Agriculture and Forestry Research, Special Issue No 362 (Braunschweig, 2012) ISSN 0376-0723
Download: www.vti.bund.de/en/startseite/vti-publications/landbauforschung-special-issues.html

Novel and underutilized feed resources – potential for use in organic and low input dairy production

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Abstract

This literature review evaluates the potential of a range of by-products from the agricultural, greenhouse, forestry, food processing and bioenergy sectors and agro-forestry systems as feed components in organic and low input dairy systems. The variability of the raw materials further modified by differing processing methods results in wide range of feed materials available. Innovative use of novel and underutilized feed resources has the potential to improve the efficiency of the "green economy".

Key words: agro-forestry, by-product, distillers' grain, oilseed meal, vegetable waste

Introduction

Organic and low input dairy production relies on feeds, especially forages, produced on-farm. To sustain milk production, feed supplements are typically used either for cattle, sheep or goats to balance the rations in terms of e.g. energy and protein supply and intake of essential nutrients. The availability and quality of forages can differ greatly both within and between years due to seasonal changes resulting in differing needs of supplemental feeds. By-products from agricultural, forestry, food processing and bioenergy sectors can be considered sustainable sources to fulfill the need of additional feeds for milk producing animals, and agro-forestry systems may provide additional roughage in the diet. Ruminants are particularly suited for converting fibrous by-products into valuable animal products. This work is part of an EU FP7 funded project "Sustainable organic and low input dairying" (SOLID, KBBE.2010.1.2-02, www.solidairy.eu).

Results and Discussion

The feeds selected to review were evaluated to be novel or underutilized, i.e. having potential to contribute to the future success of organic and low input dairy production. This review showed a wide variability in the potential novel and underutilized feed materials to be used in organic and low input dairy systems. An overview of the reviewed feeds is presented in Table 1.

The **meals obtained after the extraction of oil from Camelina, Crambe or Safflower seeds** are good options for complementing forage-based diets of ruminants within organic and low-input systems. While they can be generally described as protein-rich feeds, they also contain interesting con-

centrations of residual oil which contributes to their energy value and may have positive effects on milk quality. Camelina, Crambe and Safflower are resilient and rather low-input species which might be cultivated by organic/low input dairy farmers e.g. within business arrangements with oil-extracting factories. Although the available quantities of the by-products are currently small, they are likely to increase according to many authors following the current trends in bioenergy and food industry sectors.

Table 1. A subjective assessment based on literature review of various novel and underutilized 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	Quantit. significance	High energy value	High protein value	Effect on milk quality	Effect on animal health	Lack of antinutrit. factors	Ease of processing	Ease of preser-vation	Suitability for organic production	Suitability for low input
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	-- / ?	-/+	--	-/+	?	+	--	--	--	-
Agro-forestry	+	-/+	-	?	?	-	+	-	++	++

High-protein and low-fat distillers' grains emerged on the feedstuff market as a result of the processing factories tendency to extract as much as possible from the cereals (e.g. oil) and to diversify and add value to their by-products in order to meet the farmers' requests (e.g. the case of high-protein distillers' grains). These two by-products are likely to be followed by others, as a result of the dynamic evolution of the industry (e.g. secondary fermentation by-products), whose feeding value and effects on animal performance have not yet been properly assessed. High-protein and low-fat distillers' grains are high-protein feeds and might look less suitable for organic and low-input systems (assuming the production level is lower). However, they are good options for complementing the basal diets (e.g. cheaper source of rumen undegradable protein). An issue may be their contamination with harmful substances (e.g. mycotoxins), if the quality control of the cereals is not well regulated.

By-products from the pulse industry are good sources of protein and may by quantitatively important. Legumes are also able to fix nitrogen from the atmosphere giving them an essential role in the nitrogen supply to the organic farming. Moreover, some of these species may be cultivated by the farmer for on-farm use. A general drawback is the high rumen degradability of the protein in leguminous plants and the methods to increase the degradability are not always available to the farmers. The minor species (**buckwheat, mustard and Canary seed**) are scarcely characterized from a nutritional point of view although they may have significance as local feed resources. **Full-**

fat or locally extracted rapeseed cakes offer an on-farm produced high quality energy and protein supplement, which may well fit some organic and low-input dairy production systems. However, if rapeseed varieties intended for biodiesel production are used, the glucosinolate concentration in the cake may be harmful when consumed by livestock.

Olive leaves are collected together with olives at harvesting and are fibrous forage with low digestibility of crude protein in particular, and they promote very poor rumen fermentation. However, if adequately supplemented, they may be successfully used in animal diets. In lactating animals olive leaves result in an improvement in milk fat quality compared to diets based on conventional forages. However, more research is needed to assess the potential toxic effect of the high levels of copper found in olive leaves. The use of **olive cakes** in ruminant diets promotes different responses in rumen fermentation depending on the method of administration and the proportion in the diet. **Tomato wastes** offer a cheap source of energy and protein with high digestibility; however, the high moisture content makes the processing and storing challenging. When tomato wastes are ensiled together with other ingredients that provide easily fermentable carbohydrates (corn, apple pomace etc.), they may replace conventional forages without affecting milk production and composition in dairy cattle.

Carbohydrates from wood are available in large quantities, but because of very low digestibility of intact wood, heavy processing is required to improve their digestibility. The feasibility of using wood derived carbohydrates as energy sources in dairy diets depends on the cost of processing, preservation and logistics as well as on the supply chain acceptance, while there are no legal or biological obstacles in using them.

The unpredictability and variability of the **feed supply from agro-forestry** systems is one of the biggest challenges to their use at present as there are many different species available and the seasonal variation is so large. However, fast growing trees provide the potential for a large quantity of material. Another challenge is the lack of structured processing and distribution, and mechanisation for harvesting/handling - both for preparation and feeding. Valorisation of the silvopastoral systems requires a change in the mindset of the farmer and several practical issues in production system need to be solved. Much of the work to date has been done with tropical trees and information from temperate climates in Central and Northern Europe is limited.

The overview of the reviewed literature demonstrates the wide variation in the potential novel and underutilized feed resources to be used in organic and low input dairy systems, and in many cases also the lack of scientific knowledge which may prevent the efficient use of some feeds. The variation is caused by the diversity of the raw materials and variability in raw material composition, which are further diversified by the processing technologies applied. General assessments of nutritional or economic value are not possible as they vary from product-to-product. The variability in the geographical production of some of the by-products implies that they might have to be managed locally to ensure feasibility of use. Specific local programs would need to be developed to raise the awareness and to build the capacity of local farmers and stakeholders to introduce the use of such products in the feeding of ruminants. On the other hand, the variability in the feed materials may provide opportunities to find suitable supplements in terms of e.g. energy, protein and mineral concentrations to various situations depending on the type of animals and basal feeding. By-product feeds often have a high moisture content and transportation and/or preservation may significantly increase the cost of the feeds, emphasizing the importance of logistics. Preservation also plays an important role in ensuring safety of the whole food-production chain. Harvesting, preservation and transportation questions also need to be solved for agro-forestry based systems before they can be adopted in wider use.

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, but they may also influence milk quality and health of the animals. This review was unable to draw any clear-cut conclusions on the latter because of lack of information and large variability among and within feed materials reviewed, but some general concepts can be identified. Generally, modifications in the quality of animal products can be achieved through diet manipulation. For ruminants, the microbial activity in the rumen diminishes the effect of diet composition on the quality of the animal products compared to single-stomached animals. Still, several feeds traits, e.g. the residual fat concentration and profile of fatty acids, are relevant enough to influence quality of animal products, e.g. milk fatty acids profile. If the feeds contain some bioactive compounds such as tannins or salicylic acid in fodder trees, or some harmful substances or residues, substantial responses can sometimes occur in animal health or product quality. The key issue in controlling the potential positive or negative effects on product quality and animal health is to know the chemical composition and concentrations of bioactive compounds in the particular feed material used as well as their fate in the rumen. According to EU legislation, the producer of the feed material is responsible for the safety of the product emphasizing the need of knowledge of potential deleterious effects of feeds.

Legislation and public opinion set rather strict rules on the acceptability of feeds, particularly in organic but also in low input conventional dairy systems. Highly processed or globally traded feed materials are likely to be considered undesirable even if they would be nutritionally and economically feasible and this can be an obstacle in using feeds like the new distillers' grain products. Increasing demand of processed organic foods for human consumption gives rise to the availability of organically labelled by-products as well. This may favour the broadening of the feed supply for organic livestock. The possibility to use the by-products as organic feedstuffs should also increase their economic value compared to alternative uses such as consumption as conventional feedstuffs or in bioenergy production.

In some cases, particularly in adopting truly novel feeding practices such as agro-forestry systems in intensive temperate production systems, or including novel industrial by-product feed ingredients, the socio-economic aspects play an important role. The role of biological research in such cases is to provide reliable information of the feeding value and safety of the new feeding methods. It is ultimately up to the whole supply-chain, consumers and authorities to decide which new feeding methods will be taken into use. The innovative and conservative approaches need to find a sound balance, and solutions are likely to vary in different regions. A broad-minded approach to valorise novel or under-utilized feed materials may also be valuable in cases of a crisis situation when availability of conventional feeds would be impaired.

Suggestions to tackle the future challenges of organic animal husbandry

Innovative use of novel and underutilized feed resources has the potential to improve the efficiency of the "green economy". There is a particular chance for increasing the supply of new feed supplements acceptable in organic production, and this would in many cases also allow for an increase in the supply of organic milk.

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