Environmental conditions affects wheat grain texture: consequences on grain fractionation and flour properties ?

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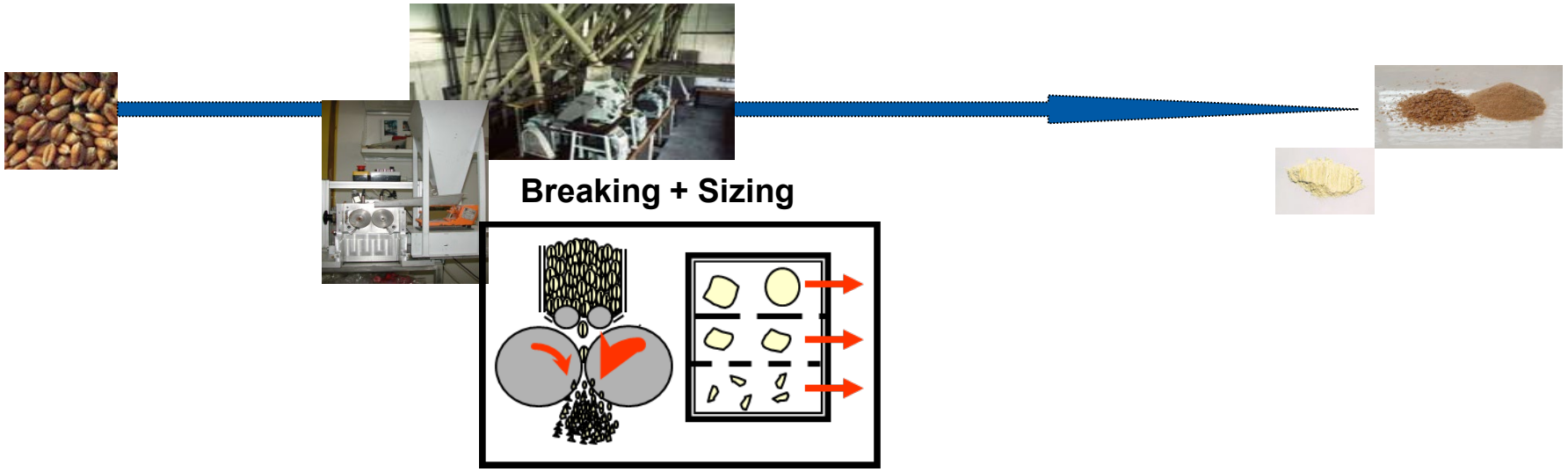
Texture **:** composition, consistency, constitution, structure, …

Fate of the different wheat grain tissues along milling has a main effect on yield and biochemical composition of the recovered products



Main involvement of the **grain tissue mechanical properties** (breaking resistance/hardness)

Wheat Hardness can be controlled through genes located in CH5D encoding puroindolines A et B

involved in the adhesion between starch granules and the protein network

T. durum
AABB genome
Mechanical Resistance
+++

Translocation in durum cv. Svevo of both **wild** type alleles *Pina-D1a* et *Pinb-D1a* (***Morris et al., 2011)***

Durum(Svevo)-Pin (expected soft phenotype)

T. aestivum
AABBDD genome

2 hardness class in locus *Ha*/CH5Ds
(*Law et al., 1978*)

Hard
++

Soft
+

Near-isogenic lines for hardness

wild type allele *Pina-D1a,*
mutated *Pinb-D1* allele (**b** or **d**)

wild type alleles *Pina-D1a* et *Pinb-D1a*

To evaluate the respective effect of genetic or environmental factors on grain characteristics & milling behavior…

common wheat
near-isogenic lines (≠<1.6%)
for hardness
wild or **mutated allele**
*Pinb-D1**a*** *Pinb-D1* (**b** or **d**)

durum wheat
Svevo or *Svevo* +
*Pina-D1**a**/Pinb-D1**a***

+ cultivars whose
puroindoline alleles were identified:
*Pinb-D1**a*** (wild) or mutated (**b**, **c** or **d**)

+ durum wheat cultivars
(no puroindolines)

grown in different environments (locations, years, N supply)

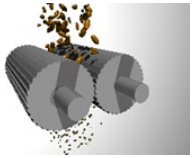
Examine grain characteristics (« hardness/vitreousness » reported) & milling behavior including tissue distribution

Grain characteristics

Hardness

Indirect measurement

(linked to particle size)

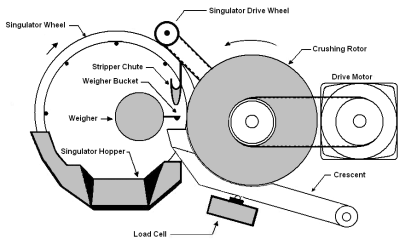


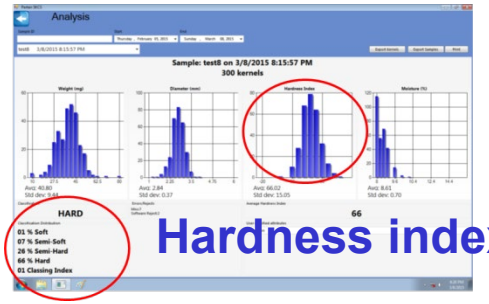
75 µm

% fine particles
= **PSI value**
or through IR measurement
= **NIRS** value

90>	NIRS	<10
Extra hard		*Extra soft*

Direct mechanical resistance measurement (SKCS)

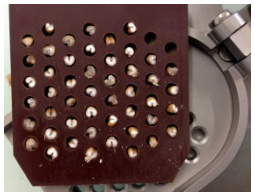


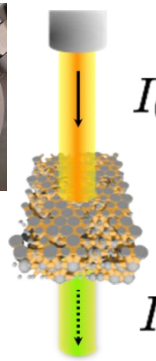


Hardness index *Hi* values

Vitreousness

Estimated through Pohl grain cutter





Quantified through measurement of light transmission (*Beer Lambert* law)
Chichti et al., 2018

I_T Reflects **porosity** level

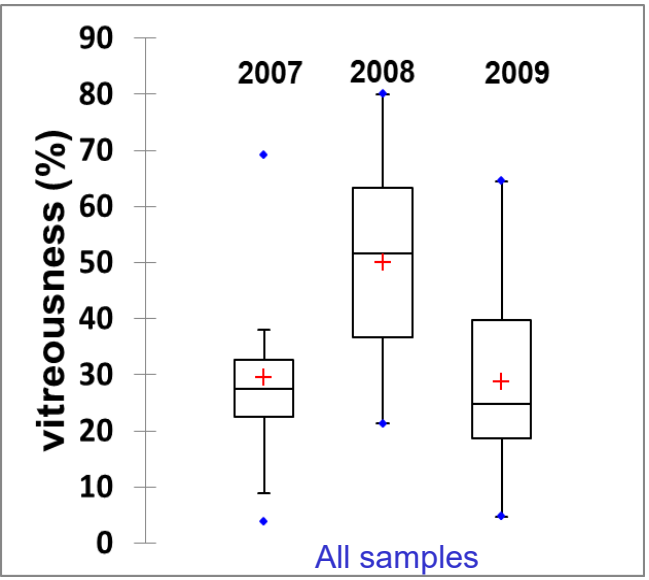
Effect of environmental conditions on grain texture

common wheat near-isogenic lines + ct cultivar, 3 years, 7 sites, 2 ≠ N supply (n=304 samples)

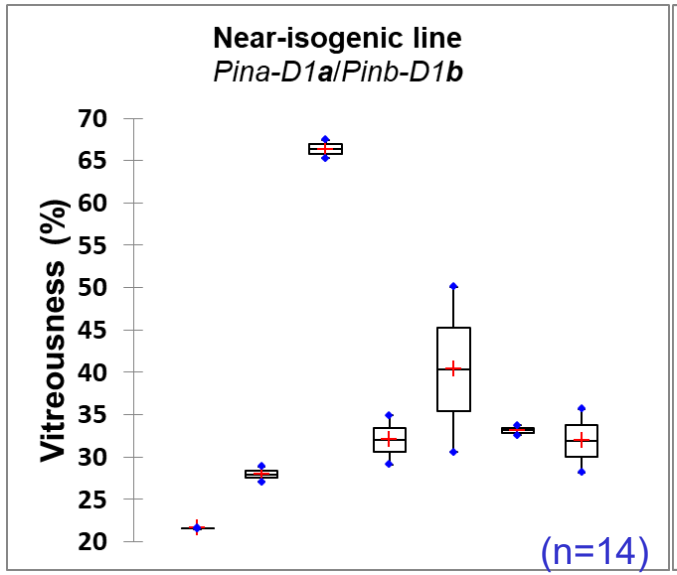
ANOVA study revealed the **high significance on vitreousness**

Oury et al. TAG (2015)

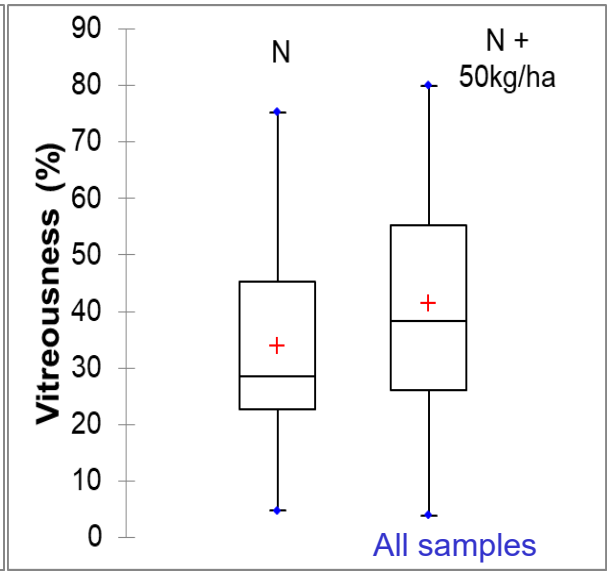
Marked effect (*p* value <0.001) of :



year



location



N supply

Effects on Pinb-D1 alleles on grain characteristics

Independent study on comparison between NILs
* with wild type *Pinb-D1a* (or mutated *Pinb-D1b* allele)
* with (*Pinb-D1b* or *Pinb-D1d*)

ANOVA study revealed **no significant differences between NIL pairs for TGW, TW** or **protein** mean values

	NIRS mean value	SKCS mean value	Vitreousness mean value (%)
Pinb-D1a	20.2	18.9	29.2
Pinb-D1b	61.6	52.3	41.5
Significance	***	***	***
Pinb-D1b	73.3	51.1	44.9
Pinb-D1d	67.1	46.9	42.1
Significance	***	(*)	ns

x3

b>d

b>d

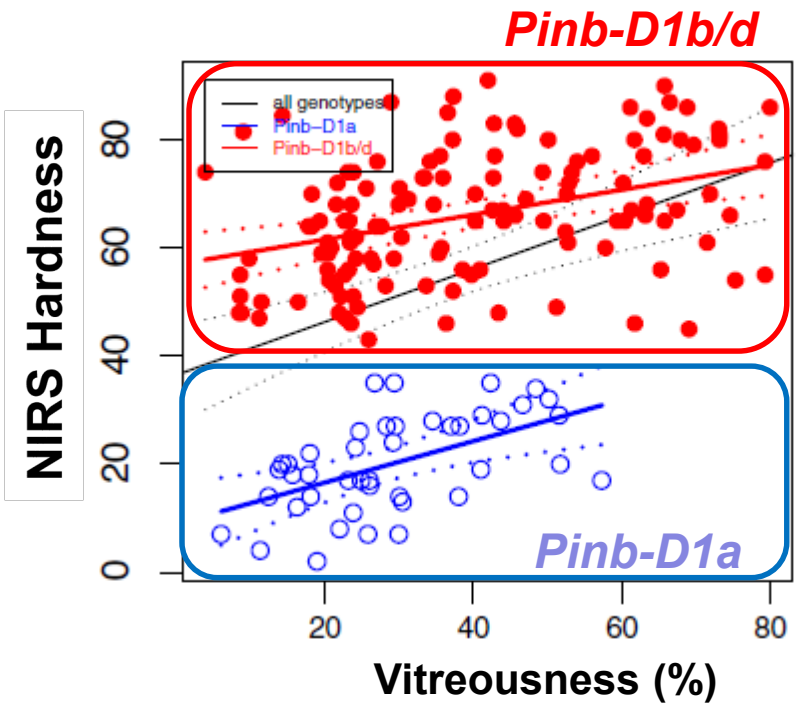
X1.5

Pinb-D1 allele impacts vitreousness

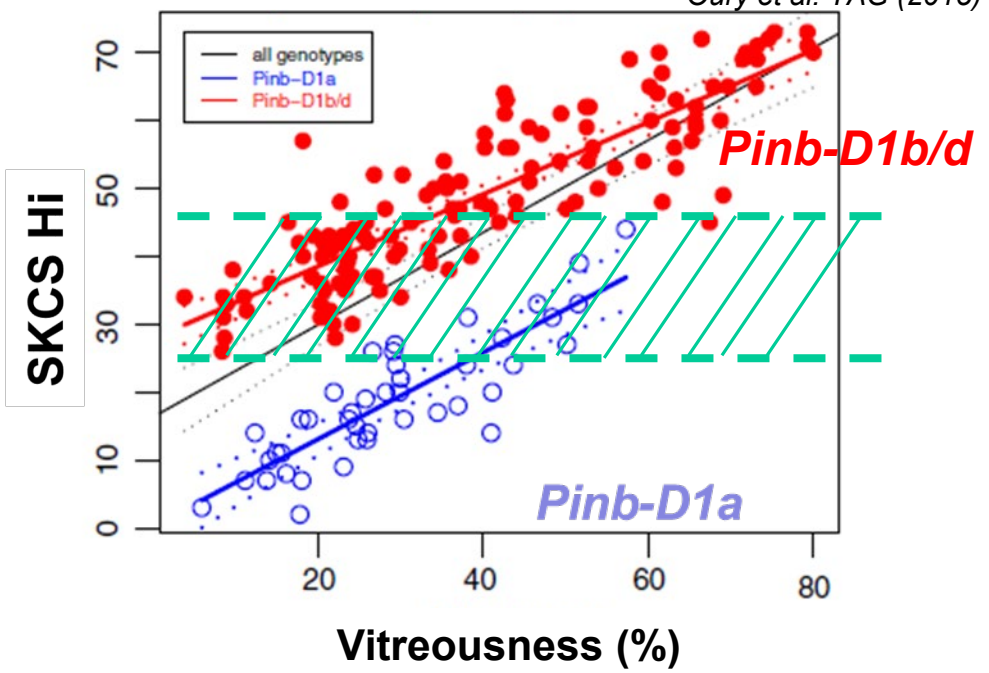
*** *p* value < 0,001 ; (*) *p* value < 0,1 ; ns non significant

Oury et al. TAG (2015)

Relationship between NIRS hardness, SKCS Hi & vitreousness depending on *Pinb-D1* allele



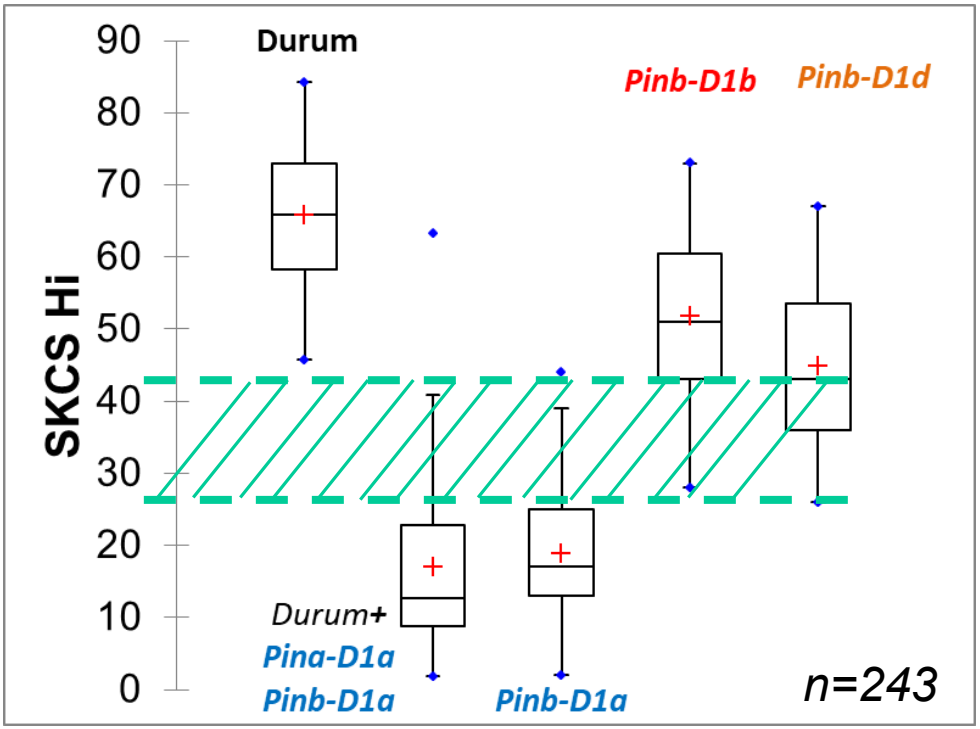
Oury et al. TAG (2015)

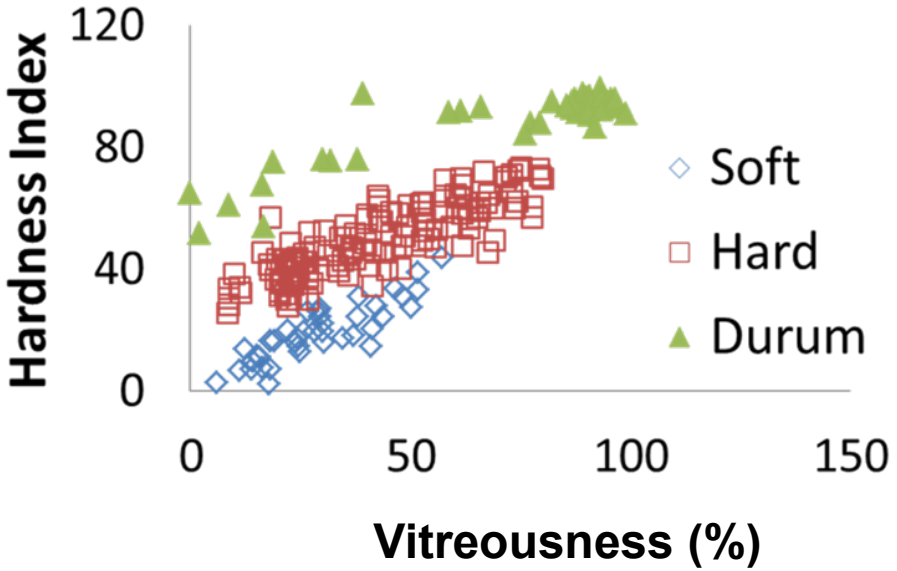


Vitreousness increases the E to break whatever the Pin allele
A **threshold of vitreousness and SKCS value** was observed if ***Pinb-D1a*** allele is present

Grains carrying *Pinb-D1b*/or *d* **+ low** vitreousness can be mixed with those carrying ***Pinb-D1a*** **+ high** vitreousness

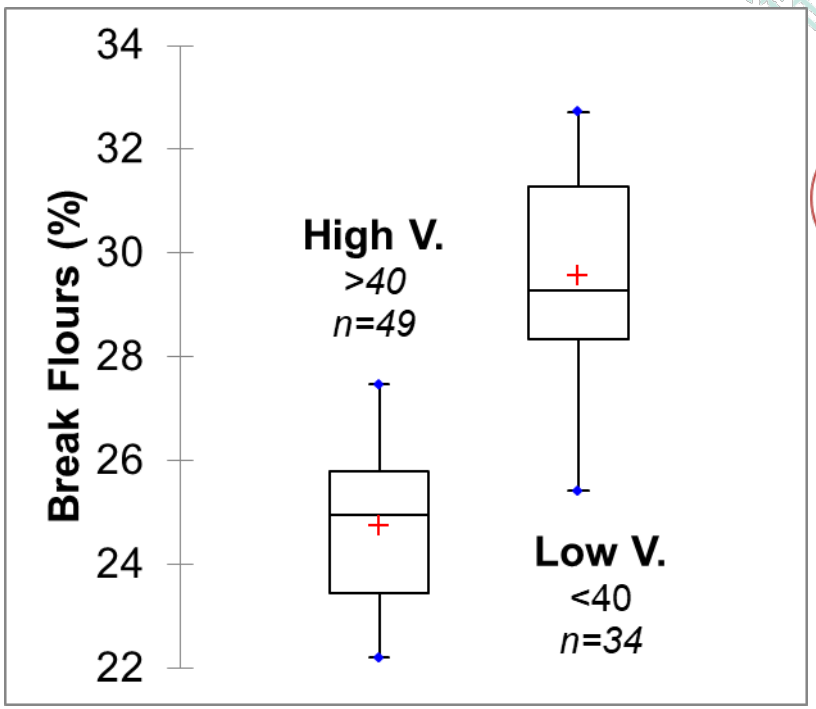
SKCS Hi values depends on *Pinb-D1* allele but possible overlap due to environmental conditions

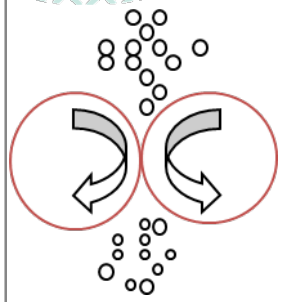


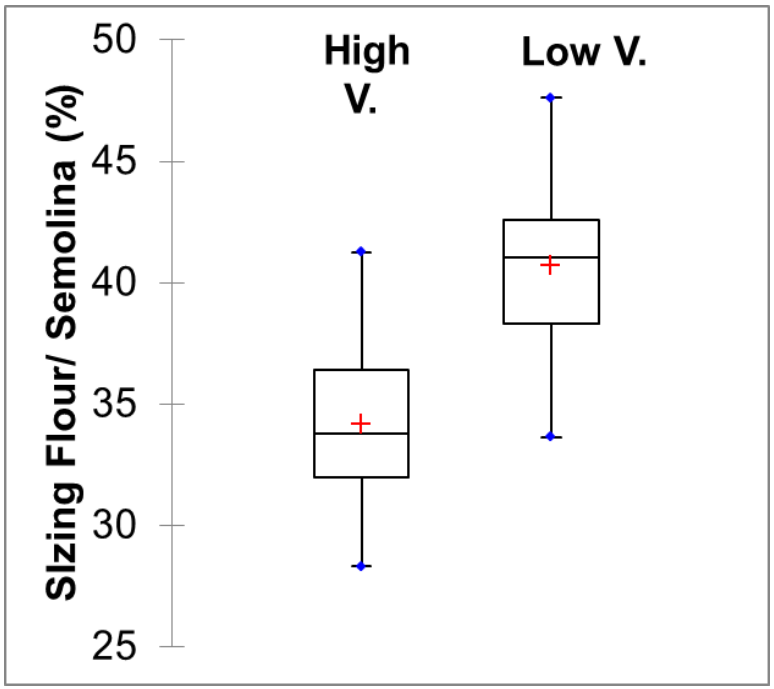


Oury et al. TAG (2015)
Joubert et al. Ind Cereales (2016)
Heinze et al. JCS (2016)

How distinct vitreousness will affect the milling behaviour (samples carrying *PinbD1b/d*)?





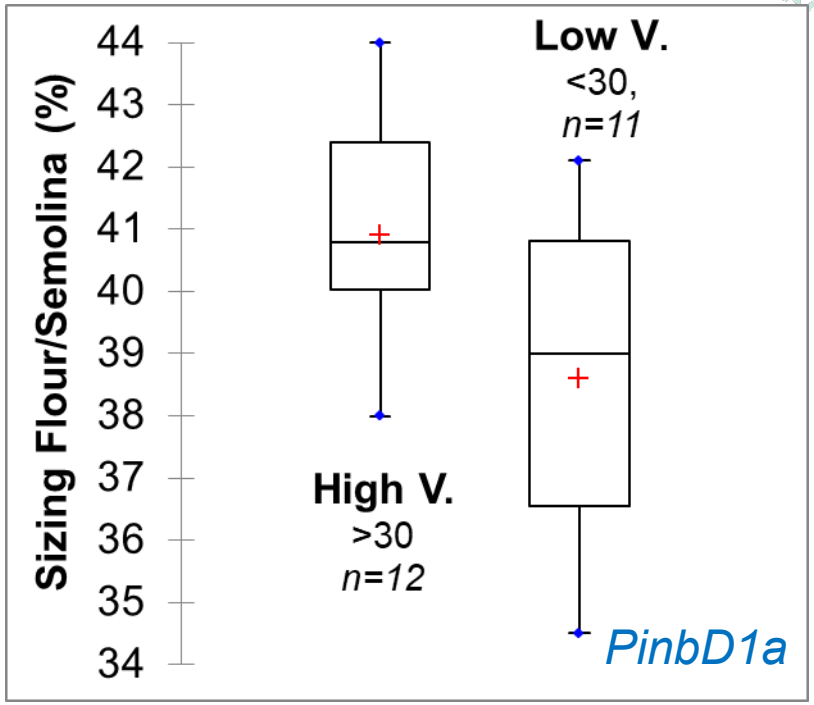


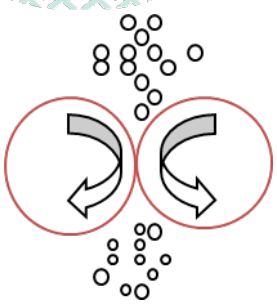
Vitreousness leads to :

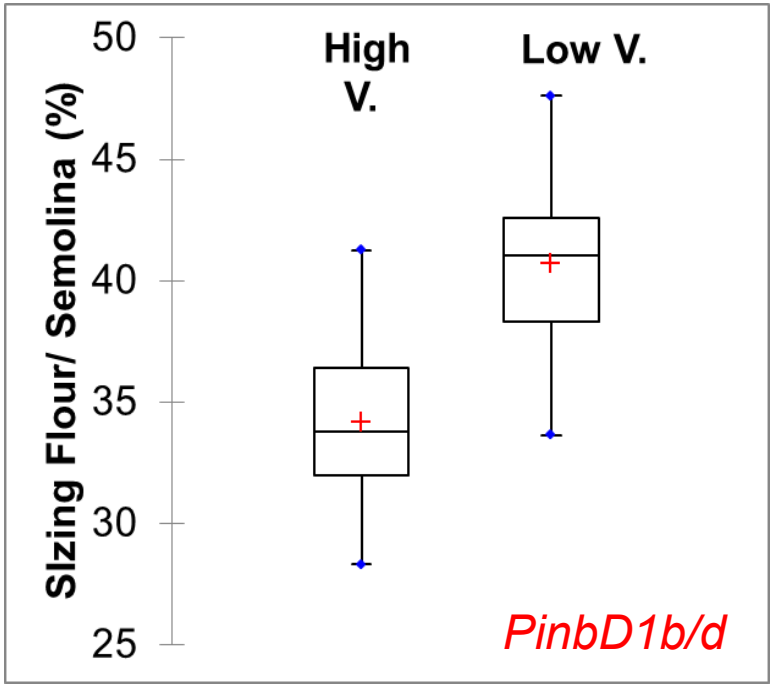
- Lower the ability to produce flour
- Increase the amount of E to break
- Increase starch damaged in flour

Mayer et al, IFSET (2018)
Oury et al, TAG 2017
Chichti PhD 2013
Lasme et al. Cereal Chem 2012
Greffeuille et al. TAG 2006

How distinct vitreousness will affect the milling behaviour (*PinbD1a* versus *PinbD1b/d*)?





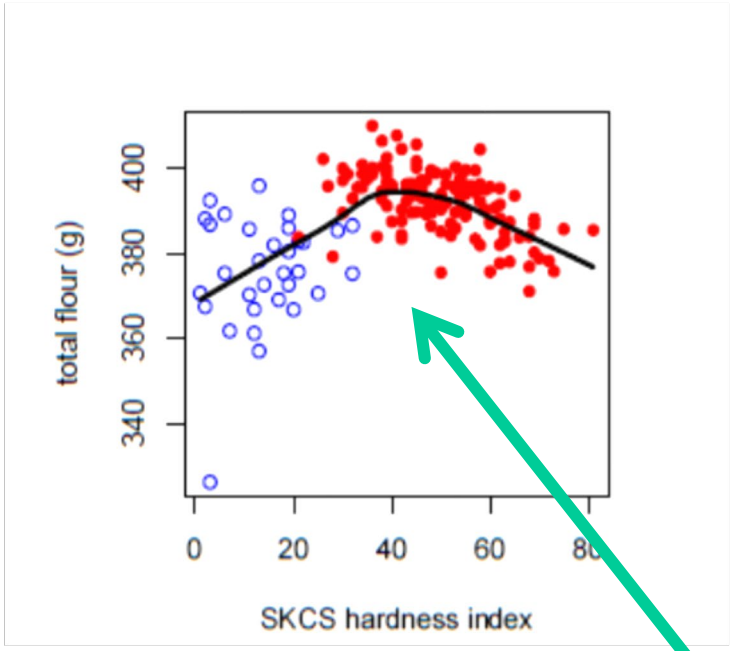


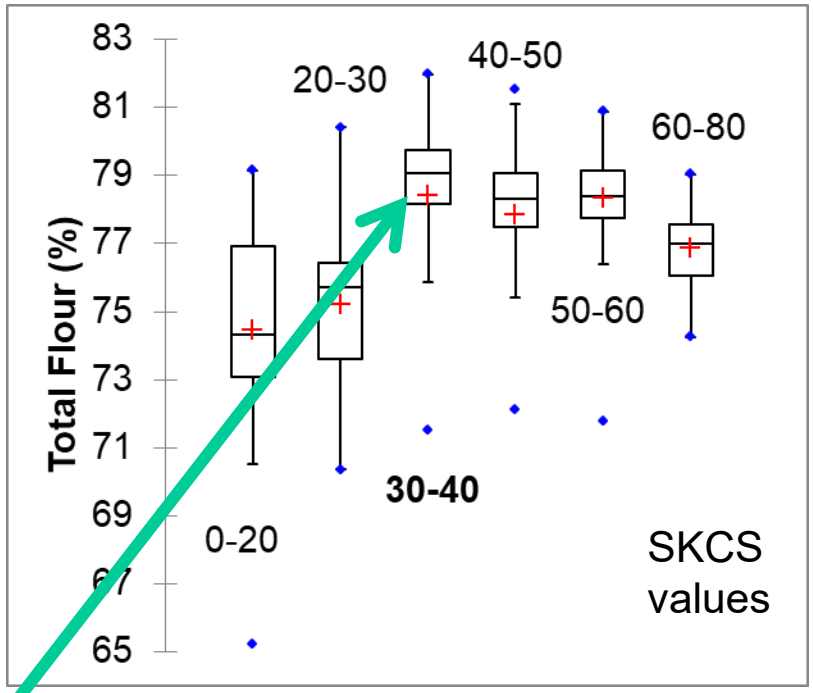
Different behaviour depending both on *Pinb-D1* allele & environment

* Favorable effect of vitreousness if *PinbD1a* is present
* Unfavorable effect of vitreousness if *PinbD1b/d* is present

Oury et al, TAG 2017
Greffeuille et al. TAG 2006

Combining vitreousness and *Pin B-D1* allele leads to an optimum for total flour yield

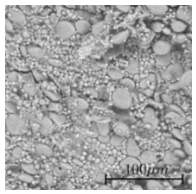


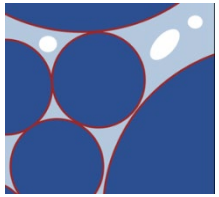


Optimum total flour amount corresponds to either grains carrying *Pinb-D1b/c/d* with low vitreousness or carrying *Pinb-D1a* + high vitreousness (**SKCS values ~ 30-40**)

Oury et al. TAG (2017)

CONCLUSIONS





Grain texture affects its mechanical properties & depends on :

- **Genetics: puroindoline allele**
- **Environmental conditions: vitreousness (=1/porosity)**

(Year, Sites, N supply) impacts **Vitreousness**

- whose level depends on *Pinb-D1* presence a<<d<b

- which is related linearly with SKCS values but with specific equation depending on puroindoline alleles

- which affects grain milling behaviour: increase the breaking E, starch damage, modify the ability to produce & reduce semolina
  (>0 for grains carrying *Pinb-D1a*, <0 for those carrying *Pinb-D1b/c/d*)

Optimum total flour production for SKCS values ~ 30-40
(vitreous grains with *Pinb-D1a* or porous grains with *Pinb-D1b/c/d*)

Numerical modelling of the starchy endosperm was developed to mimic & describe breakage behaviour

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Near-isogenic lines

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Durum wheat + Pin genes

USDA

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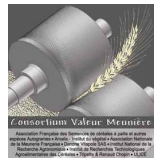
Projects

Consortium Valeur Meunière I



Consortium Valeur Meunière II: UFS, ANMF, ARVALIS-Institut du végétal, Bühler, Chopin Technologies, ENILIA-ENSMIC, IRTAC, INRA, Lu France + Fonds de Soutien Obtention Végétale