Danish Research Centre
for Organic Farming

Status Report 2003 and
Application for Continuation in 2004

For research projects financed by grants from
The Directorate for Food, Fisheries and Agro Business
under the Danish Ministry of Food, Agriculture and Fisheries

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1. Research program

Research in organic farming 2000-2005 (DARCOF II)

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2. Project title and number

II.3 Organic production of steers and use of bioactive forages in livestock *(Acronym: **PROSBIO**)*

merged with

II.12 Product quality of organic beef and pork in relation to grazing system and feeding with bioactive crops (*Acronym: **PROSQUAL***)
*Complementary research to: WP8: 'Organic production of steers and use of bioactive forages in livestock' in DARCOF II' (Acronym: **PROSBIO**)*

***PROSQUAL** is now included as part b of WP 8 (i.e., WP8b)*

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6. Project period (month, year)

Start of project: **01.05.2000**
End of project: **31.10.2004**

7. Description of the project, its results and progress, and application for continuation in 2004

A. Project summary

Organic meat production in Denmark covers mainly beef and pork. The present market share of organic beef and pork is only 2.1% and 0.5%, respectively. The demand for organic high quality beef and pork is thus restricted despite a large number of organic dairy farms and a growing number of organic pig farms. Economic profitability is seen as the major constraining factor. However, the interest in organic meat production is increasing and the need for reliable information on production parameters and strategies is evident. The objective of this project is to contribute to the development of environmentally and economically viable farming systems for the production of high quality organic beef and pork. The investigations include the use of selected bioactive crops (e.g. chicory roots) with a possible positive influence on health, meat and eating quality in organic beef (steers) and pork. Therefore, the project attempts to improve the internal and external quality of organic produce, thereby illuminating both challenges and possibilities connected to integration livestock in organic productions systems.

Emphasis is on steer production that attempts to improve animal health and welfare, product quality and improved nature value of marginal areas through grazing. This may provide a scientific basis for decision support to organic beef producers and provide future guidelines for management of marginal areas to increase biodiversity. One of the major achievements in part of the project in 2002 was the development of a model for steer production making use of results from the entire project. The model was developed to optimise the grazing strategy, feed level in winter and time of fattening and slaughter in organic steer production with regard to economic output at steer level. The steer model is a 4-level hierarchical Markov process with decisions defined at three levels. Decisions taken in the model include grazing strategy (permanent or ryegrass/clover pasture), feed level in winter (high and low), time for beginning of fattening (age 19-27 months) and time of slaughter (age 19-30 months). Overall optimal strategies were low feeding level in the winter period, grazing on permanent pastures in the first grazing season, whereas use of ryegrass/clover pastures gives the optimal net return per steer in the second and third grazing season. The optimal strategies from the model suggested that the effect of fattening in steer production might be overstated. However, results from modelling have to be proved under practical conditions. It was concluded that the natural well-defined phases in organic steer production are well suited to be analysed by a multilevel hierarchic Markov processes.

The approach of using selected forage species to improve meat quality and health of animals, particularly parasite control, is novel and may amongst others limit the unwanted use of medication. Some plants contain compounds that may affect establishment, fecundity or expulsion of parasitic worms (nematodes). The preliminary conclusions on the experiments with sheep as a ruminant model indicate it is possible to substantially reduce the nematode faecal egg excretion when infected lambs are moved to a paddock with bioactive forage, e.g. sainfoin (*Onobrychis viciifolia*). A remarkable reduction in abomasal nematode counts was observed following the move to new pasture whether it was grass or a bioactive crop. This may provide new information on the effect of repeated moves for control. In 2001, the establishment of abomasal nematodes in lambs while grazing chicory was significantly reduced (by 85%). A reduction was also noted in 2002 but it was not significant. There are also clearly promising prospects for use of selected bioactive crops to improve product quality, in particular eating quality. Overall, groups of pigs fed chicory roots were perceived as more acceptable relative to the other feeding treatments. In steers finished on chicory or barley before slaughter, there was a clear difference in the sensory perception, although it is too early to define what is best!

Table A.1: Work package list (from application)

No.	Work package title	Participants*	Budget (1,000 DKK)	Start	End	Deliverable no(s):
WP 1	On-farm description and analysis of production and management strategies for steers	SMT,TK, BN	411	4/2000	2/2003	D19, D20, D21, D22, D23
WP 2	Production strategies for steers on clover grass pastures	SMT,TK, BN	94	4/2000	2/2003	D13, D24
WP 3	Grazing systems for steers on marginal land	HRA,TK, BN, LLH, BN	1,997	4/2000	12/2003	D15, D29, D30
WP 4	Influence of different grazing strategies on biodiversity on marginal land	ABH, KS	810	4/2000	12/2002	D2, D15, D18, D27, D28
WP 5	Preparation of extracts for estimation of direct anthelmintic effect of plant species	KB, RN	376	8/2000	12/2003	D1, D5, D6, D10
WP 6	Influence of bioactive forages on animal health with emphasis on parasitic infections	SMT, AR	1,242	4/2000	6/2004	D7, D14, D16, D35, D37
WP 7	Test and large scale cultivation of bioactive forages	CO	376	4/2000	6/2004	D8, D9, D31
WP 8a	Influence of bioactive forages on meat and eating quality (PROSBIO)	LLH, MM, AR, MV; CO, TK, SMT, DB	1,264	1/2001	6/2004	D17, D34, D36
8b1	Sensory eating quality of pork in relation to the influence of bio-active forage feeding (chicory) (PROSQUAL)	LLH, JHN (DIAS) and DVB, (KVL)	534	2/2002	6/2004	D34 and D36
8b2	Content of conjugated linoleic acid (CLA) in beef from steers produced on pasture (PROSQUAL).	MV, TK, Søren Krogh Jensen (DIAS) and Mie Strårup (DTU)	230	1/2002	12/2003	D29, D30 and D34

* Responsible participants are underlined

B. Objectives and expected achievements

The overall objective is to develop and document economically viable production systems for organic meat of beef and pork with emphasis on steer production that attempts to improve animal health and welfare, product quality and the natural value of marginal areas by grazing. Furthermore, bioactive forages with a possible influence on health and meat quality will be investigated. Specific goals:

1. To describe and develop steer production on organic farms with focus on pasture based production, particularly grazing strategies
2. To evaluate the effect of different management strategies on production, and health and welfare of organic steers.
3. To compare production, parasitism and herbage intake in steers and heifers grazing marginal areas at different stocking rate or grazing systems.
4. To examine the interaction of grazing, forage production, and development in biodiversity in marginal areas of different initial richness of species.
5. To investigate the use of bioactive forages and products for improvement in health with particular reference to parasitic infections.
6. To improve meat and eating quality in relation to fattening strategies and bioactive forages.

The investigations related to steer production will provide a scientific basis for decision support to organic beef producers and provide future guidelines for management of marginal areas. Emphasis will be on improvement of animal health and welfare and product quality of steers, and on utilisation and conservation of the biodiversity of marginal areas by grazing. The perspective of having bioactive plants controlling parasitic infections and/or improving meat quality and flavour are fascinating. It may limit the unwanted use of medication and prolonged withdrawal times may be avoided. Also the combination of steer production with improvements and conservation of biodiversity of marginal land in low-lying areas seems beneficial for nature conservation as well as environment. All of these different aspects may improve economy of organic steer production or will help justify the higher prices of organic products and improve the image of organic farming systems as being special compared to conventional farming systems. Nevertheless, concepts and ideas developed in the present study regarding use of bioactive forages will be equally applicable in conventional farming.

Item 6 (and item 2) above is specifically addressed in WP8a,b which comprise part of the PROSBIO project and the entire PROSQUAL project. These items deserve a more detailed description. The overall objective of the studies in WP8a,b was to improve the meat and eating quality, including an increase in the content of matters with a potentially beneficial effect on human health in organic meat from cattle and pigs raised outdoors and (or) finished with bioactive crops.

Compared with conventional pork production, organic pork has diverging quality parameters such as higher content of polyunsaturated fatty acids due to organic foodstuffs (protein sources and use of forage as e.g. clovergrass and clovergrass silage) and sometimes lower tenderness due to production systems resulting in lower daily gain. Although a higher content of polyunsaturated fatty acids is a positive aspect from a human health perspective, the higher disposition to rancidity as a result of oxidation is a negative aspect. This oxidation can be a problem with meat products used in catering products as they involve reheated meat. However, antioxidant substances such as vitamin E and enzyme systems selenium (gluthatione peroxidase) with antioxidative activity can inhibit the oxidation of polyunsaturated fatty acids in meat.

Lacking economic profitability is seen as a major constraining factor in using dairy-type calves and young bulls in organic beef production. However, the interest in organic beef production is increasing and the need for reliable information on production parameters, feeding strategies, and ways to increase the domestic market share of organic beef from dairy-type steers is evident. Also knowledge of the effect of production system on the product composition that may confer health benefits to human consumers is important, e.g. the content of conjugated linoleic acid (CLA).

The following specific objectives from PROSQUAL are included in WP8a,b:

1. to examine the eating quality and the content of vitamin E and selenium (gluthatione peroxidase) and fatty acid composition in pork from pigs fed bioactive crops, i.e. chicory roots.
2. to examine the eating quality and to determine the fatty acid composition and CLA content in meat from extensively raised steers finishing-fed by use of different combinations of clover-grass silage, concentrates, and chicory roots
3. to compare the fatty acid composition including CLA in tallow and meat from steers and young bulls raised in various production systems

C. Results and progress

C.1 Description (summary) of main results and conclusions

WP1: On-farm descriptions and analysis of production and management strategies for steers

The objective of this study was to describe organic steer production on farm level. Six Danish organic farms were part of the registration program including 3 dairy farmers and 3 crop farmers buying dairy breed bull calves from organic dairy farmers. All farmers had a steer production, some of them were recently started and some had an established steer production. The experiment endured 2½ years from January 2000 to April 2002. Registrations included liveweight, feed consumption, welfare-related observations and slaughter results with special emphasis on the fattening period. Welfare registrations were based on a scheme describing the system as well as the animal during winter when stabled in the barn and during summer on pasture. Daily gain on pasture varied from 533 to 823 g and included on most of the farms both grazing on ryegrass/clover pastures and marginal grazing areas. Gains during the stable period varied from 562 to 867 g/day between the farms. Average feed consumption per steer per year was 1770 Scandinavian Feed Units (SFU) ± 186 based on 4 farms (Fig.1). Feed consumption in summer accounted 0.47 to 0.57 of total feed consumption per year. Pasture accounts for 0.22 to 0.56 and concentrates for 0.16 to 0.37 of the total dry matter (DM) consumption per year. Management strategies concerning the fattening of steers were different between the 6 farms, as liveweight (458-595 kg) and age (20-25 months) at start of fattening and at slaughter (565-667 kg and 23-28 months) and length of fattening period (2.3-3.4 months) varied. Feeding during the fattening period was based on 1.3 to 4.7 SFU concentrates per steer per day and silage ad libitum. The total amount of cereals consumed in the fattening period was 100-357 kg/steer. Only few steers were fattened on pasture. It seemed that whole crop silage is preferred to grass silage in the fattening period. Slaughter results show a variation between farms in slaughter percentage from 49.4 to 53.8, carcass conformation from 3.5 to 4.9 and fatness from 2.5 to 3.2. Liveweight at slaughter was the only variable with general effect on carcass conformation on 5 farms (0.6 point on the EUROP-scale with increase in 100 kg liveweight at slaughter). The welfare registration scheme indicates good conditions both in the barn and on pasture, low disease rate and minor problems concerning welfare aspects in organic steer production (Table 1 and 2, Fig. 2). It is concluded that great variation between farms concerning management strategies shows the possibilities for improving the production system. Fattening strategy should focus on liveweight at slaughter. Length of fattening period as well as daily gain during the fattening period in the range practiced on the farms seemed to be of minor importance with regard to carcass conformation.

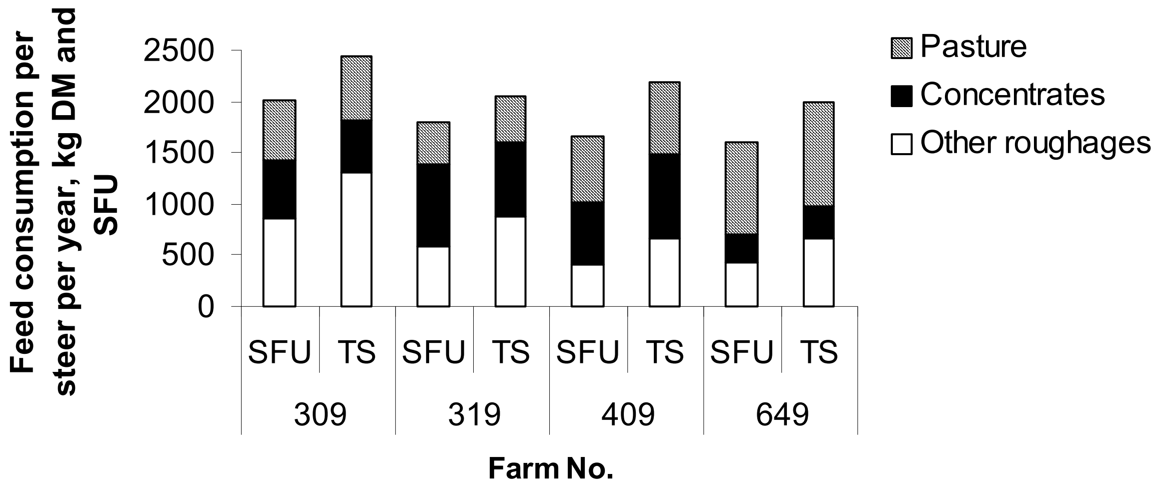

Figure 1. Feedstuffs used per steer per year

Table 1. Description of housing facilities (during winter) and the conditions on pasture (during summer) by observations using a common welfare assessment scheme.

	Winter [2)]	Summer [2)]
Number of observations [1)]	555-650	200
Number of animals per pen /paddock	14 ± 12	38 ± 27
Slipperiness (1= good grip; 4= very slippery)		
- Lying area	1.1 ± 0.3	---
- Feeding area	2.1 ± 1.2	---
Feed hygiene (1=clean; 3=contaminated with faeces, stones etc.)	1.1 ± 0.4	---
Feed quality (1=good; 4=bad (mould))	1.3 ± 0.5	---
Water supply (1=continuous; 2=daily; 3=less than daily)	---	1.0 ± 0.3
Cleanliness of drinking trough (1=no faeces, straw or others; 3=a lot of faeces, straw or others)	1.5 ± 0.7	1.3 ± 0.6
Air quality (1=normal; 3=pungent smell of ammonia)	1.3 ± 0.4	---
Daylight (1=light; 4=medium)	2.1 ± 1.0	---
Atmospheric humidity (relative)		
- Inside	83.2 ± 7.8	---
- Outside	74.1 ± 16.7	
Temperature, ºC		
- Inside	12.4 ± 5.4	---
- Outside	7.9 ± 6.5	

1) The number of observations describes total observations done on all pasture and boxes on all farms, i.e. a total of 555 and 650 boxes dependent on observation and 200 paddocks were observed in the registration period.
2) Standard deviations were given between all observations and were rather high, because the values are dependent and at some observations it might be ranked 0% for "total dry" and 90% for "moist" and in another case the rankings were 90 and 0% respectively.

Table 2. Welfare-related observations on steers during housing and on pasture. Values are given according to scale: 1=0%; 2=<10%; 3=10-50%; 4=50-90%; 5=>90% of the animals [1].

	During housing	On pasture
Number of observations	765	146
Cleanliness of the animals		
- No faecal contamination	2.5 ± 1.5	3.1 ± 1.3
- Little contamination	3.4 ± 1.4	2.8 ± 1.1
- Strong contamination	1.2 ± 0.6	1.1 ± 0.4
Wetness of the hair coat		
- Dry	3.2 ± 1.6	---
- Moist	2.5 ± 1.4	---
- Wet overall	2.0 ± 1.3	---
Length of the hair coat		
- Trimmed	1.1 ± 0.6	---
- Not trimmed but short	3.7 ± 1.5	---
- Long	2.0 ± 1.3	---
Hair coat		
- Nice	2.7 ± 1.5	3.4 ± 1.3
- Not nice nor ruffled	3.0 ± 1.4	3.0 ± 1.2
- Little ruffled	1.8 ± 1.1	1.5 ± 0.9
- Much ruffled	1.1 ± 0.4	1.0 ± 0.1
Body condition score		
- Very poor	1.2 ± 0.6	1.1 ± 0.3
- Poor	2.3 ± 1.1	2.4 ± 0.9
- Normal	3.6 ± 1.3	3.9 ± 0.8
- Fat	1.4 ± 0.9	1.7 ± 0.9
- Grossly fat	1.1 ± 0.5	1.0 ± 0.2

[1] The registrations were done on a scale from 1-5, according to the proportion of animals in the observed groups, as i.e. some steers in the box may be strong contaminated with faeces and some steers may be without any contamination. Every single observation thus sum to 100%, however in the table average values of all observations are given and thus the total sum may not exactly sum to 100%.

Figure 2. Moisture of lying area during housing / pasture in summer. Values were given according to the scale (during housing / pasture): 1 = Total dry / Total dry; 2 = Moist / Water covers a part of the hooves; 3 = Wet / Animals walk in water to the knees; 4 = Very wet / ---

Organic steer production demand several decisions concerning grazing strategy, feeding level in the winter and factors as slaughter weight and length of the fattening period. The production system can be difficult to optimise, therefore the objective of this study was to develop a model to optimise the grazing strategy, feed level in winter and time of fattening and slaughter in organic steer production with regard to economic output at steer level. The steer model is a 4-level hierarchical Markov process with decisions defined at three levels. Decisions taken in the model include grazing strategy (permanent or ryegrass/clover pasture), feed level in winter (high and low), time for beginning of fattening (age 19-27 months) and time of slaughter (age 19-30 months) (Fig.3). Overall optimal strategies at child level 1 with regard to economic output per produced steer were low feeding level in the winter period, grazing on permanent pastures in the first grazing season (Fig. 4), whereas ryegrass/clover pastures gives the optimal net return per steer in the second and third grazing season. The optimal strategies from the model suggested that the effect of fattening in steer production might be overstated. However,

results from modelling have to be proved under practical conditions. It was concluded that the natural well-defined phases in organic steer production are well suited to be analysed by a multi-level hierarchic Markov processes.

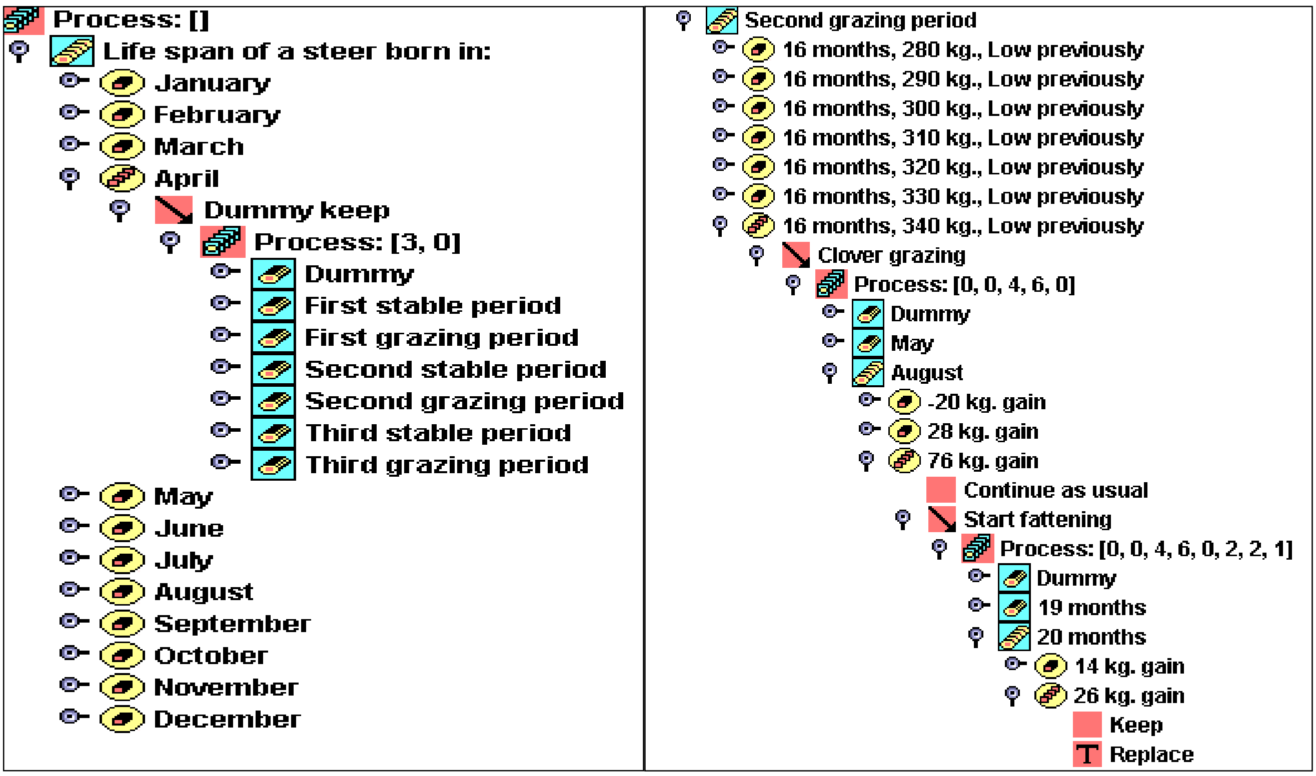

Figure 3. Model structure as shown in the software: Founder process shown as month of birth and child level 1 presented as periods of grazing or winter season (to the left). Clover grazing in second grazing period is chosen in child level 1. In child level 2 (august, a gain of 76 kg since start of period in May) and start fattening as action is chosen. In child level 3 the actions replace or keep are possible.

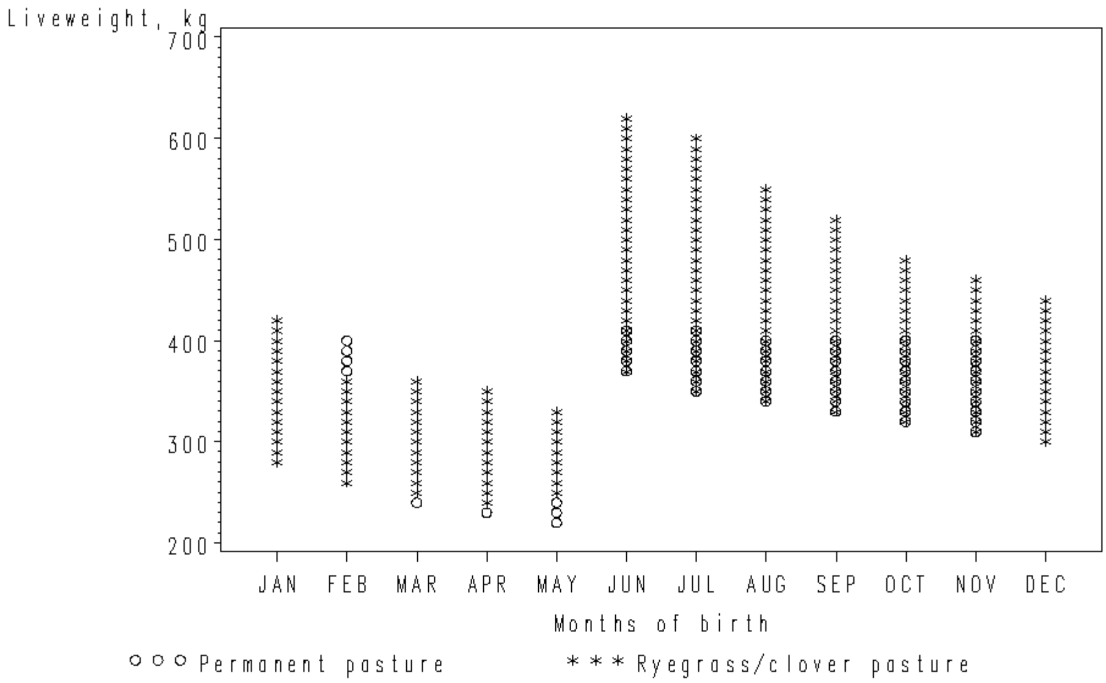

Figure 4. Optimal strategy in the second grazing period (child level 1) according to month of birth and LW. Birth months June to November: Use of permanent pastures is optimal following high feed level in previous winter period and ryegrass/clover pastures are optimal following low feed level in previous winter.

WP2: Production strategies for steers on clover grass pastures

All work was terminated in 2002.

WP3: Grazing systems for steers on marginal land

Grazing season 2002

At Fussingø, on marginal land two different grazing systems were compared in 2001 and 2002; continuously grazing (set-stocking) and rotationally grazing with only two rotations. Each grazing system consisted of four replications and included both dairy breed heifers and steers in the first year (2001). The goals were to compare the production, feed intake and health of steers and heifers being co-grazed on marginal land, to investigate the influence of a rotational versus a continuous grazing system on utilization of potential sward production, performance and health of steers on marginal low-lying land and to investigate the influence of different finishing strategies, including bioactive forages, on composition of muscular fatty acids.

According to plans, the 40 second-grazing season steers were turned on pasture on 22 May 2002. The weight loss during the first two weeks was approximately 10%, which is about the same as that experienced in previous experiments. During the entire period at pasture in 2002 there were no differences in daily gain due to grazing system, as seen in table 3.

Table 3. Liveweight during the grazing period (2002) for 2nd year steers in two grazing systems

	22-05-2002	05-06-2002	05-07-2002	07-08-2002	28-08-2002
Set stocking	436,5	397,4	423,0	441,3	458,4
Rotation	442,5	411,8	431,9	448,3	460,3

Others

During the autumn feeding in 2001, chicory roots were tested on young stock on Rugballegård to study the palatability when mixing the roots in the complete ration. By visual inspection the chicory roots compared to fodder beet, i.e. neither influencing the eating behaviour nor the feed intake. The nutritional value of chicory was analysed and showed the following results: dry matter 23.9% of OM; ash 4.2% of DM; crude protein 8.1% of DM; fat 1.3% of DM; crude fibre 5.8% of DM; digestibility of organic matter 88.8%.

At housing on 1 October 2002 the steers were allocated to four treatments with different amount and type of concentrates. At all treatments was clover grass silage fed ad libitum. The four treatments were
1: 1.7 kg DM barley
2: 3.4 kg DM barley
3: 1.7 kg DM chicory roots
4: 3.4 kg DM chicory roots
Daily gain in the previous period at pasture was the same, 400 g daily, in all treatments. Daily gain during the finishing period until slaughter at 10 December was 852, 827, 668 and 760 at the four different treatments (Figure 5). More details are given by WP 8.

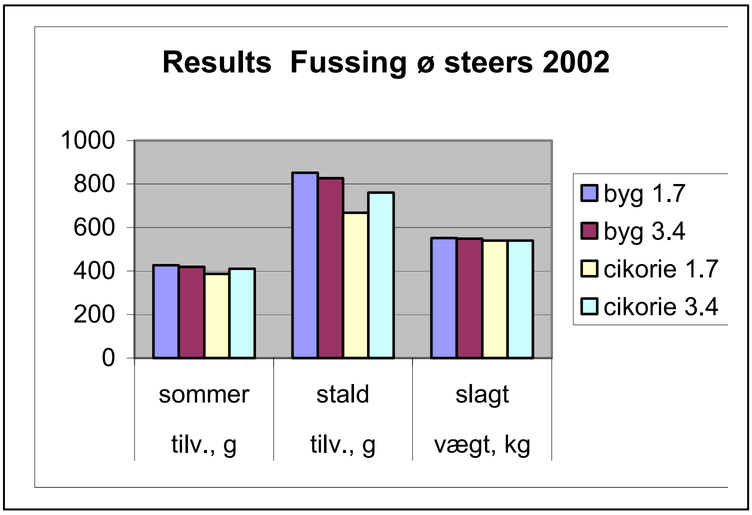

Figure 5. Weight gains during the grazing season and housing period

WP4: Influence of different grazing strategies on biodiversity on marginal land

At the two different grazing systems, continuously and rotationally grazing, at Fussingø in 2001 and 2002 herbage production, herbage quality and sward structure were measured five to six times during the grazing season. The paddocks were very heterogeneous with dense grazed areas, rejected areas, and high top-grazed tufts. The mean sward height is shown in Figure 6. The sward was generally highest before grazing at rotational grazing, lowest after the grazing period at rotational grazing, and the height at continuous grazing was in between. About 20 % of the area was above 20 cm at continuous grazing and was defines as rejected areas.

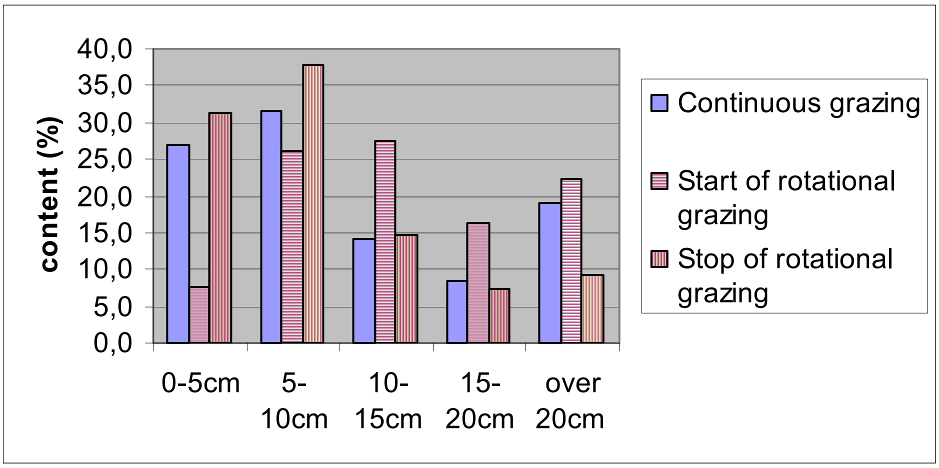

Figure 6. Compressed sward height grouped at different levels. Mean over years. Six times per year with 200 measurements per paddock.

The herbage quality was measured throughout the season. The effect of the sampling method was examined. Sampling with hand simulating cattle grazing was compared with sampling with electric scissors. The hypothesis was that the herbage quality was higher at hand sampling because of lower content of dead plant material. However, there was no effect of the sampling method and it was concluded that the scissor method was satisfactory for estimating herbage quality. The herbage quality was in general very low (Table 4). It was, however, highest in the beginning of the grazing season as expected, but still with a low quality. IVOMD was for example only 65%. The quality was in general highest at the beginning of the grazing phase at rotational grazing.

Table 4. Herbage quality at the different grazing systems. Mean over season. Crude protein and crude fibre in per cent of dry matter. *In vitro* organic matter digestibility (IVOMD) in per cent of organic matter and Scandinavian feed units (FE) per kg dry matter.

System		Crude protein	Crude fibre	IVOMD	FE/kg DM
Continuous		13.8	29.3	53.2	0.65
Rotationally	Start	14.1	28.7	57.3	0.72
	Stop	14.0	29.0	53.0	0.65

WP5: Preparation of extracts for estimation of direct anti-parasitic effects of plant species

All extracts for the *in vitro* assay of anti-parasitic effects (to be used in WP6) have been prepared 2002 and early 2003. The bioactive forages and plants have been examined for secondary compounds. The different plant sources (such as birdsfoot trefoil, chicory, sainfoin, sulla and ryegrass) have been extracted and analysed for the contents of flavonoids, epicatechin and condensed tannins. Analytical HPLC and spectrometic colour measurements (vanillin-HCl and BuOH-HCl) were used to quantify the contents of tannins. Furthermore the HPLC measurements in combination with UV-vis measurements gave us an idea about the highmolecular tannins attached to the HPLC column during a run. To our knowledge this is the first time a method for quantification of highmolecular compounds by using HPLC have been reported. The contents of quebracho equivalents found in the plant sources varied from 4 mg/g dried plant material to about 20 mg/ g dried plant material.

WP6: Influence of bioactive forages on animal health with emphasis on parasitic infections

Evaluation of anti-parasitic activity of plant extracts (*in vitro* studies)

A number of various plant extracts have been tested against the sheep nematodes *Teladorsagia circumcincta* and *Haemonchus contortus* in a larval development assay (LDA). Preliminary results suggest that acetone extractions of chicory and sulla inhibit the development of both species while an acetone extraction of white clover inhibited the development of *H. contortus* but not that of *T. circumcincta*. In addition buffer extractions of 'Hvidmelet Gåsefod', *Lotus spp.*, 'Gåsepotentil' and 'Rejnfan' also inhibited the larval development of both species. In comparison, previous testing suggests that the development of the pig nematode *Oesophagostomum dentatum* is generally more susceptible to interruption by these extracts. This may be due to inherent differences between the species or may result from the extraction process since the buffer extraction method was modelled after the pig digestive tract.

Anti-parasitic activity of bioactive forages: grazing trial with lambs in 2002

The experiment in 2002 was a partial repetition of 2001 focusing only on sainfoin and chicory against a reference of clovergrass and including groups infected before and after being introduced to pastures with bioactive forages. The studies were partly funded by FØJO and our EU-project (Wormcops, see later).

Materials and methods

Areas and animals

The following areas (1-1.3 ha plots) with bioactive and control forages in pure stands were sown in April/May 2002: sainfoin (*Onobrychis viciifolia*), chicory (*Cichorium intybus*, cv. Grasslands Puna) and mixed white clover-rye grass (*Trifolium repens* cv. Milo; *Lolium perenne*). Each area was fenced with electrical wires or mesh into 8-12 smaller paddocks. 58 castrated, Texel crossbred lambs were purchased from a farm near Sakskoebing and turned-out on a separate parasite-free clover-grass pasture (1.0-1.5 ha) on 9 July 2002. The lambs were born in the period 14 April-8 May 2003, i.e. age of 2-3 months when introduced in the study and weaned at the same time. They had been reared out-door on permanent pasture but were treated with fenbendazole (recommended dose; Panacur vet. oral susp. 10%, Hoechst Roussel Vet.) on 16 June. Most of the lambs were treated for coccidiosis with toltrazuril (Baycox; 6 ml/lamb) between 17-29 June.
All animals were treated with fenbendazole at turn-out. In order to avoid cross-infections, lambs were moved to a new clean area two times during the egg excretion phase.

Design

The lambs were allocated according to body weight into the following 7 groups of 7 or 8 lambs, and 6 lambs were used as tracers:
Infected prior to move to bioactive forages:
Pre-Clovergrass (Pre-G) (7 lambs)
Pre-Sainfoin (Pre-O) (7 lambs)

Pre-Chicory (Pre-C) (7 lambs)
Infection control (IC) (7 lambs)
Infected after the move to bioactive forages:
Post-Clovergrass (Post-G) (8 lambs)
Post-Sainfoin (Post-O) (8 lambs)
Post-Chicory (Post-C) (8 lambs)
Uninfected tracer lambs:
3 x 2 lambs on each of: clovergrass, sainfoin and chicory

All animals were moved to bioactive forages on 5 August (day 1). The lambs of pre-groups and infection control were infected with 8750 infected larvae (L3) *T. circumcincta* and *T. vitrinus* on days -24, -21, -18 and -14 before the move, totalling 35,000 L3 per animal. The calculation of dose was based on an estimated daily dose of 2500 L3 in 2 weeks. 2500 L_3 per day is the level similar to that encountered when grazing a moderately contaminated pasture (Kyriazakis *et al.*, 1996). The L3 were from the Moredun ovine susceptible isolates of *T. circumcincta* and *T. vitrinus,* kindly supplied by Frank and Bob. Group IC were killed for worm counts at the time of the move. The move was thus on day 28 after first infection.

The post-groups were drenched again with fenbendazole at the time of move (day 1). They were infected on days 15, 18, 22 and 25 after the move with the same amounts of infective larvae. To prevent cross-infection between lambs and ensure optimal usage of the pastures, the animals were moved 2-3 times weekly, depending on the size of the previous pasture sub-plot and how much the animals had eaten. Lambs were grazed for 6 weeks (Pre-groups) and 8 weeks (Post-groups).

Sampling and analysis

The lambs were weighed and faecal sampled weekly (a few times twice a week). Faecal egg counts (FEC) were performed by a modified McMaster-method. For each set of groups quantitative larval cultures were set up two times (Pre-groups days 29 and 36; Post-groups days 50 and 57), with vermiculite and incubating for 14 days at room temperature.

Faeces consistency was visually classified according to the following guideline:
1: loose pellets, 2: soft pellets, 3: paste-like (pellets cannot be distinguished) and 4: diarrhoea
Faecal dry matter was calculated from a sub-sample dried in a force-draught oven at 95^{o}C for 24h (data not shown). FECs were then corrected for faecal dry matter percentage.

Lambs of Pre-groups were killed on days 44+45 (17-18 September) and Post-groups on days 58+59 (1-2 October). Abomasum (2 x 5% samples) and small intestine (2 x 5%) were examined for nematodes using the agar-gel migration technique (Githigia et al., 1995) followed by abomasal digestion according to MAFF (Reference Book 418). Up to 40 adult male nematodes were identified to level of species from the organs of each lamb (Barth & Visser, 1991). Assessment of fecundity by counting number of egg *in uteri* of gravid females was performed in post-groups. Furthermore, lengths of 10 male and 10 female were measured from abomasum and small intestine of each lamb.

Herbage sampling was conducted on day 25 (29 August) and day 53 (26 September) and sent to Steins Laboratory A/S for analysis. The freeze-dried samples were returned for determination of the content of condensed tannins at Aarslev. Forage samples were analysed for dry matter (DM, 80^{0}C for 16h), crude protein (N x 6.25; CP, Dumas), crude fibre, *in vitro* solubility of organic matter (IVSOM) (Tilley and Terry, 1963), and ash according to standard procedures of Steins. The IVSOM was then corrected to *in vivo* organic matter digestibility (OMD%) of roughage by the regression function OMD = 4.1 + 0.959 x % IVSOM (Møller *et al.*, 1989).

Preliminary statistical analysis has been performed on log-transformed faecal egg counts (repeated measurements), DM%, consistency and worm counts, using a simple ANOVA (PROC GLM of SAS) (SAS, 1990) followed by pair-wise comparisons with the reference forage (grass or infection-control). The daily liveweight gains were calculated for four periods:

1. Time from start until turnout on bioactive forages (WG1)
2. Time from turnout on bioactive forages to first day of infection of post-groups (WG2)
3. Time from first day of infection of post-groups to day of slaughter (WG3)
4. Time from turnout on bioactive forages to day of slaughter (week 6 or 8) (WG4)

Results and discussion

Forages

The growth of the forages in the season of 2002 was good in early season with above normal rainfall and temperatures (June+July) while the late season was considerably drier. September had less than 50% of average precipitation and was warmer than usual. The weeds taller than chicory and sainfoin were cut a couple of times in early season. Both forages were topped (upper parts cut) to ensure vegetative growth on 2 July, and half of the chicory area received commercial fertilizer (70 kg N/ha) to improve growth. Slurry was not use in order to avoid faecal contamination with parasite eggs (as experienced at Foulumgård previous year).

The DM% was highest in sainfoin, followed closely by clovergrass, whereas the DM% was considerable lower in chicory, a juicy herb (Table 5). The variability of crude protein in the clovergrass does probably not indicate a change with time but rather that the paddocks used initially in the trial were dominated by grass with less clover. This was also reflected in crude fibre and digestibility. Sainfoin was at all times lower than clovergrass and chicory (9-16%) in digestibility (and higher in crude fibre). Chicory is having a relatively low content of protein. The estimations of CT have not been performed yet.

Table 5. Chemical analysis of forages after 7 and 11 weeks (29 August/26 September 2002)

	DM (%)	Crude ash (% of DM)	Crude protein (% of DM)	Crude fibre (% of DM)	IVSOM (%)	OMD (%)
Clovergrass	23.8/25.8	11.5/10.2	13.6/22.3	23.3/18.4	70.3/77.2	71.5/78.1
Chicory	10.2/13.1	13.8/15.5	14.1/11.4	15.6/16.8	76.9/75.1	77.8/76.1
Sainfoin, pure	27.0/28.2	7.5/9.0	19.8/13.4	20.6/24.5	61.0/60.2	62.6/61.8
Sainfoin, weeds	22.8/30.6	9.3/8.7	23.7/18.8	24.4/25.4	64.6/66.8	66.1/68.2
Sainfoin, total	24.8/31.8	8.1/8.6	21.1/14.9	20.8/28.1	61.0/59.2	62.6/60.9

Clinical observations

The lambs did not show any reluctance to eat the forages provided. Water consumption varied according to weather conditions as can be expected. Faeces consistency changed during the trial, particularly in relation to the common clovergrass paddock to bioactive forages. This resulted in an increased occurrence of dags, especially in lambs grazing chicory. No clinical signs due to the nematode infections were observed.

Faecal egg counts

The log-transformation of FECs did not change the general picture, and therefore arithmetic means are used in Figures 7-8. The general picture is very similar whether based on wet basis and corrected for DM.

The mean FECs of the pre-groups were not significantly different before the move (day -7 and -4) (data not shown). Following the move, the FECs and the DM-corrected FECs of the Pre-groups were not significantly different in the repeated measurements ANOVA ($p=0.3$ and $p=0.2$). However, the pairwise comparisons of DM-FECs showed repeatedly significantly lower means in sainfoin compared to clovergrass (day 4, 9, 12, 15 with $p=0.05$, $p<0.05$, $p<0.01$ and $p<0.05$, respectively). This reduction of about 40-50% remained evident up to the time slaughter, although the general levels diminished (Figure 7).

Larval coprocultures showed somewhat higher percentages of *Teladorsagia* compared to *Trichostrongylus* in chicory and sainfoin groups versus clovergrass (4%, 8% and 17% in the 3 groups, respectively on day 29; 23%, 19% and 45% on day 36). This may reflect the lower abomasal worm counts observed in the former two groups (see later).

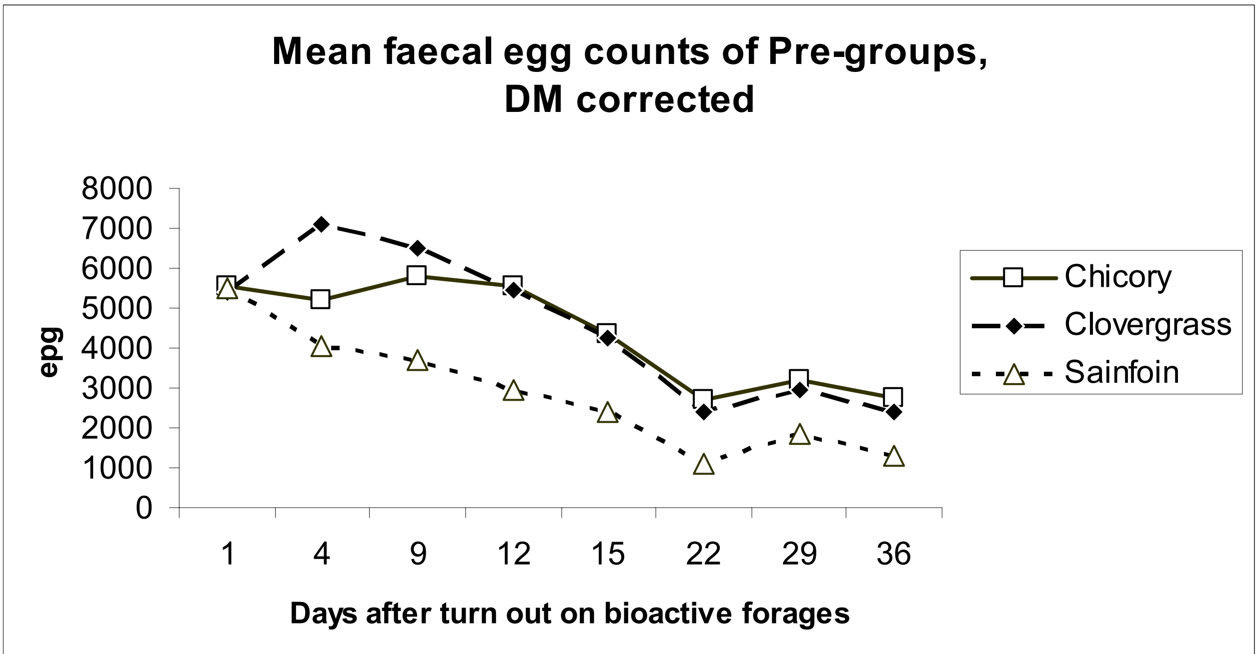

Figure 7. Mean faecal egg counts (arithmetic) of Pre-groups corrected for faecal DM%

Table 6 shows the relative FECs of the Pre-groups. It is clearly evident that FECs were decreasing in all groups after the move. The sainfoin group showed the fastest decline within 1-2 weeks after the move.

Table 6. The weekly faecal egg counts (DM corrected) in pre-group relative to the levels at the time of the move (average of day 0).

	Faecal egg counts relative to week 0 (%)					
Group	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5
Pre-G	100 (=5397epg)	120	78	45	54	45
Pre-O	100 (=5507 epg)	67	43	20	33	23
Pre-C	100 (=5547 epg)	104	79	49	58	50

The FECs of Post-groups grazing chicory were consistently higher than those for both clover-grass and sainfoin (data not shown). The lowest FECs throughout the experiment were found in lambs grazing sainfoin. The first positive FECs were seen 2 weeks after the first day of infection (i.e. 4 weeks after turnout on the bioactive forages). In Post-groups, the repeated measures ANOVA showed that overall FECs (wet) were significantly different between groups ($p<0.05$). The FECs in wet faeces were marginally lower ($0.05<p<0.10$) in lambs grazing sainfoin than in those grazing clovergrass 4 weeks after infection. After 5 weeks the mean FECs in lambs grazing sainfoin was significantly lower than in clovergrass ($p<0.01$).

FECs corrected for DM after 4 weeks for lambs grazing sainfoin were significantly lower than FEC for lambs grazing white clover ($p<0.05$) (Figure 8). After 5 weeks this difference was marginal ($0.05<p<0.1$). Curiously, it was also shown, that 6 weeks after infection, the DM-FECs in sheep grazing chicory was significantly higher than in lambs grazing clovergrass ($p<0.01$). The repeated measurements ANOVA showed that overall lambs grazing sainfoin had lower DM-FECs than lambs grazing clovergrass ($p<0.01$).

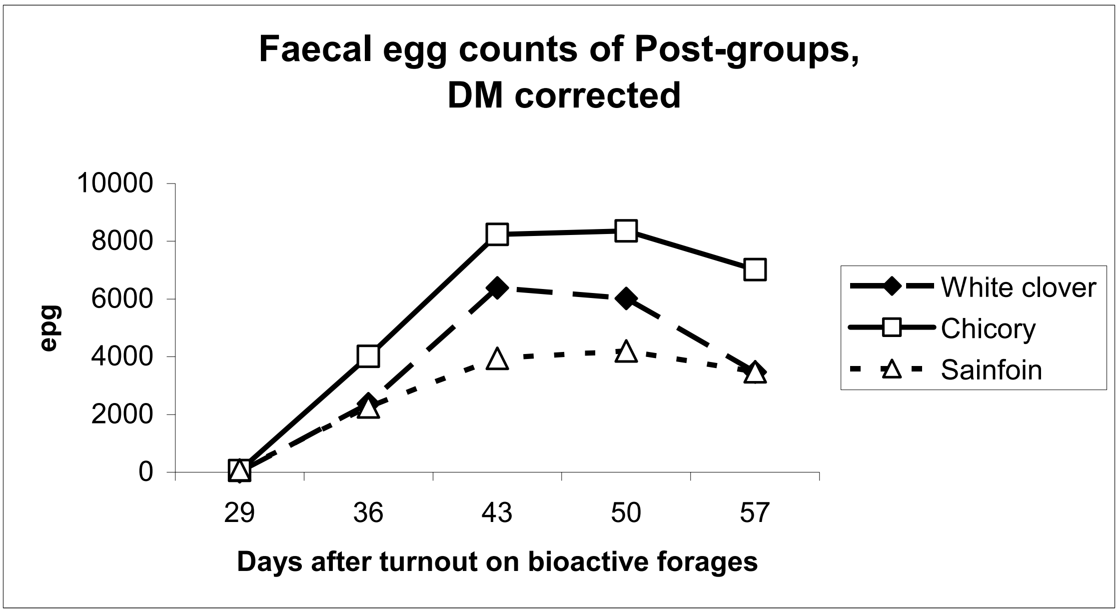

Figure 8. Mean faecal egg counts (arithmetic) of Post-groups corrected for faecal DM%

To complement the statistical evaluation of significant results, Table 7 shows the reductions in FECs observed in lambs grazing sainfoin and chicory compared to lambs grazing clover-grass. Higher FECs were observed in the chicory group.

Table 7. The weekly faecal egg counts (DM corrected) in groups grazing sainfoin (Post-O) and chicory (Post-C) are calculated relative to Post-G on clovergrass.

	Faecal egg counts relative to Post-G (%)				
Group	Week 0	Week 3	Week 4	Week 5	Week 6
Post-G	0	2377	6384	6023	3468
Post-O	0	2261 (-5%)	3947 (-38%)	4200 (-30%)	3476 (0%)
Post-C	0	4015 (+70%)	8236 (+29%)	8361 (+39%)	7020 (+102%)

Larval coprocultures on the Post-groups on days 50 and 57 showed no major difference in ratio between *Teladorsagia* and *Trichostrongylus*. The proportion of *Teladorsagia* was slightly lower in clovergrass in contrast to finding in the Pre-groups.

Worm counts

The *Teladorsagia* counts of the pre-groups showed a marked reduction from the time of the move until slaughter in all groups (Table 8) but the difference in relation infection control was not significant due to very large variation.

Table 8. Worm counts in Pre-groups (aritmetic means)

Group	*Teladorsagia circumcincta*			*Trichostrongylus vitrinus*		
	n	Mean	Range	n	Mean	Range
Inf-ctrl. (IC)	7	10,895	4759-21,509	7	17,430	13,209-27,540
Clovergrass (Pre-G)	7	7,060	1,080-16,794	7	12,796	8,260-18,943
Sainfoin (PRE-O)	7	4,267	1-9,019	7	16,170	6,438-24,540
Chicory (PRE-C)	7	3,239	182-6,753	7	15,978	7,976-21,609

Brief statistics on log-transformed counts:
Teladorsagia: no significant differences
Pre-G, Pre-O and Pre-C not sign. different from IC (p=0.2); pairwise Pre-O versus IC p=0.13
Pre-O and Pre-C not sign. different from Pre-G (pairwise Pre-C versus Pre-G p=0.12 on non-trans. counts)
Trichostrongylus: no significant differences between any of the groups at any stage

Table 9. Worm counts in post-groups (arithmetic means)

Group	*Teladorsagia circumcincta*			*Trichostrongylus vitrinus*		
	N	mean	Range	n	Mean	range
Clovergrass (POST-G)	8	7,544	601-21,526	8	14,445	9,020-18,920
Sainfoin (POST-S)	8	13,050	4,501-23,835	8	13,873	10,340-17,040
Chicory (POST-C)	8	6,792	3,204-10,350	8	17,300	11,860-19,800

Brief statistics on log-transformed counts:
Teladorsagia: no significant differences (CG versus S: p=0.07)
Trichostrongylus: no significant differences (CG versus C: p=0.11)

Weight gains

Means of cumulative weight gains for Post-groups were not significantly different at any single point in time. The differences in daily weight gains prior to turnout on the bioactive forages in Post-groups (Table 10; WG1) were not significantly different overall, nor when chicory and sainfoin were pairwise compared with clovergrass. The daily growth rates of Post-groups doubled when moved to the new clovergrass paddocks and tripled when moved to chicory and sainfoin. Although not significantly different ($0.05 < p < 0.1$) growth rates were markedly higher on chicory compared to clovergrass, and the result did indicate an interaction prior to infection (WG2). During the period of infection (WG3) there was no significant difference between the weight gains of lambs grazing chicory or sainfoin, when compared to those grazing white clover. For the whole period of grazing bioactive forages (WG4), the mean growth rate of Post-S was significantly higher than Post-C ($p < 0.05$) and Pre-S was significantly higher than Pre-G ($p < 0.05$).

It has to be added that the relative differences in growth rates cannot easily be related to the relative quality of the forages as such because the availability was low in some paddocks and lambs were thus not fed *ad libitum*.

Table 10. LSMean of daily weight gains of lambs in all groups.

	Group	Daily weight gains (g/day)			
		Start to move (WG1) (21 days)	Move to infection (WG2) (14 days)	Infection to slaughter (WG3) (Post:42 days)	Move to slaughter (WG4) (Pre:35 days; Post:56 days)
Pre-	Infection-ctrl.		-	-	-
	Clovergrass	69	70	(259)	183
	Sainfoin	82	235	(247)	242
	Chicory	84	235	(118)	165
Post-	Clovergrass	81	214	189	196
	Sainfoin	48	290	212	232
	Chicory	91	308	170	204

Pre-groups: no significant differences, except
WG3: p=0.06; Pre-C different from Pre-G (p=0.06)
WG4: p<0.05; Pre-O different from Pre-G (p=0.06)

Preliminary conclusions and perspectives

Findings regarding the Pre-groups = already established infections at time of move to bioactive forages:

- FECs declined after move in all groups but fastest and largest decline in sainfoin
- Worm counts of *T. circumcincta* reduced 40-50% in chicory and sainfoin compared to clovergrass. However, these differences were not significant.
- Grazing chicory leads to softer faeces and sainfoin clearly leads to more solid faeces compared to clovergrass. These effects were highly significant.

Findings regarding the Post-groups = establishing infections on bioactive forages:

- Sainfoin reduced FECs relative to clovergrass (30-40%)
- Chicory may result in increased FECs!
- Worm counts largely unaffected, both in abomasum and small intestine

The sainfoin-groups showed best productivity during the entire grazing period.

These results open up for several perspectives. It is evident that chicory may lead to reduced *Teladorsagia* spp. burdens. The results in 2001 were highly significant whereas the study in 2002 only showed a trend in the Pre-group and nothing in the Post-group. This is remarkable, as the Post-group was most likely to be affected, considering this the infection is under exposure during the whole phase. We have to perform more studies on chicory to confirm these findings before a decision is made on implementation.

One of the reasons for non-significant differences is related to a very high variation in the worm counts of experimentally infected lambs. This is in clear contrast to results of 2001. Although we have used different breeds in 2001 and 2002, the most likely explanation is related to previous exposure of animals in 2002. We know that several animals had positive FECs at the time of entry into the study and this indicates that the deworming procedure on the farm of origin was not sufficient, resulting in very variable establishments of our experimental infections. All lambs in 2001 were taken directly from the stable but this has become almost impossible, if breeds most suitable for grazing are wanted. Another factor is related to later time of slaughter compared to 2001 and use of a second year crop in 2001.

Pig experiment with chicory 2002/2003

As in the first experiment the purpose was to test if inulin rich chicory roots may have an adverse effect on established and establishing intestinal parasites. Diet composition are described in detail under WP8, but in short, 4 groups of 8 entire male pigs fed a diet of organic concentrate and grass silage were infected with 3000 *O. dentatum* larvae (week –4). Four weeks later, when the *O. dentatum* should be adult, the diet was changed for 3 of the groups while the fourth remained on the concentrate + silage diet (silage group) (week 0). The other 3 diets consisted of concentrate and either fresh roughly shredded chicory roots (fresh chicory group), dried finely shredded chicory roots (dried chicory group), or inulin (inulin group). Four weeks after the diet change all pigs were infected with 2000 *A. suum* eggs and 3000 *O. dentatum* larvae (week 4). After an additional 2 weeks, all pigs were slaughtered for recovery of adult worms (1^{st} infection) and immature worms (2^{nd} infection)(week 6).

Within a few days after the introduction of the experimental diets the *O. dentatum* egg counts dropped drastically in the inulin, fresh and dried chicory groups compared to the silage group (Figure 8). However, as in the first experiment the egg counts in the fresh chicory group steadily increased with time and ended at the same level at slaughter as the silage group. In contrast the egg excretion remained depressed in the inulin group and especially in the dried chicory group. The results seem to indicate a varied effect on the fecundity *of O. dentatum* of the experimental diets. Part of the reason may be differences in faecal output due to differences in the feed volume given to the 4 groups. The total feed volume was especially high in the fresh chicory group. This may have led to a dilution of the parasite eggs and thereby exaggerated the apparent depression of egg excretion. The same problem should not be as marked for the inulin and fresh chicory groups. To assess the differences in faecal output, chrome was added to the concentrate given to the pigs for the last 2 weeks before slaughter. By analysing the chrome content in both faeces and feed it is possible to give an estimate of faecal output. Though the samples have now been analysed the egg excretion data has not yet been corrected for faecal volume. Correction for differences in dry matter does not change the relative egg excretion patterns.

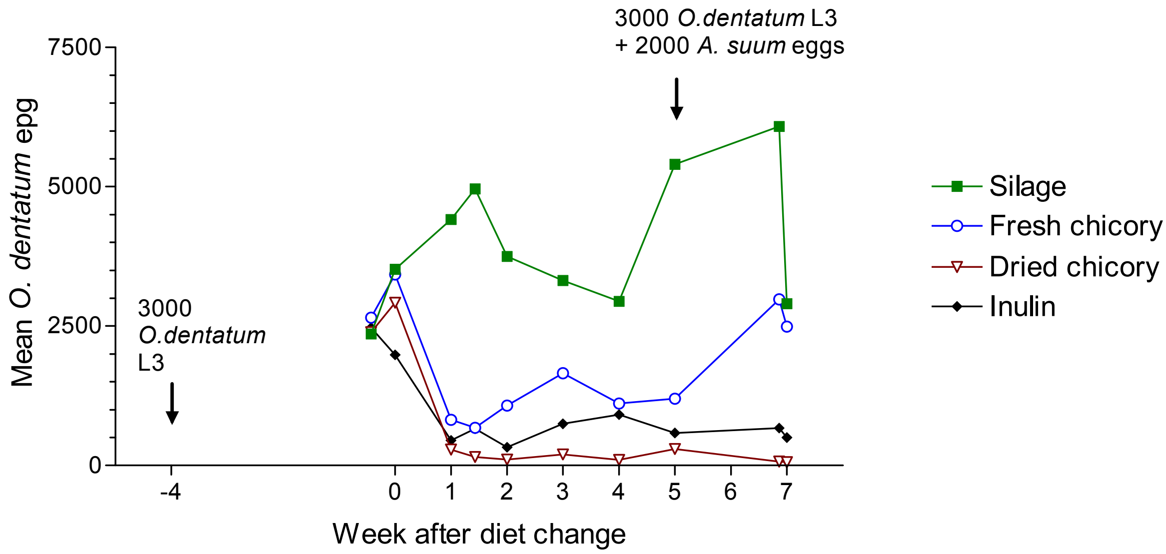

Figure 8. Mean *O. dentatum* faecal egg counts (epg=eggs/g faeces) in groups of pigs fed different diets.

The worm burdens are given in Table 11. Due to the variation within groups there is no significant difference (p=0.28) between the groups with respect to the number of established adult *O. dentatum*. However, significantly fewer and smaller immature worms were recovered in the dried chicory group (p<0.001) compared to the silage group. This may be because the worms did not establish well in the pigs fed dried chicory and/or that the worms were delayed in their development. The lifecycle of this parasite involves a tissue dwelling stage and the changes in intestinal environment due to the diet may have caused the worms to remain in and emerge later from the intestinal tissues. For *A. suum,* there was more worms present in the pigs from the silage group compared to the fresh chicory group (p=0.015), the dried chicory group (p=0.015) and the inulin group (p=0.002).

The results from the present trial seem to indicate that all 3 experimental diets had an effect *on A. suum* and that the dried chicory roots is the most effective way of affecting *O. dentatum*. However, the relative effectiveness of the diets may depend on the amounts of inulin that was in the different diets. The analyses of feed composition have been carried out but the results have not yet been compared between diets.

Table 11. Mean worm burden ± standard deviation of *O. dentatum* and *A. suum* in groups of pigs fed different diets

Group	n	*O. dentatum*		*A. suum*
		Adult	Immature	Immature
Silage (control)	8	2301 ± 577	2362 ± 354	667 ± 290
Fresh chicory	8	1962 ± 316	2029 ± 364	361 ± 223
Dried chicory	8	1819 ± 946	693 ± 705	344 ± 165
Inulin	8	1682 ± 704	1912 ± 741	236 ± 141

WP7: Test and large-scale cultivation of bioactive forages

The work package investigated factors that affect production and management of bio-active crops containing e.g. a high concentration of condensed tannins or inulin. Yield and quality were determined during the growing season. White clover and perennial ryegrass were used as standard crops and compared with the other crops listed in Table 12. The justification to study tannin-containing crops was partially to treat against intestinal worms and partially to improve protein utilization in the rumen in cattle and sheep. The justification to study inulin-rich crops was partially to improve meat quality and eating quality of meat, and partially because inulin has an anti-parasitic effect in mono-gastric animals.

Materials and methods
All species except for Jerusalem artichoke were sown on 3 May 2001. Jerusalem artichoke was planted in the autumn of 2000 at 60 cm row distance and 60 cm between plants within the row. Unfortunately, Jerusalem artichoke did not survive the winter and, therefore, had to be re-established in spring 2002. Other species in the study were sown at 13.5 cm row distance by using an experimental sowing machine. The sowing rates are described in table 12. It has to be emphasized that the selected cultivar of chicory (Grasslands Puna) has been developed in New Zealand for grazing ruminants. It can sustain repeated grazing periods but it does not form a large inulin-rich root like the cultivar produced and used in the feeding experiments with pigs and finish-fed steers.

Crops in a plot were cut three times during the harvest season in 2001 and 2002. At each cut, the dry matter (DM) yield was determined in addition to the quality parameters total N, ash, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin and in vitro organic matter digestibility (IVOMD). In 2001 and 2002, sulla and big trefoil did not establish well and plots contained many weeds. Before quality analyses were conducted on these species, weeds were removed from the sample.

Table 12. Common name, cultivar name and sowing rates for PROSBIO plants established at DIAS, Foulum on 3 May 2001.

Common name	**Cultivar**	**Sowing rate**
		kg seed ha^{-1}
Perennial ryegrass	Mikado	22
Chicory	Puna	5
Sainfoin	Unknown	60
White clover	Milo	6
Birdsfoot trefoil	Oberhaunstaedter	12
Big trefoil	Maku	7
Sulla	Unknown	12

In 2001 and 2002, Jerusalem artichoke, perennial ryegrass and chicory were fertilized with 150 kg N ha^{-1} chicken manure (5-2-4). The manure application was split in equal portions and applied in early spring, after first cut and after the second cut.

Results
Seasonal DM yields in the first year, 2001, were low and likely so because of the late sowing date on 3 May. Ordinarily, crops are sown in early April at Research Center Foulum. Sowing was delayed in this study, however, as we received incorrect rhizobium bacteria for sulla and big trefoil. No results are shown for Jerusalem artichoke in 2001, as it did not survive the

winter. Furthermore, stands in sulla and big trefoil plots were poor. Therefore, DM yields in these plots were more a reflection of weeds than the actual crop. As mentioned previously, all quality determinations were done after removing weeds from the samples.

Among the bio-active crops, birdsfoot trefoil and chicory had the highest yields in both years, 2001 and 2002. In table 13 results from 2002 are shown. Dry matter yields were lower in 2001 than those in 2002, however. This was partially due to the late sowing in 2001. Sainfoin had relatively good, but thinner stands than those of perennial ryegrass, chicory, white clover and birdsfoot trefoil.

Table 13. Seasonal yield and quality data for bio-active crops grown at Research Center Foulum in 2002. Perennial ryegrass and white clover were used as standards.

Common name	Latin name	Dry matter[2]	Yield	Ash	NDF	Total N	ADF	Lignin	IVOMD
		$g\ kg^{-1}$ fm	kg dm ha^{-1}	------------	$g\ kg^{-1}$ dm			------------	$g\ kg^{-1}$ om
Perennial ryegrass	*Lolium perenne*	248	6264	75	437	17	267	25	726
Chicory	*Cichorium intybus*	136	11292	123	349	15	303	34	662
Sainfoin	*Onobrychis viciifolia*	233	6205	81	347	23	295	59	644
White clover	*Trifolium repens*	153	7331	107	258	37	265	51	741
Jerusalem artichoke	*Helianthus tuberosus*	368	6944						
Birdsfoot trefoil	*Lotus corniculatus*	206	9754	81	399	28	345	83	618
Big trefoil[1]	*Lotus uliginosus*	180	2749	93	341	28	313	133	550
Sulla[1]	*Hedysarum coronarium*	215	1784	122	294	18	265	111	575

[1]Results from 2001

[2]FM=Fresh matter; Dry matter yields are pooled over three cuts, i.e. 19 July, 6 September and 17 October; NDF=Neutral detergent fiber; Total N determined according to the Dumas method; ADF=Acid detergent fiber; IVOMD=*In vitro* organic matter digestibility.

Sainfoin and birdsfoot trefoil had the poorest forage quality of the crops in the experiment. Particularly digestibility of organic matter (IVOMD) was low and lignin concentration high. In spite of having the highest total fiber concentration (NDF), perennial ryegrass had the highest digestibility. Generally, digestibility was low and lignin concentration high in all of the bio-active crops, i.e. sainfoin, birdsfoot trefoil, big trefoil and sulla. Furthermore, the ash concentration was higher than usual in all crops.

Unresolved issues

Chicory may be sown densely to optimize stand density and thereby herbage on offer for grazing animals. Chicory (cv. Puna) in the PROSBIO project was sown at 5 kg seed ha^{-1} and by using the same sowing machine as the one used to sow the other forage species in the project (Table 12). In a different experiment, the inulin-rich cultivar of chicory was sown more sparsely, like fodder beet, at 50 cm row distance and 12 to 15 cm distance within the row (intra row distance). By sowing more sparsely, root yield should be higher. Consequently, the seeding rate for chicory is dependent on the use of the plant. Regardless of sowing rate, it is difficult to remove all parts of the chicory root at harvest. This may seriously limit the introduction of chicory into organic crop rotations, as organic farmers are not allowed to use herbicides, should plants establish from the left-over roots the following season. Researchers are aware of the problem and currently a beet harvester at Research Center Bygholm is being rebuilt to be able to operate more deeply in the soil. The beet harvester is also modified to be able to remove more soil from the chicory root.

WP8: Influence of bioactive forages on meat and eating quality of pork and beef (PROSBIO and PROSQUAL merged: WP8a, WP8b1 and WP8b2)

Due to interesting results regarding specific parameters during the 2 trials wig pigs in 2001-2002 (Experiment 1) and 2002-2003 (Experiment 2) we (DIAS and KVL) are presently involved in a patent application. For this reason, we are not allowed to deliver detailed results at this time other than the information presented below. We have, however, informed a DARCOF-representative of this situation. It was decided at end of October 2002 to proceed with the patent application supported by our parent institutions. Publication of the experimental results will take place from 25 September 2004 due to the rules of our patent application.

No activities were planned for year 2000 but an inulin-rich cultivar of chicory was collected in November 2000 at Beder Gartnerskole, Malling. In a pilot study the inulin-rich cultivar was tested for palatability of the blended chicory roots by 2 fattening pigs at Research Centre Foulum. The 2 60-80 kg live-weight pigs were able to eat 2.6 kg blended chicory roots plus 2.3 kg concentrate. The inulin content of chicory roots was approximately 18% and the content of feed units for pigs was as high as 33.1 SFUpigs per 100-kg chicory roots.

An inulin-rich cultivar Orchies of chicory has been grown with success at the research station Rugballegård year 2001 for the first feeding experiment with fattening pigs. The crop yield of the chicory roots was 30 t/ha. A very good chicory stand has been grown with success at Foulumgaard for the second pig experiment (2nd replication of the pig experiment). The crop yield of the chicory roots was 40 t/ha and a good crop of chicory has been grown at Rugballegård meant for the steer experiment October - December 2002.

WP8a Experiment 1: Sensory and chemical investigations of eating quality of pork in relation to the influence of bioactive forage feeding 2001-2002 (PROSBIO)

Experimental design and preliminary results

Experiment 1: Chemical investigations 2001-

The inulin content of chicory roots for the first fattening pig experiment was approximately 18-20% and the content of feed units for pigs was 27 SFUpigs per 100-kg chicory roots in November 2001. According to the feeding value of the chicory roots the first of 2 pig experiments began 5 November 2001. The experiment consisted of 4 treatments each of eight pigs plus extra 8 pigs. All 40 pigs totally free of parasites were infected with a specific parasite in the period between 5 November and 10 December. The 40 pigs (20 intact male and 20 female pigs) were kept in litters of 8 pigs and fed 100 % organic concentrate and semi ad libitum grass silage (se WP 6). Eight pigs half of each sex were slaughtered on 10 December (se WP 6). From 10 December the 32 pigs were distributed to the 4 treatments according to litter and sex in individual pens. Treatment 1 was a (conventional) control group given 100 energy % organic concentrate and no roughest from 10 December until slaughter. Treatment 2 was an organic control group given 95 energy % organic concentrate and semi ad libitum grass silage from 10 December until slaughter. The 25 % blended chicory roots on energy bases plus 70 % organic concentrate were given from 10 December until slaughter of treatment 3. Treatment 4 was given 95 energy % organic concentrate and semi ad libitum roughage from 10December until 14 January. From 14 January until slaughter of treatment 4, 25 % blended chicory roots on energy bases plus 70 % concentrate were given. Strategic blood samples were collected during the experiment. Finally, 16 male pigs were slaughtered 11 February and 16 female pigs 13 February 2002 for measuring meat and eating quality according to the plan (see Table 14). The pigs ate the high amount of raw and bitter blended chicory roots without problems after 1 week of adaptation by giving increasing amounts of chicory roots. The health status and production results of the chicory treatments were as good as the control treatments 1 and 2, and the daily gain corresponded to the results of treatment 2 (the pigs ate 2.6 kg chicory per day from the beginning of treatment 3 and finally 3.0 kg per day during the final 4 weeks of both treatment 3 and 4). All planned meat and eating quality measurements have been analysed. Furthermore, several additional measurements, financed by other sources, have been analysed.

Table 14. Experiment 1 design for the final feeding period of the 4 treatments feeding with or without the bioactive chicory roots for different periods from 55 to 120 kg live weight (9 weeks)

Treat-ment	No. of pigs	Food composition and energy level compared to semi ad lib. (100 %) (from 55 – 120 kg)	Bioactive food
1	8 4 female + 4 male	100 % organic concentrate	None
2	8 4 female + 4 male	95 % organic concentrate + semi ad lib. clover-grass silage	Clover-grass silage from 55 kg until slaughter
3	8 4 female + 4 male	70 % organic concentrate + chicory roots (25 %) from 55 kg until slaughter	Chicory roots (2,6-3.0 kg per day) from 55 kg until slaughter
4	8 4 female + 4 male	95 % organic concentrate + semi ad lib. clover-grass silage from 55 kg until 4 weeks before slaughter 70 % organic concentrate + adaptation to bitter chicory roots from 4-3 weeks before slaughter 70 % organic concentrate + chicory roots (25 %) the last 3 weeks before slaughter	Clover-grass silage semi ad lib. from 55 kg until 4 weeks before slaughter 4 – 3 weeks before slaughter adaptation to bitter chicory roots chicory roots (25 %) (3.0 kg per day)

Results of feeding chicory roots long and short time (treatment 3 and 4) on meat and eating quality (the last measured by a sensory panel) have been compared to results of the control treatments (1 and 2).

Experiment 1: Sensory profiling investigation 2001-2002.

A sensory profile was carried out to evaluate the effects of silage and chicory (bioactive) feeding on the flavour of cooked organic pork. In addition, warmed-over flavour (WOF) de-

velopment, i.e. stability to lipid-oxidation derived off-flavours in cooked, chill-stored and re-heated pork patties was also investigated. The patties were derived from the *Longissimus dorsi* of animals from the 4 feeding treatments, i.e. Control, Silage, long time Chicory and, short time Chicory (Table 14). All patties were stored in oxygen permeable bags at 4^{o}C for 0 and 3 days to facilitate WOF development. In addition, Gas Chromatography/Mass Spectroscopy (GC/MS) measurements of the volatile compounds in the cooked meat patties were performed. A data analytical strategy involving Analysis of Variance-Partial Least Squares Regression (ANOVA-PLSR), to determine relationships between the design variables (WOF and feeding treatment) and the sensory-chemical data, and PLSR to elucidate predictive links between the sensory and GC/MS data will be utilised to analyse the data.
Preliminarily, WOF was found to involve the development of lipid oxidation derived nuance off-flavour and odour notes, e.g. rancid-like flavour and linseed oil-like odour, in association with a concurrent decrease in cooked pork meat-like flavour. The sensory variation related to chicory appeared to be distinct from WOF variation. Moreover, long time Chicory and short time Chicory feeding were found to produce variation in the flavour characteristics of the cooked pork. Pork from these feeding treatments was more bitter and sour. However, this was perceived by the sensory panel to be 'acceptable' in terms of eating quality. Publication of the experimental results will take place from 25 September 2004 due to the rules of our patent application.

WP8a,b1: Experiment 2: Sensory and chemical investigations of eating quality of pork in relation to the influence of bioactive forage feeding 2002-2003 (PROSBIO + PROSQUAL)

Experiment 2: Chemical meat quality investigations 2002-2003
The second pig experiment 2002-2003 of the PROSBIO/PROSQUAL project - has been accomplished by slaughtering the entire male pigs the 17 and 19 February 2003 according to the plan. The experiment was initiated the 9 December 2002 and consisted of 4 treatments each of entire 8 entire male pigs. The male pigs were distributed to the 4 treatments according to litter and initial weight. From 9 December until 6 January 2003 the 32 pigs were fed 100% organic concentrate diet according to scale plus ad libitum grass silage and were infected twice with parasites. From 6 January 2003 until slaughter (17 and 19 February) the pigs were fed to the plan (see Table 15). Treatment 1 was an organic "control" treatment fed 95% organic concentrate plus clovergrass silage. Treatment 2 was fed 70% organic concentrate plus 25% bioactive blended raw chicory roots. Treatment 3 was fed 70% organic concentrate plus 25% dried chicory roots. Treatment 4 was fed 70% organic concentrate plus 14% poor inulin corresponding to the amount of inulin in the chicory roots of treatment 2 and 3. The pigs were slaughtered at 120-kg liveweight to secure sexual maturity of the entire male pigs after a 6 weeks experimental period.

Table 15. Experiment 2 design for the final feeding period of the 4 treatments.

Treatment	No. of entire male pigs	Food composition and energy level compared to "ad libitum" feeding* (100%) (from 6 January to 17 or 19 February)	Parasitter (*O.dentatum* og *A.suum*)	Bioactive feed
1	8	95% organic concentrate plus semi ad libitum clovergrass silage	Yes	
2	8	70% organic concentrate plus chicory roots (25%) from 6 January until slaughter	Yes	Chicory roots (2.6 kg the first week and-3.0 kg per day the rest of the experiment until slaughter)
3	8	70% organic concentrate plus chicory dried roots (25%) from 6 January until slaughter	Yes	Dried chicory roots (770 g the first week and 880 g per day the rest of the experiment until slaughter)
4	8	70% organic concentrate plus poor inulin from 6 January until slaughter	Yes	Inulin (390 g the first week and 450 g per day the rest period until slaughter

***) Energy level of the experiment is 95 % according to scale of Madsen et al., (1990).**

The pigs ate the high amount of raw and bitter blended chicory roots without problems after 1 week of adaptation by giving increasing amounts of chicory roots. The dried chicory roots were given without an adaptation period presumably because the dried chicory roots were less filling and had a sweet taste besides a bitter taste like the raw chicory roots. The health status and production results of the chicory treatments were as good as the control treatment. Strategic blood and meat samples have been collected according to plan before start of the experiment the 6 January and just before and after slaughter. Analysis (chemically and statistically) of the meat and eating quality measurements are on-going according to the plan. The traditional meat quality measurements collected just before (glycogen) and after slaughter (meat percent in carcass, pH, temperature, Minolta-colour values and driploss in the loin) has been statistical analysed. Furthermore Derek Byrne, KVL has performed the sensory profile of the loin during May/June 2003. Mika Tuomola (Turko, Finland) has performed Androstenone analysis in blood plasma during the summer 2003 and Jens Hansen-Møller (DIAS) has performed analysis of skatole in blood plasma during spring 2003. Vitamin E, selenium (gluthatione peroxidase) and fatty acids analysis has just been performed by Jacob Holm Nielsen. This means that most of the chemically analysis are statistically analysed and the rest is ready for statistically analysis 29 September 2003 according to the plan. The androstenone and skatole analysis in blood plasma collected before start of the experiment and just before slaughter have not been promised and financed by PROSQUAL or PROSBIO, but has been analysed in the spring/summer 2003 for a better evaluation of the boar taint aspects of the pig experiment. Publication of the experimental results will take place from 25 September 2004 due to the rules of our patent application.

WP8b1: Experiment 2: Sensory profiling investigations 2002-2003 (PROSQUAL)

A sensory profile was carried out to evaluate the effects of silage and chicory (bioactive) feeding on the flavour of cooked organic pork. The sample chops were derived from the

Longissimus dorsi of animals from the 4 feeding treatments (Table x2). A data analytical strategy involving Analysis of Variance-Partial Least Squares Regression (ANOVA-PLSR), to determine relationships between the design variables (feeding treatment) and the sensory data.. The sensory variation related to the different kinds of chicory was found to produce differences in the flavour characteristics of the cooked pork. Pork from these feeding treatments was more bitter and sour as in Experiment 1. Moreover, the chicory fed meat was perceived by the sensory panel to be acceptable in terms of eating quality. Subsequent to this experimental work the sensory results will be linked to the chemical measurements above to enable interpretation of the mechanisms responsible for the sensory effects of chicory. Publication of the experimental results will take place from 25 September 2004 due to the rules of our patent application.

WP8a: Influence of bioactive forages on meat and eating quality of steers (PROSBIO)

Task 27 according to Table C.2 was completed by December 2002. A short description of the production performance (i.e., daily gain) in the steer-experiment during the last grazing period (summer 2002) and during the finishing period (October – December 2002) is given under WP3 (PROSBIO) and was also described in the previous status report for PROSQUAL (former WP2, now WP8b2).

In short: the 40 steers of the PROSBIO project had grazed in either a rotational grazing system or in a continuous grazing system at Fussingø. The steers were finishing-fed at Research Centre Foulum starting the 1 October 2002. A total of 39 steers completed the finishing period and were slaughtered in Aalborg 10 December 2002. One steer was sacrificed during the experimental period due to severe health problems (i.e., encephalitis), which was not related to the treatments. There were 4 different finishing rations based on grass silage ad libitum and fixed amounts of the different combinations of chicory and barley. There were 2 levels of barley and 2 levels of chicory roots (1.7 and 3.4 kg dry matter/day for both feeds), so treatments were arranged in a 2x2 factorial design (see the revised plan for finishing feeding, Table 16).

Table 16. Feeding plan and growth rates for the finishing period of 39 steers

Treatment No. animals	B-1 10	B-2 10	C-1 9	C-2 10
Assigned feed per day				
Barley, kg DM	1.7	3.4	-	-
Chicory root, kg DM	-	-	1.7	3.4
Clover grass silage, kg DM	ad lib (8.4 kg DM.)	ad lib (6.9 kg DM)	ad lib (8.5 kg DM)	ad lib (7.0 kg DM)
Commercial mineral mix, g	75	75	75	75
Expected feed intake per day				
Energy intake, SFU	9.5	10.0	9.5	10.0
Fill units, FF_u	11.1	11.3	11.2	11.3
Digest. crude protein, g/SFU	125	112	121	104
Average daily gain, g	852	827	668	760

We succeeded in making 4 very similar groups of steers based on sire, grazing system in the summer period, weight of the steer, and weight gain in the summer period. The steers ate the chicory roots very well. The feedstuff analyses and the calculation of the actual feed intake and feed conversion are currently being made. Overall, the production results and carcass quality (meat percent) of the 4 treatments were not statistical different.

However, the growth rate of the C-1 group was numerically 18% lower than the other 3 groups (see also WP3, Figure). Furthermore, carcass conformation score and fatness were lowest in C-1 steers. Remarks from the slaughter house also included signs of a former parasite infection in 3 out of these 9 C-1 steers, in contrast to only 1 such remark for the remaining 30 steers. These facts have to be taken into consideration, when evaluating the sensory data (WP8a) and the intramuscular fat (IMF), fatty acid composition and CLA data. Thus, we expect that the C-1 steers will have a lower IMF percentage, which probably will affect the sensory evaluation negatively and change the fatty acid profile, due to an expected lower triglycerid:membrane lipid ratio.

The results from the sensory evaluation with the 10-member panel made at KVL (Derek Byrne) in the summer 2003 include very solid data from these sessions and an advanced statistical evaluation of these data. This gives very important information and the main conclusions are presented below. It is also mentioned, that further analyses of these data are needed. However, the results should be considered preliminary, as they most likely have to be adjusted before publication. A possible co-variant adjustment could be the growth rate during the finishing period, which was expected to be similar between the 4 groups. Another possible adjustment of the data will come from looking at the indvidual feed conversion ratios of the steers in order to find possible outliers, e.g. in the C-1 group.

The preliminary conclusions from the sensory profiling (*Byrne et al., manuscript in preparation*) were:

- Overall, this pattern of sensory differentiation/discrimination indicates that the sensory nature of each of the treatments can be described as individual in character, to a certain extent.
- Moreover, it can be stated that the sensory variation in the high feeding treatments (i.e., B-2 and C-2) was relatively more important than in the lower level treatments (i.e., B-1 and C-1).
- However, there is a degree of commonality in sensory character even between the different types of feeding treatments, namely barley and chicory.
- Overall, the derived level of detail in discrimination and description can be considered a validation of the sensory vocabulary developed to describe the sample treatments.
- It was clear that the high barley-fed treatment (B-2) had a significantly higher liking score relative to the other 3 treatments.
- Overall, the flavour and taste descriptors scored very highly in the barley samples versus the chicory samples. This was particularly true in the case on high barley-fed samples (B-2). Thus, most likely why it scored highest in 'overall impression'.
- It can be stated that none of the samples were disliked significantly. Thus, it could be concluded that feeding chicory has no adverse sensory effects with respect to low barley feeding. However, high barley feeding is preferred relative to chicory feeding.
- Overall, the implications of the sensory effects must be further considered with respect to the biochemical effects of barley and chicory feeding before one can give an impression as to which type of feeding and at what level is most preferable.

Further analysis

- Further data analysis is to be performed to determine in more detail which sensory modalities and specific descriptors are relevant in relation to the 'overall impression' for each feeding treatment. This is possible as additional data was collected from the panellists

with respect to which sensory modality was largely responsible for their positive or negative overall impression of a sample.
- Further analysis will be performed to investigate the relative difference between the Barley and more importantly the Chicory samples as pairs. This will give an even clearer picture as to what sensory aspects are important to each treatment with respect to level of feeding. In general, thus far the analysis gives much of the information with respect to this, however, more subtlety and interpretation may be achieved with further analysis.

The deliverable (D34) from this part of WP8 (and from WP3) has initially been described as a paper entitled: "Effect of different finishing strategies and bioactive forage on meat and sensory quality in steers". Now, it seems more likely, that the sensory evaluation will be presented in a paper entitled: "Sensory profiling of the effects of chicory (bioactive) feeding on eating quality of cooked beef" authored by Byrne *et al.* (paper in preparation). Furthermore, D29 and D34 will be fulfilled by a paper on: "Production performance of steers during finishing, including consequences for IMF, fatty acid profile, and CLA in the meat" authored by Vestergaard *et al*. As seen below (WP8b2), the data for this paper will not be available until the end of October 2003. Thus, M25 is delayed by 4 months.

WP8b2: Content of conjugated linoleic acid (CLA) in beef from steers produced on pasture (PROSQUAL)

The Danish Meat Research Institute (DMRI) collected the 39 samples of muscle and fat tissue (for fatty acid profile including CLA) and *M. long. dorsi* meat samples (for the sensory evaluation, see WP8a) from the Fussingø experiment. According to a decision taken at the steering committee meeting (March 2003), we have decided to analyse the meat for IMF, as IMF is very important for evaluating both the fatty acid profile and for the sensory evaluation of the meat.

Instead, we have given up analysing the *meat* samples from the KFC-experiment (88 steers and 10 reference young bulls) for CLA content. Thus, we only have the fatty acid profile and CLA in the tallow of these steers and young bulls. These data have recently been published in 2 Danish articles. The results of the CLA analyses have shown that the CLA content in tallow from steers is significantly higher than in young bulls and that Jersey steers have more CLA than Holstein Friesian steers. The tallow CLA content is lowest in April after winter feeding with whole crop silage, increasing during the grassing period until August, decreasing a bit in the autumn period due to supplementary barley feeding during the grassing period, and is highest in December after a long grassing period and a short finishing feeding period (35 days) with barley and whole crop silage. It was initially the plan to include the data from the KFC-experiment in the paper from the Fussingø experiment (according to Table C2; M9 will include data from the steers in the KFC-project), but this is given up. Instead, another Danish publication will cover the fatty acid profile of these steers. The KFC-experiment was mainly supported by Dansk Kvæg.

The 39 meat samples from the Fussingø experiment will be prepared for IMF analyses in September 2003 and split, so that 1 part is kept at DMRI for IMF analyses in October 2003 and 1 part will be shipped to Biocentrum (DTU) on 3 October to be analysed for fatty acid composition, including CLA by Pia Lund et al.

Evaluation and statistical analyses of these data will be made during November-December 2003. A draft manuscript (D29 and D34 mentioned above) will be available in spring 2004 which is 3 months delayed according to the plan.

C.2 Fulfilment of deliverables and milestones

WP1: On-farm description and analysis of production and management strategies for steers	Time schedule according to application	Deviations, if any*
Task		
1 Description and evaluation of existing steer production	5/2000-9/2002	OK
2 Examination of different winter feeding regimes	11/2000-4/2001; 11/2001-4/2002	OK
3 Investigation of grazing strategies including adaptation to grazing	5/2000-10/2000; 5/2001-10/2001	OK
Deliverables		
19 Report: Production strategies in steer production: A model	11/2002	OK
20 Report: Grazing strategies for dairy breed steers with focus on calves	11/2002	OK
21 Paper: Effect of different finishing strategies on steer production on organic farms	11/2002	OK, published together with D23
22 Paper: Supplementation and adaptation of calves to grazing	11/2002	OK
23 Paper: Evaluation of different winter feeding strategies for steers on organic farms	11/2002	OK, published together with D21
Milestones		
1 Comparison of grazing strategies for steers and calves	12/2000 + 12/2001	OK
2 Comparison of winter feeding strategies in steer production	2/2001 + 7/2002	OK
3 Evaluation of models of welfare and production strategies	6/2002	OK

** Deviations are to be further discussed at C3*

WP2: Production strategies for steers on clover grass pastures	Time schedule according to application	Deviations, if any*
Task		
4 Estimation of herbage intake following different winter feeding levels	6-7/2000	OK
5 Developing a model for feeding management and time for slaughter	5/2000-4/2002	OK
Deliverables		
13 Paper: Feed intake in dairy breed steers on clover grass pasture and on wet riparian pasture	12/2001	OK
24 Popular paper: Body condition as a management tool in organic steer production	11/2002	Delayed (12/2003) (change from popular to scientific)
Milestones		
4 Estimation of feed intake by steers on clover grass pasture	9/2000	OK
5 Development of a model for using body condition score as a management tool in steer production	6/2002	Delayed (12/2003)

** Deviations are to be further discussed at C3*

WP3: Grazing systems for steers on marginal land	Time schedule according to application	Deviations, if any*
Task		
6 Evaluation of different stocking rates and grazing strategies	5-10/2000; 5-10/2001	OK
7 Estimation of herbage intake following different winter feeding levels	6-7/2001	OK
8 Evaluation of different grazing strategies and finishing diets including bioactive forages	5/2001-2/2003	OK
9 Examination of meat quality from steers in task 8	11/2002-2/2003	OK

Deliverables		
15 Paper: Grass intake, liveweight gain and parasite load in steers and heifers compared to grazing strategy, sward structure and herbage quality	6/2002	Delayed, 12/2003
29 Paper: Liveweight gain, parasite load and slaughter results in steers grazing in rotational versus continuous grazing systems.	6/2003	Delayed, 12/2003 (cf. WP8b2)
30 Popular paper: Steer production on marginal land	6/2003	OK (cf. E)
Milestones		
6 Comparison of herbage intake in co-grazed steers and heifers	8/2001	OK
7 Comparison of performance of 1-year grazing steers and heifers	12/2001	OK
8 Evaluation of the effect of different grazing strategies on production and health of steers	3/2003	OK
9 Establishment of the relationship between finishing strategy and fatty acids in meat, including CLA (PROSQUAL-added activities to this milestone)	5/2003	OK (more data will be generated by fatty acid analysis in late 2003)

** Deviations are to be further discussed at C3*

WP4: Influence of different grazing strategies on biodiversity on marginal land	Time schedule according to application	Deviations, if any*
Task		
10 Evaluation of sward production and herbage quality under different grazing strategies	5-10/2001; 5-10/2002	OK
11 Evaluation of effect of grazing heterogeneity on sward structure	5-10/2001; 6-8/2002	OK
12 Examination of biodiversity dynamics	11-12/2000; 6-12/2001; 6-7/2002	OK
13 Inventory of plants	7-12/2001	OK
14 Occurrence of bioactive plants in swards under different grazing strategies	6-7/2001; 6/2002	OK
Deliverables		
2 Delivery of plant species from WP4 to WP5	7/2000	OK
15 Paper: Grass intake, liveweight gain and parasite load in steers and heifers compared to grazing strategy, sward structure and herbage quality	6/2002	Delayed, 12/2003 (close to submission)
18 Popular paper: A challenge for organic farmers: steer production for maintenance of biodiversity including bioactive plants of low-lying marginal areas (In Danish)	6/2002	Delayed, 12/2003
27 Paper: Organic steer production for maintenance of biodiversity of low-lying marginal areas	12/2002	OK (cf. E)
28 Paper: Bioactive plants in long-term swards with a high or low botanical diversity	12/2002	Delayed, 12/2003
Milestones		
10 Evaluation of sward structure dynamics	11/2001	OK
11 Evaluate the content of bioactive plants in the swards with different botanical composition	12/2001	Delayed, 12/2002
12 Evaluation of bioactive plants, forage production and quality in relation to grazing strategy	12/2001 + 12/2002	Partially fulfilled
13 The dynamics in biodiversity are analysed	3/2002 + 12/2002	Partially fulfilled

** Deviations are to be further discussed at C3*

WP5: Preparation of extracts for estimation of direct anthelmintic effect of plant species	Time schedule according to application	Deviations, if any*
Task		
15 Development of controlled degradation procedure	5/2002	Delayed (10/2002)

16 Estimation of secondary metabolites e.g. condensed tannins in the gut mimetic procedure	12/2002	Delayed (02/2003)
17 Analysis of inulin and tannin content in bioactive forages	(continuously)	OK
Deliverables		
1 Determinations of inulin and condensed tannins in forages	2000-2003	OK
5 Report: Development of a gut-mimetic system for extraction of bioactive secondary metabolites	4/2002 (delayed 12/2002)	OK
6 Extracts of cultivated plants	4/2002	OK
10 Extracts of wild plants	4/2002	OK
Milestones		
14 Development of a gut-mimetic system for extraction of bioactive secondary metabolites	5/2002	OK
15 Extracts of cultivated and wild plant species for testing of anthelminthic activity	5/2002	OK

** Deviations are to be further discussed at C3*

WP6: Influence of bioactive forages on animal health with emphasis on parasitic infections	Time schedule according to application	Deviations, if any*
Task		
18 Evaluation of anthelmintic activity of plant extracts (*in vitro* studies)	5/2000-12/2001	Delayed (12/2003)
19 Evaluation of anthelmintic effect of bioactives forages in grazing ruminants	5-10/2000; 5-10/2001; 5-10/2002	OK (completed)
20 Evaluation of anthelmintic effect of bioactives forages fed to pigs	5-10/2001; 5-10/2002	Cancelled, incorporated into task 21
21 Studies on antiparasitic effect of chichory in pigs after palatability test	11/2001-2/2002; 11/2002-2/2003	OK
Deliverables		
7 *In vitro* assays for anthelmintic activity of plant extracts	12/2000	Delayed (12/2003)
14 Paper: *In vitro* studies of the anthelmintic effect of bioactive plants on infective larvae of bovine and porcine parasites	12/2001	Int. paper cancelled (report 12/2003)
16 Paper: *In vivo* studies of the anthelmintic effect of bioactive plants on helminth parasites in sheep	6/2002	Delayed (12/2003)
35 Identification of plant/forages with short or long term anthelmintic effects	6/2004	
37 Paper: *In vivo* studies of the anthelmintic effect of bioactive plants on helminth parasites in pigs	10/2004	
Milestones		
16 Development of *in vitro* methods for evaluating anthelmintic activity	12/2000	OK
17 Comparison of *in vitro* anthelmintic activities of different plant extracts	12/2001	Delayed(12/2003)
18 Evaluation of anthelmintic effects of inulin-rich chicory in pigs	4/2002 + 12/2003	OK
19 Assessment of anthelmintic effects of different forages/plants in lambs	12/2002	OK
20 Screening of anthelmintic effects of different forages/plants in pigs	12/2003	Cancelled, incorporated into M18

** Deviations are to be further discussed at D3*

WP7: Test and large scale cultivation of bioactive forages	Time schedule according to application	Deviations, if any*
Task		
22 Evaluation of limiting factors for establishing bioactive forages (laboratory test)	5-12/2000	Cancelled
23 Evaluation of culturing bioactive forages (plot study)	5-10/2000; 5-10/2001	Phase in 2001 OK
24 Field testing of bioactive forages grazed by lambs	5-10/2001: 5-10/2002	OK 2001/2002: exp. at KVL only
25 Evaluation of chicory fed to slaughter pigs and steers	5-9/2001; 5-9/2002; 5-9/2002	Cancelled, included in WP8

Deliverables		
8 Forage for lambs	7/2001 + 7/2002	OK 2001/2002: exp. at KVL only
9 Silage for pigs and steers	8/2001 + 002 + 003	OK
31 Paper: Growth and quality of bioactive plants	10/2003	Delayed (05/2004)
Milestones		
21 Laboratory establishment of bioactive crops completed	12/2000	Cancelled
22 Analysis of data collected from large scale production of silage to pigs and steers	10/2001+10/2002+ 10/2003	OK 2001, 2003
23 Evaluation of bioactive stands from small plots or grazing studies	10/2002	OK

** Deviations are to be further discussed at C3*

WP8: Influence of bioactive forages on meat and eating quality	Time schedule according to application	Deviations, if any*
Task		
26 Evaluation of meat and eating quality and putative anthelmintic effect of bioactive forages fed to pigs	11/2001-2/2002; 11/2002-2/2003	OK
27 Evaluation of effect of bioactive forages in the finishing ration for steers on sensory quality at slaughter and fatty acids composition	11/2002-1/2003	OK
Deliverables		
17 Report: Preliminary report on the effect of a bioactive forage on meat and sensory quality in pigs	6/2002	OK (is fullfilled but kept confidential to public until 25/9/2004 due to a patent application of the 24/3/2003)
34 Paper: Effect of different finishing strategies and a bioactive forage on meat and sensory quality in steers	12/2003	A manuscript on the sensory profile is circulating among co-authors
36 Paper: Effect of chicory on meat and sensory quality in pigs	10/2004	Will be fullfilled but kept confidential to public until 25/9/2004 due to a patent application of the 24/3/2003
Milestones		
24 Assessment of the influence of chicory (and a related bioactive species) on meat and sensory quality in pigs	4/2002 + 4/2004	Completed (detailed reporting delayed because of a patent application)
25 Evaluation of the effect of different finishing strategies on fatty acids composition and sensory quality in steers fed a bioactive forage	6/2003	Delayed 10/2003 (sensory analyses completed, but awaits fatty acid analyses in October 2003)

** Deviations are to be further discussed in D*

D. Description of deviations and subsequent adjustments of plans

Comments on changes in staffing:
The departments of TK+CO+KS are now merged (Dept. of Agroecology). KB has moved to Dept. of Food Science, DIAS. LN and CO are no longer employed at DIAS and have left the project. KS has taken over the main responsibilities of CO/LN.

WP5/6:
As mentioned at mid term evaluation, we have had serious problems with the establishment of the *in vitro* assay (LDA) to assess the possible anti-parasitic effects of different bioactive plants, following extraction through the gut-mimetic system. However, we have recently (September/October 2003) been able to run some tests without the earlier problems in the control wells. This has enabled us to examine all the available extracts in October 2003 and we expect to submit a report in late 2003 (D14). It will not be an international paper because the results are deemed not publishable. For these reasons we believe that Task 18, D7 and D14, although seriously delayed, will be fulfilled by end of 2003. The report will still be able to support D35.

WP8a,b1:
The publications of the 2 PROSQUAL/PROSBIO pig experiments (deliverable October 2004) will not be delayed due to a Danish patent application No. PA 2003 00453 with the title: “Methodologies for improving the quality of meat, health status of animals and impact on environment”. Because of promising results in the first and the second pig experiment of PROSBIO/ PROSQUAL further international publications than originally planned are expected from the 2 pig experiments.

WP8b2:
Based on a discussion among the participants, D34 has been split into two papers: one on the sensory profile data (Byrne *et al.,* manuscript in prep. September 2003), and one on the production performance during finishing feeding including IMF, fatty acid profile and CLA in the meat (Vestergaard *et al*.).The second paper also fulfills D29. However, according to a decision taken at the steering committee meeting (March 2003), we have just recently decided to analyse the meat for IMF (intramuscular fat), as IMF is very important for evaluating the fatty acid profile and for the sensory evaluation of the meat. Thus, M25 and the second paper (D34/29) will be delayed due to the IMF and CLA analyses are being made October 2003. Evaluation and statistical analyses of these data will be made during November-December 2003. A draft manuscript will be available in spring 2004, which is 3 months delayed according to the plan. However, a final manuscript cannot be available in late December 2003.

E. Project publications and other products

[Produkter under 1. – 3. skal kunne genfindes I Organic Eprints. Der må gerne nævnes produkter, som kun er delvist finansieret af FØJO. Der er 3 klasser: 1) 75-100% uden markering. 2) 25-75% markeres med *. 3) 5-25% markers med **]

1. Articles in international, scientific journals with review procedures

Nielsen, B., S. M. Thamsborg, H. R. Andersen, and T. Kristensen, 2003. Effect of winter feeding level and season on herbage intake in dairy breed steers on perennial ryegrass / white clover pasture. *Animal Science* 76: 341-352.

Nielsen, B., S. M. Thamsborg, and T. Kristensen, 2003. Feed supplement to young dairy calves after turn-out to pasture: effect on weight gain and subclinical coccidiosis in organic production systems. *Acta Agric. Scand. Animal Science* 53:1-10.

Nielsen, B., S. M. Thamsborg, H. R. Andersen, and T. Kristensen, 2003. Herbage intake in Danish Jersey and Danish Holstein steers on perennial ryegrass / white clover pasture. *Livestock Production Science*. In press.

Nielsen, B., A. R. Kristensen, and S. M. Thamsborg, 2003. Optimal decisions in organic steer production - A model including winter feed level, grazing strategy and slaughtering policy. *Livestock Production Science*. Accepted.

Nielsen, B., T. Kristensen, and S. M. Thamsborg, 2003. Organic Steer Production Based on Dairy Breed Bull Calves - a Farm Study in Denmark. *Acta Agric. Scand. Animal Science*. Submitted.

** Thamsborg, S.M. & Roepstorff, A., 2003. Parasite problems in organic livestock and options for control. Journal of Parasitology, 2003, 89(Suppl.):S277-S284.

In preparation (i.e. presently circulated amongst co-authors):

Byrne, D.V. Vestergaard, M, & Hansen, L.L., 200? Sensory profiling of the effects of chicory (bioactive) feeding on eating quality of cooked beef.

*Guldberg, C,, Nørbæk, R., Thamsborg, S.M. & Brandt, K.A, 200? Comparison of Techniques for Quantifying Tannins in Plant Sources and in Faecal and Stomachal Samples from Shropshire Lambs. Manuscript for Journal of Food, Agriculture & Environment.

Kristensen, T., Thamsborg, S.M., Søegaard, K., Andersen, H.R. & Nielsen, B., 200? Comparison of production, parasitism and health in Holstein heifers and steers grazing marginal areas at different stocking rate and grazing systems (Livestock Production Science or Animal Science)

*Nielsen, B. and Thamsborg, S.M., 200?. Organic beef production with emphasis on welfare, health and product quality. Livestock Production Science.

2. Papers presented at congresses, symposiums, etc.

*Hald, A.B., Nielsen, A.L., Debosz, K. & Badsberg, J.H., 2001. Genopretning af ferske enge - potentielle indikatorer. Konf.: Græsning som drift og pleje af naturområder, Gl. Avernæs, Helnæs, Fyn, 8-9 oktober 2001. 8 pp.

*Hald, A.B., Nielsen, A.L., Debosz, K. & Badsberg, J.H. 2002. Restoration of agriculturally improved grassland on humic soil - scale, management, role of persistent seed bank, and indicators of potential botanical nature. Theme 5. Ecological basis of restoration. 3rd European Conference on Restoration Ecology, Budapest 25-31 August 2002: 88.

**Nielsen, A.L. & Andersen, H.R., 2001. Husdyrenes behov i forhold til målet for naturforvaltningen. Konf.: Græsning som drift og pleje af naturområder, Gl. Avernæs, Helnæs, Fyn, 8-9 October, 2001. 3 pp.

**Nielsen, A.L. & Søegaard, K., 2000. Forage quality of cultivated and natural species in semi-natural grassland. Grassland Science in Europe, 5, 213-215.

*Nielsen, B and Thamsborg, S.M. 2003 Organic beef production with emphasis on welfare, health and product quality. Paper presented at 54th annual meeting of EAAP in Rome.

**Thamsborg, S.M. & Kapel, C.M.O. Options and practices for parasite control in organic livestock production. Meeting of the French Food Safety Agency (AFSSA) on: How to evaluate the nutritional value and health benefits and risks of organic foods? Paris, 18 October 2002.

*Thamsborg, S.M., Mejer, H., Bandier, M. & Larsen, M. Influence of different forages on gastrointestinal nematode infections in grazing animals. Proc. 19th Int. Conf. of the WAAVP, New Orleans, USA, 2003, p. 189.

3. Reports, articles in agricultural journals, etc.

**Andersen, H.R., Kristensen, T., Bliggard, H.B., Madsen, N.T., Nielsen, B. 2003. Produktionssystemer for kontinuert produktion af efterårsfødte stude. DJF-rapport Husdyrbrug nr. 48. DJF-Foulum, pp 90.

Kristensen, T. 2002. Muligheder i at producere øko-stude. Økologisk Jordbrug, nr 257, 6. (D30)

Nielsen, B., A. R. Kristenen, and S. M. Thamsborg. 2003. Optimal decisions in organic steer production - A model including winter feed level, grazing strategy and slaughtering policy. Report in Ph.D. course: Advanced Herd Management at KVL.

Nielsen, B. 2003. Dairy breed bull calves in organic beef production – with emphasis on rearing and fattening of steers. Ph.D. Thesis. Royal Vet. and Agric. Univ. Copenhagen, Denmark.

**Nielsen, L., Hoffmann, C.C. & Thamsborg, S.M., 2002. En multidisciplinær undersøgelse af ferske enge med ekstensiv landbrugsdrift. DJF intern rapport nr. 154, 2-6.

**Nielsen, L., Hansen, H.H., Badsberg, J.H. & Søegaard, K., 2002. Planteproduktion og fødevalg. DJF intern rapport 154, 7-13.

*Vestergaard, M. 2003. Fodringen kan påvirke fedtsyremønsteret i oksekød – og måske gøre kødet sundere. Nyhedsbrevet Danmarks JordbrugsForskning, nr. 3, juni 2003 p. 4.

*Vestergaard, M, & Andersen, H.R. 2003. Produktionssystemet kan påvirke indholdet af specielle fedtsyrer (CLA) i kød og talg fra stude. Kalveproducenten 21 (3), 10-12.

4. Oral presentations, public meetings, field days, etc.

Kristensen, T. 2003. Studeproduktion. Efteruddannelse for økologiske landmænd. Koldkærgaard 29 januar (D30)

Kristensen, T. 2003. Studeproduktion på marginalarealer. Demonstration for landmænd og konsulent på Fussingø, 24. september (D30)

**Thamsborg, S.M. and Larsen, M., 2003. Introduction to organic farming and parasite control. Workshop on organic farming and novel approaches to control of parasites. WAAVP 2003, New Orleans, August 10-14 (SMT workshop convenor).

**Mejer, H. & Roepstorff, A., 2003. Parasites in organic swine production in DK and options for control. Workshop on organic farming and novel approaches to control of parasites. WAAVP 2003, New Orleans, August 10-14.

**Roepstorff, A., 2003. Summary: Parasites in organic swine production. Workshop on organic farming and novel approaches to control of parasites. WAAVP 2003, New Orleans, August 10-14.

**Thamsborg, S.M. Parasitbekæmpelse på græs – får og geder (Parasite control in sheep and goats on pasture), Forum for Sheep and Goats, Danish Cattle Farmers yearly meeting, Herning, 24 February 2003. (oral presentation)

F. Scientific education

WP1+2+3 formed part of the Ph.D. study of Bea Nielsen, terminated in June 2003 with the thesis: Dairy breed bull calves in organic beef production – with emphasis on rearing and fattening of steers. Affiliated to the SOAR research school.

WP5+6+8 form part of the Ph. D. study of Helena Mejer, in collaboration with the DARCOF II project MANORPIG. Affiliated to the SOAR research school (plan finishing August 2004).

M.Sc. (agriculture) student Diana Thomsen has been associated with WP3 and she graduated with a thesis on Herbage intake and botanical composition of the diet on12 July 2002.

M.Sc. (biology) student Christina Guldberg Hansen has been associated with WP5 and WP6 in 2001/2002 and graduated in April 2003 (Thesis: The effect of bioactive forages on gastrointestinal nematode infections in sheep, KVL, 81 pp + appendices)

M.Sc. (veterinary science) student Michala Bandier has been associated with WP5 and WP6 in 2002. She graduated in January 2002 (Thesis: The effect of chicory (*Cichorium intybus*) and sainfoin (*Onobrychus viciifolia*) on establishing nematode infections in grazing lambs, KVL, 146 pp.).

G. National and international cooperation

LLH and the Dept. of Food science, DIAS co-operate with the project leaders Chris Claudi-Magnussen and Patricia Barton-Gade at the Danish Meat Research Institute and consultant Hanne Maribo, The National Committee for Pig Production, Dept. of Nutrition and Reproduction in projects concerning the meat and eating quality of organic pork, among other things in the project 'The importance of organic pig production for meat and eating quality'.

The Dept. of Animal Nutrition and Physiology, DIAS already has collaboration with DTU (Mie Strårup replaces the late Carl-Erik Høy) concerning CLA analyses in cow's milk. HEF also has a well-established collaboration with the Danish Meat Research Institute (DMRI) (Ina Clausen and Niels T. Madsen) concerning all types of meat production experiments in cattle.

Dept. of Food Science also co-operates among others with head of the project Martin Tang Sørensen and project members Søren Krogh Jensen and José Fernandez, Dept. of Animal Nutrition and Physiology, DIAS, and Chris Claudi-Magnussen the Danish Meat Research Institute and Hanne Maribo, The National Committee for Pig Production, Dept. of Nutrition and Reproduction in projects in the project 'Pig feeding under organic conditions with emphasis on nutrient utilisation, product quality and health (II.7)'.

Bio-active crops form part as an essential element of a project within the 5 EU framework programme: 'Worm control in organic production systems for small ruminants' (WORMCOPS) (2001-2004) in a co-operation between KVL (SMT), Swedish University of Agricultural Sciences (SLU), University of Utrecht, Moredun Research Institute, Scottish Agricultural College and others.

SMT participates in the Sustaining Animal Health and Food Safety in Organic Farming (SAFO) concerted action of EU FP5 (2003-2005). AR and SMT will probably be included in a EU FP6 project: Food Quality and Safety in the European Organic Supply Chain, starting in 2004.

The Dept. of Food Science, DIAS has started a co-operation with Ph.D. Mika Tuomola, University of Turku Finland concerning androstenone measurement in blood plasma from male pigs and Jens Hansen-Møller, Dept. of Animal Nutrition and Physiology, DIAS concerning skatole measurement in blood plasma from male and female pigs. The WP8 in PROSBIO and the WP1 in PROSQUAL has no funding for this measurement of androstenone and skatole in blood plasma.

H. Critical reflection on the project (PRSOBIO/PROSQUAL)

The project is getting very close to termination. Although the project is progressing as planned and we expect to fulfil most of the objectives and tasks outlined in the application, the resources are scarce in this end. In the last two years we have furthermore suffered from 2-3 researchers leaving the project thereby creating a vacuum of knowledge and enthusiasm difficult to fill in by other personnel.

FØJO should bear in mind that special efforts are needed when several original projects are merged into one large project, and secondly, all the part-projects need to have a reasonable size in order to have all the participating researchers as equal and responsible partners.

Scientific content and methodologies

The section was detailed discussed in the last status report.

We would like to add that the recent study in steers has clearly indicated that you are able to manipulate the quality of the product (i.e. meat sensory profiling) by feeding small amounts of bioactive forages but apparently the high-barley fed group was preferred. Further analysis is needed. The results of using bioactive forages in the feed for pigs have again been promising, and we are now patenting some of our findings. We will proceed with further investigations to support the preliminary patent application through funding from DIAS and KVL. Although this may represent a commercialisation of our findings, we are confident it will feed back new ideas and technologies to organic livestock production.

The project has had a high level of publication, particularly through Bea Nielsen's Ph.D. study.

Research development

We have experienced a natural transition from a focus on production parameters measured on-farm or in field trials to a focus on product quality. The PROSBIO-project has gained a lot by the amalgamation with PROSQUAL. We find that this is very much in line with developments in the FØJO research programme and in the organic farming community, as such.

The project has opened up for new perspectives and collaborative links.

The experiences from PROSBIO/PROSQUAL have enabled us (AR and SMT) to participate in an application on "Improving quality and safety and reduction of cost in the European organic and "low input" food supply chains" (QualityLowInputFood) that is most likely to get funded in 2004. The aims are to develop the use of diet in parasite control in pigs to a practical tool. KB from PROSBIO will take up a new position in Newcastle related to the management of this EU-project.

PROSBIO (small ruminant part of WP5 and 6) has again benefited tremendously from the complementary EU-project WORMCOPS (July 2001-December 2004) in which KB and SMT are partners. Furthermore, we have, based on our own funding, started preliminary trials with cattle and bioactive plants in relation to parasite control.

Relevance of the project in relation to recent development in the farming community and structural changes

Like stated last year, we still think several issues in organic animal husbandry in relation to integrity need to be re-addressed. New ideas, like rearing of non-castrated bull calves in new production systems and production of entire male pigs need to considered. In the organic pig production, there is a need for improvement of methods and products characteristic of organic farming systems.

The change in focus of our project to product quality is mentioned above and reflects a change perhaps from quantity to quality in organic farming.

Major adjustments and deviations

This has been discussed in the report.

Future prospects

This has been mentioned above in several places. However, even if we have increased awareness on product quality, we have to remember that the coupling of nature preservation and steer production on marginal land was one of the basic ideas behind this project. This is also a question of integrity as organic farming are supposed to contribute to a better natural environment. It needs to be addressed politically through subsidies.

The concept of using bioactive forages (or natural functional feeds for animals!) to improve product quality and animal health has now been documented and the possibilities seem far from exhausted.

Lastly, more discussion and information between projects (formal and informal) within FØJO is needed on scientific topics related to organic farming and project/research management, particularly between project leaders.

8. Budget

A. Account for any change in budgets

B. Budget for the whole project (1.000 DKK)

Total consumption of funds from DARCOF and expected consumption this year and coming years

PROSBIO + PROSQUAL

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel	39.3	17.6	9.9	0	66.8
Technical personnel	52.2	16.8	3.1	0	72.1

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	1472	663	346	0	2481
Technical personnel	1296	417	72	0	1785
Other operational costs	1254.5	188.5	42	0	1485
Equipment	47	33	1	0	81
Others (please specify)	112.8	87.8	71.2	0	271.8
Direct costs	4183.3	1389.3	532.2	0	6104.8
Indirect costs (20% of direct costs)	836.5	278.1	106.8	0	1221.4
Total	5018.8	1667.4	638	0	7324.2

Comments:

9. Signatures and stamps

Name	Institute	Date	Signature
Head of project			

Appendix I. Detailed budget

A. Budget for each participating institute (1.000 DKr)

PROSBIO + PROSQUAL
Name of Institute: Danmarks Jordbrugsforskning (DJF)

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel	22.7	9.6	5.6	0	37.9
Technical personnel	24.5	6.8	3.1	0	34.4

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	930	417	229	0	1576
Technical personnel	605	164	72	0	841
Other operational costs	744.5	93	40	0	877.5
Equipment	47	12	1	0	60
Others (please specify)	58.8	53.8	66.2	0	178.8
Direct costs	2386.3	739.8	408.2	0	3534.3
Indirect costs (20% of direct costs)	477.5	147.6	81.8	0	706.9
Total	2863.8	887.4	489	0	4240.2

Comments:

A. Budget for each participating institute (1.000 DKr)

PROSBIO
Name of Institute: National Environmental Research Institute (DMU)

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel	5.1	0	0	0	5.1
Technical personnel	1.7	0	0	0	1.7

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	188	0	0	0	188
Technical personnel	40	0	0	0	40
Other operational costs	35	0	0	0	35
Equipment	0	0	0	0	0
Others (please specify)	0	0	0	0	0
Direct costs	263	0	0	0	263
Indirect costs (20% of direct costs)	53	0	0	0	53
Total	315	0	0	0	315

Comments:

A. Budget for each participating institute (1.000 DKr)

PROSBIO + PROSQUAL
Name of Institute: The Royal Veterinary and Agricultural University (KVL)

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel	11.5	8	4.3	0	23.8
Technical personnel	26	10	0	0	36

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	354	246	117	0	717
Technical personnel	651	253	0	0	904
Other operational costs	475	95.5	2	0	572.5
Equipment	0	21	0	0	21
Others (please specify)	54	34	5	0	93
Direct costs	1534	649.5	124	0	2307.5
Indirect costs (20% of direct costs)	306	130.5	25	0	461.5
Total	1840	780	149	0	2769

Comments:

B. Budget for each participating department (1.000 DKK)

PROSBIO

Name of Institute and department: Afdeling for Prydplanter og Vegetabilske Fødevarer, DJF (Kirsten Brandt)

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel	2.8	0.5	0	0	3.3
Technical personnel	4	0.2	0	0	4.2

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	131	27	0	0	158
Technical personnel	92	6	0	0	98
Other operational costs	49	7	0	0	56
Equipment	0	0	0	0	0
Others (please specify)	2	1	0	0	3
Direct costs	274	40	0	0	314
Indirect costs (20% of direct costs)	55	8	0	0	63
Total	329	48	0	0	376

Comments: Consumption before 2003 and expected consumption 2003 are based on information in the status report from October 2002 as current data has not been given to the project leader.

B. Budget for each participating department (1.000 DKK)

PROSBIO

Name of Institute and department: Afdelingen for Plantevækst og jord, DJF (Karen Søegaard)

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel	5.4	0	0	0	5.4
Technical personnel	4.7	0	0	0	4.7

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	225	0	0	0	225
Technical personnel	122	0	0	0	122
Other operational costs	60.5	0	0	0	60.5
Equipment	0	0	0	0	0
Others (please specify)	5	0	0	0	5
Direct costs	412.5	0	0	0	412.5
Indirect costs (20% of direct costs)	82.5	0	0	0	82.5
Total	495	0	0	0	495

Comments:

B. Budget for each participating department (1.000 DKK)

PROSBIO

Name of Institute and department: Afdeling for Plantevækst og Jord, DJF (Christer Ohlsson)

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel	1.5	1.0	0	0	2.5
Technical personnel	4.0	0	0	0	4.0

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	65	47	0	0	112
Technical personnel	101	0	0	0	101
Other operational costs	83	0	0	0	83
Equipment	0	0	0	0	0
Others (please specify)	13	3	0	0	16
Direct costs	263	51	0	0	313
Indirect costs (20% of direct costs)	53	10	0	0	63
Total	316	61	0	0	376

Comments:

B. Budget for each participating department (1.000 DKK)

PROSBIO + PROSQUAL

Name of Institute and dept.: Dept. of Food Science, DJF (Laurits Lydehøj Hansen)

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel	4.0	3.6	3.6	0	11.2
Technical personnel	6.8	5.1	2.6	0	14.5

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	155	142	145	0	442
Technical personnel	149	114	60	0	323
Other operational costs	119	72	40	0	231
Equipment	0	12	1	0	13
Others (please specify)	18	5	52	0	75
Direct costs	441	345	298	0	1085
Indirect costs (20% of direct costs)	88	69	60	0	216
Total	529	414	358	0	1301

Comments:

B. Budget for each participating department (1.000 DKK)

PROSBIO

Name of Institute and department: Afdeling for Husdyrernæring og Fysiologi (Refsgaard Andersen), DJF og Afdelingen for Jordbrugssystemer, DJF (Troels Kristensen)

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel	8	4	1	0	13
Technical personnel	4	1	0	0	5

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	316	182	46	0	543
Technical personnel	117	32	0	0	149
Other operational costs	433	14	0	0	447
Equipment	47	0	0	0	47
Others (please specify)	18	3	10	0	30
Direct costs	931	181	56	0	1216
Indirect costs (20% of direct costs)	186	36	11	0	243
Total	1117	277	67	0	1460

Comments:

B. Budget for each participating department (1.000 DKK)

PROSQUAL

Name of Institute and department: Afdeling for Husdyrernæring og Fysiologi, DJF (Mogens Vestergaard)

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel	1.0	0.5	1.0	0	2.5
Technical personnel	1.0	0.5	0.5	0	2.0

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	38.0	19.0	38.0	0	95.0
Technical personnel	24.0	12.0	12.0	0	48.0
Other operational costs	0	0	0	0	0
Equipment	0	0	0	0	0
Others (please specify)	2.8	41.8	4.2	0	48.8
Direct costs	64.8	72.8	54.2	0	191.8
Indirect costs (20% of direct costs)	13.0	14.6	10.8	0	38.4
Total	77.8	87.4	64.0	0	230.0

Comments: transfer of 18.600 DKK from 2002 to 2003 to cover preparation of meat samples on analyses of intramuscular fat at Danish Meat Research Institute in Roskilde

B. Budget for each participating department (1.000 DKK)

PROSBIO

Name of Institute and department: Afdeling for Landskabsøkologi, DMU (Anna Bodil-Hald)

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel	5.1	0	0	0	5.1
Technical personnel	1.7	0	0	0	1.7

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	188	0	0	0	188
Technical personnel	40	0	0	0	40
Other operational costs	35	0	0	0	35
Equipment	0	0	0	0	0
Others (please specify)	0	0	0	0	0
Direct costs	263	0	0	0	263
Indirect costs (20% of direct costs)	53	0	0	0	53
Total	315	0	0	0	315

Comments:

B. Budget for each participating department (1.000 DKK)

PROSBIO + PROSQUAL

Name of Institute and department: Mejeri og Levnedsmiddelinstituttet, KVL (Derek Byrne)

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel	3	8	0	0	11
Technical personnel	0	0	0	0	0

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	123	216	0	0	339
Technical personnel	0	0	0	0	0
Other operational costs	20	41.5	0	0	61.5
Equipment	0	0	0	0	0
Others (please specify)	4	0	0	0	4
Direct costs	147	257.5	0	0	404.5
Indirect costs (20% of direct costs)	29	51.5	0	0	80.5
Total	176	309	0	0	485

Comments:

B. Budget for each participating department (1.000 DKK)

PROSBIO

Name of Institute and department: Danish Centre for Experimental Parasitology, Department of Veterinary Microbiology, KVL (Allan Roepstorff)

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel	6	0	2.8	0	8.8
Technical personnel	4	5	0	0	9

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	163	30	76	0	269
Technical personnel	99	126	0	0	225
Other operational costs	50	30	2	0	82
Equipment	0	0	0	0	0
Others (travels)	14	16	0	0	30
Direct costs	326	203	78	0	606
Indirect costs (20% of direct costs)	65	41	16	0	122
Total	390	244	94	0	728

Comments: A total of 118,000 DKK was transferred from 2002 (38,000 from scientific salary, 14,000 from operational costs and 16,000 from travels) to the same categories in 2003 to cover costs incurred in connection with sample analysis and presentation of results at an organic workshop. In addition, it is asked that 50,000 DKK is transferred from scientific salary in 2003 to technical salary in 2003, as it has proven very time consuming for the technicians to coordinate the practical work and analyse the different samples collected in the chicory trials (task 21). The money can be spared from the scientific salary because the Ph.D. salary is less expensive than the salary that was originally proposed in the project application. It is also suggested to transfer 76,000 DKK from scientific salary in 2003 to 2004. The reason is that the Ph.D. student (Helena Mejer) employed by the project had a leave from the Ph.D. in 2003.

B. Budget for each participating department (1.000 DKK)

PROSBIO

Name of Institute and department: Danish Centre for Experimental Parasitology, Department of Veterinary Microbiology, KVL (Stig Milan Thamsborg)

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel	2.5	0	1.5	0	4
Technical personnel	22	5	0	0	27

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	68	0	41	0	109
Technical personnel	552	127	0	0	679
Other operational costs	405	24	0	0	429
Equipment	0	21	0	0	21
Others (travels)	36	18	5	0	59
Direct costs	1061	190	46	0	1297
Indirect costs (20% of direct costs)	212	38	9	0	259
Total	1272	228	55	0	1556

Comments: A total of 26,000 DKK has been transferred from 2002 (scientific salary, operational costs and travel) to the same categories in 2003 to cover delayed expenses in connection with sample analysis and presentation of results from the lamb trial in 2002. Furthermore, a total of 46,000 DKK (41,000 DKK from scientific salary and 5,000 DKK from travel) that is expected to be underspent in 2003 is transferred to the same categories in the 2004 budget. The reason for this proposed change is that the Ph.D. student (Helena Mejer) employed by the project had a leave from the Ph.D. in 2003.

C. Budget for co-financing from each participating institute (1.000 DKK)

Name of Institute:

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months Scientific personnel Technical personnel					

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries Scientific personnel Technical personnel					
Other operational costs					
Equipment					
Others (please specify)					
Direct costs					
Indirect costs (20% of direct costs)					
Total					

Comments:

Appendiks I.

Fyldigt dansk sammendrag af forskningsprojektet og dets resultater

Økologisk kødproduktion i Danmark omfatter hovedsageligt okse- og svinekød. Økologisk okse- og svinekøds nuværende markedsandel af den samlede okse- og svinekødsproduktion er kun på hhv. 0.5% og 2.1%. Der er således en begrænset efterspørgsel efter økologisk højkvalitets okse- og svinekød. Projektets formål er at bidrage til udvikling af økonomisk og miljømæssigt bæredygtige produktionssystemer til fremstilling af økologisk okse- og svinekød af høj kvalitet. Forsøgene omfatter studier på gårde, græsningsstudier med drøvtyggere samt eksperimentelle forsøg i stalden. Projektet inkluderer brugen af specielt, ikke-konventionelt foder (eksempelvis cikorierødder) med en forventet positiv effekt på sundhed samt kød- og spisekvalitet i økologisk oksekød (fra stude) og svinekød.

Kun 10-15% af tyrekalvene fra økologiske malkekvægsbesætninger bliver slagtet økologisk. Forventet manglende økonomisk rentabilitet anses for at være den største hindring for at bruge kalve og ungtyre fra malkekvægsproduktionen i økologisk oksekødsproduktion. Interessen for økologisk oksekødsproduktion er dog stigende, og der er et betydeligt behov for pålidelig information om produktionsparametre, fodringsstrategier og metoder til øgning af hjemmemarkedsandelen af økologisk oksekød fra stude af malkekvægstypen. Der vil blive lagt vægt på forbedring af dyresundhed og –velfærd, produktkvalitet fra studeproduktion samt anvendelse og bevaring af biodiversiteten af marginale græsningsarealer.

Visse undersøgelser tyder på, at enkelte afgrøder kan påvirke dyrs parasitstatus i forbindelse med afgræsning og/eller kødets kvalitet efter slagtning. Disse afgrøder betegnes som bioaktive afgrøder, idet effekten tilskrives planternes indhold af bestemte bioaktive stoffer. Muligheden for anvendelse af disse afgrøder og andre relevante planter i økologiske produktionssystemer er ikke tilstrækkeligt belyst

Økologisk svinekød afviger fra konventionelt svinekød mht. visse kvalitetsparametre såsom højere indhold af flerumættede fedtsyrer, hvilket skyldes de økologiske fodermidler (proteinkilder og grovfoder), og i nogle tilfælde lavere mørhed, hvilket skyldes produktionsformer, som resulterer i lavere daglig tilvækst. Til trods for et højt indhold af flerumættede fedtsyrer er positivt set ud fra et humant sundhedsperspektiv, betyder det samtidig, at kødet er mere disponeret for oxidation og dermed for harskning. Denne oxidation kan udgøre et problem i kødprodukter, som anvendes til cateringprodukter, da disse involverer genopvarmning af kødet. Oxidationen af flerumættede fedtsyrer i kød kan imidlertid hæmmes af visse antioxidanter såsom E-vitamin og enzymsystemer med antioxidativ aktivitet.

De komplementerende undersøgelser i PROSQUAL og PROSBIO omfatter effekten af produktionssystemet og anvendelse af udvalgte bioaktive fodermidler (cikorierødder rå og tørrede) med mulig positiv indflydelse på sundhedsegenskaber, kødkvalitet og sensorisk spisekvalitet af kødet fra både stude og slagtesvin (bl.a. conjugere linoleic acid (CLA) og andre fedtsyrer i oksekød samt selen (gluthatione peroxidase), harsked, dryptab og afvigende lugt og smagsstoffer i svinekød). Denne indgangsvinkel har til formål at forbedre kødkvalitet og sensorisk spisekvalitet samt fremme human sundhed. Det formodes at bl.a. CLA kan have sundhedsfremmende egenskaber hos mennesker. Det er således projektets hensigt at udvikle metoder til at forbedre kvaliteten af økologiske produkter.

Mål og resultater

Projektets overordnede formål er således at udvikle og dokumentere økonomisk bæredygtige og sundhedsmæssigt forsvarlige produktionssystemer for økologisk kød (okse- og svinekød). Særlig vægt vil blive lagt på studeproduktion med henblik på at forbedre sundhed og velfærd og produktkvalitet samt at øge naturværdien på marginaljorde ved afgræsning. Anvendelse af udvalgte bioaktive afgrøder til drøvtyggere og svin til forbedring af produktkvalitet og sundhed, primært til forebyggelse af parasitære infektioner, indgår ligeledes i undersøgelserne. Hvad angår kød- og spisekvalitet indgår følgende nye, specifikke mål fra projektet PROSQUAL:

1. at undersøge kød- og spisekvaliteten samt indholdet af E-vitamin og selen (gluthatione peroxidase), samt fedtsyresammensætningen i svinekød fra so- og hangrise fodret med bioaktive afgrøder (rå og tørrede cikorierødder).
2. at bestemme fedtsyresammensætningen og CLA-indholdet i talg og kød fra ekstensivt opdrættede stude slutfedet med forskellige kombinationer af kløvergræsensilage, byg og cikorierødder.
3. at sammenligne fedtsyresammensætningen inklusiv CLA i kød fra stude og ungtyre opdrættet i forskellige produktionssystemer.

Der er opnået mange resultater på kød- og spisekvalitetsområdet i de to svineforsøg (2001/2002 og 2002/2003). De foreløbige resultater har bl.a. peget på, at det har været muligt at påvirke spisekvaliteten i tilberedt kød fra de cikorierodsfodrede slagtesvin i en mere bitter og sur smagsretning, men med acceptabel spisekvalitet til følge. Desuden ser det ud til, at cikoriefodrede grises kød ikke harskner så let (mindre WOF). En dansk patent ansøgning er indsendt til Patent og Varemærkestyrelsen, Erhvervsministeriet.

Undersøgelserne vedr. fedtsyresammensætning inkl. CLA i talg og kød fra stude sluttede med udgangen af 2002. Resultaterne vedr. produktionssystemets betydning for talgens CLA-indhold er publiceret på dansk og viser, at såvel race (Jersey vs. Holstein Friesian) som fodring har væsentlig betydning for talgens CLA-indhold. De sensoriske analyser er gennemført i august 2003, men endnu ikke færdigtolket.

Perspektiver

Projektet vil på længere sigt bidrage til den videnskabelige basis for retningslinier til økologisk oksekødsproduktion og dermed beslutningsstøtte til producenter. Anvendelsen af bioaktive afgrøder til fremme af kødkvalitet og/eller begrænsning af udegående dyrs parasitbelastning er et nyt perspektiv. Det vil kunne begrænse anvendelsen af lægemidler og dermed undgå lange tilbageholdelsestider. Kombinationen af studeproduktion baseret på afgræsning og bevarelse eller forøgelse af biodiversiteten på marginale arealer må anses for ønskværdig i sammenhæng med naturpleje og miljø. Det forventes, at de planlagte tiltag samlet kan forbedre økonomien i økologisk kødproduktion, primært studeproduktion, eller bidrage til en synliggørelse af de forøgede udgifter ved denne produktion, der retfærdiggør en nødvendig merpris. Samtidig skal projektet bidrage til billedet af økologisk husdyrproduktion som en miljømæssigt fordelagtig produktion.