SOLID | Sustainable Organic and Low Input Dairying

Feeding home-grown protein and novel feeds to dairy cows

Introduction

This technical note focuses on the potential of grain legumes and by-products as feeds for dairy cows. We also take a look at a case study from Italy where a diet based on home-grown feed was compared with a diet utilising a commercial protein supplement. Low protein self-sufficiency is a concern at European level (European Parliament 2011) and it is important to find alternatives to feeds based on imported soya beans. Forages also play a crucial role in the protein supply to dairy cows, but this is beyond the scope of this note.

Peas

Grain legumes can replace soya

Grain legumes are annual plants which are well-suited to organic farming practices because they fix nitrogen. Their seeds can easily be incorporated into animal feed. Grain legumes can also be harvested as whole-crop silage or even grazed, in which case the biomass of leaves and stems can also be utilised as feed.

Grain legumes can be cultivated throughout Europe, although in the North the short length of the growing season can be a limiting factor for seed-ripening. Statistics show that the area used for growing grain legumes has decreased during the last few decades, which is mainly due to competition with feeds based on imported soya beans. The challenges for grain legume production remain to obtain a high yield and to minimise the annual variation in yield so that farmers can see an economic incentive to including grain legumes in crop rotations.

Peas (*Pisum sativum*) can be grown as a pure stand or mixed with cereal grains such as wheat. There are many varieties available which are suited for biomass or seed production. The protein concentration of peas is relatively low so that rather large amounts are needed in the diet. Peas contain up to 25% protein and can be considered a 'dual-purpose' feed providing both protein and energy to livestock diets.

Faba beans (*Vicia faba*), also called horse beans, broad beans or field beans, are one of the oldest crops cultivated and they are commonly used globally for both food and feed. Faba beans contain more protein than peas (typically around 30%) but they contain anti-nutritional factors such as tannins and vicin + convicin. The microbial activity in the rumen destroys most anti-nutritional factors, but they must be taken into account when the beans are used for feeding pigs and particularly poultry.

Lupins *(Lupinus spp.)* There are various species e.g. white, blue or narrow-leafed and yellow lupins, which provide seeds with rather high protein and also oil concentration. Native lupins contain alkaloids which prevent their use as feed or food, but breeding of so-called sweet lupin varieties, which are suitable for feed, has allowed their increasing use.

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By-products and novel feeds

There is a wide variation in the properties of novel and underutilised feed resources available for use in organic and low-input dairy systems. The variation is caused by the diversity of raw materials, the variability in their composition, and the impact of the different processing technologies used (Rinne et al. 2014). The variability in feed materials may provide opportunities to find suitable supplements in terms of energy, protein and mineral concentrations, depending on the type of animals and basal feeding.

Not many by-product feeds are labelled organic, but as the organic food and beverage industries develop, more will become available in organic production, where ruminants must be fed a diet with 100% organic ingredients. Increasing the supply of new feed ingredients that are acceptable in organic production would, in many cases, allow for an increase in the supply of organic milk by giving greater flexibility in terms of feeding strategies and overcoming potential periods of feed shortage.

Certain by-products may have a large impact locally: in the vicinity of the processing plant they may provide an important additional feed resource. By-products may also be cheaper than standard feeds. Using by-products as feeds prevents the energy and nutrients they contain from being wasted.

- **Oilseeds.** Meals from oilseeds such as camelina, crambe, safflower and rapeseed provide protein-rich supplements after oil extraction. Their on-farm production could offer a good opportunity to increase supply of oils for human consumption or biodiesel, to produce high quality protein supplements for animals and to improve the farm's finances.
- **High-protein and low-fat distillers' grains** are the result of sophisticated industrial processes to extract as much as possible from the cereals (e.g. oil) and to diversify and add value to by-products in order to meet farmers' requirements (e.g. the case of high-protein distillers' grains). Guidance on suitability for organic diets needs to be obtained from a Control Body before use.
- **Olive leaves and cakes** are by-products from olive oil production and, if adequately supplemented, they may be successfully used in animal diets.
- **Vegetable and fruit industry by-products** such as tomato wastes offer a cheap source of energy and protein with high digestibility; however, the high moisture content makes processing and storage a challenge. This can be overcome e.g. by co-ensiling them with straw.
- **Carbohydrates from wood** are available in large quantities, but because of very low digestibility of intact wood, a great deal of processing is required to improve their digestibility. Currently this is not economically viable.
- **Feed supply from agroforestry systems.** Fast growing trees provide potential for a large quantity of material, but unpredictability and variability is a challenge to their uptake. The use of silvopastoral systems requires a change in the mindset of the farmer. Harvesting, preservation and transportation questions also need to be solved for agroforestry based systems before they can be adopted in wider use (for more information refer to SOLID Technical Note 12).

Case study: Climate friendly organic milk production - Modena, Italy

The study aimed at evaluating the carbon footprint of organic milk produced by cattle on two different diets:

- Control, based on purchased ingredients - crushed maize (7%) and protein (mainly based on sunflower and soya bean) meal (10%) - and on-farm produced ingredients - lucerne hay (60%), crushed barley (13%), crushed sorghum (10%)
- Home-grown feed based almost solely on feed ingredients produced on-farm- lucerne hay (64%), crushed barley (16%), crushed sorghum (19%), with protein meal (1%) as the only purchased feed.

The feeding trial was conducted using 136 dairy cows (Italian Friesians) divided into two homogeneous groups (in terms of parity and days in milk) for 3 months at the Hombre farm in Modena, Italy.

The average daily milk production of the home-grown feed group was 3.9 kg lower than the control group. Milk quality (fat and protein concentration, number of somatic cells) was not affected by the diets. The results obtained for the milk yield have been confirmed by other authors that studied the substitution of soybean with alternative protein plants on a dairy cow ration (Martini et al., 2008; Mordenti et al., 2007).

The impact of the home-grown feed system on global warming, calculated in terms of kg of CO_2-eq per kg of fat and protein corrected milk (FPCM) produced was higher than the control system (Figure 1). This is mainly due to the reduction in milk production in the home-grown feed system. This is in agreement with literature showing that the milk yield per cow is one of the main factors affecting the carbon footprint of dairy farms (Rotz *et al.*, 2010; Hermansen & Kristensen, 2011; Opio *et al.*, 2011).

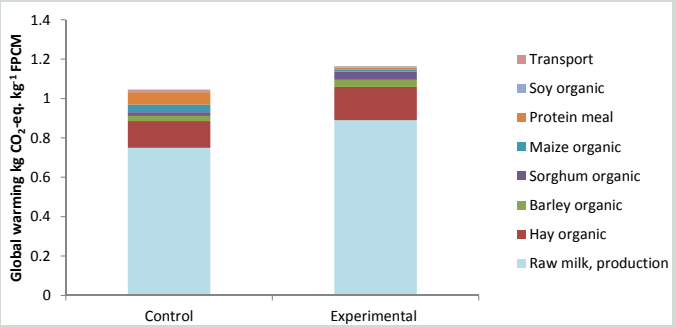

Figure 1 - Global warming potential of control and home-grown feed systems and the contribution from different processes

As with most case study analyses, some aspects of our study (for example crop rotation and herd management) limit the generalisation of the results. Despite these limitations, the results gave useful insights into the choices that a farmer must make before deciding to modify a diet.

Hombre farm, Modena, Italy

First of all, in addition to lucerne hay, we suggest the use of faba beans or peas to improve home-grown protein supply to low input dairy systems. Those sources could be viable alternatives to soya based feeds. Secondly, as well as considering possible effects on milk yield, dairy farmers should also consider the environmental impact. This study demonstrates that lower milk production generates not only a lower profit for the farm, but also a higher environmental impact.

Furthermore, solutions at farm level should be linked to consumers preferences. In particular, consumers are unlikely to be willing to pay more for changes in animal diets. According to a survey of European consumers (Zanoli *et al.*, 2015) changes in animal diet are relevant only if they reduce the risk of GM contamination and can improve the quality of milk, especially in terms of human health.

Faba beans are suitable for ruminant feeding as whole-crop silage or the beans can be used as protein supplement.

Table 1. An overview of various novel and underutilised feedstuffs as supplements in organic and low input dairy production. A minus (-) includes negative and a plus (+) positive effects whereas a question mark (?) indicates lack of knowledge.

Feed	Quantitative availablility	High energy value	High protein value	Effect on milk quality	Effect on animal health	Lack of antinutritive factors	Ease of processing	Ease of preservation	Suitability for organic production	Suitability for low input production
Camelina meal	-	+	++	+	?	+	+	+	++	+
Crambe meal	-	+	++	-	-	-	+	+	+	+
Safflower meal	-	+	+	+	?	?	+	+	++	+
Reduced fat distillers' grains	++	+	+	+	?	+	--	+	?	-
High protein distillers' grains	+	+	++	+	?	+	--	+	?	-
Whole rapeseeds (on-farm)	+	++	++	+	?	-	+	+	+	++
Rapeseed expeller (on-farm)	+	++	++	+	?	-	-	+	+	++
Lupin by-products	-	++	++	+	?	-	+	+	++	++
Pea, bean, chickpea and lentils	+	+	+	+	?	+	+	+	++	+
Buckwheat, mustard, canary seed	-	?	?	?	?	-	?	+	?	+
Olive leaves	++	+	-	+	-	-	+	+	-	++
Olive cake	++	++	-	+	+	-	-	-	-	++
Tomato pomace	++	++	+	++	?	+	-	-	-	++
Wood by-products	-- / ?	-/+	--	-/+	?	+	--	--	--	-
Agroforestry	+	-/+	-	?	?	-	+	-	++	++

Conclusions and recommendations

The amount and quality of feeds offered to animals have significant effects on feed intake and milk production, which largely dictates the economics of production. In addition they may also influence milk quality and the health of the animals. Although ruminants rely mainly on forages and microbial protein synthesis in the rumen for their protein supply, adequate supplemental protein is typically required to obtain better economic performance and environmental efficiency.

In order to maximise the home-grown protein content in the dairy ration, firstly it should be explored whether the protein supply from legume based forages (clovers, lucerne, sainfoin and whole crop silages with pulses) can be increased. It may be possible to increase their contribution to both protein quantity, for example with red clover, and protein quality, for example by using sainfoin with its rumen protected proteins.

There are viable alternatives to imported soya bean based feeds, grain legumes and rapeseed-based feeds being the most obvious. By-products, some traditional and some novel, some home-grown or locally available and some industrial, may also play a role. The developing bio-economy, increased use of bioenergy and development of different bio-refineries provide potential new opportunities to the feed sector in the future.

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See also SOLID workshop on new research and practical experience of feeding dairy cows in Jan 2016 http://tinyurl.com/SOLID-feed

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