

UMR Herbivores

Team Feed, Digestion, Microbes, Metabolism and Nutrition (Dinamic)

Faba bean and lupin seeds as alternatives to soybean meal for dairy cows

In a context of research of alternatives to soybean meal imported from America for dairy cow rations, combinations of "French protein seeds × extrusion" were tested. The aim was to improve their nitrogen value by reducing the ruminal degradability of proteins without reducing their intestinal digestibility. Two trials have shown that with isoprotein rations and methionine recommendations covered, the use of extruded faba bean or lupin seeds at 140°C (after conventional maturation or with an enzyme cocktail) does not alter the quantity of milk produced by the cows, compared to soybean meal. On the other hand, faba bean or lupin seeds extruded at 160°C after conventional maturation, or extruded at 140°C after maturation with reducing sugars, reduces the absorption of amino acids in the small intestine. It is therefore possible to replace soybean meal by faba bean or lupin seeds in dairy cow rations, if the thermal processes used are properly optimized.

Very rich in protein, soybean meal is the main source of vegetable protein in ruminant farming. Each year, France imports more than 3 Mt of it from America (Terres Univia, 2017). However, soybean meal imported for livestock feed has been singled out because it is most often GMO and contributes significantly to deforestation (Karstensen et al., 2013). In this context, alternative local resources for dairy cattle feed are needed. For example, the use of protein seeds (faba beans, lupin, and peas) produced in France could be a way of substitution due to their relatively high protein content. However, when raw seeds are distributed to the animals, their proteins are highly degradable in the rumen, which impairs their nitrogen value for the cows. To overcome this problem, one technical option is to apply heat treatments to the seeds to protect their proteins from being too degradable in the rumen (Cros et al., 1991; Benchaar et al., 1992). The PROLEVAL project (PRoteaginous, OLEaginous, and their animal VALorization) aimed to set up a French production chain for selected protein seeds submitted to appropriate technological processes in order to improve the digestive use of their proteins to feed dairy cows.

Following preliminary *in vitro* and *in situ* trials to determine the most promising protein seed × heat treatment combinations, diets based on faba bean and lupin seeds, distributed raw or extruded under different conditions, were tested in two *in vivo* trials on dairy cows, in which the rations were isoproteic and methionine was not limiting. The first trial compared the use of soybean meal with bean or lupin seeds, distributed raw, extruded at 140°C and extruded at 160°C. The results showed that soybean meal can be replaced by faba bean or lupin seeds, regardless of the treatment, without significantly altering the amount of milk produced by the cows. At 140°C, measurement of Maillard compounds confirmed that Maillard reactions protected the proteins from excessive ruminal degradability compared to raw seeds, without altering the absorption of amino acids in the small intestine. In addition, a tendency to obtain better milk production (+1.8 kg milk/day) was observed with extruded faba bean seeds at 140°C compared to soybean meal. On the other hand, at 160°C, the Maillard reactions appeared to overprotect proteins, which were less well absorbed in the small intestine. In the second trial, faba bean seeds were distributed raw, extruded at 140°C as in the 1st trial, and extruded at 140°C after a specific maturation aimed at improving the complexation of proteins with exogenous sugars (maturation with reducing sugars) or endogenous (released by maturation with an enzyme cocktail). The results confirmed that extrusion at 140°C without specific maturation of bean seeds protects the proteins from ruminal degradation. The addition of reducing sugars led to an overprotection of the proteins, whose amino acids were less well absorbed in the small intestine. The addition of the enzyme cocktail, on the other hand, led to a level of amino acid absorption in the small intestine similar to that obtained with faba beans extruded at 140°C without specific maturation conditions. These trials showed that faba bean and lupin seeds could replace soybean meal in the feed of dairy cows, if the technological cooking processes implemented on these seeds - in particular the appearance of various Maillard compounds- are optimized. In parallel with these trials, a quantitative literature review was carried out on the use of raw and heat-treated protein seeds in dairy cow feed. This meta-analysis confirms the results obtained *in situ* and *in vivo* in our study: heat treatment protects proteins from degradation in the rumen, but the benefits of this protection on the performance of the animals require good control of the treatment applied.

This work carried out as part of the PROLEVAL project will continue with a final *in vivo* trial on dairy cows using an analytical approach to understand the appearance of Maillard compounds during extrusion better, as well as their role in protein protection.

Publications

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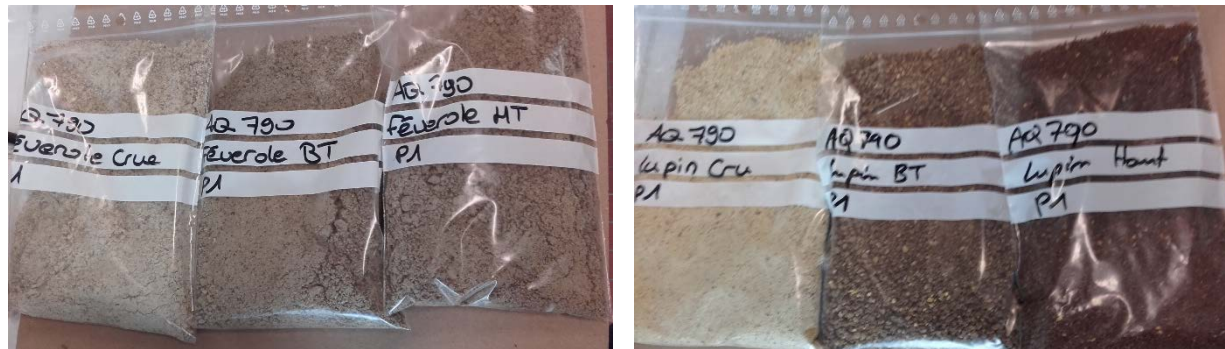
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Legend: Faba bean and lupin raw and extruded seeds (from left to right: faba bean: raw; extruded at 140°C, extruded at 160°C; Lupin: raw, extruded at 140°C, extruded at 160°C).

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