**Rumen degradability and intestinal digestibility of toasted faba beans**

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**Application**

Toasting increases the soya bean meal replacement potential of faba beans for ruminants.

**Introduction**

The soya bean meal replacement potential of faba beans for ruminants is constrained by their lower levels of crude protein (CP; Premier Nutrition, 2025), and thus both rumen degradable protein (RDP) and digestible undegradable protein (DUP). Earlier studies demonstrated the potential of experimental pressure toasting to increase DUP in faba beans (Goelema et al., 1999). Heat treatments such as toasting are expected to reduce CP solubility. Here, the effects of two types of commercial scale toasting were assessed on CP solubility, rumen degradability and intestinal digestibility of faba beans.

**Materials and methods**

Faba beans (var Lynx, harvest 2023, Lincolnshire, UK) were either left untoasted (FB) or toasted in a commercial scale oil-fuelled or electric toaster. Nine temperature and duration combinations were chosen based on literature to create a wide matrix of toasting intensity; three designed temperature-duration combinations could not be achieved due to limitations of the electric toaster. All resulting samples were analysed for crude protein and protein solubility in potassium hydroxide. The latter informed selection of nine samples for RDP determination in ruminally fistulated cows (four nylon bags per sample per cow; 8×10 cm; 37 µm pore size; 3 g milled sample per bag) using an 8-h incubation protocol. Rumen undegradable CP (RUP) was estimated using linear regression from an unrelated data set of untoasted and toasted faba beans for which RUP was determined using a full degradation protocol (CBS, 2004). Intestinal CP digestibility was determined in duodenally fistulated cows, in which four bags with RUP material collected after 12-h rumen incubation were inserted every 20 minutes (3×7 cm; 37 µm pore size; 1 g milled sample per bag). Resulting residuals for both rumen and intestinal samples were pooled by sample pending CP analysis. These outcomes were used to calculate DUP levels by multiplying RUP with intestinal CP digestibility. Data were analysed through Pearson’s correlations between protein solubility and the various CP degradability and digestibility parameters.

**Results**

Table 1 shows that toasting reduced protein solubility, by up to -25% and -31% for the oil-fuelled and electric toaster, respectively. The effect on protein solubility of the samples not selected to the animal study ranged from -6% to -19% for the oil-fuelled toaster, and from -8% to -21% for the electric toaster (data not shown). Table 1 also shows that toasting reduced RDP (up to -45%) and increased RUP (up to +94%), with effects generally increasing with increased toasting intensity (Table 1). Within each toasting type, the greatest toasting intensities (Temp H and Duration H) resulted in the greatest intestinal CP digestibility; the latter did not correlate with RUP (r=0.3006; P=0.47). Figure 1 shows strong negative correlations between protein solubility and DUP, which was stronger for the electric toaster (r=0.9965; P=0.004) compared to the oil-fuelled toaster (r=0.9091; P=0.012), though with a stronger slope for the oil toaster (-0.64) compared to the electric toaster (-0.51).

Table 1. Crude protein (CP), CP solubility (Sol), ruminal degradable CP after 8 hours of incubation (RDP8), rumen undegradable CP (RUP) and intestinal CP digestibility of RUP (Dig) of untoasted faba beans (FB) or eight samples of FB toasted at different temperature and duration combinations in an oil-fuelled or electric toaster.

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| --- | --- | --- | --- |
|  | Toasting conditions1 |  | Protein parameters |
| ID | Type | Temp | Duration |  | CP, % | Sol, % CP | RDP8, % CP | RUP, % CP | Dig, % CP |
| FB | - |  |  |  | 24.1 | 95.2 | 73.1 | 21.8 | 92.4 |
| TFB1 | Oil | L | L |  | 24.3 | 95.1 | 59.5 | 30.4 | 92.7 |
| TFB2 | Oil | L | H |  | 24.9 | 79.7 | 49.4 | 36.7 | 90.4 |
| TFB3 | Oil | M | M |  | 24.9 | 84.9 | 54.9 | 33.2 | 94.7 |
| TFB4 | Oil | H | L |  | 25.4 | 78.1 | 52.5 | 34.7 | 94.0 |
| TFB5 | Oil | H | H |  | 26.5 | 71.2 | 40.3 | 42.4 | 96.3 |
| TFB6 | Electric | L | L |  | 24.8 | 84.8 | 68.1 | 24.9 | 94.0 |
| TFB7 | Electric | M | M |  | 24.3 | 80.1 | 63.2 | 28.0 | 93.2 |
| TFB8 | Electric | H | H |  | 25.2 | 65.9 | 49.6 | 36.6 | 95.2 |

1Toasting equipment names and processing parameters kept confidential due to commercial sensitivity



Figure 1. Relationship between protein solubility and digestible rumen undegradable protein (DUP) of faba beans (var Lynx) toasted at different temperature and duration combinations in an oil-fuelled toaster (open circles) or electric toaster (closed circles), or untoasted (diamond).

**Conclusion**

This data supports the view that under the conditions used there was little evidence of post ruminal over-protection following toasting. Thus, toasting increases the level of DUP, which would as such increase its soya replacement potential in nutritionally balanced ruminant rations, However, the relationship between protein solubility and DUP seem to differ between the oil-fuelled and electric toasting equipment, which may have implications in terms of using protein solubility to predict final DUP levels, and the DUP yield per unit energy input.

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