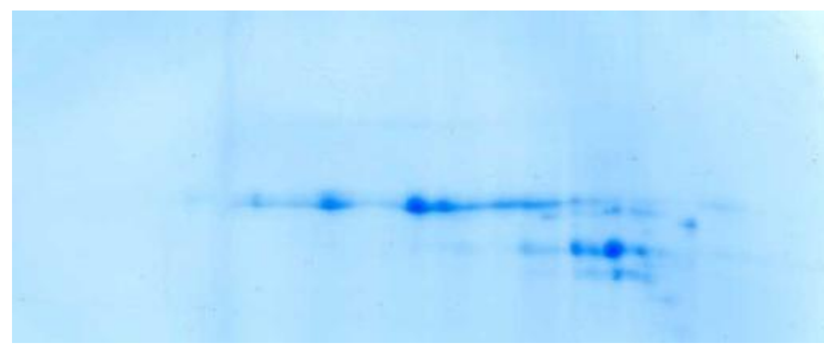
Dauno III
Glu A1 2 ? Glu B1 6+8?



Cappelli
Glu B1 20

Simeto
Glu B1 7+8

Saragolla
Glu B1 6+8



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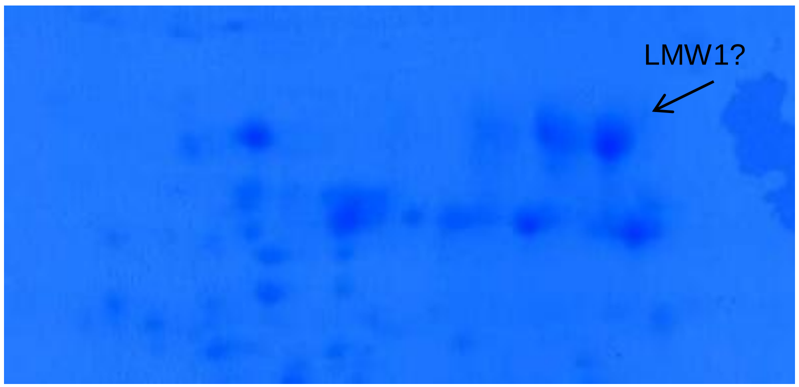
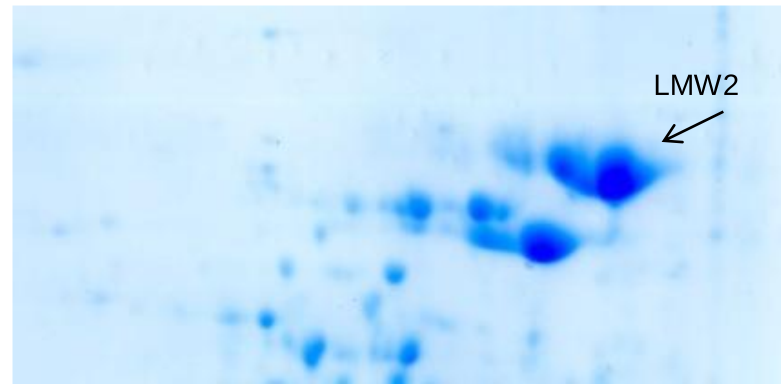
# B- type LMW-GS (m)

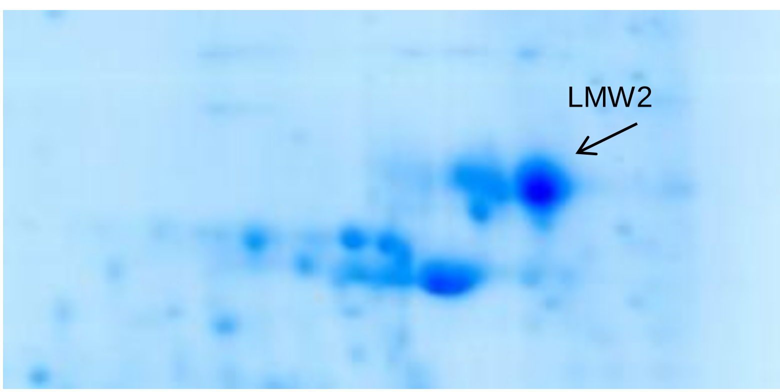
Dauno III



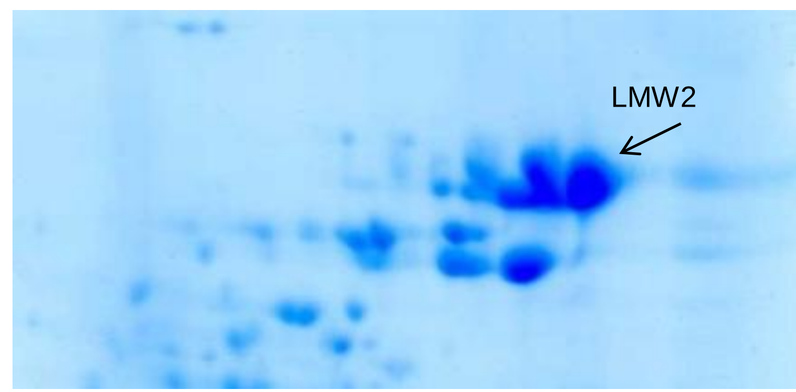

Cappelli




Simeto




Saragolla



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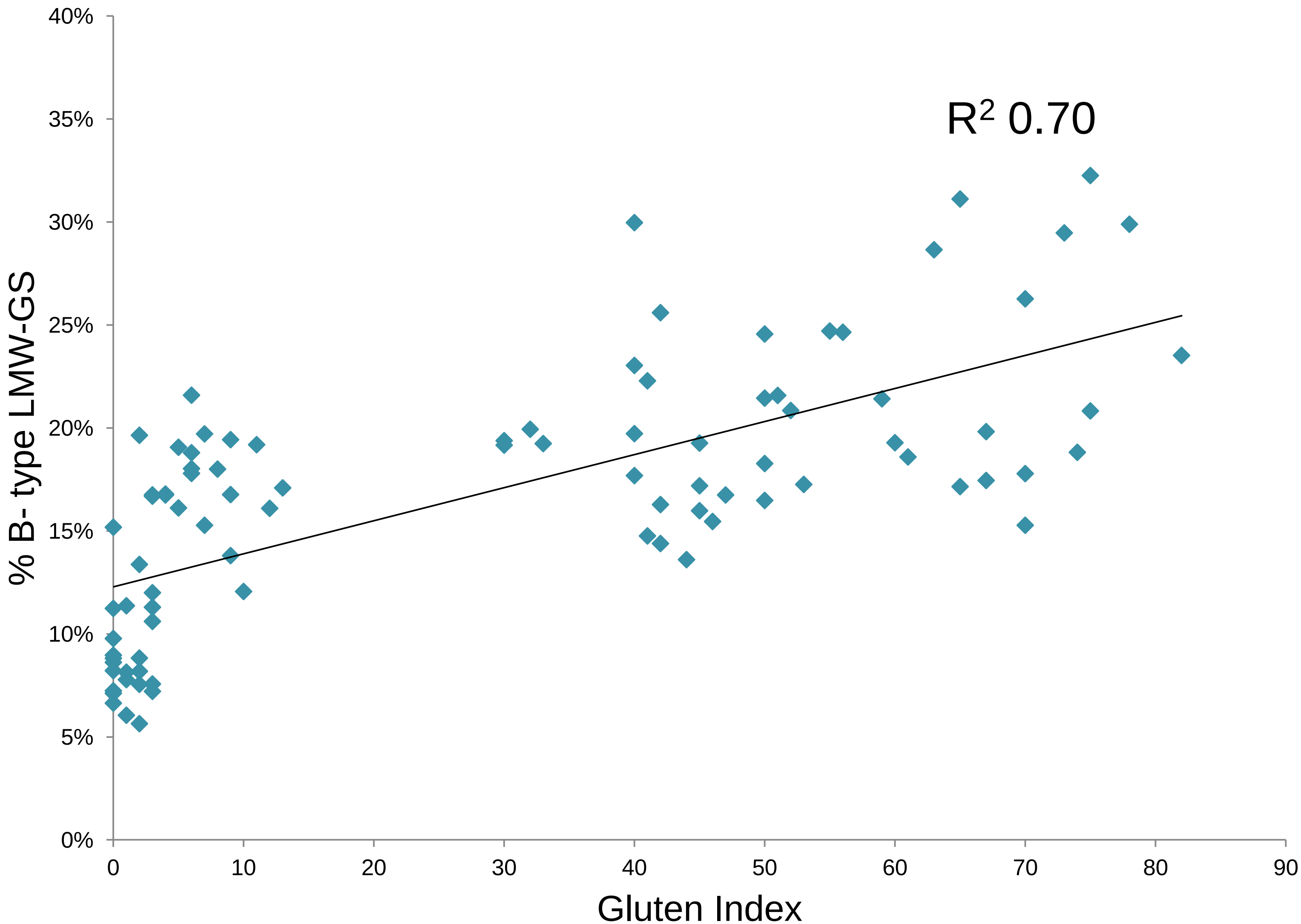
# Linear correlation between Gluten Index and %B- type LMW-GS



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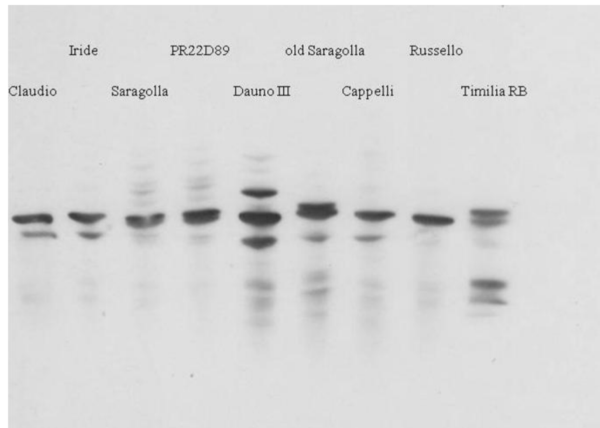
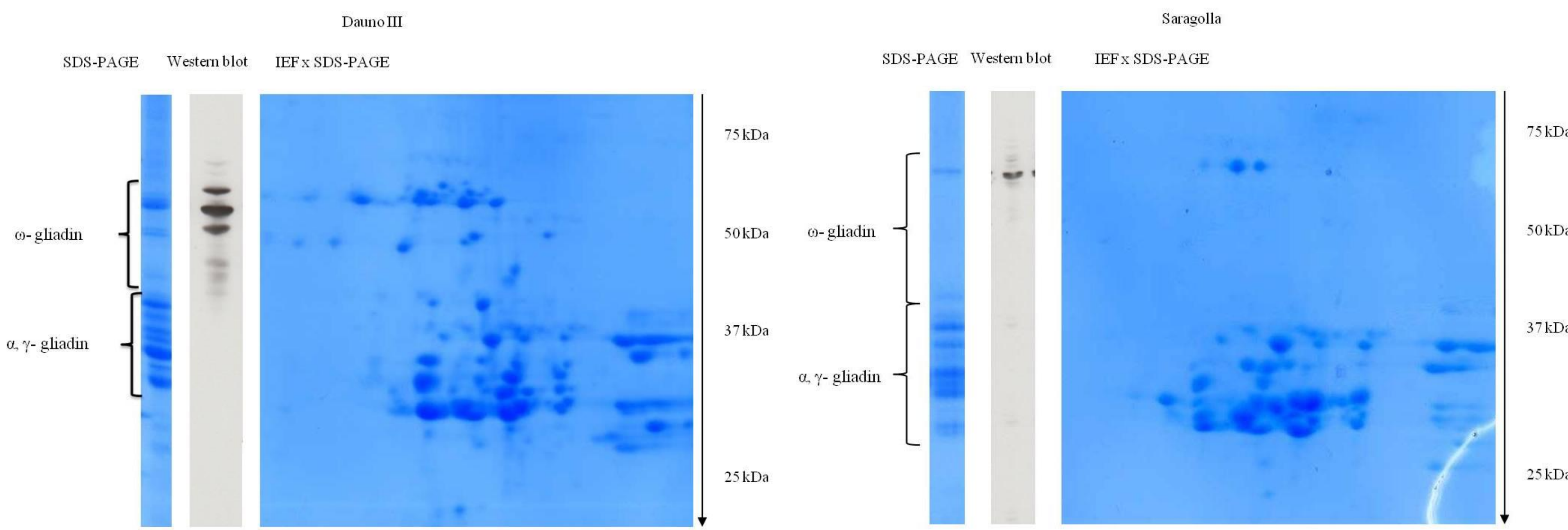
# Western blot with ω-5 gliadin (Tri a 19)



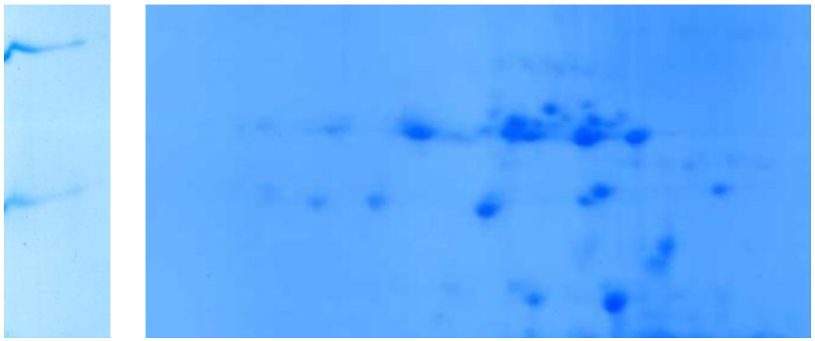



# ω-5 gliadin

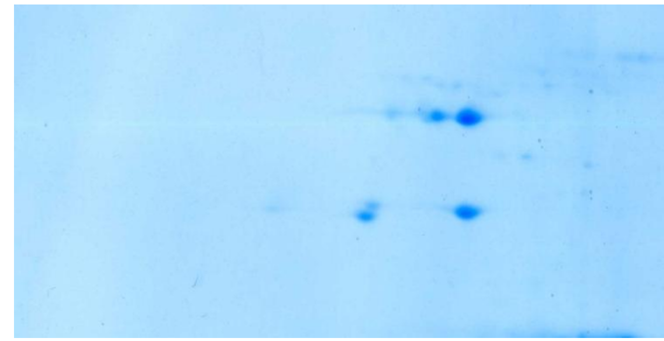
## Dauno III

75 kDa

50 kDa



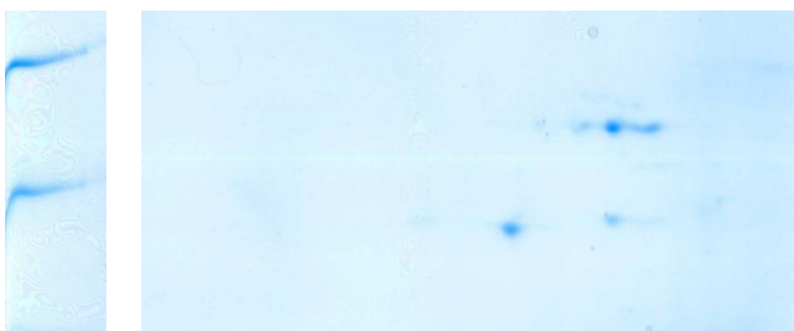
## Cappelli



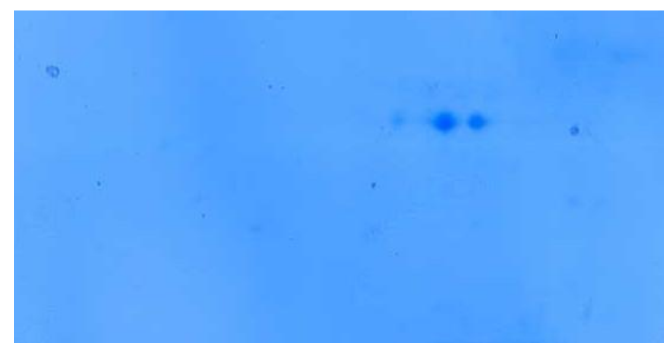
## Simeto

75 kDa

50 kDa



## Saragolla



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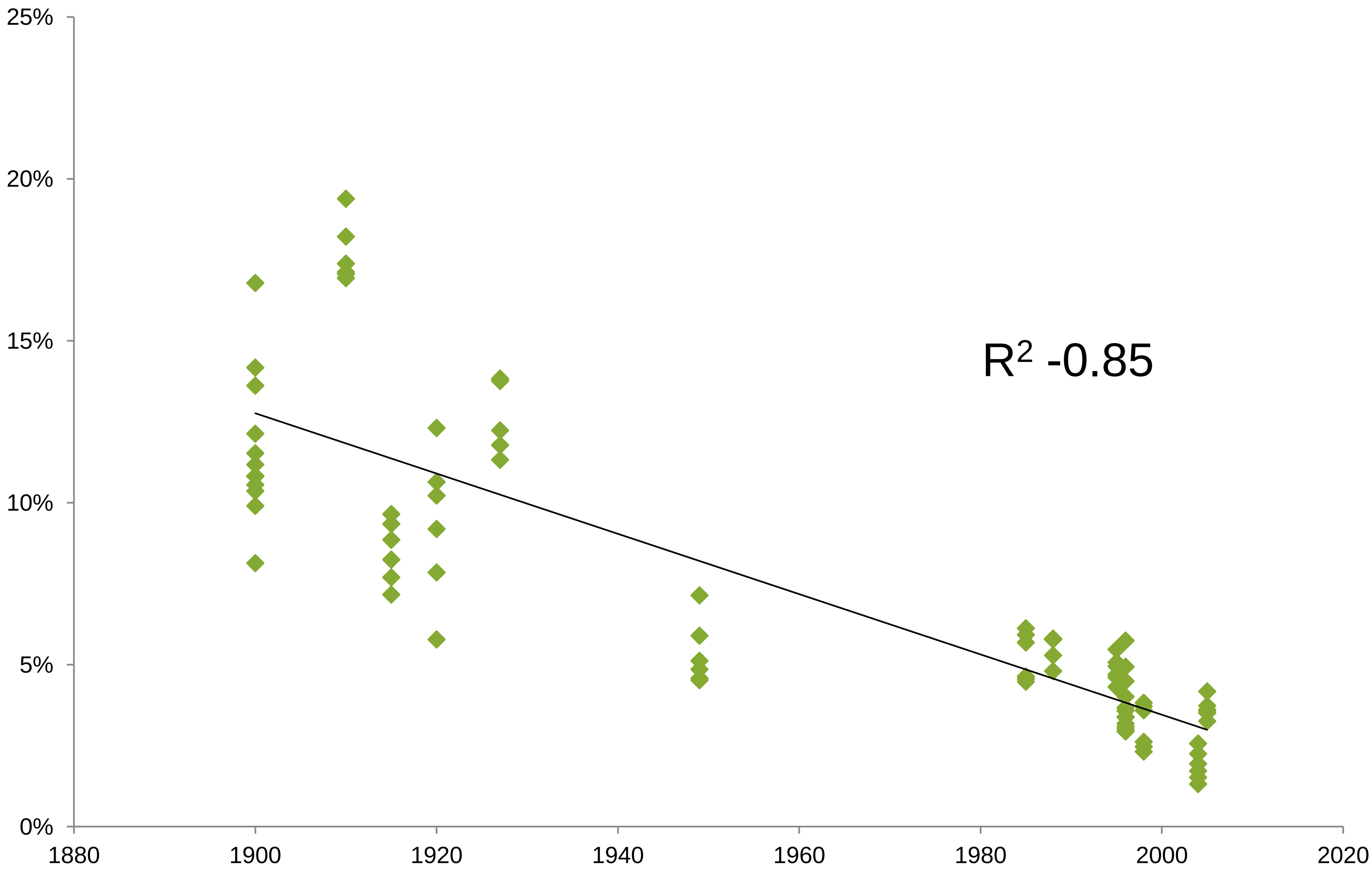
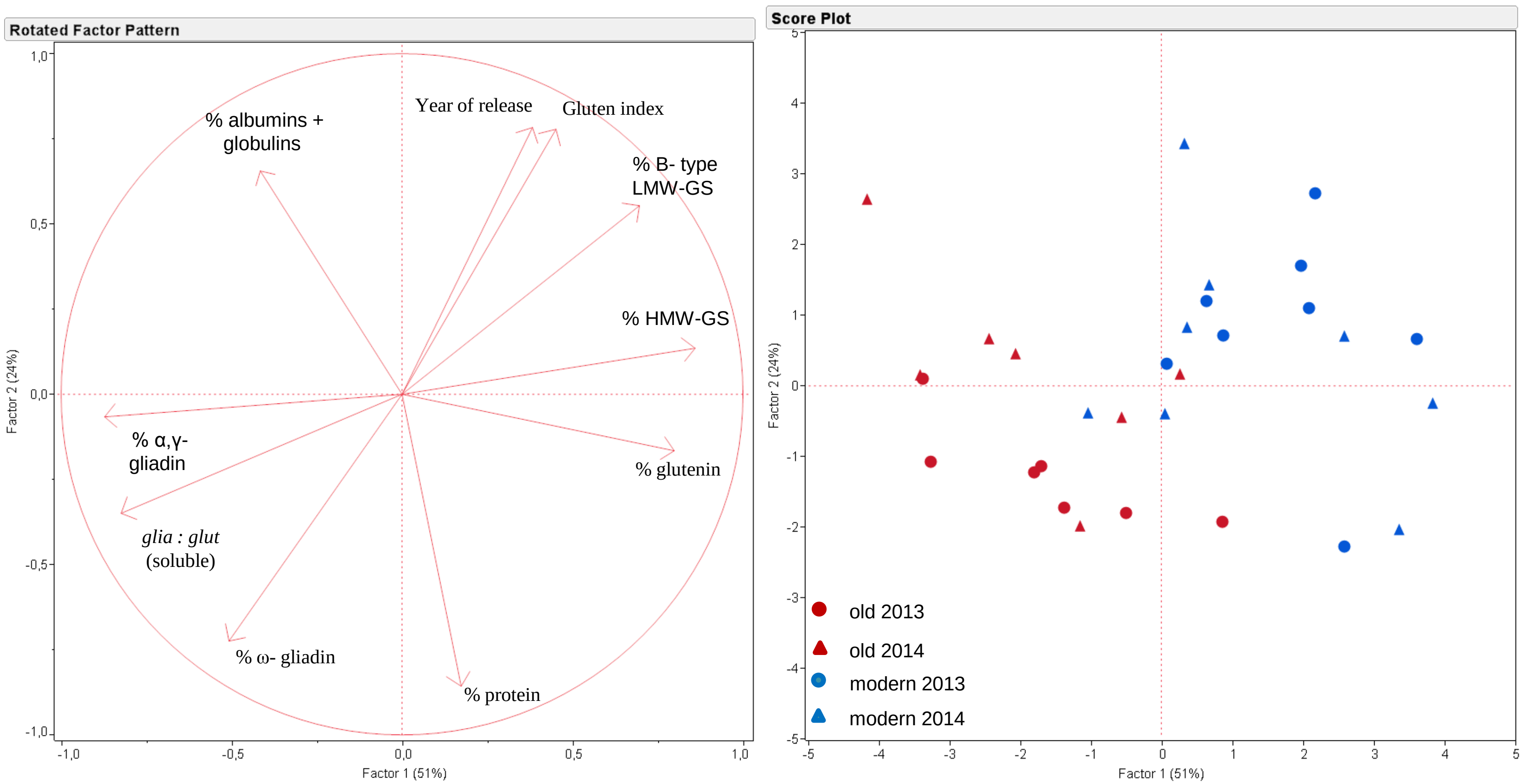
# Linear correlation between ω- gliadin expression and year of release



# Principal Component Analysis



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# Take home messages

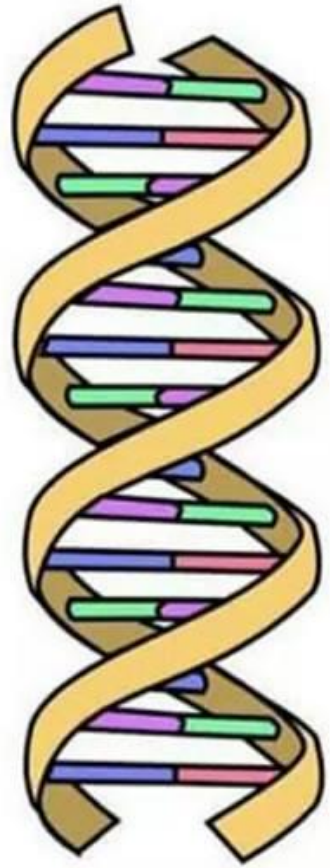
- Increase of technological quality was associated not only to allelic composition, but was due to:

➢a significant higher expression of the B- type LMW-GS in the modern genotypes
➢reduction of the HMW-GS : B- type LMW-GS ratio, associated to a reduction of the protein content
➢reduction of ω-type gliadin expression
➢ reduction of ω-5 gliadin (Tri a 19) expression, also due by a different number of isoforms
➢no significant differences in overall α-type and γ-type gliadins expression
Environmental differences due to a different rainfall distribution during grain filling resulted in :
➢a higher expression of HMW-GS,
➢differential expression of health-related gluten proteins (ω-5 gliadin)

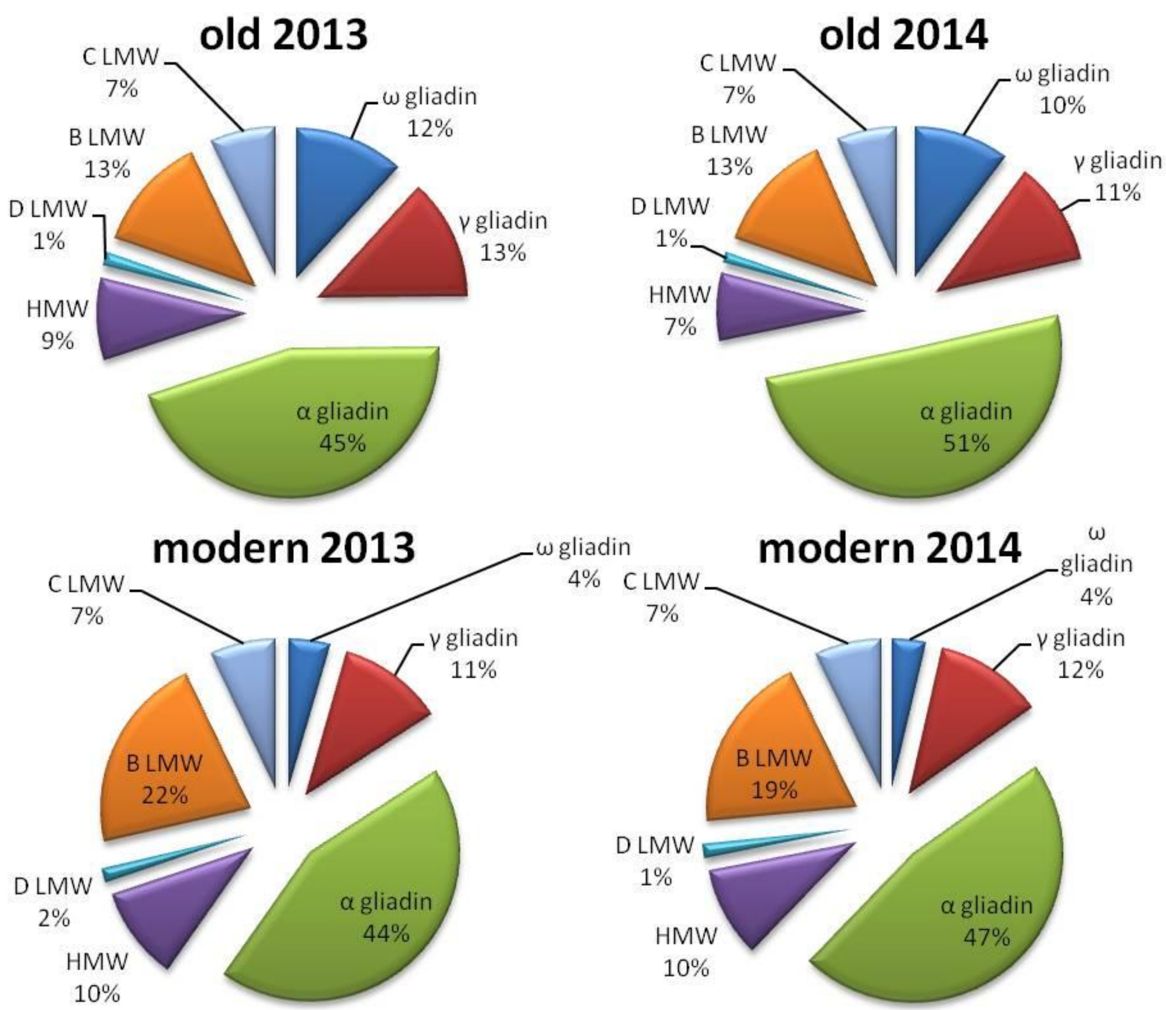
**In conclusion, 20th century breeding seems to have improved both the technological and health quality of Italian durum wheat genotypes by:**

| higher B- type LMW-GS<br>responsible for better gluten quality | lower content of ω-5 gliadin<br>lower allergic potential of modern genotypes gluten |
|---|---|

**NORMAL DNA** **ITALIAN DNA**



THANKS


old 2013
C LMW 7%
ω gliadin 12%
B LMW 13%
γ gliadin 13%
D LMW 1%
HMW 9%
α gliadin 45%
old 2014
C LMW 7%
ω gliadin 10%
B LMW 13%
γ gliadin 11%
D LMW 1%
HMW 7%
α gliadin 51%
modern 2013
ω gliadin 4%
C LMW 7%
γ gliadin 11%
B LMW 22%
D LMW 2%
α gliadin 44%
HMW 10%
modern 2014
ω gliadin 4%
C LMW 7%
γ gliadin 12%
B LMW 19%
D LMW 1%
α gliadin 47%
HMW 10%

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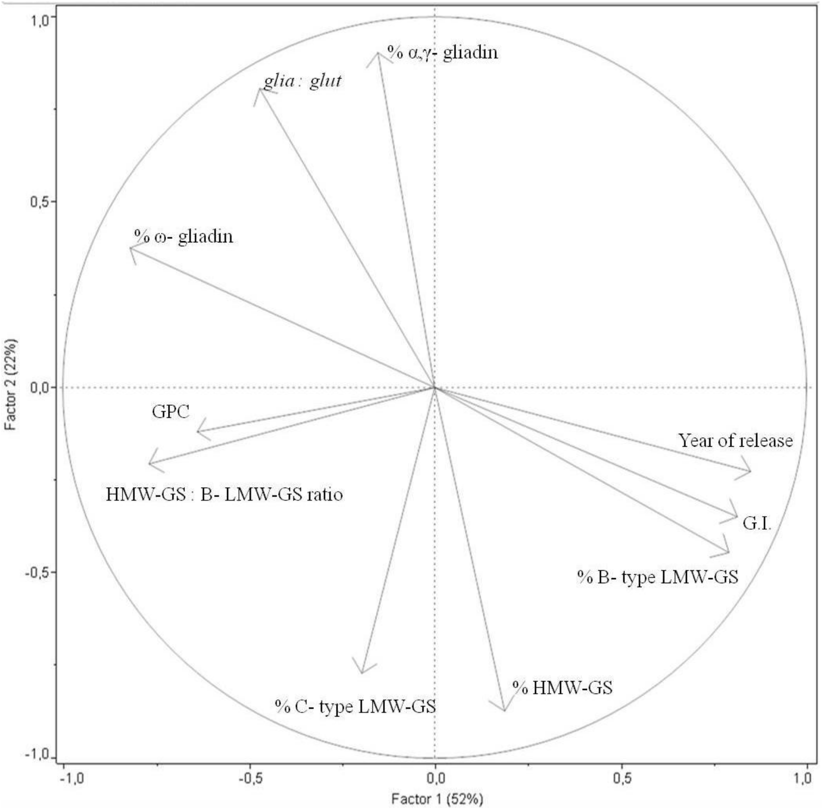
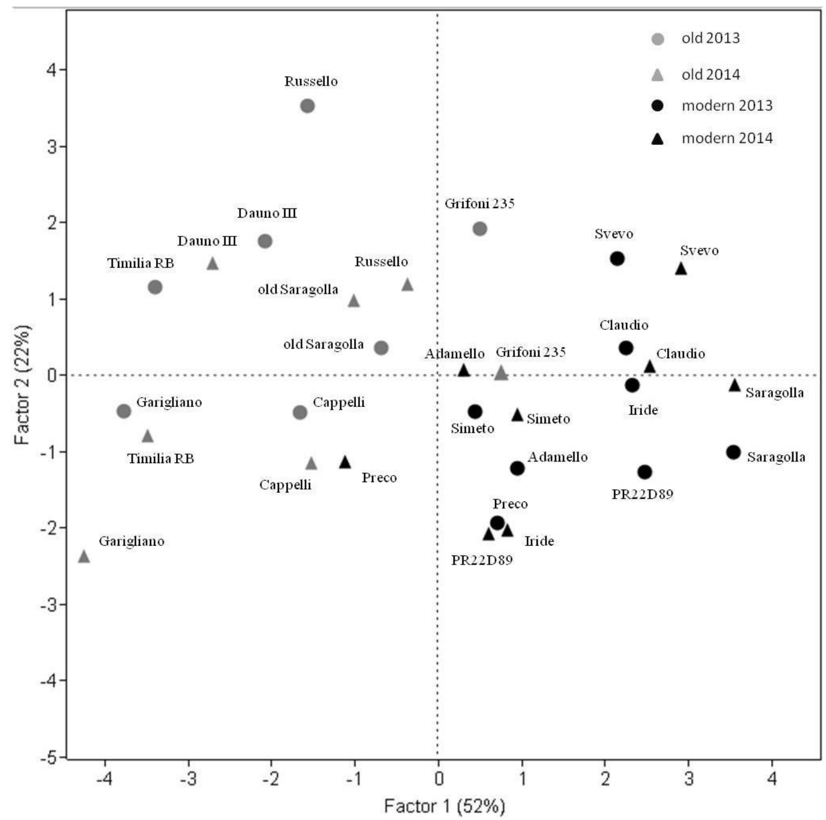
| | Yield (t ha-1) | | TKW (g) | | n. kernel m-2 | | TW (kg hl-1) | | GPC (% dm) | | Gluten index | | Carotenoids pigment content (ppm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 |
| 1900-1949 | | | | | | | | | | | | | | |
| Dauno III | 3.1ijk | 3.1ijk | 47.9ef | 45.8fg | 6389j-m | 6842h-m | 77.2l | 78.4k | 15.8e | 14.2i | 8g | 7.3g | 5.0no | 5.1mn |
| old Saragolla | 2.8 jk | 2.8 jk | 49.3ef | 49.2ef | 5765klm | 5791klm | 80.5c | 76.6m | 15.3g | 16.3c | 9g | 5g | 4.2r | 4.4r |
| Cappelli | 3.3g-k | 2.8g-k | 54.5bcd | 48.5ef | 6174j-m | 5686klm | 81.1g | 79.0j | 16.9a | 14.6h | 9g | 3g | 4.9op | 5.3kl |
| Russello | 2.9ijk | 3.0ijk | 48.8ef | 54.8 bc | 6041klm | 5484lm | 78.8jk | 79.0j | 16.6b | 13.7k | 7g | 6g | 5.7fg | 3.8ij |
| Timilia R.B. | 3.7f-i | 2.6k | 36.0 jk | 34.7jkl | 10246ef | 7602g-k | 80.4h | 79.0j | 16.5b | 14.0j | 5.2g | 5.2g | 3.8s | 5.3s |
| Garigliano | 3.3g-k | 3.4g-k | 55.9 bc | 64.3a | 5976klm | 52611m | 79.0j | 76.0n | 15.3fg | 14.8f | 6g | 5.3g | 4.8jk | 5.4p |
| Grifoni 235 | 3.9d-g | 3.4f-i | 53.5cd | 54.8bc | 7381g-m | 6292j-m | 80.5h | 75.5o | 15.8e | 13.0m | 13g | 10.3g | 4.5jk | 4.9q |
| 1985-2005 | | | | | | | | | | | | | | |
| Adamello | 3.9e-h | 4.1c-g | 55.4bc | 37.5j | 6990g-m | 11044de | 79.8i | 67.4s | 14.1ij | 16.1cd | 65ab | 43def | 5.3op | 5.2klm |
| Simeto | 3.9d-h | 4.4c-f | 47.5ef | 38.0ij | 8287ghi | 11702de | 69.4i | 81.6r | 15.5f | 13.5l | 46def | 47cde | 6.1klm | 6.4c |
| Preco | 3.7f-i | 4.0c-g | 57.3b | 31.5l | 6392i-m | 12819bcd | 79.7ef | 66.9t | 13.1m | 16.0de | 39f | 13g | 8.5b | 8.7a |
| Svevo | 4.7cd | 4.8c | 45.8fg | 33.6kl | 10327ef | 14176ab | 82.1de | 73.5q | 16.2cd | 15.1g | 51cd | 41def | 8.1 c | 7.9cde |
| Claudio | 4.5cde | 6.0ab | 51.0de | 41.5hi | 8833fg | 14358ab | 84.3 a | 81.6fg | 12.5o | 11.8q | 66ab | 72a | 6.2jkl | 5.9no |
| Iride | 4.6cde | 5.7b | 54.2bcd | 35.9jk | 8568fgh | 15797a | 82.3d | 80.4h | 13.1m | 11.6q | 48cd | 45def | 6.0lmn | 6.6gh |
| Saragolla | 4.6cde | 6.6a | 37.9ij | 43.7 gh | 12086cde | 15077 a | 82.9c | 80.1hi | 12.8n | 12.1p | 73ab | 75a | 7.8de | 7.7ef |
| PR22D89 | 4.6CDE | 5.7B | 56.8BC | 41.2 HI | 8091G-J | 13928ABC | 83.7B | 74.6P | 12.5 O | 13.0M | 59BC | 36EF | 7.3HI | 8.0CD |
| 1900-1949 | 3.3c | 3.0c | 49.4 a | 50.3 a | 6853 c | 6137 c | 79.6 ab | 77.6 b | 16.0 a | 14.1 b | 9.6b | 7.5b | 4.7 b | 4.9 b |
| 1985-2005 | 4.3b | 5.2a | 50.7a | 37.9 b | 8697 b | 13613 a | 82.0 a | 74.2 c | 13.7 b | 13.6 b | 55.3a | 46a | 6.8 a | 6.9 a |


% α,γ- gliadin
glia : glut
% ω- gliadin
GPC
HMW-GS : B- LMW-GS ratio
Year of release
G.I.
% B- type LMW-GS
% C- type LMW-GS
% HMW-GS
Factor 1 (52%)
Factor 2 (22%)


old 2013
old 2014
modern 2013
modern 2014
Russello
Dauno III
Timilia RB
old Saragolla
Grifoni 235
Svevo
Claudio
Adamello
Saragolla
Gargliano
Cappelli
Simeto
Iride
Preco
PR22D89
Factor 1 (52%)
Factor 2 (22%)

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## Storage protein composition of old and modern durum wheat genotypes

| Genotypes | glia :glut | | HMW-GS (%) | | B- type LMW-GS (%) | | C- type LMW–GS (%) | | HMW-GS : B-type LMW-GS | | ω-type gliadin (%) | | α, γ-type gliadin (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 |
| 1900-1949 | | | | | | | | | | | | | | |
| Dauno III | $2.4^{DEF}$ | $2.9^{CDE}$ | $9.7^{F}$ | $9.2^{FGH}$ | $11.3^{HIJ}$ | $8.1^{J}$ | $7.4^{B-J}$ | $7.3^{B-J}$ | $0.86^{c}$ | $1.13^{b}$ | $14.1^{C}$ | $11.2^{DE}$ | $56.3^{D-K}$ | $62.9^{B-F}$ |
| old Saragolla | $1.8^{DEF}$ | $1.8^{DEF}$ | $9.3^{FG}$ | $7^{MN}$ | $19.4^{C-F}$ | $17.9^{D-G}$ | $4.3^{E-K}$ | $8.6^{B-G}$ | $0.48^{g-m}$ | $0.39^{lm}$ | $10.3^{F}$ | $10.8^{EF}$ | $54.5^{F-L}$ | $54.0^{F-L}$ |
| Cappelli | $2.5^{C-F}$ | $2.6^{C-F}$ | $7.3^{M}$ | $6.1^{PQ}$ | $16.8^{EFG}$ | $16.7^{EFG}$ | $3.5^{H-K}$ | $4.4^{E-K}$ | $0.43^{j-m}$ | $0.37^{lm}$ | $9.2^{G}$ | $7.7^{H}$ | $62.0^{B-G}$ | $64.3^{A-E}$ |
| Russello | $2.1^{DEF}$ | $1.8^{DEF}$ | $9.4^{GHI}$ | $9.7^{GHI}$ | $7.0^{J}$ | $13.3^{GHI}$ | $14.8^{A}$ | $10.8^{ABC}$ | $1.35^{a}$ | $0.72^{c-f}$ | $10.7^{EF}$ | $7.9^{H}$ | $55.1^{E-L}$ | $55.7^{E-K}$ |
| Timilia R.B. | $3.3^{BCD}$ | $4.0^{BC}$ | $7.4^{M}$ | $5.6^{Q}$ | $8.8^{IJ}$ | $9.7^{IJ}$ | $5.7^{D-K}$ | $3.7^{H-K}$ | $0.84^{c}$ | $0.58^{e-k}$ | $18.2^{A}$ | $17.1^{B}$ | $58.5^{C-J}$ | $63.0^{B-F}$ |
| Garigliano | $4.6^{AB}$ | 5.7° | $6.2^{OP}$ | $4.9^{R}$ | $7.5^{J}$ | $6.64^{J}$ | $4.2^{F-K}$ | $2.7^{JK}$ | $0.83^{cd}$ | $0.74^{cde}$ | $13.7^{C}$ | $11.7^{D}$ | $67.7^{ABC}$ | $73.4^{A}$ |
| Grifoni 235 | $1.5^{EF}$ | $1.7^{DEF}$ | $12.8^{C}$ | $8.6^{JL}$ | $17.3^{EFG}$ | $19.7^{C-F}$ | $9.2^{B-F}$ | $8.0^{JK}$ | $0.74^{cde}$ | $0.44^{j-m}$ | $5.8^{I}$ | $4.8^{JK}$ | $52.9^{G-L}$ | $57.9^{D-J}$ |
| 1985-2005 | | | | | | | | | | | | | | |
| Adamello | $1.9^{DEF}$ | $1.9^{DEF}$ | $8^{L}$ | $6.9^{MN}$ | $17.8^{D-G}$ | $14.7^{FGH}$ | $5.7^{C-K}$ | $10.7^{ABC}$ | $0.46^{i-m}$ | $0.47^{h-m}$ | $5.8^{I}$ | $4.5^{KL}$ | $60.3^{B-H}$ | $60.6^{B-H}$ |
| Simeto | $2.0^{DEF}$ | $1.8^{DEF}$ | $8.5^{IL}$ | $9^{G-J}$ | $15.4^{FGH}$ | $16.7^{EFG}$ | $7.7^{B-J}$ | $7.8^{B-J}$ | $0.55^{f-l}$ | $0.54^{g-l}$ | $5.8^{I}$ | $5.2^{IJ}$ | $61.0^{B-H}$ | $59.1^{C-I}$ |
| Preco | $2.1^{DEF}$ | $2.9^{CDE}$ | $9.3^{FGH}$ | $8.7^{H-K}$ | $19.7^{C-F}$ | $13.7^{GHI}$ | $1.8^{K}$ | $2.9^{IJK}$ | $0.47^{h-m}$ | $0.63^{e-i}$ | $5.1^{JK}$ | $4.6^{KL}$ | $62.9^{B-F}$ | $69.4^{AB}$ |
| Svevo | $1.4^{EF}$ | $1.0^{F}$ | $14.5^{B}$ | $15^{A}$ | $22.3^{BCD}$ | $25.9^{B}$ | $8.8^{B-F}$ | $7.2^{B-J}$ | $0.65^{e-h}$ | $0.58^{e-k}$ | $4.8^{JK}$ | $3.3^{NO}$ | $48.4^{KL}$ | $46.2^{L}$ |
| Claudio | $1.4^{EF}$ | $1.4^{EF}$ | $11.3^{D}$ | $12.1^{C}$ | $17.3^{EFG}$ | $19.8^{D-G}$ | $11^{AB}$ | $9.4^{B-E}$ | $0.66^{d-g}$ | $0.61^{e-j}$ | $4.0^{LM}$ | $3.1^{OP}$ | $54.8^{F-L}$ | $54.7^{F-L}$ |
| Iride | $1.3^{EF}$ | $2.2^{DEF}$ | $9.7^{F}$ | $7^{MN}$ | $23^{BC}$ | $17.7^{D-G}$ | $9.8^{A-D}$ | $6.7^{B-K}$ | $0.42^{k-m}$ | $0.40^{klm}$ | $3.7^{MN}$ | $2.4^{PQ}$ | $52.1^{H-L}$ | $65.3^{A-D}$ |
| Saragolla | $1.1^{F}$ | $1.1^{F}$ | $10.5^{E}$ | $12.6^{C}$ | $31^{A}$ | $26.4^{AB}$ | $5.4^{D-K}$ | $7.6^{B-J}$ | $0.34^{m}$ | $0.48^{g-m}$ | $2.2^{Q}$ | $1.5^{R}$ | $49.7^{JKL}$ | $49.7^{I-L}$ |
| PR22D89 | $1.4^{EF}$ | $2.1^{DEF}$ | $9.3^{FGH}$ | $7^{NO}$ | $24.9^{B}$ | $19.2^{C-F}$ | $6.2^{B-K}$ | $4.9^{D-K}$ | $0.37^{lm}$ | $0.35^{m}$ | $3.7^{MN}$ | $3.5^{MNO}$ | $54.0^{F-L}$ | $64.3^{A-E}$ |
| 1900-1949 | $2.6^{A}$ | $2.9^{A}$ | $8.9^{b}$ | $7.3^{c}$ | $12.6^{b}$ | $13.2^{b}$ | $7.1^{a}$ | $6.5^{a}$ | $0.79^{a}$ | $0.63^{ab}$ | $11.7^{a}$ | $10.2^{a}$ | $58.1^{AB}$ | $61.6^{A}$ |
| 1985-2005 | $1.6^{B}$ | $1.8^{B}$ | $10.1^{a}$ | $9.8^{a}$ | $21.4^{a}$ | $19.3^{a}$ | $7.1^{a}$ | $7.2^{a}$ | $0.49^{b}$ | $0.51^{a}$ | $4.4^{b}$ | $3.4^{b}$ | $55.4^{B}$ | $58.7^{AB}$ |

Values in a row followed by different letters are significant different at $P < 0.05$ (small letters) and at $P < 0.001$ (capital letters) according to the Tukey's test

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# Experimental design

15 durum wheat genotypes
(*Triticum turgidum* L., spp *durum*)

(7 old + 8 modern wheats)

X

2 field trial crop seasons
(2013 and 2014)

X

3 biological repetitions
(completely randomized block)

Eur. J. Biochem. 255, 739–745 (1998)
© FEBS 1998

**Identification of major wheat allergens by means of the *Escherichia coli* expression system**

Nobuyuki MARUYAMA[1], Keiko ICHISE[1], Tomoyuki KATSUBE[1,2], Toru KISHIMOTO[1], Shin-ichiro KAWASE[1], Yasuki MATSUMURA[1], Yoshihiro TAKEUCHI[3], Tadashi SAWADA[3] and Shigeru UTSUMI[1]
[1] Research Institute for Food Science, Kyoto University, Uji, Kyoto, Japan
[2] Shimane Women's College, Matsue, Shimane, Japan
[3] Department of Pediatrics, Kyoto Prefectural University of Medicine, Kyoto, Japan

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Allergy

ORIGINAL ARTICLE — BIOTECHNOLOGY AND *IN VITRO* DIAGNOSTICS

**Multiple wheat flour allergens and cross-reactive carbohydrate determinants bind IgE in baker's asthma**

I. Sander[1], P. Rozynek[1], H.-P. Rihs[1], V. van Kampen[1], F. T. Chew[2], W. S. Lee[2], N. Kotschy-Lang[3], R. Merget[1], T. Brüning[1] & M. Raulf-Heimsoth[1]

[1]Institute for Prevention and Occupational Medicine, German Social Accident Insurance, Institute of the Ruhr-Universität Bochum, IPA, Germany; [2]Department of Biological Sciences, National University of Singapore, Singapore; [3]Berufsgenossenschaftliche Klinik für Berufskrankheiten, Falkenstein, Germany

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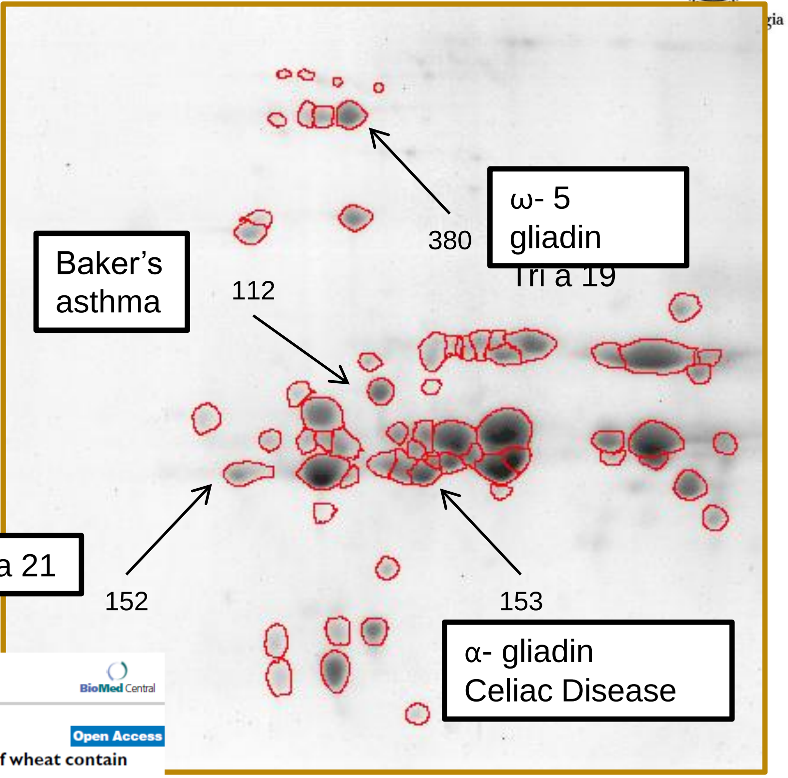


JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY — Article — pubs.acs.org/JAFC

**Differential Expression of Durum Wheat Gluten Proteome under Water Stress during Grain Filling**

Marcella Michela Giuliani,† Carmen Palermo,† Michele Andrea De Santis,† Annalisa Mentana,† Marianna Pompa,† Luigia Giuzio,† Stefania Masci,§ Diego Centonze,† and Zina Flagella*,†

†Dipartimento di Scienze Agrarie, degli Alimenti e dell'Ambiente (SAFE), Università degli Studi di Foggia, Via Napoli 25, 71122 Foggia, Italy
§Dipartimento di Scienze e Tecnologie per l'Agricoltura, le Foreste, la Natura e l'Energia (DAFNE), Università degli Studi della Tuscia, Via S. Camillo de Lellis snc, 01100 Viterbo, Italy

**BMC Genomics** — BioMed Central

Research article — Open Access

**Alpha-gliadin genes from the A, B, and D genomes of wheat contain different sets of celiac disease epitopes**

Teun WJM van Herpen*[1,2], Svetlana V Goryunova[2,3], Johanna van der Schoot[2], Makedonka Mitreva[2,4], Elma Salentijn[2], Oscar Vorst[2], Martijn F Schenk[1,2], Peter A van Veelen[5], Frits Koning[5], Loek JM van Soest[6], Ben Vosman[2], Dirk Bosch[1,2], Rob J Hamer[7], Luud JWJ Gilissen[1,2] and Marinus JM Smulders[1,2]

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from Giuliani *et al.*, 2015

| spot | Accession (NCBI nr general index) | Proteins | species | Mascot Score | sequence coverage (%) | theor Mw (kDa); pI | no. of peptide matches | peptide sequence |
|---|---|---|---|---|---|---|---|---|
| 152 | 1304264 | α –gliadin | Triticum aestivum | 84 | 14 | 30.3; 6.18 | 3 | VRVPVPQLQPQ; NPSQQQPQEQVPL; RPQQPYPQPQPQY |
| 112 (453) | 283476402 | α-gliadin precursor | Triticum aestivum | 66 | 6 | 32.9; 6.62 | 1 | QQPNIAHASSQVSQQSY |
| 506 (153) | 66393328 | α-gliadin | Triticum monococcum | 116 | 14 | 31.09; 7.14 | 3 | LQLQPFPQPQLPY; RPQQPYPQPQPQY; QQPQQQYPLGQGSFRPSQQNPQA |

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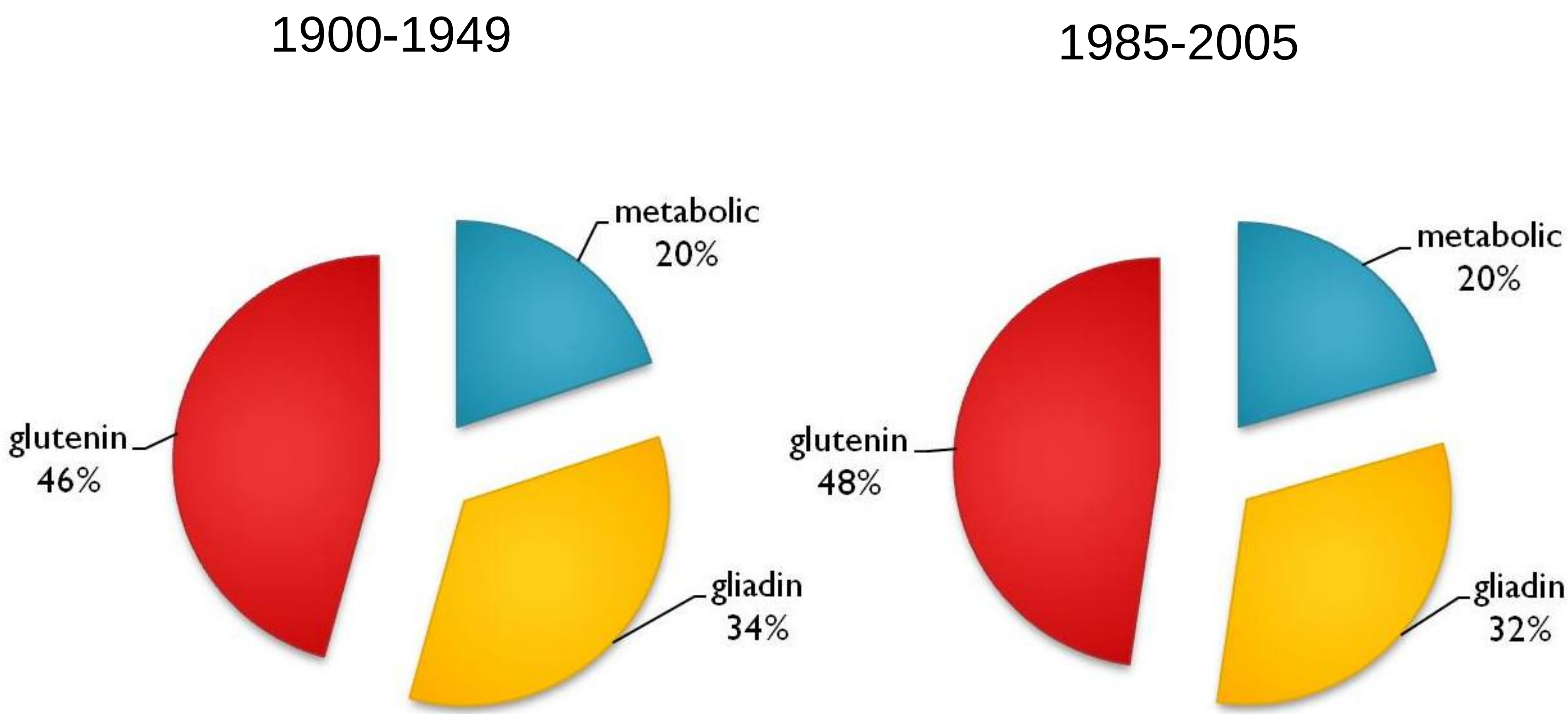
# Grain protein composition



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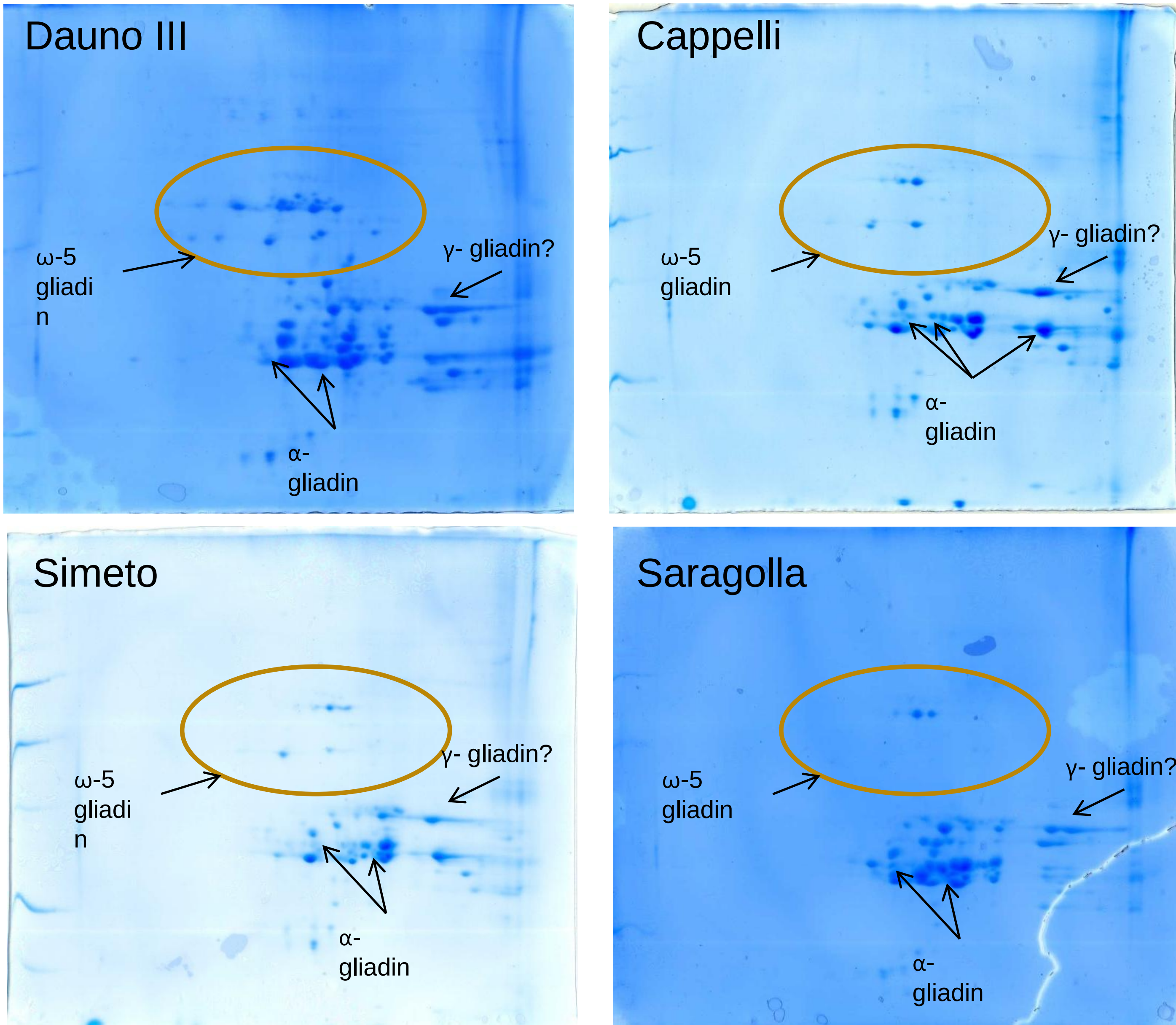
# 2DE SDS-PAGE of gliadin



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# Matrix of correlation of protein content, composition and technological quality

| | Year of release | Protein content | Gluten Index |
|---|---|---|---|
| Year of release | 1.00 | -0.50 | 0.85 |
| Protein content | -0.50 | 1.00 | -0.53 |
| Gluten Index | 0.85 | -0.53 | 1.00 |
| % metabolic | 0.16 | -0.70 | 0.22 |
| % insoluble glutenin | -0.16 | 0.29 | -0.16 |
| % gliadin | -0.27 | 0.12 | -0.35 |
| % soluble glutenin | 0.56 | -0.27 | 0.63 |
| % total glutenin | 0.19 | 0.16 | 0.24 |
| % storage | -0.16 | 0.70 | -0.22 |
| % ω- gliadin | -0.85 | 0.44 | -0.75 |
| % γ, α- gliadin | -0.22 | 0.00 | -0.41 |
| % HMW-GS | 0.39 | -0.04 | 0.44 |
| % B- LMW-GS | 0.70 | -0.33 | 0.70 |
| % C- LMW-GS | 0.07 | 0.05 | 0.17 |
| gliadin : glutenin | -0.23 | 0.02 | -0.30 |
| gliadin : soluble glutenin | -0.51 | 0.11 | -0.60 |

| | | | | |
|---|---|---|---|---|
| -0.75 | -0.50 | 0 | 0.5 | -0.75 |