



Integrating the variability of wheat minor components to model farinograph absorption

Laura REZETTE, Kamal KANSOU, Sophie LE GALL, Didier MARION, Guy DELLA VALLE, Luc SAULNIER- INRAE, UR 1268 BIA - NANTES- FRANCE



Introduction & context

Proteins and damaged starch are known to have great **impact on the water absorption of the flour** and more generally on **breadmaking**. Other components of the flour, such as **lipids and pentosans** have been acknowledged for their influence on bread quality. The aim of this study was to determine how the extent of **the natural variability of these minor components affects water absorption and, consequently, flour quality**, and to identify whether these components can provide **new quality assessment criteria**.

This work was conducted on **150 wheat samples** (2021 harvest) as part of the Evagrain project*.

*EVAGRAIN is funded by the French National Research Agency and coordinated by the INRAE research unit BIA. The aim of this project is to design a Decision Support System able to give a quality assessment of wheat for various end-uses. The project brings together 10 academic and private partners that will collect a dataset on wheat samples from different varieties grown at various locations in France in 2021 and 2022 (150 samples each year).

Investigated variables

150 wheat samples (2021 harvest) were characterized, encompassing:

36 quality variables:

scores and measurements during the breadmaking test (example: elongation during shaping).

30 professional variables:

usual measurements on wheat and wheat flour (example : farinograph water absorption).

54 scientific variables:

all non-standard measurements carried out in partner laboratories, mostly compositional variables.

22 variables were selected for the statistical analysis :

- 5 variables related to pentosans (inc. DP.AX)
- 7 variables related to lipids (inc. C18)
- 2 variables related to damaged starch (DS_p , DS_g)*
- 7 variables related to proteins
- 1 variable related to enzyme activity (Hagberg)

	Definition	Interval and unit
Proteins	Protein content	[7.85- 11.01] g/100g
DP.AX	Reflect the concentration of soluble arabinoxylans and their intrinsic viscosity	[201.0- 834.4] mV.mL
C18	Total amount of stearic acid	[11.5.10 ⁻³ - 18.0.10 ⁻³] g/100g
DS_g	Soluble glucose polymers	[2.23- 4.21] g/100g
DS_p	Iodine absorption measured with SDmatic	[8.7- 23.9] UCD

***Additional variable from flour composition : Damaged Starch glucose (DS_g):**

Quantity and composition of water-soluble and water-insoluble polysaccharides was analysed. During this analysis, we noticed that soluble glucose (DS_g) was possibly a good index for tracking starch absorption (see figure 1 and 2). Damaged starch is commonly measured by iodine absorption method (DS_p). Consequently, DS_g and DS_p collected for this study were used for the statistical analysis.

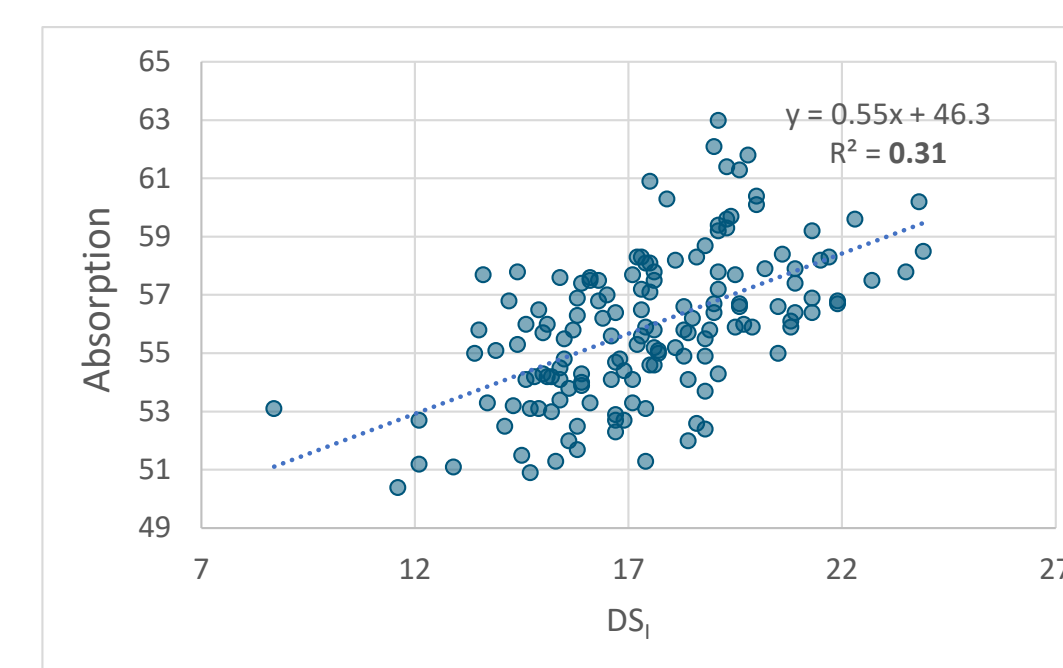


Figure 1 : Correlations between farinograph water absorption and damaged starch obtained by iodine absorption method (DS_p)

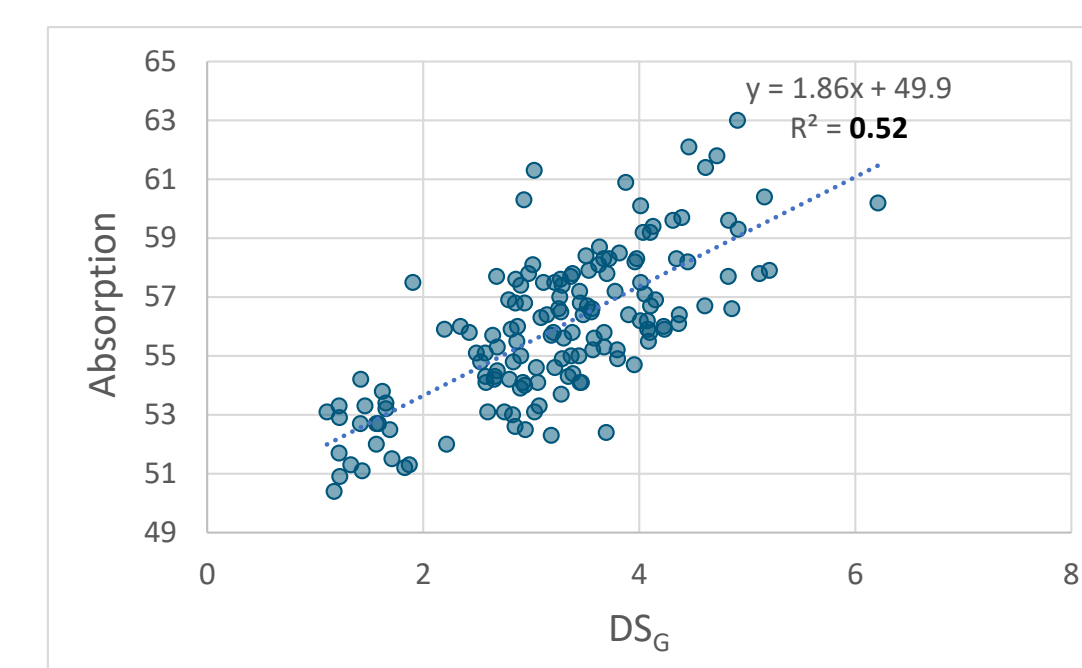
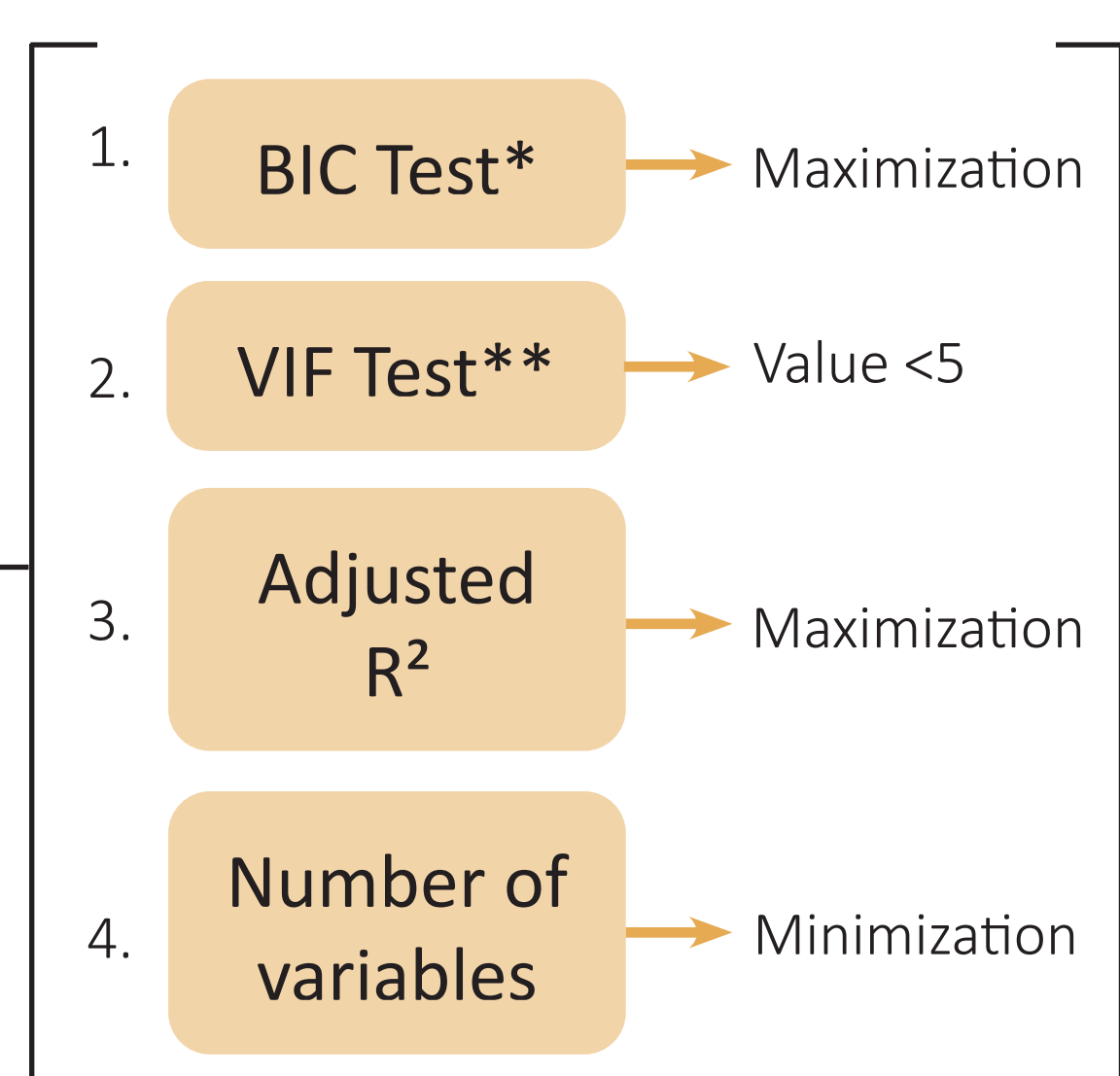


Figure 2 : Correlation between farinograph water absorption and soluble glucose (DS_g)

Statistical analysis approach: to model farinograph absorption

A script was developed using R software to facilitate the systematic implementation of the approach on different data sets and/or variables.

1. Selection of the best regression model

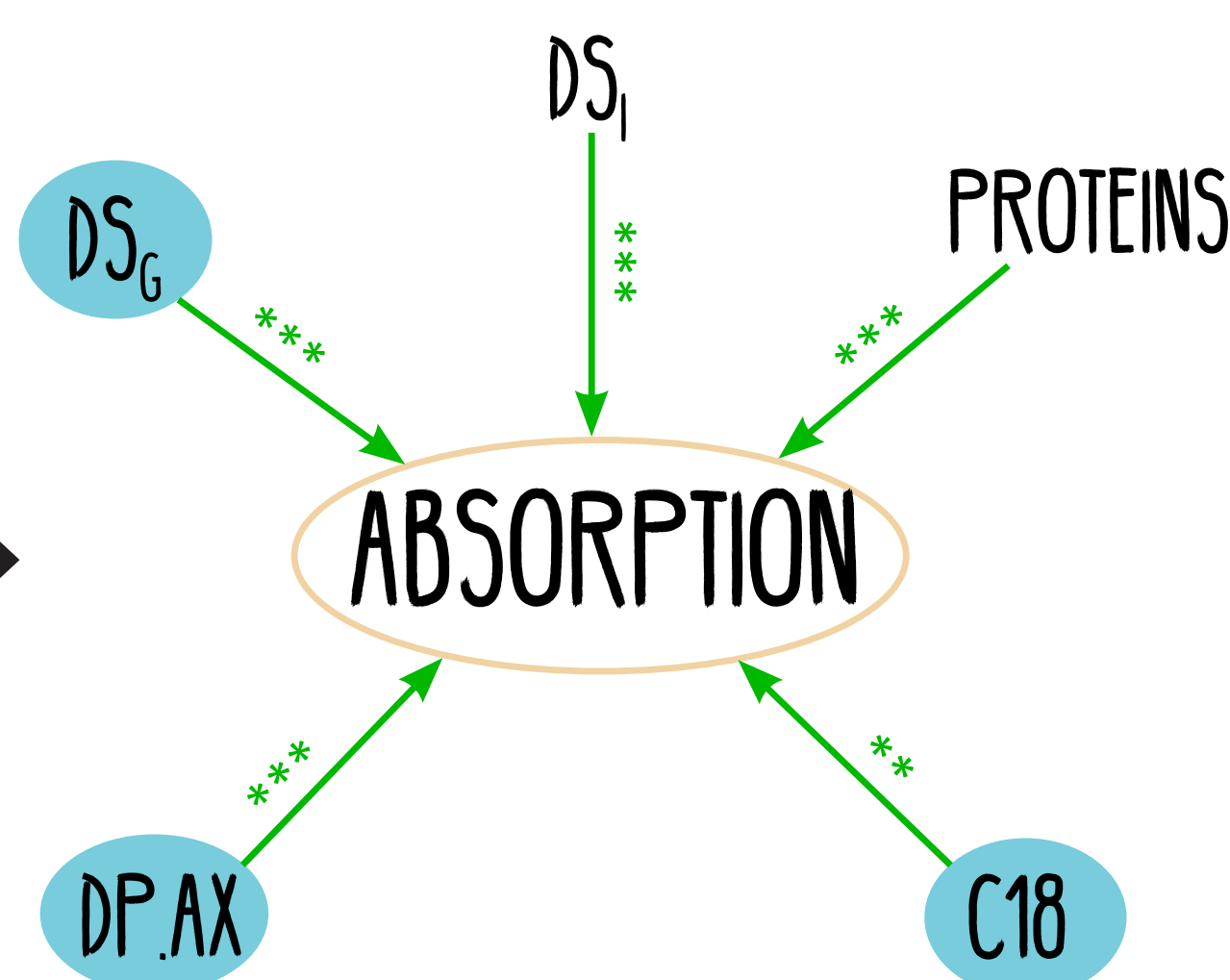


All model combinations with:

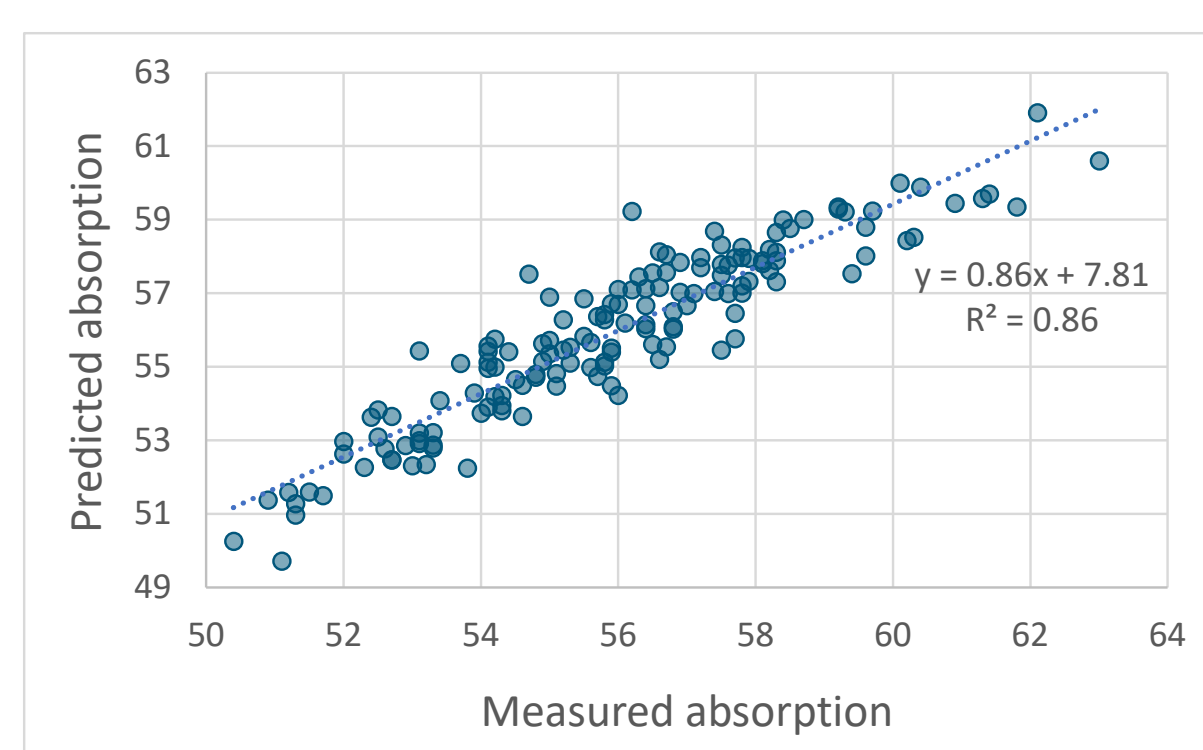
- Y = Quality variable to be explained (absorption)
- X1, X2, ... = 22 explanatory variables of composition

*BIC (Bayesian Information Criterion) test, ranks the various regression models according to the maximum likelihood principle, penalising models with too many variables and avoiding over-learning;
**VIF (Variance Inflation Factor) test, detects multi-collinearity between model variables. A VIF value of less than 5 validates the absence of collinearity.

Minor components can explain the farinograph water absorption, especially the water soluble arabinoxylans (great significance *** of the DP.AX). The model involving only usual composition quality criteria (DS_p and proteins) is improved with the selected model ($R^2 = 0.86$ vs $R^2 = 0.76$).
 DS_p and DS_g are both included in this model, suggesting that each of them explain distinct aspects.



Legend:
○ Quality variable
● New criteria
→ Negative relation
→ Positive relation
Significance of the relation:
0 *** 0.001 ** 0.01 *

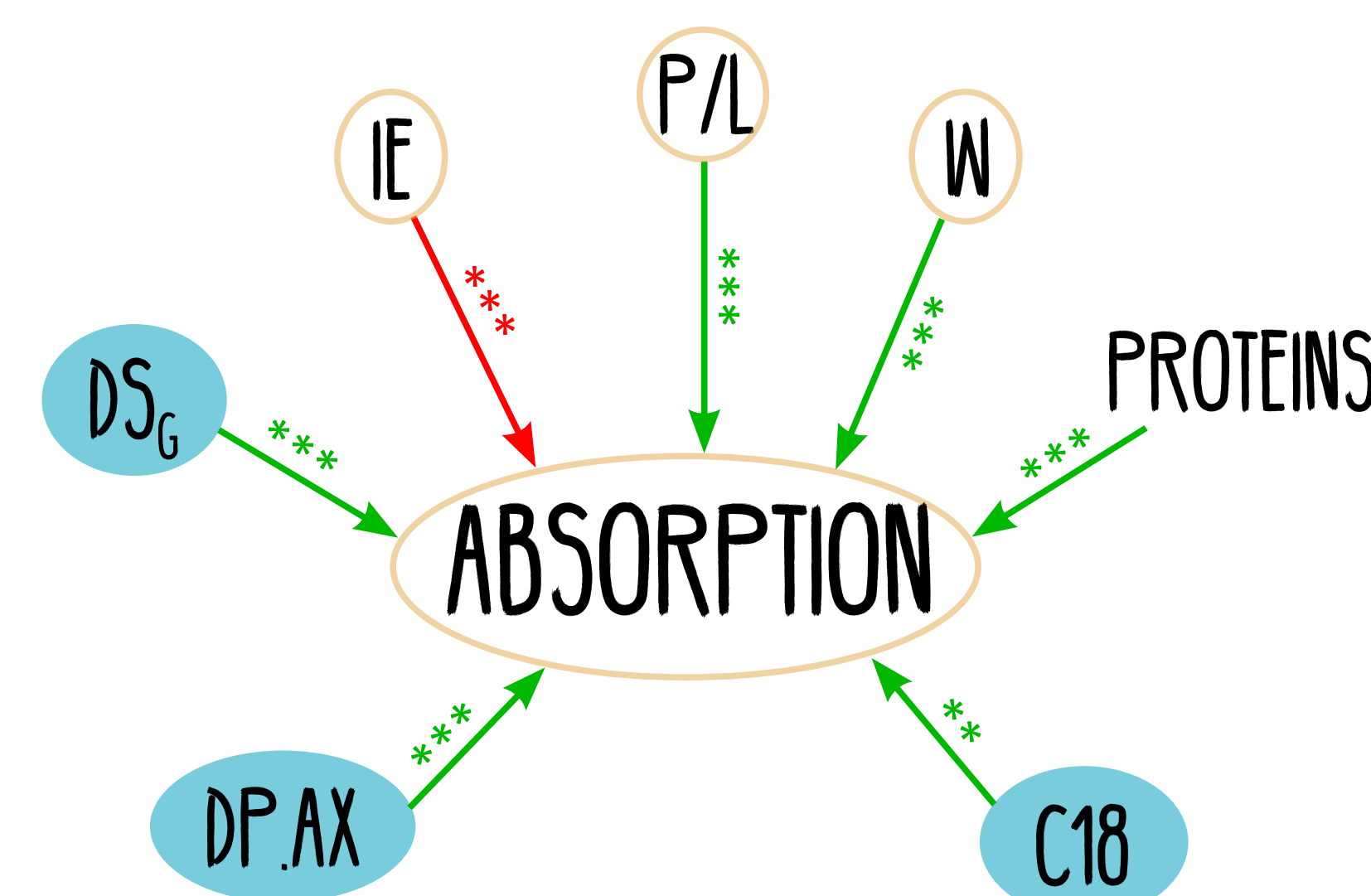


$$\text{Absorption} = 0.93 * \text{Proteins} + 0.99 * \text{DS}_g + 0.25 * \text{DS}_p + 5.10^{-3} * \text{DP.AX} + 77.2 * \text{C18} + 36.2$$

$$R^2 = 0.86$$

2. Best model obtained including professional variables

Same procedure as point 1 but adding variables related to the alveograph (current quality criteria) to the explanatory variables: **elasticity index IE**, the **P/L (Pressure/Length)**, and the **baking strength W**.



$$\text{Absorption} = 0.89 * \text{Proteins} + 0.76 * \text{DS}_g + 3.10^{-3} * \text{DP.AX} + 79.7 * \text{C18} + 1.1 * (\text{P/L}) + 1.6.10^{-2} * \text{W} - 0.16 * \text{IE} + 46.6$$

$$R^2 = 0.92$$

By including the alveograph variables in the model, we found that **DP.AX, C18 and DS_g are still significant to explain the water absorption**, and therefore provide additional information to the current quality criteria. Note that DS_p is not selected, confirming the higher interest of DS_g to model the water absorption related to starch.

Conclusion and perspectives

The wheat samples collected in the frame of the Evagrain project, exhibited a wide range of bread-making performances. Our study confirmed that in addition to damaged starch and proteins, **minor components, such as arabinoxylans (AX) and lipids (C18), also play a significant role by affecting water absorption, making them key criteria to assess wheat quality**. We also introduced **a new criterium for quality related to damaged starch: soluble glucose (DS_g) with a great potential to predict water absorption when compared with DS_p** .

Additional studies on various quality variables, including elongation during shaping or bread volume were also conducted in Evagrain. Interestingly, we found that **lipids have a greater impact on elongation compared to arabinoxylans** (data not shown). These studies demonstrate that the variability of these components actually affects the breadmaking behaviour of wheat flour. Particularly, **in the case of arabinoxylans, only variations in the water-soluble fraction showed an effect on quality criteria, while water-insoluble fraction had no impact**.