122

Organic fodder production in intensive organic livestock production in Europe: recent scientific findings and the impact on the development of organic farming

Rahmann, G. & H. Böhm

Federal Agricultural Research Centre of Germany, Institute of Organic Farming, FAL-OEL, D-23847 Trenthorst, Germany

Summary

Organic farming is practiced in over 100 countries on more than 26 million hectares. In the European Union (EU 25), about 5.6 million hectares of farm land are certified under the EU organic farming regulation 2092/91/EEC. Since 1992, these figures have been increased six times. The 160,000 organic farms in the EU 25 keep about 1.5 million cattle, 1.6 million sheep, 0.55 million pigs and 17.3 million chickens. Two different intensities can be identified: extensive and intensive organic animal husbandry. Extensive animal husbandry is mostly found on low productive and remote areas and carried out with beef cattle, sheep and goats. These systems cope easily with the organic farming standards. Intensive organic animal husbandry is found in more productive areas and done with dairy animals, pigs and chickens. High performance of production demands high quality feedstuff. For these farms, balanced diets are the major difficulty under the organic farming standards. The EU Commission decided that organic husbandry systems must have 100% organic diets by 2011, at that time conventional feedstuffs will be abandoned. This is a challenge for the development of intensive organic animal husbandry systems.

In the last years, a lot of research has been carried out to solve the problems of optimised feeding rations for intensive organic animal husbandry. Nevertheless, most of them are preliminary and not all problems have been solved. This paper will present some recent scientific findings in fodder production for intensive organic animal husbandry in Europe: high protein quality, roughage quality, feedstuff processing and "healthy feed. " The future demands for research and extension (R&D, M&E) will be derived in the conclusions.

Keywords : intensive organic animal husbandry, balanced organic feeding rations, organic feedstuff quality, fodder security and safety

Introduction

Organic farming continues to grow. In 2004, controlled organic farming took place in about 100 countries worldwide on 26.3 million ha of land (Willer & Yussefi, 2005).[1] The highest percentage of acreage of organic farming was in Europe. In 2004, more than 6.3 million hectares on about 160,000 farms, or respectively, 3.8 % of the total agricultural land in the 25 countries of

---

[1] Organic farming in the world 2004 (Willer & Yussefi, 2005): Australia / Oceania: 11.3 million ha (43%), Europe: 6.3 million ha (24%), Latin America: 6.2 million ha (23%), North America: 1.4 million ha (5%), Asia: 0.7 million ha (3%) and Africa: 0.4 million ha (1%). Most of the 462,000 organic farms are to be found in Europe (37.7%), followed by South America (30.9%), Asia (13.3%), North America (2.3%), Africa (15.4%), and Oceania (0.5%).

on about 160,000 farms, or respectively, 3.8 % of the total agricultural land in the 25 countries of the European Union, was managed organically under the EU-organic-farming-Regulation 2092/91/EEC, with a steady increase in every country.[2] In 10 years, from 1993 to 2003, the amount of organic farm land in the EU 25 has increased six times (0.9 to 5.6 million hectares, from 36,000 to 160,000 farms). In 2003, about 1.5 million cattle, 1.6 million sheep, 0.5 million pigs and 17.3 million chickens (layers and broilers) were kept on organic farms in Europe (Olmos & Lampkin, 2004). Certified organic animal husbandry is based on established and monitored production and processing guidelines. In 1999, EC-directive 1804/99/EC on the legally binding minimum standards of organic animal husbandry was passed and has been in force since August 24, 2000. It exactly describes the production processes to be adhered to before organic animal production can be advertised. The directive became part of the general organic standards written in 2092/91/EEC. These legal standards for Organic Farming were and still are a challenge for intensive organic animal husbandry. The major development needs were animal welfare, animal health, animal breeding and animal feeding. Deadlines were fixed for solving these problems. The standards were also permanently improved and adapted based on new scientific knowledge and practical needs.

In the last few years, a lot of research has been carried out in many European countries to find solutions to problems in intensive organic animal husbandry systems, particularly to develop balanced organic feeding rations for highly productive livestock. Researchers tried to find new sources of high quality feedstuff, develop new processing methods for fodder, find adapted breeds, or improve livestock management patterns in feeding. There are many scientific results available, but most of them are preliminary and are not approved for on-farm use. In the near future, research and extension has to be intensified to optimise intensive organic animal husbandry systems. The production and processing of high quality feedstuff and feeding systems is one of the major challenges. In this field, developments have to be made with a holistic system approach.

In this paper, recent scientific knowledge on high quality feedstuff and feeding regimes for intensive organic animal husbandry systems in Europe will be presented. The gaps and the challenges for the future will be described to enable scientists, as well as extension workers and farmers, to reach the target of optimised feeding rations in intensive organic animal husbandry in Europe.

Intensive Organic Animal Husbandry

Animal husbandry fulfils a central role in organic farming. Most of the organic farms in Europe practice animal husbandry. In bio-dynamic farming, the keeping of ruminants is obligatory. Alongside the production of food, animal raw-materials, and immaterial services (services delivered by animals), the services of animal husbandry delivered within a farm are especially of great importance for organic farming. Animal husbandry makes use of the growth produced by green manure cultures on fields, makes use of crop by-products and produces manure as an important fertilizer. Therefore, it is an integral part of the cycle of organic management (Figure 1).

---

[2] The proportion of organic farm land in selected countries in the European Union in the year 2003: Italy 8.9 %, Austria 8.7%, Finland 7.1%, Sweden 7.0%, Denmark 6.7%, Czech Republic 5.5%, UK 4.6%, Germany 4.1%.

The organic animal husbandry systems in Europe are very heterogeneous. They can be clustered into two different groups of production intensities and functions:

- extensive organic animal husbandry (low input – low output systems): e.g., landscape management in remote areas, hobby. Multi-functionality like biotope conservation, recreation and tourism are the major functions: low and medium productive breeds of cattle, sheep, goats for meat production are dominant. The production targets are low: growth rate of beef cattle are 800 - 1000 g per day, lamb 250 - 300 g per day.
- intensive organic animal husbandry (medium input – medium output): converted conventional livestock farms with medium to high productivity and intensity. The production of milk, meat and eggs are the major functions: highly productive breeds of dairy ruminants (cows, sheep, goats), pigs, poultry (eggs and broilers) are dominant. The production targets are high: e.g., dairy cows: 8,000 – 9,000 kg ECM per lactation (305 days), fattening pigs with 700 – 800 g daily weight gain and a minimum of 54% of lean meat in carcass, 270 – 300 eggs per layer and year.

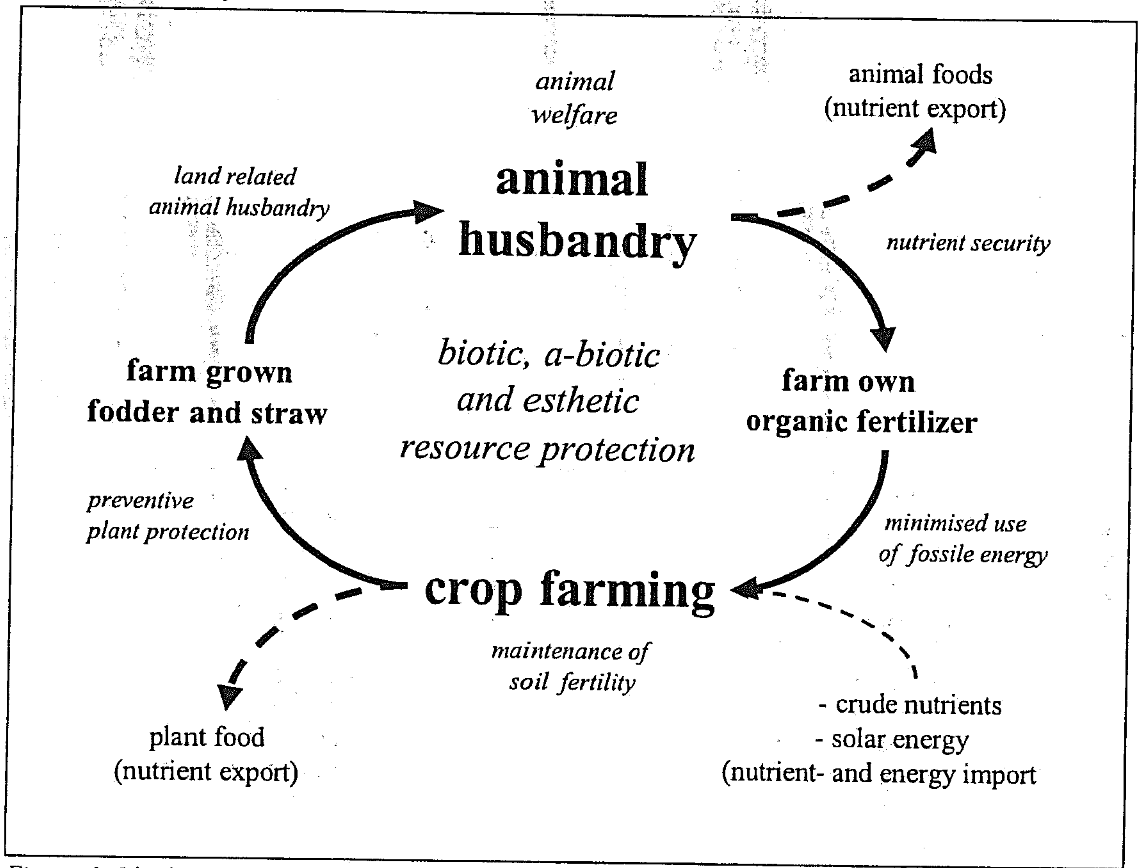

Figure 1. Ideal model of the correlation between the cultivation of plants and animal husbandry within the system of organic farming (Rahmann, 2004b)

Feeding in intensive organic animal husbandry systems

The challenge for animal nutrition is to supply nutrients as demanded by animals for maintenance and performance needs. Due to the high protein demands of growing monogastric animals (poultry, pigs), soybean meal became the most important protein source in the nutrition of monogastric animals in conventional farming. Additionally, synthetically produced amino acids are used to balance feeding rations. High performance breeds have been developed under these feeding conditions. Many of these adopted feedstuffs are not allowed in organic farming: e.g., meat and bone meal, chemically extracted soybean meal and synthetic amino acids are banned (2092/91/EEC, Annex 1, Paragraph 4.2).

Cereals, legumes, root crops, arable fodder crops like clover-grass, forage grasses, herbs, and leaves are the most important forms of fodder on organic farms in Europe. These are supplemented by salt, trace elements, and / or vitamins. The aim in organic farming is to produce all fodder on site. It is, however, a possible and established practice to buy additional fodder. Organic livestock in Europe requires about 0.74 million tons of organic cereals[3], 0.3 million tons of home grown organic pulses[2] (mainly peas and beans) and 0.1 million tons of high quality protein[2] (rich in essential amino acids). While there are enough concentrates of organic cereals for feedstuff available (total organic cereal production in EU25 in 2003: 2.8 million tons, 55% for feed) limitations are for home grown organic pulses (total organic pulses production: 0.26 million tons, 90% for feed) (Padel, 2005). The protein limitations are overcome by roughage for ruminants (grassland, field forage growing). Intensive organic animal systems like pigs and poultry need conventional feedstuff with high quality protein. While extensive organic animal husbandry has no difficulty in fulfilling the organic feeding standards, intensive organic animal husbandry must solve the following feedstuff-related problems in the next years:

- Organic feedstuff with high protein quality for monogastric animals
- Optimised processing of organic feedstuff
- Roughage quality for ruminants and monogastric animals
- "Healthy feed" to prevent diseases
- 100 % organic feeding rations for intensive organic animal husbandry

New findings on organic fodder production

The unsolved problems of organic farming have motivated governments and the EU commission to support research and extension activities. Action plans and research programmes have been launched. For example, the German government has financed a Federal Agricultural Programme in Organic Farming from 2002 to 2007. The budget of 150 Million €uro was used for research, extension and promotion support. About 300 research projects have been funded with more than 40 million €uro, the biggest budget ever paid for organic farming research in the world.[4] Only

[3] Feed demand in millions of tons for the year 2003: Cereals: ruminants 0.47, pigs 0.12, poultry 0,15; Home grown pulses: ruminants 0.19, pigs 0.03, poultry 0.07; High quality protein: pigs: 0.03, poultry 0.07.

[4] Organic animal science is still at the beginning in all of Europe. Beside the national governments (e.g., DARCOF I and DARCOF II in Denmark) and the national universities, the EU also has funded organic farming research in the last years in FP5 and FP6: e.g., ERA-Net project CORE Organic, R+D projects: Blight MOP, CHANNEL, QLIF,

17% (53 projects) were in animal husbandry, but 23 projects were in feeding and feedstuff research (Hess & Rahmann, 2005; www.organic-eprints.org).[5] This is not because of lack of research needs but a lack of scientists working in this field. Nevertheless, there are some major research activities launched and carried out. Many of them are preliminary but already show results which can be used to find solutions for the major problems in intensive organic animal husbandry.

Organic feedstuff with high protein quality for monogastric animals

For high performing animals, it is difficult to compose balanced fodder rations of 100% organic diets. In particular, sufficient quantities of essential amino acids - above all the sulphur-containing amino acids (SAA) lysine, methionine, tryptophan, cystine, and threonine - are lacking. Methionine is the first-limiting amino acid in poultry and the second-limiting in pig production. The availability under organic conditions is more restricted than in conventional production. Synthetically produced amino acids are not allowed in organic farming. Until August 2005, 20 % conventional feedstuff was allowed for monogastric animals and 10 % for ruminants. This deadline could not be kept. In July, 2005, the EU extended the allowance of conventional feedstuff and will reduce it step by step to zero by 2011.[6] Only some of the conventional feedstuffs were excluded from the positive list because organic feed stuff is sufficient and available everywhere. The difficulties of excluding conventional feedstuff are written in the preamble of 2277/03/EEC: *"Most of the conventional feed materials and in particular protein crops are still indispensable, at least in some Member States. Moreover, conventional milk by-products are still necessary in organic farming and further minerals are required to ensure the welfare of organically-reared livestock."*

Before research in organic animal nutrition and feedstuff started it was assumed that the feedstuff quantity is lower per hectare but the quality of organic feedstuff is the same as in conventional feedstuff. In the past, organic diets have been compiled on the basis of literature data originating from conventional production measures. The animals have a specific demand on essential amino acids in the diet (Table 1).

WORMCOPS, ENVIRFOOD, REPCO, INTERCROP, concerted actions: NAHWOA, SAFO (all together about 20 million €). No other part of the world has supported organic farming research like Europe.

[5] While organic plant science is established at nearly every university, organic animal husbandry could be found only in a few of them. In Germany are just four professors in organic animal husbandry, but about 30 in organic plant science, and 10 in economics. Only a few experimental stations of the universities carry out experiments with livestock: just four of the 30 organic research stations have dairy cows, only two keep pigs, and two keep chickens / poultry for experiments. This shows the gap of organic animal research compared to organic plant and organic economic research. Because of this deficit, the German Government established a Federal Research Institute in 2000 which is just working on organic animal husbandry with an interdisciplinary system approach and excellent experimental research facilities.

[6] The standing committee Organic Farming of the EU commission decided on July 1st, 2005 on the following deadlines for conventional feedstuffs in a 12 month period (in DM): ruminants: 5 % till August 24th, 2007; monogastric: 15% conventional feedstuff till August 24th, 2007, 10 % August 24th, 2009, 5% August 24th, 2011. The maximum daily allowance is 25 %.

Table 1. Optimal amino acid patterns in feed protein for various breeds (compiled by Sundrum et al., *2005)*

	Broiler	Laying hens	Growing pigs
Lysine (6.5 g / 16 g N)	100	100	100
Methionine		44	
Methionine + Cystine	72	74	50-55
Threonine	67		65-70
Tryptophan	16	16	17-19

In organic feed, the required composition is not possible by feeding rations without conventional fodder, milk products[7] or fish meal (

Table 3). Fodder of high protein quality is not produced organically (e.g., potato protein as a by-product of starch production) or can not be grown in any region (e.g., soybeans in Northern Europe). Because the animal growth and the product quantity and quality were not as expected, research on the organic feedstuff quality was necessary. Due to this effect the research has focussed on protein quality, particularly the composition of amino acids in legume crops. For example, Wlcek & Zollitsch (2003) could show already in 2000 that organic wheat and triticale have less protein and essential amino acids per kg dry matter than conventionally grown (Table 2).

Table 2. Contents of crude protein (CP) and amino acids of organic wheat and triticale in comparison with conventional values (Wlcek & Zollitsch, in Freyer, 2003)

Contents	Average values of organic samples g/kg dry matter (deviation)		Protein content in relation to conventional feedstuff	
	Wheat[1]	Triticale[2]	Wheat	Triticale
	n = 34	n = 34	---	---
Crude protein	117 (13.1)	101 (7.1)	85 %	69 %
	n = 28	n = 32		
Lysine	2.9 (0.20)	3.1 (0.22)	74 %	70 %
Methionine	1.9 (0.16)	1.7 (0.10)	83 %	79 %
Cystine	3.0 (0.25)	2.6 (0.13)	90 %	86 %
Threonine	3.3 (0.29)	3.0 (0.21)	78 %	75 %
Tryptophan	1.1 (0.20)	0.8 (0.10)	63 %	53 %

[1] Wheat varieties: *Capo, Ludwig, Silvius, Belmondo, Pegassos, Dekan;*

[7] Non-fat milk and whey powder have a high digestibility and valuable components and are considered valuable feedstuff, especially for young stock. However, the possible uses of feedstuffs are not determined exclusively by the value-giving and anti-nutritional contents or taste. Determining factors are, in particular, the availability and price (Sundrum et al., 2005).

[2] Triticale varieties: *Presto, Binava, Almo, Trimaran*

Table 3. Essential amino acids in organic fodder (in % in 87 % DM, Zollitsch et al., 2000)

	Crude protein	Lysine	Methionine + Cystine	Tryptophan
Field beans	26,0	1,67	0,50	0,23
Brewer's yeast	45,3	2,18	1,08	0,65
Peas	22,5	1,57	0,52	0,20
Flax expeller	32,6	1,14	1,14	0,62
Blue lupin	32,7	1,70	0,95	0,33
Colza cake	31,4	1,66	1,10	0,41
Sunflower cake	36,7	1,26	1,49	0,43
Soybeans, toasted	35,2	2,21	1,02	0,94
Maize gluten (conv.)	61,3	1,04	2,52	0,32
Potato protein (conv.)	67,6	5,21	2,48	0,99

Conv. : conventional production

To meet the demand of balanced diets for laying hens, broilers or growing pigs new feedstuff is being sought. Because meat and bone meal is banned, and fish meal has an negative ecological impact, new plants or new processing measures for 100 %-plant related diets are now being assessed:

- Expeller of oil plants: e.g., rape (*Brassica napus*), sunflower (*Helianthus annuus*), flax (*Linum usitatissimum)*, false flax (*Camelina sativa*),

- Grain and roughage legumes: e.g., clover (*Trifolium* spp.*)*, lupine (*Lupinus* spp., Figure 2*)*, common vetch (*Vicia sativa*)

- New varities of common plants with high protein quality and digestibility (*Vicia faba*, *Pisum sativum*)

- New sources of essential amino acids: micro algae (*Chlorella vulgaris, Spirulina platensis*), screening of bacteria

- New processing measures (e.g., toasting, fermentation, germination) are done with standard feedstuff to improve protein quality (essential amino acids) of 100% organic rations.

- By-products of organic food processing: brewer yeast, brewer grains, other daffs, potato pulp, pumpkin seeds, lentil seeds

Oil cake is considered an excellent source of high quality protein (Table 4). The problem is the difficult cultivation in organic farming (pest control, productivity) and secondary plant compounds as anti-nutritive factors (ANFs). Rape seed produced from the double low (00) glucosinolate species may only be incorporated in poultry rations at small concentrations (no more than 10 % in DM for laying hens and 5 % in DM in broiler starter rations (8 % in broiler finisher rations). This is because of egg taint problems and off flavours in poultry meat caused by the presence of ANF's in rape seed (Sundrum et al., 2005). Animal do not like bitter ingredients (alkaloids), tannins, etheric oils. Some ingredients are toxic or have negative effect on product quality (e.g., vicine, convicine, sinapine, glucosinolate). For example, to avoid fish smell in eggs a maximum of 100 mg sinapine per kg feedstuff is targeted. Another point is the taste of the feedstuff. Flax expeller is excellent as feedstuff (Table 4), but, chickens refused flax expeller in feed rations and reduced feed intake from 135 to 60 g per day (Holle, 2005).

Table 4. Crude nutrients and essential amino acid content in organic feedstuff for laying hens: wheat, expeller and legume seeds (in % DM) (Holle, 2005)

	Winter wheat	Flax expeller	Rape expeller	Pumpkin seeds	Soybean expeller	Blue lupine seeds	Common vetch seeds
Ash	1,5	5,7	5,9	3,6	6,2	4,5	6,4
Crude protein	11,4	38,3	32,4	27,2	45,3	36	32,6
Crude fibre	2,9	9,4	11,3	38	5,5	16,8	5,6
Crude fat	2,4	8,8	18,7	25,1	13,7	5,4	2
Sugar	2,3	4,2	8,8	1,2	8,8	3,3	5,3
Starch	71,3	8,5	6,1	3,6	4,9	11,3	39
ME_{total} (MJ / kg)	14,8	10,8	13,6	13,6	13,7	9,8	12,9
Methionine	0,08	0,77	0,68	0,31	0,72	0,21	0,21
Lysine	0,29	1,41	1,88	1,18	2,57	1,21	1,32
Cystine	0,2	0,72	0,86	0,21	0,75	n.d.	n.d.
Tryptophan	0,06	0,38	0,17	0,19	0,4	n.d.	n.d.

Of the grain legumes, peas are among the poorest in protein, and lupines the richest. The crude protein proportions increase in the sequence peas (about 25 % in DM), faba beans (28 %) and lupines (yellow lupines 44 %, white lupines 39 %, blue lupines 34 %). Nevertheless, the blue lupine is suitable for organic farming because they can be cultivated without the risk of Anthracnosis (*Colletotrichum lupini*). Lupines have a crude protein content similar to that of full fat soya. The lysine content is high and the methionine + cystine content is moderate. The quality of blue lupines as a feed ingredient is variable. Lupines, especially the white lupines, have a higher fat content than beans or peas. The proportions of saturated fats are relatively low at approx. 20 % (Sundrum et al., 2005).

Peas are the most important ingredient for organic poultry rations to replace soya. For layers, 25 – 30 % in DM and for broiler 15 – 20 % in DM are possible. Sweet lupines can be taken as well, but not more than 20 % in DM. However, due to wide variation between lupine cultivars (Figure 2) and in the treatment of raw materials, and therefore in their nutrient analysis, it is not possible to provide definitive universal recommendations. Beans do not appear to be a good alternative protein source for use in organic poultry rations. This is because of the low concentration of sulphur amino acids and the presence of ANF's.

Processing of feedstuff

Digestibility is not same as availability. Digested and absorbed amino acids are not completely available for protein synthesis. For example, thermally damaged amino acids are digestible and absorbable, but not effective. With thermal treatment, the sinapine content of organic rape expeller could be reduced from 14,800 mg to 266 mg per kg DM (Holle, 2005). Therefore colza cake has to be treated in order to become feed stuff for laying hens (maximum 27%).

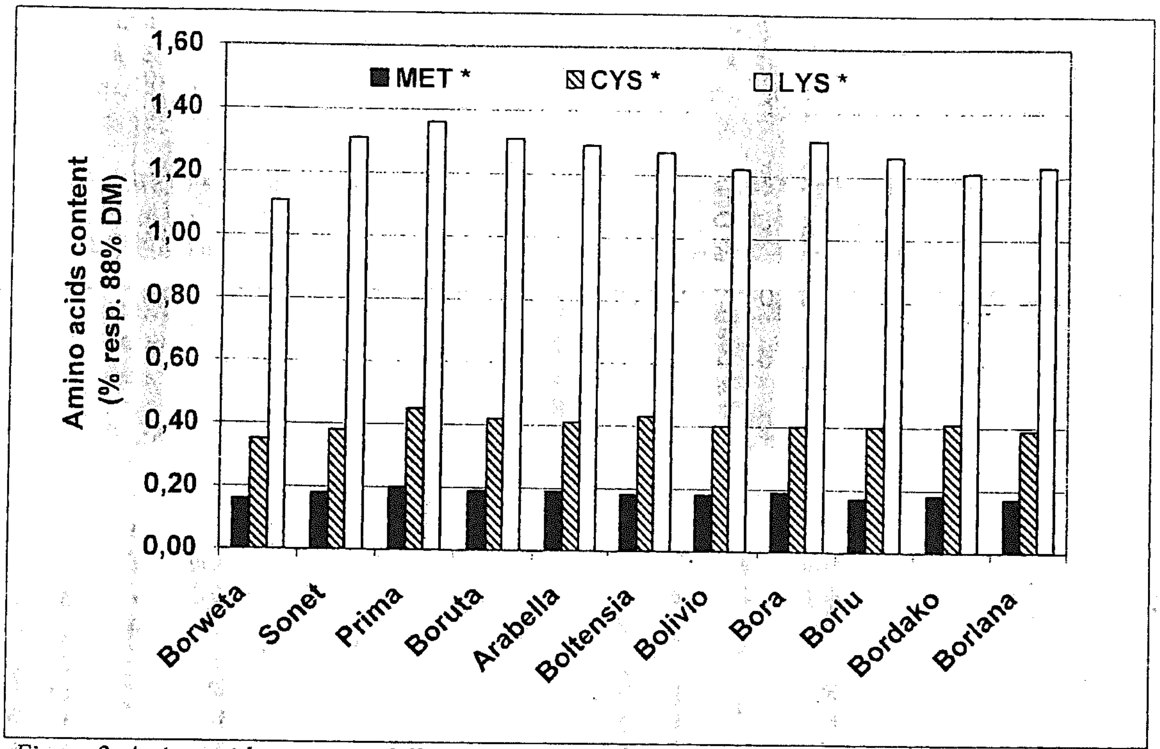

*Figure 2. Amino acid content in different varieties of organic produced blue lupine (Lupinus angustifolium), cultivated in northern Germany in the year 2003 * MET: Methionine,CYS: Cystine, LYS: Lysine, (Böhm, 2004)*

Hydrothermically treated lupines increase the amount of ME from 14.92 to 15.08 MJ / kg, the rumen undegradable protein (UPD) from 20 to 45 % (UDP5 from 73 to 262 g/kg CP and UDP8 from 88 to 310 g/ kg CP) and nXP values from 196 to 245 g / kg. Pries et al. (2005) could show that hydrothermically treated lupines increased milk yield and milk protein and did reduce the urea protein in organic dairy farming significantly.

Germination of cereals is discussed to improve the quality of chicken feed. It is not clear if sprouts of cereals are better than non-germinated cereals. Sedding et al. (2005) analysed the content, composition and properties of different germinated grains produced organically (summer wheat, winter wheat, triticale, rye, barley and dinkel (*Triticum spelta*). The digestibility and acceptance by chickens was assessed as well. The enzyme status (α-Amylases) did change rapidly with the start of germination (96 hour duration), while the compounds of nutrients did change later. The starch content decreased and in respect to this the sugar content increased. The crude protein level remained, but the protein nitrogen decreased and the free amino acids increased. The germination had an effect on the amino acids. The lysine content did increase, methionine and threonin content did not change and cystine did decrease a little. Considerable changes could be observed for vitamins. Vitamin B1, B2, B6, C, E and K1 did increase significantly. Vitamin A and D3 could not be detected. The reduced viscosity of rye seed was significant and an important factor for feed improvement.

Roughage quality for ruminants and monogastric animals

60% of ruminants diet shall consist of roughage (hay, silage, green forage, straw, etc.). Even monogastric animals get roughage for digestion improvements. Therefore roughage quality is more important for high performance dairy cows in organic farming than for conventional farming. In organic farming, roughage is produced on permanent grassland (pastures, meadows) and crop land (e.g., maize, arable fodder cropping like clover grass or catch crops, total plants silage). However the proportion of hay, clover-grass silage, cobs (technical dried grass) and silage of whole plant cereals is higher and the proportion of maize silage much lower than on conventional farms (Rutzmoser, 2003). By-products of crop production (straw, residues of vegetable production) and processing are also important seasonal sources of roughage. Research in organic arable fodder production became important because this was not practiced in conventional farming and research has not been carried out.

The increase of roughage in animal diets has an effect on the fatty acid composition of the products (particularly high tannin contents). The content of conjugated linolic acids CLA (C18:2*c*9*t*11), α-Linolenic acids ALA (C18:3, n-3) and long chain Ω3 fatty acids (n-3 PUFA) is higher in the milk and meat produced on the basis of roughage (Leiber et al., 2005). These fatty acids reduce the risk of cancer and have a high nutritive value for humans. This is an advantage for organic milk production and several organic milk products advertise high contents of CLAs and Ω3 fatty acids.

Due to nitrogen fixation, legumes are of special significance for the maintenance and improvement of soil fertility in organic farming. The share of legumes is therefore on average 41 % of arable land (dried pulses, arable feed cropping, etc.). Animal feed is the most important use for these crops. A total of 98 % of the farms practice fodder production with legumes. Only 16 % grow silage maize, five percent pure field grass and four percent whole plant silage. Silage, at 79 %, is the most important form of conservation. Hay is still made by 34 % of the farms (Rahmann & Nieberg, 2005).

The different species and varieties of clover (northern Europe) and alfalfa (southern Europe) are the most important nitrogen fixing legumes in monoculture or mixed with grasses. Besides the major function as nutrient collectors, legumes are used as arable field fodder (silage, green fodder). In organic farming, the nutrient content in roughage feeds differs only a little from conventional farming (Table 5).

In grassland related feedstuff (hay, green fodder, silage), the content of crude ash, crude protein and crude fibre was about 4 - 10 g/kg lower in dry matter (DM), although the organic farms cut the grass about 1 –2 weeks later. This can be explained by the slower growth development of grass due to the prohibition of mineral fertilizer. The content of crude nutrients of roughage feeds differs between the farms. The lower contents of crude protein, calcium or nitrate point to less available nitrogen in the soil of organic farms and a higher proportion of herbs and legumes on grassland (Table 6). These results have to be considered in feeding rations. The average concentrate use of 69 randomly selected farms throughout Germany was 0.9 t per cow and year (Rahmann & Nieberg, 2005). The concentrate use showed a very high variation: some farmers feed no concentrates, others a great amount of them. Some farmers attain milk yields of more than 5,000 kg milk per cow and year exclusively feeding with hay, silage and pasture – meaning no concentrates at all (Figure 3).

Table 5. Nutrient content of basic fodder in organically and conventionally managed farms in Bavaria, southern Germany (samples from 1996 – 2000, in DM, Rutzmoser, 2003)

Kind of fodder	Farms	Number of samples	DM (%)	Crude protein (%)	Crude fibre (%)	ME MJ/kg
Grass silage	Org.	380	362	156	249	10.60
	Conv.	20,490	350	168	254	10.47
Clover + grass silage	Org.	269	357	157	270	10.18
	Conv.	19,193	339	173	260	10.40
Meadow hay	Org.	58	864	109	284	9.03
	Conv.	820	862	108	295	9.29
Maize silage	Org.	77	325	79	207	11.17
	Conv.	22,992	336	82	204	11.26

Org.: organic, Conv : conventional

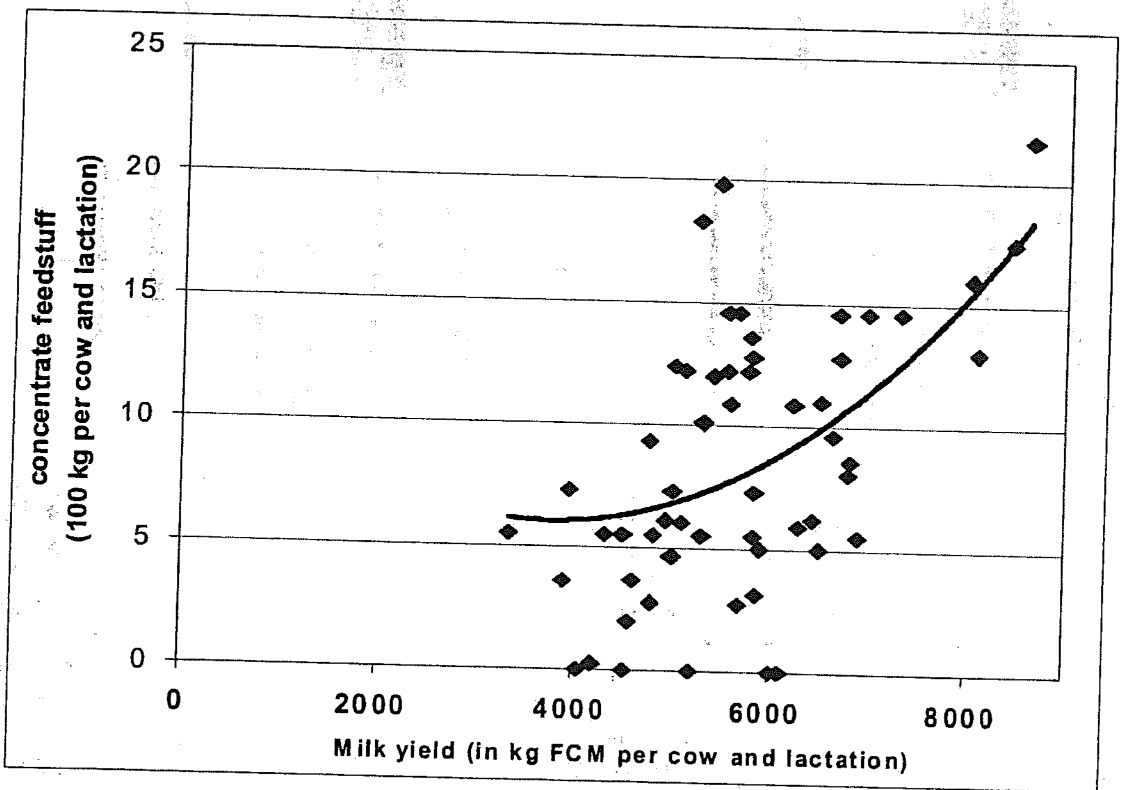

Figure 3. Milk yield and amount of concentrate fed per cow and lactation on randomly selected 69 organic dairy farms in Germany2002 (Rahmann & Nieberg, 2005)

The high performance dairy farming focused on roughage has to equalize the energy and protein content of the several compounds as well as the minerals (e.g., magnesia). On several organic farms – particularly on bio-dynamic farms - leaves of shrubs are fed to ruminants (goats, sheep and cattle) to respect their ethological behaviour. This natural fodder resource received no attention in conventional farming and animal nutrition research, despite the fact that goats, sheep and even cattle like leaves as a portion in their diet (Rahmann, 2004a). The minerals of several shrub species are rich in minerals.

Table 6. Mineral (g/kg dm), nitrate (mg/kg dm), anion (g/kg dm), and trace element (mg/kg dm) contents in basic fodders produced on organically and conventionally managed farms in southern Germany (samples from 1996-2000, see Table 5, Rutzmoser, 2003)

Kind of fodder	Farm	Ca g	P g	Mg g	Na g	K g	Nitrate mg	Cl g	S g	Cu mg	Zn mg	Mn mg	Se mg
Grass silage													
1st cutting	Org.	7.3	3.5	2.5	0.5	28.4	453	4.5	1.8	8.4	49	86	0.03
	Conv	6.3	3.8	2.3	0.9	29.6	950	7.8	2.2	8.6	51	91	0.04
2nd cutting	Org.	10.3	3.7	3.2	0.6	26.0	324	3.4	2.0	9.3	58	88	0.07
	Conv	8.2	3.7	2.9	1.1	25.7	1183	7.5	2.3	9.5	58	108	0.04
Meadow hay													
1st cutting	Org.	5.4	2.5	2.0	0.4	21.5	647	5.4	1.3	6.3	35	65	0.05
	Conv	4.8	2.7	1.9	0.7	21.7	1183	6.5	1.4	6.3	40	82	0.04
2nd cutting	Org.	6.4	3.1	2.3	0.4	22.4	213	4.5	1.6	7.6	48	76	0.01
	Conv	6.1	3.3	2.3	0.6	24.0	1366	5.7	1.9	7.8	48	94	0.03

Org.: organic, Conv : conventional

Roughage has to be fed to monogastric animals as well. Sundrum & Weissmann (2005) found that high performance growing pigs did not gain weight on crop land with red clover (green manuring) without grain legume supplementation. The protein quality and digestibility was not suitable for pigs. The clover did not contribute to the protein demand of growing pigs. Silage for laying hens is not suitable either. The chickens have problems in the crop and the intestines with stalks which are too long (>1 cm length). Only fresh and young grass and legumes can be eaten by chickens but not dried roughage (OEL-FAL, 2005).

"Healthy fodder" to prevent diseases

Further important feedstuff research is the search for "healthy fodder." While the impact of feed on animal growth and performance as well as the product quality was the major focus in animal nutrition science, the health aspect becomes more important in organic farming. The diseases are the same as in conventional farming but the prophylactic prevention is prohibited and the therapy with normal drugs restricted. On the other hand, the animals have living conditions with a higher impact by infections and diseases, especially parasitic infections in the compulsory outdoor keeping on grassland.

For these reasons, scientific research has been intensified in pursuit of alternative parasite control methods in livestock, such as nematode-trapping fungi, genetically resistant and/or tolerant breeds, vaccines, and/or other simple management procedures (e.g., rotational grazing, alternate/mixed grazing), and some tanniniferous plants (e.g., *Hedysarum coronarium, Lotus corniculatus, Onobrychus viciifolia).*

A lot of research has been done to find feedstuffs with secondary plant compounds with anthelmintic properties. In the last years, the use of tanniniferous plants – usually an ANF – has been developed as a scientific approach for the alternative control of ruminant GIN. Bioactive plants or forages with secondary metabolites, particularly legumes with a high content of proanthocyanidins (Condensed tannins) have been reported to reduce worm burdens. While there are several tropical plants with reported anthelmintic effects (*Quassia* spp, *Azadiracta indica*, *Albizia* spp., *Ananas comosus*, *Areca catechu*, *Argemone mexicana*, *Artemisia* spp., *Caesalpinia crista*, *Carica papaya* (latex), *Castella tortuosa*, *Chenopodium ambrosioides*, *Fumaria parviflora*, *Matteuccia orientalis*, *Melia azeradach*, *Vernonia anthelmintica)* there was only little interest in the past and therefore little knowledge in anthelminitic effects of plants growing in Europe (Rahmann, 2004b). Some preliminary results with bird's foot trefoil (*Lotus coniculatus*, *Lotus uliginosus)*, Chicory *(Cychorium intybus)*, sainfoin (*Onobrychis viciifolia*), white clover (*Trifolium repens*), fenugreek (*Trigonella foenum graecum*), pine tree (*Pinus maritime)*, spruce (*Picea abies)*, hazel nut shrub *(Corylus avellana)* and oaks *(quercus spp.*) are encouraging. (Rahmann, 2004a). The nutritive value, the impact on product quality and the toxicity is not known and needs special attention in future research (Scharenberg et al., 2005).

Conclusions and future research needs

Although not all the questions related to 100% organic fodder rations for high performing animals have been answered, the farmers need recommendations for daily feeding practice. Today it is possible to design 100% organic feeding rations, but many of them have not been verified in practice or are not suitable (e.g., high price, production constraints). All expected product quantities and qualities for 100% organic feeding rations can probably not be reached today. Organic feeding rations for high performing animals are based on recent knowledge in organic animal nutrition research – which is still at the beginning and not sufficient. Conventional feedstuff research is not applicable for many questions and circumstances in organic farming. Therefore further organic animal nutrition research is needed to improve intensive organic animal husbandry:

- Organic feedstuff with high protein quality for monogastric animals
- Optimised processing of organic feedstuff
- Roughage quality for ruminants and monogastric animals
- "Healthy feed" to prevent diseases
- 100 % organic feeding rations for intensive organic animal husbandry
- Warranty of GMOs-free organic feedstuff
- Natural and organically produced growth promoters
- Improved product qualities through feedstuff
- Understanding of the genotype – feedstuff interaction in organic farming systems
- Detection and reduction of toxicity and anti nutritional factors in organic feedstuff
- Reduction of the greenhouse effect of organic livestock through optimised feeding rations

References

Böhm, H., 2004. Data amino acids of different blue lupine varieties in organic farming. unpublished (OEL-FAL), Trenthorst

FAO / WHO, 1999. Codex Alimentarius Commission, Guidelines for the Production, Processing, Labelling and Marketing of Organically Produced Foods. cac/gl, 32, Rome

Freyer, B., (eds.), 2003. Beiträge zur 7. Wissenschaftstagung zum Ökologischen Landbau: Ökologischer Landbau der Zukunft. 24.-26. Februar 2003 in Wien. Wien, pp 650

Hamm, U. and F. Gronefeld, 2004. Analysis of the European market for Organic Food: An updated analysis. Organic Marketing and Rural Development Vol 5. School of Management and Business, Aberystwyth, UK

Hess, J. and G. Rahmann, 2005. Ende der Nische – 8. Wissenschaftstagung Ökologischer Landbau. Kassel, pp 684

Holle, R., 2005. Amino acids of different oil expeller, wheat and legumes of a feeding trial for organic laying hens, unpublished data (OEL-FAL), Trenthorst

Hovi, M. and T. Baars, 2001. Breeding and feeding for animal health and welfare in organic livestock systems. Proceedings of the fourth NAHWOA workshop in Wageningen, 24-27 March 2001, pp 224

IFOAM (International Federation of Organic Agricultural Movements), 2002. Basic Standards of Organic Farming. Tholey-Theley (update to be found under www.ifoam.org)

Leiber, F., M. Kreuzer, M.R.L. Scheeder and H.-R. Wetstein, 2005. Milk fatty acid profile of cows fed biodiverse forages only. In: *Hess & Rahmann, 2005. Ende der Nische – 8. Wissenschaftstagung Ökologischer Landbau. Kassel, 369-372*

Pries, M., A. Hauswald, A. Schöneborn, H. Spiekers and M. Freitag, 2005. Hydrothermically treated Lupines to ensure protein supply for dairy cows. In: *Hess & Rahmann, 2005. Ende der Nische – 8. Wissenschaftstagung Ökologischer Landbau. Kassel, 365-368*

OEL-FAL, 2005. Unpublished data of the Institute of Organic Farming of the German Federal Agricultural Research Centre. Trenthorst, Germany

Olmos, S. and N. Lampkin, 2005. Statistical report on the development of Organic Farming in EU member states and Switzerland for the period 1997-2002 with update for 2003. D5 of EU-CEE-OFP Organic Farming Policy. Aberystwyth, University of Wales, Aberystwyth, UK

Padel, S., 2005. Overview of supply and demand for concentrated organic feed in the EU in 2002 and 2003 with a particular focus on protein sources for monogastric animals Preliminary report sub-work package 4.2 in the EU- project SSPE-CT-2004-502397: Research to support the EU-regulation on Organic Agriculture (www.organic-revision.org). University of Wales, Aberystwyth, UK, April 2005

Rahmann, G. and H. Nieberg, 2005. New insights into organic farming in Germany - empiric results of a survey in 218 farms. *Landbauforschung Völkenrode,* **55(3)**:193-202

Rahmann, G., 2004a. Gehölzfutter - eine neue Quelle für die ökologische Tierernährung. Landbauforsch Völkenrode SH 272:29-42

Rahmann, G., 2004b. Ökologische Tierhaltung. Stuttgart, Germany, pp 135

Rutzmoser, K., 2003. Nährstoffgehalte von Grundfuttermitteln aus ökologisch wirtschaftenden Betrieben. Pommer, G. (ed.). Forschung für den ökologischen Landbau in Bayern - Ökolandbautag der LfL am 10. 02. 2003 in Triesdorf, Tagungsband Schriftenreihe 3/03, Freising

Scharrenberg, A., Y Arrigo, A. Gutzwiller, C.R. Soliva, A. Perroud, U. Wyss, M. Kreuzer and F. Dohme, 2005. Palatability of plants containing condensed tannins by sheep and their content of utilizable crude protein. In: Hess & Rahmann, 2005. Ende der Nische – 8. Wissenschaftstagung Ökologischer Landbau. Kassel, 381-382

Sedding, S., G. Jansen, C. Kurpjun, H.-U. Jürgens and W. Flamme, 2005. Germinated seeds in feed. In: Hess & Rahmann, 2005. Ende der Nische – 8. Wissenschaftstagung Ökologischer Landbau. 389-390

Sundrum, A. and F. Weißmann, eds., 2005. Organic pig production in free range systems. Landbauforschung Völkenrode, SH 281, pp 50

Sundrum, A., K. Schneider and U. Richter, 2005. Possibilities and limitations of protein supply in organic poultry and pig production: Research to support the EU-regulation on Organic Agriculture (www.organic-revision.org). University of Kassel, Witzenhausen, Germany, Preliminary report April 2005

Willer, H. and M. Yussefi, (editors), 2004. The World of Organic Agriculture - Statistics and Emerging Trends. International Federation of Organic Agriculture Movements, Bonn, Germany

Wlcek, S. and W. Zollitsch, 2003. Rohprotein- und Aminosäuregehalte von Winterweizen und Triticale aus Biologischem Anbau. In B. Freyer, Ökologischer Landbau der Zukunft. BOKU, Wien, 269-272

Zollitsch, W., S. Wlcek, T. Leeb and J. Baumgartner, 2000. Aspekte der Schweine- und Geflügelfütterung im biologisch wirtschaftenden Betrieb. 27. Viehwirtschaftliche Fachtagung BAL Gumpenstein, Irdning

→ VG WORT → GR

Proceedings of AHAT/BSAS International Conference:

Integrating Livestock-Crop Systems to Meet the Challenges of Globalisation

Volume 1

Editors:

Rowlinson, P., Wachirapakorn, C., Pakdee, P. and Wanapat, M.

November 14-18, 2005, Khon Kaen, Thailand

Hosted by Tropical Feed Resources Research and Development Center
Khon Kaen University, Thailand

Published by British Society of Animal Science

ISBN: 0 906562 50 3