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Inclusion of reducing sugars before extrusion influences rumen degradability of faba bean blends

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Objectives

*The aim of this study was to compare the influence of the **inclusion of reducing sugars** and **different extrusion conditions** on the **nitrogen (N) ruminal degradation** of **faba bean/rapeseed** blends. Several technological parameters were recorded during the treatments.*

Background

Proteaginous and oilseeds present a lower crude protein content than most of the oil-meals commonly used in animal feeding. Moreover, their proteins are highly degradable in the rumen. So their protein value needs to be improved in order to enhance their utilization for ruminants.

Among technological treatments, extrusion has already been widely described as one of the most effective ways to reduce nitrogen ruminal degradation. Moreover, reducing sugars are known to induce Maillard reactions and could lead to a decrease in nitrogen degradation.

Material and methods

Experimental treatments

__16 treatments__ on faba bean/rapeseed blends (90%/ 10%), ground on 3 mm screen at 77 ms^{-1}:

- *2 types of reducing sugars with different dextrose equivalent (30%, **Red+** vs 95%, **Red++**), included at 2 doses (5%, **D5** vs 10%, **D10**)*
- *Different technical conditions of maturation (60°C; duration of **1/4h** vs **1h**; 5% of added water, **W5**, vs 15%, **W15**) and of extrusion (weak constraints, **WK**, vs medium, **MD**; final product temperature of 110°C, **T110** vs 140°C, **T140**).*

Measurements & Statistical analysis

- ✓ *Crude protein (**CP**) and nitrogen in vitro enzymatic degradation (**NED1**, Aufrère et al., 1989).*
- ✓ *In sacco measurements of N degradation (Ndeg): double Latin square (3 cows and 6 replicates); degradation of a standard feed (DMdeg_stand) to account for within-cow & -day variations (Michalet-Doreau et al., 1987)*
- ✓ *Kinetics adjusted with non-linear model (Ørskov & McDonald, 1979): Ndeg(t) = $a + b\,(1 - e^{-ct})$ (a: soluble fraction, b: degradable fraction and c: degradation rate of b fraction).*
- ✓ *Nitrogen effective degradability: **NED6** (%) = $a + b \times c / (c + kp)$ with a rumen turnover rate of particles kp=6%h^{-1} (INRA 2007), and **NED** (%) = $a \times 100/(100 + kl) + b \times c / (c + kp)$ with a turnover rate of liquid (kl=9.71%h^{-1}) and of particles (kp=4.97%h^{-1}) (INRA 2018).*
- ✓ *Variance-covariance analysis (GLM Procedure with Minitab) applied on kinetic parameters, with « sample » (α_i), « cow » (β_j) and « day » (γ_k) effects, and DMdeg_stand$_{jk}$ as a covariable:*

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \delta\ DMdeg\_stand_{jk} + \varepsilon_{ijk}$$

- ✓ *The "sample" effect (α_i) separated into main studied factors (sugar and dose, maturation duration, added water, mechanical and thermal effects) and their double interactions.*
- ✓ *The 2 components, mechanical (MecaPow) & thermal (ThermPow), of the total power (TotPow) generated in the extruder (W) were calculated with the measured extrusion parameters.*

Results and discussion

- ➢ NED6 variations between 75.5 and 91.5 % (mean ± SD = 86.1 ± 5.0 %).
- ➢ No effect of temperature, but a lower N effective degradability NED6 ($p<0.001$) for Red+ sugar (Red+: 84.9 *vs* Red++: 87.2 %), dose 5% (D5: 84.2 *vs* D10: 88.0 %), 1/4h duration (1/4h: 85.2 *vs* 1h: 87 %), 5% additional water (W5: 83.2 *vs* W15: 89.0 %) and medium extrusion constraints (MD: 84.6 *vs* WK: 87.6 %) (Figure 1).
- ➢ However, all double interactions significant ($p<0.05$, at least), except for sugar x dose ($p<0.10$) and water x temperature ($p<0.20$) (Figure 2).
- ➢ NED6 < 80 % for 3 particular combinations of treatments (Figure 3).
- ➢ NED6 variations not precisely related with *in vitro* enzymatic NED1 ones (NED1 = 32.2 ± 3.5 %; min-max = 27.2 - 42.8 %).

Figure 1: Effect of treatments on N effective degradability

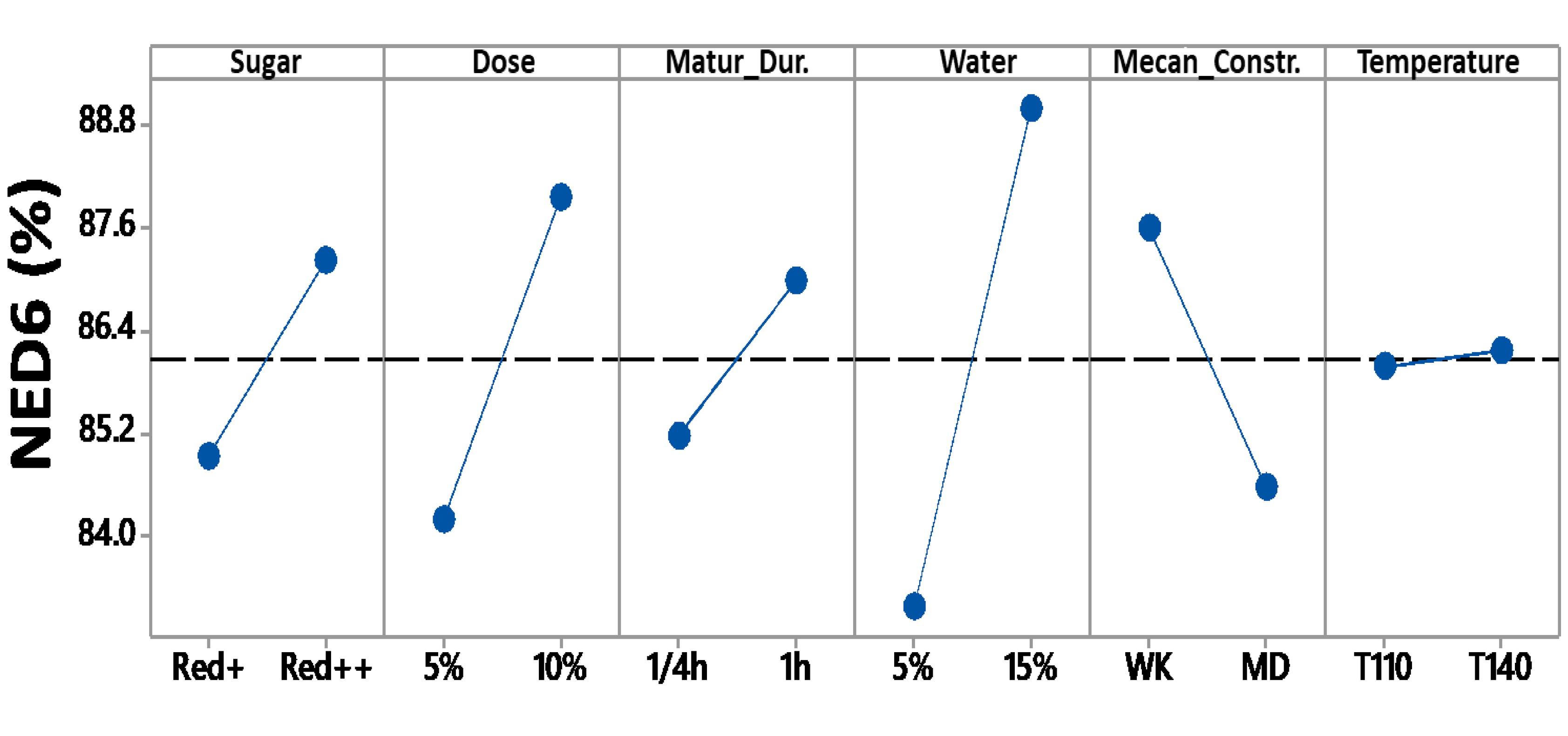


Figure 2: Double interactions between treatments on NED6 (%)

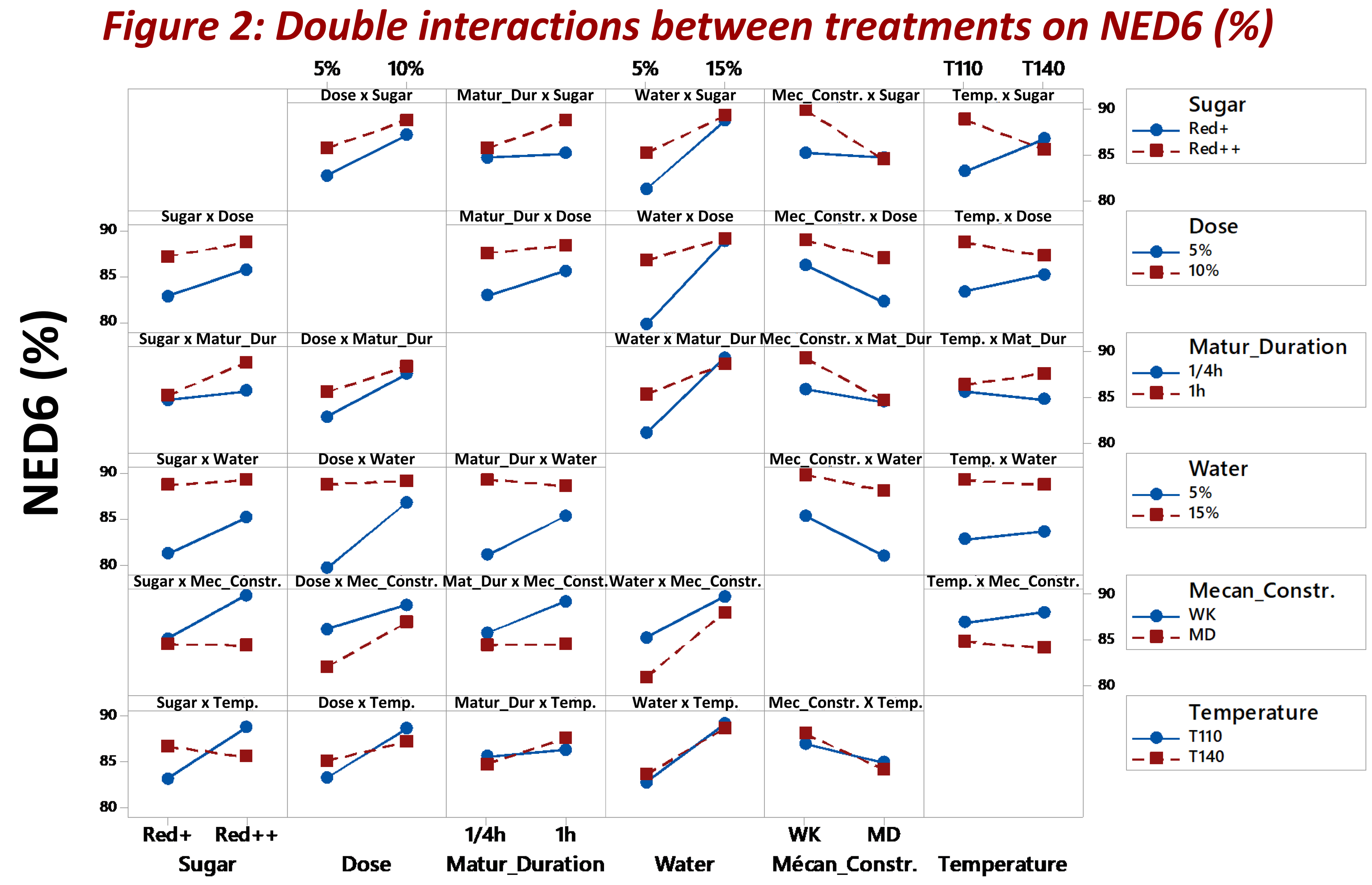
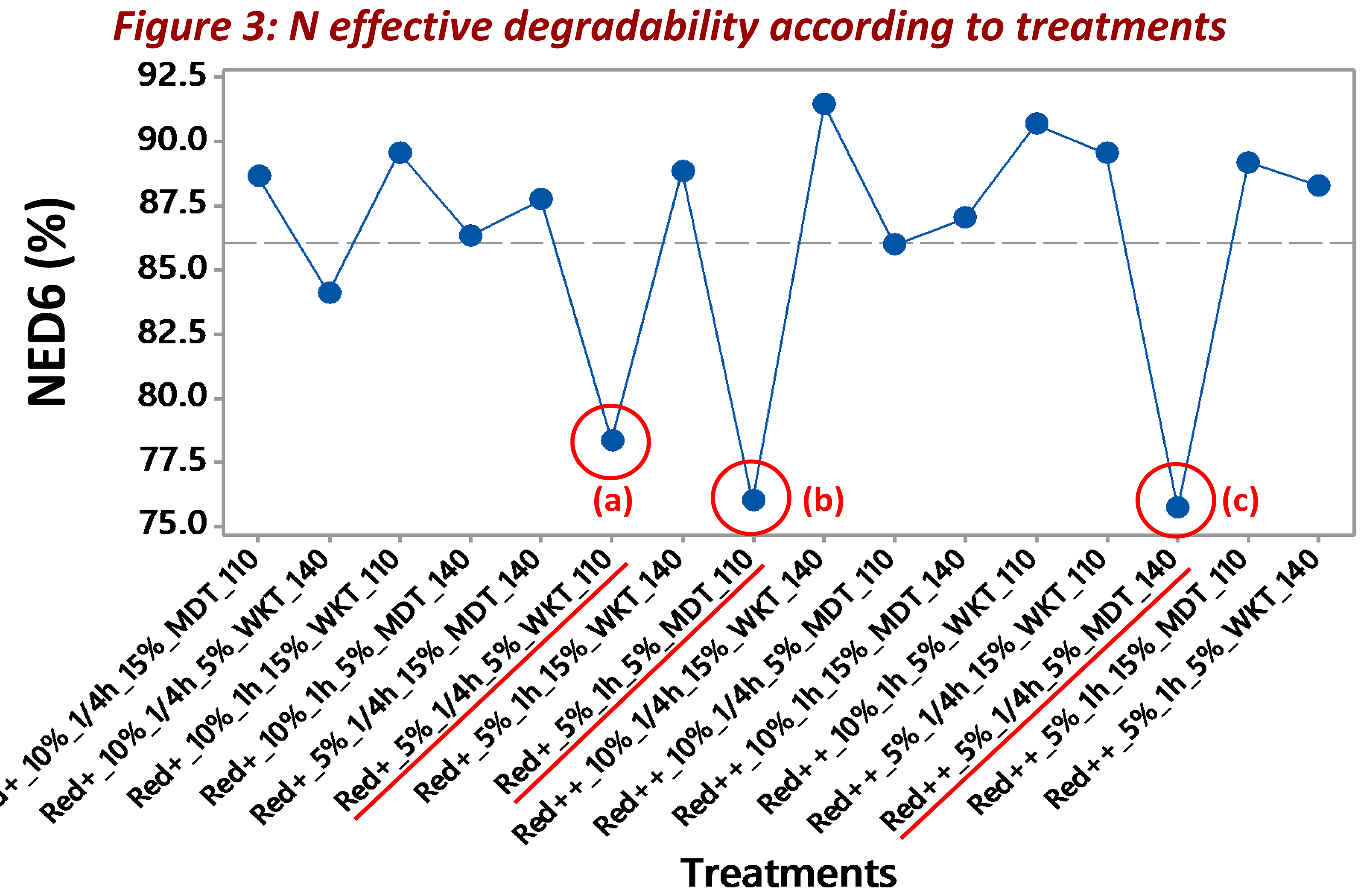


Figure 3: N effective degradability according to treatments



- ➢ In contrast to Dhumez et al., (2018), on this data set, NED6 reduction was slightly and negatively linked to the total power inside the extruder (6168 ± 1089 W, min-max = 4328-8070 W): *NED6 = 105.8 - 0.0032 TotPow (n=16; R^2=0.49; RSD=3.7).*

  The two components, MecaPow (5456 ± 1060 W) & ThermPow (712 ± 646 W), weighed quite similarly in the relationship and their inclusion in the regression did not increase the accuracy of the prediction.
- ➢ Calculated in the new INRA 2018 system, NED values of the 3 best treatments (figure 2) were 78, 75 and 73% respectively for (a), (b) and (c), higher than INRA 2018 Table value for a similar extruded faba bean/rapeseed blend (65%).

  Then, according to their chemical composition, the protein values of these 3 best products varied between 110 and 120 g/kg DM for PDI & from 110 to 100 g/kg DM for RPB, respectively compared to PDI = 150 and RPB = 85 g/kg DM for a similar simply extruded blend in INRA Tables.

Conclusion

- ❖ ***Inclusion of reducing sugars before extrusion associated with different technological conditions decreased nitrogen ruminal degradation and, thus, improved the protein values of oilseeds and proteaginous.***
- ❖ ***Effects on N degradability were not connected to the various treatment conditions and not precisely related with in vitro results.***
- ❖ ***For these treatments, total power generated in the extruder could predict the reduction of N degradability.***
- ❖ ***The tested products had lower PDI/RPB ratios compared to INRA 2018 Table.***

References

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