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Brief description of the Deliverable

Recommendations on innovative strategies related to supporting animal health and welfare and preventing disease in dairy herds to meet low-input farming strategies with a focus on low-input of antibiotics. This is based on five small projects on farmer innovations related to animal health, out of a total of 18 projects within the SOLID project, involving researchers, in Denmark or UK.

Target audience(s)

Researchers, farmers and extension services.

Executive Summary

The SOLID project (Sustainable Organic Low-Input Dairying) carried out research to improve the sustainability of low-input/organic dairy systems in different ways. This deliverable is part of a series of three that summarise recommendations arising from participatory research with innovative strategies involving farmers, supply chain partners and researchers in the SOLID project.

Multiple strategies in use to support animal health and welfare

Farmers apply a number of diverse strategies to improve animal health and welfare and through this, explicitly reduce antibiotic use. These include use of herbs in grass fields, letting calves suckle their mothers at least a month after calving, and establishing farmer groups to reduce use of antibiotics via health promoting strategies. The results of these trials cannot be claimed conclusive in terms of actually improved animal health and welfare, especially not through long-term effects, but they emphasised the relevance of including 'low inputs of antibiotics' as an important element in what can be defined as 'low input farming', because low input of antibiotics reflects the use of strategies which are supportive to the animals' well-being. This points to the relevance of highlighting low input of antibiotics as an important low-input criterion.

Five farmer participatory studies, all related to animal health and welfare promotion in organic and low input dairy herds, were conducted in Denmark and UK. The participatory methods included single farm case studies, observational comparative studies, farmer group development and experiments. The five studies revealed the following results: 1) A Danish study on long-term pastures with herbs showed that farmers, who had started growing herbs in pastures were consistently and persistently continuing developing their systems and experimenting, e.g. with herbs in strips versus herbs sown into the pasture. Even though the actual benefits on animal health and production were not possible to document through these studies, they still felt motivated to offer their animals herbs either in grass or silage, and they believed that it had some good effects on animal health and welfare; 2) Two studies (one in UK and one in DK) monitoring performance of a system leaving calves suckling with milking cows emphasised the importance of development of context relevant, farm specific and experience based management routines; 3) & 4) A UK based study in two phases aimed at reducing antibiotic use and using mint liniment, respectively, began in the so-called Farmer Field Labs, where farmer group discussions and mutual advice was given and stimulated farmers to think in innovations and developments. Four of the farmers engaged in testing a certain udder liniment with the aim of keeping SCC low after calving, with the result that a significant difference between treated and untreated cows could be demonstrated, to the favour of the mint liniment; 5) A UK based study on mineral content of milk related to animal health was initiated in another project with an aim of studying human health effects of low iodine content in milk, but investigated in this project whether low milk-iodine content was reflected in poor animal health. This connection could not be demonstrated based on data collected.

All studies pointed to the relevance of developing practical solutions and modes of implementation on the farms, which to a large extent could happen through farmers' mutual inspiration and exchange of existing technical knowledge, and their generation of context specific and relevant knowledge. The researcher involvement could be shown to facilitate systematic data collection and plan dissemination strategies which extended the results beyond what was interesting for the group of participating farmers. For example, in relation to maternal suckling, researchers were involved to help collecting data about cow and calf behaviour, and make systematic interviews regarding practices at each stage of the calves' lives.

Some of the other projects which were not explicitly related to animal health and welfare, were nevertheless of potential interest in forming future research on animal health and welfare issues.

For example, diverse swards were shown to serve as a viable alternative to conventional pastures, such as grass and clover pastures, and they demonstrated the maintenance of both pasture and animal productivity at high levels. On-farm trials and case studies indicate that rotational, high stocking, grazing of bio-diverse pastures has a remarkable effect on the build-up of the soil organic matter. In addition herbage production of diverse leys is remarkably high in addition to their high protein content. However – impacts on animal health and welfare were not possible to collect and evaluate based on these trials, but bio-diverse pastures could potentially have a positive effect on animal health and welfare, based on the same arguments as herbs in pastures above.

Potential Stakeholder impact(s)

This research showed how farmers are active contributors to agricultural innovation and developing knowledge about sustainable organic and low-input-antibiotic dairy farming. They demonstrated certain practices to other farmers and in the farmer environment and they furthermore contributed to articulate and create debate about non-traditional methods. Close collaboration between farmers and researchers, as practised in the 18 participatory projects (of which the 5 are presented in this report) that were carried out as part of the SOLID project, showed that such experiments can play a significant role in developing the knowledge about sustainable low-input and organic agriculture in local farmer communities and partly on national and international levels. The exchange processes between farmers and other agricultural professionals further contributed to the debates and development of innovative strategies. This method of attempting to set up farmer trials had its challenges, because many farmers were under financial and labour constraint pressure, and did not have much time or financial back-up to engage in testing strategies systematically. These challenges were addressed in a journal paper which is under submission, and partly explained the diverse nature of the farmer-researcher-collaboration. Recommendations to future project strategies in terms of budgeting for compensation of time and investments of farmers, are developed as part of this.

Project no. 266367

Project acronym: **SOLID**

Project title:
Sustainable Organic and Low Input Dairying

Collaborative Project

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Title of Deliverable:
D 1.3 Recommendations on innovative strategies related to animal health management

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Contents

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1. Introduction

Participatory research approaches in relation to agriculture have been shown to be an effective means of stimulating change and developing context relevant knowledge and practices. However, these methods have been applied less widely in Europe, compared to other parts of the world, such as Australia and Africa. One advantage of participatory research approaches is the accommodation of complexity, because they take their starting point in the realities in which people – all the participants in the research - exist, and the participants will ensure that the research includes recognition of their reality which influences the relevance and implementation of any new technology or strategy. In addition, it also opens up to consideration, aspects which matter to the participants and potentially can have great importance in decision making and adaptation, such as social elements, environmental concerns and ethical views. This means that participatory research approaches can both inform and lead setting research and policy agendas.

On one hand, participatory research projects have the potential to stimulate a strong ownership among the participants, who will make a great effort to find solutions and create bridges with the surrounding community. At the same time, it has often been shown to be difficult to ensure natural scientific strictness in participatory research projects, because challenging methods or undesired outcomes can discourage commitment, among other things. Likewise, failure of a certain technique will cause the participants to decline the trial because it poses a risk, often an economic risk, to the participant in whose own surroundings the research is taking place. Consequently, they change practices in order not to lose products or money, hence leave the experimental protocol. However, this does not take away the qualities and value of the research, which can contribute very positively to problem solving, implementation of existing knowledge and generation of new relevant knowledge or open new questions, both in the local context and beyond the borders of the involved farms and region.

Lowering the use of antibiotics in animal farming is an aim which can be backed up by many arguments. It is an explicit aim of organic farming, and it is a very logical part of any 'low-input farming strategy'. The recent decade's increasing awareness of antibiotic resistance and residuals of antibiotics in animal products as well as in soil, water and the environment provides strong arguments for reducing antibiotic use as an independent and general goal, to not lose the ability to treat disease with antibiotics. However, seeing it from an animal health and welfare perspective, it becomes very clear that the most ethically right way of reducing antibiotic use is through elimination of the agents that set the use antibiotics as a necessity. Health can be viewed as "resilience", and supporting health is supporting every animal's ability to balance, and withstand shocks and changes Döring et al., 2015). Health promotion logically, supports the resilience of the animal, and this can happen by giving the animals good living conditions and supporting their general welfare and wellbeing. As the collection of widely different studies and focus areas in this report shows, this can be met in a wide spectrum of ways, some of which are 'health and welfare promoting' and others are 'disease preventing'.

The participatory or farmer-led research in the SOLID project (Sustainable Organic Low-Input Dairying) was aimed at promoting innovation trough actively involving stakeholders (i.e. organic or low-input dairy farmers, farmer groups and farm advisors) and researchers. To identity research priorities, sustainability assessments were carried out on more than 100 (organic/low-input) dairy cow or dairy goat farms in nine countries across Europe. The results were discussed with farmers and stakeholders in national workshops where specific research topics were identified (see Leach et al. 2013 for further details).

In total eighteen on-farm participatory trials, discussion groups or case-studies were conducted in the UK, DK, FI, RO, ES, GR, AT and IT, covering aspects related to feeding and forage, use of natural resources, environmental impact and animal management and health. This work was co-ordinated by the Organic Research Centre as part of the SOLID project. This deliverable is one of three that are resulting from this work on innovation through stakeholder engagement and participatory research (WP1). It presents recommendations on innovative strategies related to health and welfare of ruminants and aims to unfold the discussion on how to lower the use of antibiotics in organic and low-input dairy farming by presenting the results of the participatory studies and stimulating the debate on how to further promote animal health and welfare with continuous developments driven by farmers. The results and recommendations of other farmer-led studies are presented by Zaralis et al., (2016) and by Yanez-Ruiz et al., (2016).

2. Using herbs in pastures

2.1 Aim and research question

Feeding ruminants with herbs in the pastures, in silage or hay has raised interest among many organic farmers and animal researchers, even though systematic health benefits have not been proven or demonstrated. This interest was also present among these dairy producers and many of them had participated in earlier on-farm-trials related to milk quality and feeding. The overall aim of this research was to give recommendations regarding the use of herbs in pastures under Danish climatic and farm conditions. In general use, herbs are any plants used for food, flavoring, medicine, or perfume. Culinary use typically distinguishes herbs from spices. Herbs refer to the leafy green parts of a plant (either fresh or dried), while a "spice" is a product from another part of the plant (usually dried), including seeds, berries, bark, roots and fruits. In botanical English the word "herb" is also used as a synonym of "herbaceous plant", which are plants that have no persistent woody stem above ground. In this study we focused on the plants which Danish organic farmers had tried in their fields: plants like caraway, lucerne, salad burnet, ribwort plantain, chicory, birdsfood trefoil, sainfoin, starflower and yarrow, but not grasses and since clover is often present in organic grassfields, we did not focus on it, since it could not be regarded as ‘an innovation’. To do this, we summarise and investigate current practical on-farm experiences and research results on the use of herbs in pastures for dairy cows through answering the following intermediary research questions:

- What motivates Danish organic dairy farmers to use herbs in their pastures for dairy cows, how do they use it, and what is their experience of using it over a period of some years?
- How do herbs survive and establish in long term pastures used for grazing at organic dairy farms?

What does Danish research on use of herbs in grass fields show regarding the characteristics of the pasture (e.g. mineral content), the establishment of herbs in the pasture, the effects on milk yield and milk quality as well as animal health?

2.2 Background

2.2.1 Research background

At a workshop for Danish organic dairy farmers which took place in June 2012 as a part of the SOLID-project, several farmers discussed the need for collecting information on farmer's experience of long-term use of herbs on pastures. There was a particular focus on the survival of herbs in long-term pastures because some farmers wished both to have herbs but also to prolong the number of years between ploughing with the aim of reducing CO_2 emission and carbon sequestration in the soil. Obviously, it is not an option to investigate 'long term effects' of the use of herbs in a short research project, but the Danish SOLID partners, Aarhus University and Thise Dairy Company, decided that the SOLID project offered the possibility to contribute to valuable knowledge sharing between the farmers through interviews with those who had long-term-experiences they wished to share. In addition, research has been conducted in Denmark over many years regarding the use of herbs in grass fields, and this research could be summarised and fed into the process of finding recommendations and directions for the future, regarding the use of herbs in pasture.

2.2.2 Farmer background

Organic farmers have shown an increasing interest in growing herbs in their pastures because they potentially can have health benefits (e.g. cicory having benefits on immunity, high mineral content and parasite prevention, sometimes tested in combination with birdsfood trefoil (https://www.uvm.edu/~susagctr/Documents/GrazingYourway.pdf; http://www.northcentralsare.org/Educational-Resources/From-the-Field/Researchers-Study-Forage-Chicory-for-Parasite-Reduction-in-Sheep and others), positive influence on the milk and the milk yield, and contribute to the variety and 'naturalness' of the pasture, among other things by offering the cows a variety of different tastes and additional micro minerals and other substances. A few farmers have had herbs in their fields over many years, and have long-term experience of this, while other farmers hesitate because they have heard about some of the challenges related to growing herbs (Smidt & Brimer, 2005). Some of these challenges concern competition with other plants, surviving drought and winters and ensiling/harvesting methods.

2.3 Method of data collection

2.3.1 Farmer Interviews

An invitation was sent to 75 dairy farmers delivering milk to the private organic dairy company "Thise". Farmers were asked to share their experiences of growing herbs in grazing systems or for hay or silage production. Eight farmers responded and they were all interviewed during October 2013. Seven farmers were visited and interviewed at their home. The interview was supplemented with a plant cover analysis of relevant fields to describe the actual distribution of herbs in the fields, and one farmer was interviewed over the phone. The interviews were semi-structured; they were based on an interview guide and were subsequently analysed. The farmer interviews and plant coverage analysis were conducted in September-October 2013, and the literature survey took place in February-April 2014.

2.3.2 Plant coverage analysis on seven farms

The plant coverage analyses were conducted in order to know more about the state of the grass-fields of interviewed farmers, and to identify potential patterns related to species, survival and development of the botanical composition of the crop. The botanical composition of herbs, grasses and legumes in relevant fields were analysed visually by estimating the percentage each species covered the ground in a square of 0.5 m2. Such a square was analysed in each of at least two randomly chosen sites for every hectare of the field. The size of the smallest fields was 2 ha. In small or more heterogeneous fields, one to two additional sites were analysed for every hectare.

2.3.3 Literature survey

Seventeen Danish studies were selected which represented research on herbs – although few of them were focused on animal health and welfare using herbs. They covered the following aspects regarding the use of herbs' effects on: 1) yield and forage quality, 2) milk yield and quality, 3) animal health, and 4) biodiversity and CO_2 storage, in the dairy industry. The literature study is described in the report: 'SOLID participatory research from Denmark: Use of herbs in pastures for dairy cows: Farmers' experience, pasture coverage analyses, and literature survey of Danish research results', which can be found on Organic Eprints: http://orgprints.org/28754/.

2.4 Results

2.4.1 Interview study of eight farmers

Farmers started using herbs to offer their cows a variety of tastes, and because of the potential mineral content and medical effects

Half of the farmers started using herbs 15 to 18 years ago when they converted to organic production. As far as they remembered, their decision about using herbs was not influenced by advisors; they just wanted to offer their animals a more varied feed with different tastes. Some farmers had noticed that their cows preferred to eat trees and wild species of herbs if offered, rather than the grass which was available in the field in abundance. Other farmers emphasised that mineral supplementation was a reason because they perceive herbs - especially herbs with deep root systems like chicory - to draw up minerals from deeper soil-layers. A third reason given by farmers was the expectation of the medical effects of using herbs e.g. against parasites and against ruminant bloat/ tympanitis.

Milk producers of Thise dairy company have a long traditionof cooperating with Aarhus University in research projects. Four of the interviewed farmers started using herbs when they took part in such projects, while a fifth project-farmer had already used herbs for many years. One project had aimed at investigating the cow's mineral uptake from herbs, their preferences for different herb-species and the competitiveness of the herbs. It took place in 2006-2007 where 10 different herbs were sown broadcasted together with grass-seeds to establish a mixed herb-grass field (Søgaard et al., 2010). On one of the farms this field had not been ploughed since then, but there were only very few herbs left except clover. The other project focused on the effect of feeding with pure herb silage (without grasses) on the content of fatty acids in the milk, and on three farms a pure herb-field was established in 2011, and they still existed on two of the farms in 2013. All farms except one had used herbs in all pastures since they were involved in the research projects. On one farm not using herbs anymore the herbs were poorly established in the field, the crop was too open and the yield too low compared to the costs for seed. This farmer wanted to wait to sow herbs again in the field until more cost-effective methods were developed.

Farmers make their own experiments with herb mixtures

The famers who started using herbs on their own initiative 14-18 years ago have over the years tried different compositions of herbs. One herb which has been used continuously is Chicory (Cichorium intybus). This herb normally establishes quite well in the field, the cows like it, it is believed to have a medical effect on parasites and on ruminant bloat and to have a high mineral content. Herbs like dill and parsley have been tried but given up again. Dill had a poor re-growth after harvest or grazing and parsley germinated very slowly, lost competition with other herbs, and never really established in the field. These very experienced herb-farmers continue to develop their methods and experiment with different mixtures. This is also the case for the two farmers who took part in the research projects by Karen Soegaard in 2007. In this specific project, seven different herb-species (chicory (Cichorium intybus), ribwort plantain (Plantago lanceolata), caraway (Carum carvi), salad burnet (Sanguisorba minor), birdsfoot trefoil (Lotus corniculatus), chervil (Anthriscus cerefolium) and sainfoin (Onobrychis viciifolia) were sown. These two farmers both continued using herbs in all pastures, although just one (chicory) or a few species are used now.

Farmers use what is currently on the market

The herbs currently chosen by the farmers seem to reflect which herb-seed mixtures which are available on the market. Most farmers use these mixtures which include herbs like chicory, Sainfoin, ribwort plantain, caraway, dill (Anethum graveolens), birdsfoot trefoil and salad burnet. The farmers however, know that some of the species often establish very poorly in their pastures, and if they had the possibility they would have adjusted the balance of herb species in the mixture. Some farmers add other herbs to these mixtures like alsike clover (Trifolium hybridum) while others choose just to add chicory seeds to the traditional grass-clover seed mixtures. The three fields with pure herb-culture which were established on three farms in 2011 during a research project by Petersen (2012 & 2013) with the aim of studying the content of fatty acids in milk when the cows were fed pure herb silage. The seeds sown on these fields were a mixture of 11% lucerne (Medicago sativa), 2% red clover (Trifolium pratense), 12% birdsfoot trefoil, 8% yellow sweet clover (Melilotus officinalis), 12% chicory, 24% salad burnet, 12% ribwort plantain, 12% caraway, 2% yarrow (Achillea millefolium) and 5% starflower (Borago officinalis). Lucerne is considered a herb in most trials, because it is not a part of a traditional grass mixture.

Farmers' experience that some herbs are better 'survivors' than others

Farmers had experiences with some herbs surviving better than others. Herbs like chicory, caraway, lucerne, red clover and ribwort plantain are relatively large plants with deep roots and they both have a high competitiveness the year the pasture is established, and they are also the best survivors over the long-term. Herbs like lucerne and ribwort plantain seemed better suited for cutting than for grazing and chicory and caraway seem to be the only plants able to survive grazing over several years. However, in general, farmers said that all sown herbs had difficulties surviving the winters, their occurrence were markedly reduced every year and barely existing after 3-4 years.

Farmers also experienced that in very dry periods, herbs coped better with drought than grass. Especially deep rooted herbs like chicory, lucerne and alsike clover had a remarkable drought resistance. Several farmers experimented with keeping their herb/grass pastures for more and more years before ploughing. The oldest pasture was 6 years old.

Sowing herbs broadly versus in stripes

Almost all interviewed farmers used herbs in all of their grass-fields, both fields used for grazing and for silage production. They either buy seed mixtures including herbs or they mix herb seeds with grass and clover seeds before sowing and in that way the herbs are broadcasted all over the fields. Only one farmer was sowing the herbs in 30 cm broad stripes for every 4th meter. He had observed that in this way the survival of the herbs was increased because the competitive pressure from grasses and clover was decreased. Most other farmers considered also to try herb-stripes in the pastures to increase the competitiveness. Some planned regular stripes all over the field while other farmers planned broad stripes at the edge of the field. To improve competitiveness and survival of the herbs, some of the interviewed farmers had added an increasing amount of herb seeds pr. ha.

Herb fields were not used for hay, but silage production worked well

The herb fields were normally never used for hay production because the dry leaves crumble away if they are handled more than once. Only one farmer had made hay one time on a field dominated by lucerne and in a period with stable sun and warm weather.

Silage production seems to work well except in one of the pure herb fields without grass. Here the leaves from chicory fall to the bare soil when cut, and when they dry they get sticky and difficult to pick up without soil. In this way the silage quality is markedly reduced due to soil contamination. In the other pure-herb field a cover of low grasses (poa annua) had established from the seed bank in the soil, and in this field there were no problems with soil contamination because the chicory leaves were carried up by the grass cover.

The cows enjoyed eating herbs

All farmers reported that their cows were happy to eat both fresh herbs when grazing (except the old tough stems of chicory) and silage made from herb-grass fields. Only the silage including sticky chicory and soil was disliked by the cows. Some farmers had the impression that especially in the springtime the cows preferred herbs and leaves from bushes and trees in hedgerows before grass. The farmer who established bands of herbs on the pasture described how the animals could stand in rows grazing primarily these stripes of herbs.

Farmers perceived herbs as contributing to good animal health

The farmers were asked whether they had noticed any effect from use of herbs on the health of their cows. Since there had not really been a before-after situation for many years, they were not able to see any difference. They all stated that they generally perceived their cows to be very healthy.

Cows which had taken part in the herb-silage project only got the pure herb-silage for 3-4 weeks, which was not enough to observe any difference on their health. Several farmers were convinced that the herbs contributed to the mineral supply of the cows. One interviewed farmer had not given other supplementary minerals to the cows the last six years – and had not experienced any negative side effects. One farmer had a high prevalence of ruminant bloat in his herd many years ago. He solved that problem by exchanging red clover with alsike clover and adding caraway to the herb-seed mixture. In general the believed health-related effects on the cows and the fact that the cows seemed to enjoy the herbs were the main reason for the farmers to continue sowing herbs in the grass fields.

Seven of the eight interviewed farmers would use herbs in the future

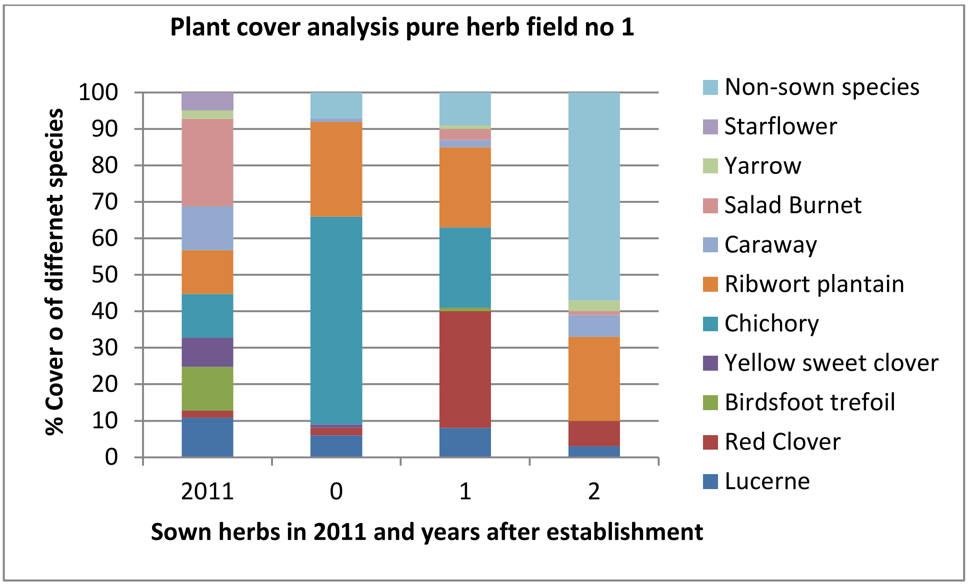
Seven out of eight farmers stated that they planned to continue using herbs in their grass-fields, despite the facts that 1) herb seeds are quite expensive, 2) they do not have a proven effect on the cows, and 3) growing herbs involves a lot of challenges in terms of survival of the herbs. All farmers constantly adjusted their way of growing herbs to improve the outcome.

2.4.2 Plant coverage analysis

Research results from project at two Danish organic Thise farms

Of the three pure-herb fields which were a part of Petersen's research project in 2011-2013 (Petersen et al. 2012), one field was ploughed after two years, but the last two fields still existed on two of the visited farms. A plant coverage analysis was performed after the interview and compared to the plant cover analyses performed in 2011 and 2012 as a part of Petersen's project. The figures below, show that the development of the two fields turned out very differently. The field placed in the northern part of Jutland (no 1) had in 2013 been spontaneously invaded by 6% wild herbs, 25% rough blue grass (poa trivialis) and 26% white clover (Trifolium repens) probably originating from a seed-bank in the soil. Of the originally sown herb (column to the left) the following species remained: 23% ribwort plantain, 7% red clover, 6% caraway, 3% lucerne and 3% yarrow. The other sown herbs had disappeared.

The other pure herb field placed in the central part of Jutland was in 2013 very open (cut two weeks before the plant analysis was performed). 50% was covered by the dominating lucerne and beside that a 5% coverage of caraway, 4% red clover, 2% ribwort plantain and <1% chicory and salad burnet. In both fields, birdsfoot trefoil, yellow sweet clover, sainfoin and starflower never established although the originally seed mixture had quite a high content of their seeds. The bar labelled as "2011" (left bar in the figures) shows the original composition of the seed-mixture.



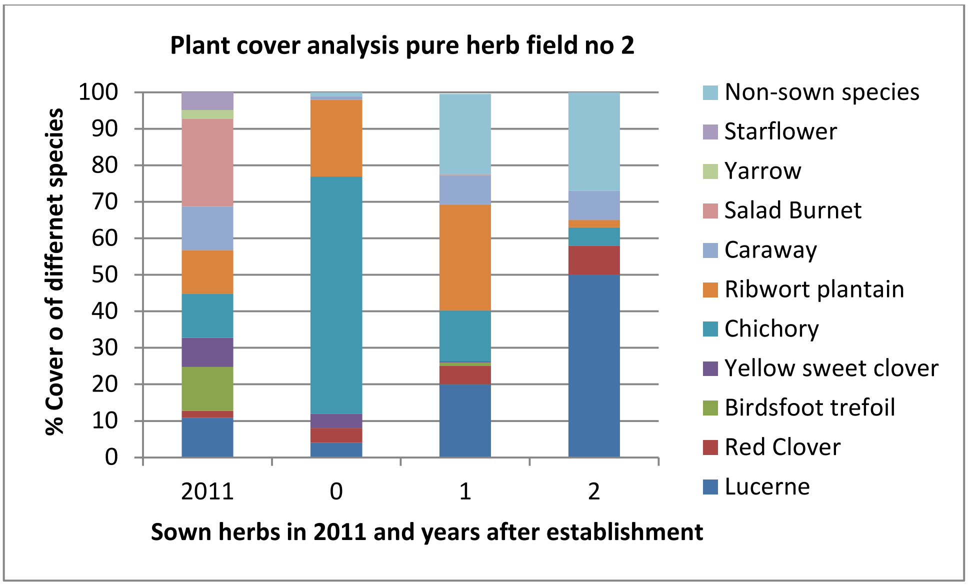
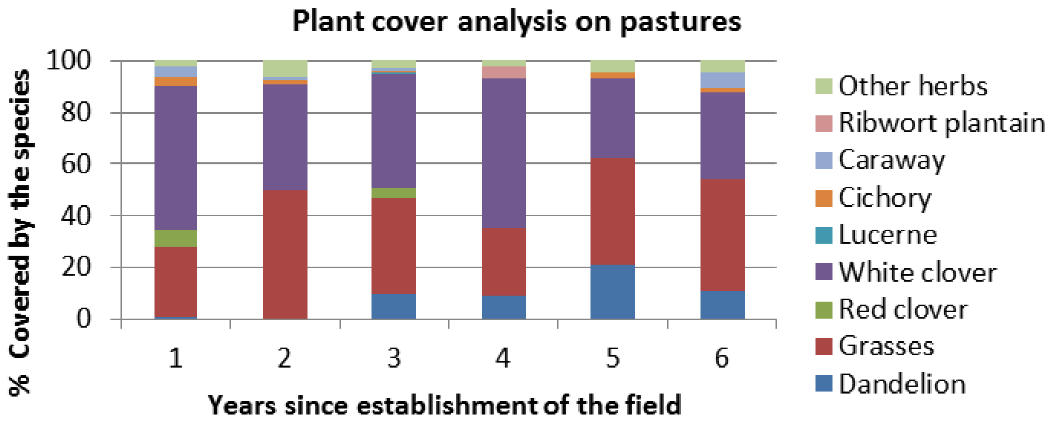


Figure 2.1. The results of 3 years plant coverage analyses of pure herb fields on two farms of which the analysis done in the first two years (The bars '0' and '1') was done in a research project by Petersen et al. (2012) and the analysis in the last year was a part of this project (the bar '2'). The left bar (2011) shows the original seed mixture.

Plant coverage analysis done on seven farms, Sep.-Oct. 2013

On the seven farms that had still herb-grass-fields, plant coverage analyses were performed on all relevant fields meaning one to six fields on each farm. The findings mostly confirmed the statements from the farmers, and it also confirmed findings in previous Danish studies. Grasses and white clover were dominating all over in different balances, and only ribwort plantain, chicory and especially caraway survived several years in the grass fields, although becoming more and more scarce. While the sown herbs diminished from year to year the wild herbs became more and more abundant – on pastures especially dandelion, different thistles and curly dock. On the fields used for silage production, the grown herbs covered a much higher percentage and seemed to survive better.

Especially in one field, lucerne was very dominating. The figures below show the average % cover of 10 pastures with an age of one to six years after establishment, and five fields used for silage production, with an age of one to two years after establishment. Only chicory and caraway were found in 5-6 year old pastures and with only a few specimens in each field.



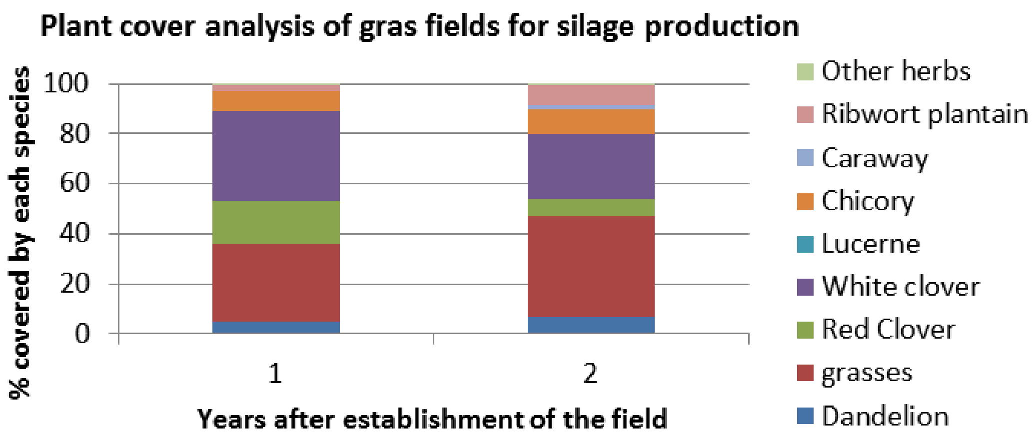


Figure 2.2. Results of plant coverage analyses on 10 fields at seven farms, at two-six fields per farm, over a six year period (Panel A) for grazing and over a two year period (Panel B) for silage production.

2.4.3 Short summary of literature study

A literature survey was undertaken with a focus on Danish studies, and 17 studies were in-depth reviewed with a focus on pasture characteristics and qualities as well as milk composition, yield and content, and potential effects on animal health. The focus areas of the different types of research were very different and complex, and the larger report can be found here: http://orgprints.org/28754/ .

The following points can be drawn out of the research conducted under Danish conditions:

- The annual herbage yield was found to be highest in lucerne, ribwort plantain and birdsfoot trefoil, and lowest in perennial grass.
- In many studies, the yield was not found to be affected by or in different mixtures.

- Yield of fields with herbs was generally greater from grazed plots, compared to plots that were cut.
- Some mixtures, e.g. with 10 and 13 species of grasses, legumes and herbs had better performance compared with the standard mixture of perennial ryegrass, white clover and red clover.
- Proportions of herbs in the field changed a lot over time, e.g. a growth season or a couple of year. This varied with cutting frequency, seed mixture, and other factors.
- Herbs in grass fields have several competitors, and should be sown and planted at times where they could have advantage over competitive grass types for example.
- Herbs influenced fat composition in milk in different ways, e.g. chicory lowered the urea content in milk.

2.5 Short recommendations

- Ruminants like herbs, and farmers who had herbs in the pastures were greatly encouraged due to the fact that they could see that the cows preferred herbs, and perceived it as a part of animal welfare improvements to offer them herbs.

- Sowing herbs in stripes in the pasture seems a viable strategy, making it relatively easy to re-establish in a long-term grass field.

- All (non-poisonous) herbs – including those which establish themselves and in some cases are considered ‘weeds’ – can potentially have some beneficial effects on one or more of the areas of health and welfare of cows, the milk, and / or the biodiversity on the field. The organic principles and ideas generally encourage many types of plants, grasses and plants in pasture, and discourage plain mono-cultural grass fields. It also points to a more explorative approach to develop strategies to keep more robust herbs, treasure those which naturally grow on fields, instead of focusing on expensive seed mixtures of herbs which have difficulties in competing on many pastures. For example, Birdsfoot trefoil, yellow sweet clover, sainfoin and starflower were all identified as herbs which were difficult to grow.

- Silage making seems to be a better option than hay making based on herbs, under Danish and similar conditions.

3. Maternal feeding

3.1 Background & motivation for the study

Keeping calves with their mothers is probably the rearing system which allows most cow-calf interaction and meets the natural needs of both cow and calves in a dairy farming system. It is rarely practiced under Danish production conditions, for different reasons: it can be practically difficult to manage, and it will reduce the amount of milk for sale quite significantly. However, in the organic principles, letting animals meet their natural needs is highly valued as a quality and as a part of animal welfare. The alliance between humans and animals is based on the combination of allowing the animals to express their natural behaviour and have their natural needs met as much as is possible under domesticated conditions, and at the same time, that humans take the responsibility to interfere and take over when it is needed. To find the balance and 'when it is needed' is a challenge, which needs to be identified and met in each context, and which requires a great deal of learning.

The motivation for taking this piece of research up as a means of farmer innovation was that more farmers are curious about the system and acknowledge its potential to meet animals' needs which is emphasised in the organic principles. However, many also reject the idea because of the milk loss and the difficulties in managing such a system, including e.g. perceived risks of damaging the calves. In this particular farm, the system has been practiced in different forms over the last 20 years and therefore offers a great learning regarding how to manage it in a smaller herd and with calving seasons.

In the Netherlands, more farmers practice the system in different ways, which has been explored by among others Wagenaar et al. (2007) and Verwer & Kok (2012). To support the study in the Danish herd, the research team involved in this research also went on a short study trip to The Netherlands and visited 6 dairy farmers who practiced a cow-calf rearing system in dairy herds, to interview them about the practical implications and management.

3.2 Aim and research question

The aim of this research was to give a basis for determining whether and under which circumstances, letting calves stay with their mothers (or for some calves, foster cows) in a suckling system under different circumstances can be a practical and animal friendly way of rearing calves:

- How can it be practically manageable to keep cows with calves in a dairy herd? What should be considered regarding management in such a system?
- Does it have positive or negative effects on animal growth rate, health and welfare and milk production?

3.3 Material and methods

3.3.1 The participating herds and farmers

This piece of research took its starting point from two small case studies in Denmark and the UK, respectively. The experience from these two studies was combined with a research visit to 6 Dutch dairy herds including informal farmer interviews about their practical experiences regarding letting calves suckle their mothers in loose housing systems with an even calving pattern throughout the year.

The Danish study was conducted with a farmer in a Danish dairy herd with seasonal late-summer / autumn calving, where a cow-calf suckling system had been developed over the last two decades. It was a relatively small farm characterised by the following:

- an average of 49 cows per year,
- all calvings during August-November,
- about 6500 kg milk per cow,
- access to outdoor areas for cows in the milking cow area, and heifers,
- crossbreeds of Jersey, RDM (red Danish) and SDM (Danish black and white),
- bull calves fattened until slaughter on the farm,
- a strategy of extensive farming and phasing out of antibiotics through health promotion.

The British study was conducted during the first year of trying to rear calves with their mothers. A farmer in South West Scotland had commenced rearing calves with their mothers as a component within a move to a "lean farming" approach, because he believed that it could potentially reduce the costs of rearing calves for beef due to lower bought-in feed costs. It could potentially also contribute to better animal welfare, and prolong the productive life of the cows. This farmer approached the SOLID team with the wish to monitor the effects on animal health, welfare and productivity, within the whole system. The objective of this single farm case study was to record the impact of the change in rearing practises on the health and performance of cows and calves in this system, and the system level inputs and outputs. It was one such observational case study that allowed the farmer to use his own initiatives in the system tested, with regards to rearing calves on milking cows in his farm. The farmer and a member of staff was responsible for carrying out the management operations and for collection of the data while he was free to make modifications in the system tested.

3.3.2 Data collection and analysis (Danish study)

Table 3.1 summarises the type of data and the methodology of data collection. The data was collected to achieve knowledge on 1) available milk for sale / estimated milk per calf per day, 2) calf growth rates, 3) health implications for cows and calves, 4) management challenges, and the solutions to these, and 5) cow-calf behaviour. Data was collected between August and December 2013.

3.3.3 Data collection and analysis (UK study)

An assessment of whole farm sustainability for the year before prolonged suckling was introduced was carried out in October 2012, using the ORC Public Goods Tool (Figure 3.1). Milk yield, cow somatic cell counts (SCC) and weights of calves at sale from previous years were available for comparison, but information on cow body condition, calf growth rates and teat condition had not previously been recorded. In addition, due to some technical difficulties (as explained below) collection of data was only carried out with the autumn born calves in 2012. Table 3.2 summarises the type of data that were collected and the methodology used for data collection.

Table 3.1. Type of data collected and the methodology used for data collection in the Danish study

Parameter	Method	Frequency of data collection
Milk yield	Electronically recorded in milking parlour	Every morning (the cows were only milked once per day)
Calf measures	Using a weight at birth. Weigh tape after this.	Every 2 weeks.
Measures of one year heifers	Weigh tape.	Once
Disease treatments (cows and calves)	Danish central cattle data base	When events occur
Non-medical disease treatments	Herd book	When events occur
Feed use – for cows and calves	Farm records; observations of feeding troughs	Once; observations at every fortnight visit
Time registration during a work day	Walking after the farmer one whole day	One full day
Human-animal interaction	Avoidance distance test of 1 year heifers	Once; 14 heifers
Cow and calf behaviour	Observations of interactions, suckling and positions of cows and calves in relation to each other.	Two full days 7.30-15.30.

Table 3.2. Type of data collected and the methodology used for data collection in the UK study

Parameter	Method	Frequency of data collection
Milk yield	Recorded in parlour electronically	2 x day
Cow body condition score	DairyCo method	At calving and then monthly
Cow teat condition	National Mastitis Council method	Monthly
Calf weights	Weigh tape	a. At birth b. When sold
Feed use – for cows	Farm records/parlour	Annual summary
Feed use – for calves	Farm diary	Use of calf creep feed during feeding period
Cow and calf behaviour	General informal daily observations Two specific observations of calf feeding area	Two occasions when creep feed first introduced
Overall farm inputs and outputs	Invoices	Annual summary
Farm energy data	Invoices	Annual summary

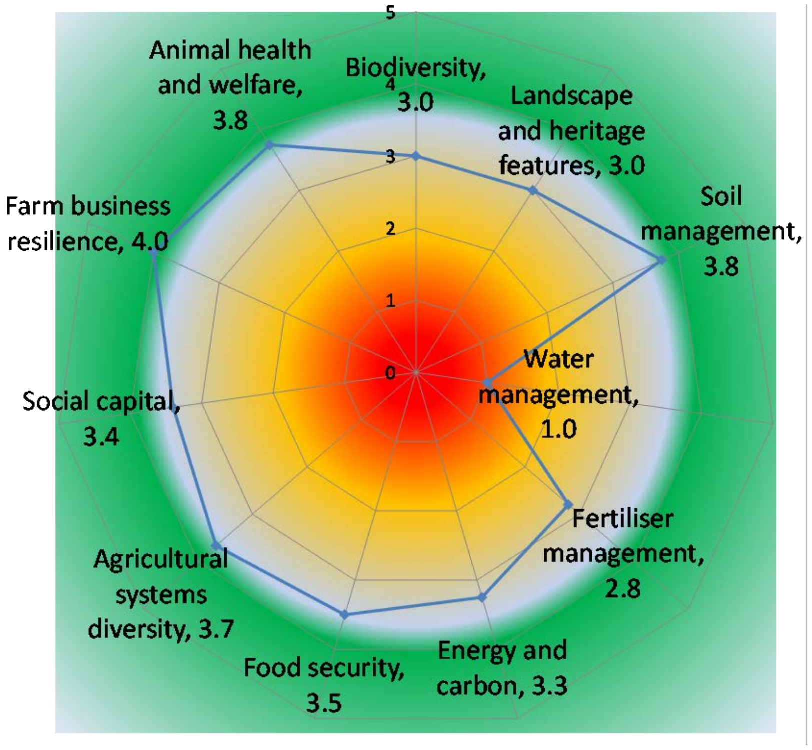


Figure 3.1. Results of the sustainability assessment carried out using the ORC's Public Goods Tool during for the period 1st Sept 2011 to 31 Aug 2012.

3.4 Results from the Danish Study

3.4.1 System characteristics

Each cow gives birth to the calf in a common area, outdoor or indoor according to her preference. The cow and calf will then be transferred to a separate box to build up the bond between them, and to relax after the calving. After a complicated birth, or birth of twins, the cow and calf will stay in their own box for more days. The cow will normally not be milked during the first day, but start on the second day. If the calf has not been observed suckling or there is a suspicion that it has not had sufficient milk, it will be offered milked-out milk. After this, they normally have a box where a few cows and their calves go for some time, where they are under special observation. Then the little group will be included in a bigger group.

The system involves cows and calves being together between morning milking and until after evening milking. The suckling cows are milked in the morning, and not at the evening milking when they have been with their calves during the whole day. Avoiding evening milkingmeans that the amount of suckling calves and litres of milk available has to be balanced. The consequence of this is that not all calves will have their own mother with them in the cow-calf-area. The farmer will start selecting which cows should stay with the calves, and which should go into the milking herd of cows being milked twice per day. He selects them based on their behaviour towards the calves: if there is any sign of aggressive behaviour or a lack of interest in the calf, she is taken out of the cow-calf group. This means that approx. 20 calves are staying with 12 cows. There are at least three cow-calf areas in use, and the sizes of the different groups depend on the size of the area in combination with size of calves and temper of all the animals. Other factors that may be considered can be presence of disease (in particular Johne's disease and Salmonella which was present in the herd 2004-2006), ability to let down milk at machine milking, or whether they are on the list of cows that are signed in as 'cows to be culled' for one reason or the other. If they are separated from the calves because of temper, they will always get a second chance in the following year. The farmer may help the 'left-alone calves' to find foster cows which are willing to adopt them, but often they find their own ways; they are used to suckle, and quick and persistent, so they 'steal' when the cow's own calf start suckling.

By the end of December, the cows and calves will be separated. For many years this has happened abruptly: the cows are not going back to the calves after morning milking. Since they are used to spending only part of the day together, there is not so much 'panic', but there is still, some calling (sometimes a lot !), no matter what the age of the calves. The calves will be between 1 and 4 months old, and some of them are already almost weaned because they have started eating a huge amount of silage and hay, and others will be milk fed from a teat bucket. This means that some calves are only staying in the cow-calf system for a month, before they are milk-fed by buckets only, and others during an extended milk feeding period of up to 4 months. After weaning they have silage, hay and some concentrate until grazing from the following spring.

The year of this research, based on the results of the interviews of Dutch farmers, this farmer chose to try fence line weaning, where cows and calves are on each their side of a fence and can see and touch each other and during the first days suckle through the fence. This worked well.

Bull calves will often have some extra time with foster cows that are meant to be culled after the suckling period. Sometimes the bull calves go with the grown-up cows until they are 1 year old and being slaughtered.

3.4.2 Disease, health and mortality

There were no stillborn or dead calves in 2013, and no assisted calvings. The calves had an average birth weight of 35.3 kg. No peri-partum complications in terms of retained placenta or milk fever occurred.

There were no treated diseases among cows or calves during the study period (vet or farmer treated), and there were no observed cases of disease at any of the research observation days, or reported by the farmer. (Historic data showed 5 cases of pneumonia and one case of diarrhoea in the period between 2008 and 2013). Almost all slaughtered animals from the farm have traces of liver flukes in their livers.

The bulk tank SCC was 327.000 in average during the study period.

Weight gains and milk production

All calves followed a weight curve above the standard average, except one which was from a Jersey bull. The weight gains were generally a bit lower (not significant) among the youngest calves, compared to the first born. This could indicate that the 'big and old calves' were stronger and simply took more milk than the smaller and younger ones, which in some cases maybe were outcompeted. It could also indicate that they just took advantage of having more available milk during the first weeks, where all the mothers were in the cow-and-calf-area. The calves which had their own mother during the whole period, generally became bigger than the calves which partly suckled 'aunts'. The heifers from 2012 were also weighed at an age of 11.8 years. Their average weight was about 300 kg, which is quite a lot, given that half of them had Jersey fathers. It could indicate that they continued to grow well, and in combination with the fact that they never became sick, they probably had a steady growth curve.

Based on the morning milking, milk intake was estimated to be 5.26 litres/calf/day. This seemed to be very low and probably under-estimated, given the weight gain of the calves.

Behaviour of calves, heifers and farmer

Cows and calves were observed during two full days. A wealth of detailed info was recorded, a highly complex dynamic pattern between cows and calves was also witnessed, which is difficult to summarise but the following points should be highlighted:

- Calves suckled their mother in a 'reverse parallel position' where their bodies were parallel,
- Calves suckled foster cows generally in a 'stealing position' between their hind legs, with few exceptions; there was e.g. one cow which seemed to be a favourite cow for many calves, and one small calf that seemed to be easily adopted by more cows which allowed it to stand parallel.

- Young calves generally only suckled their mothers if she was available; slightly older calves could also cross-suckle when their own mother was present, although not so often. E.g. one twin generally suckled quite a lot from other cows as opposed to its own mother, whereas its twin seemed closely connected to the mother.
- Young calves seemed to rest more close to their mother, where older calves went into a calf group and slept together as a group. Mothers of young calves also seemed more protective of them, and attempted to keep them closer.
- When 'feeding and milking sounds' started, the calves would start suckling because they know that now their mothers/aunts will soon leave.
- The calves were playing and running when the mothers / aunts left for the evening milking, because it gave them space for running and playing. The cows seemed happy having a bit of evening concentrate and being able to be with the other cows and have outdoor access. In the morning, both groups seemed to enjoy getting back together.
- The calves were observed eating roughage within the first weeks of life, often together with their mother or other grown up cows.

The farmer taking care of the cow-calf system was observed over one day, where an observer followed him around on the farm. On that day, 80 minutes were spent with cows and calves in the system, distributed between the following activities:

- Collecting cows for milking and bringing them between calves and milking	16 min
- Feeding the calves	13 min
- Straw supply	20 min
- Talking and patting the calves and cows	28 min
- Helping calves to get milk	3 min
- In total	180 min

The 'talking and 'patting' periods could be while talking on a mobile phone or waiting for the water troughs to be filled.

Fear tests were performed at 14 heifers in a group, to see if they seemed wilder than 'normal heifers'. One heifer walked away at a distance of 2 metres, and 4 allowed the farmer to go as close as he could pat them behind their ears. The rest allowed him to approach between 0.5 to 1.5 metres.

3.5 Results from the UK Study

3.5.1 Housing system in the UK cow-calf study

The cows and calves were housed in a cubicle housing system with a concrete floor, and calves were allowed to be with their mothers throughout the day (24 hrs) in the cubicle area. As shown on the picture 3.1 the design allowed cows to lie in a variety of positions, including diagonally across the cubicle space, and even parallel to the dung passage, underneath the cubicle divisions.

3.5.2 Disease, health and mortality

Horizontal lesions on the teats were observed in approx. 40% of the suckling cows in January and February, and vertical lesions in 7.6% and 11.8% of the cows in January and February, respectively, which was much more than in non-suckling cows (<4%). The prevalence of warts was similar in suckling and non-suckling cows (20.7% vs. 16.7%), and the suckling cows had significantly dryer skin than the non-suckling cows. The dry skin was only observed in December at the beginning of the suckling period.

Based on statements from the farmer, anoestrus periods in the cows which had suckling calves, were extended, but data was not available to confirm this.

Picture 3.1. Calves are resting together with their mothers in the cubicle area.

3.5.3 Weight gains and milk production

Calf weights at birth were estimated using a weigh tape, although not followed during the suckling periods due to lack of funds and difficulties of physical handling of the calves. A subsequent Glasgow University student project provided data on lifetime growth rates of the suckled calves compared with previous bucket reared calves. On average, suckled calves were slaughtered 193 days earlier than the previous bucket reared calves (T Harris, unpublished data), although there might be a multitude of reasons behind this. Calculated from birth weights and estimated slaughter weights (assuming a dressing (KO) percentage of 48%; i.e. KO% = (Carcass weight/Liveweight before slaughter) x 100), suckled calves achieved a daily live weight gain of 0.9 kg/day and bucket fed calves 0.65 kg/day.

During the first two weeks after calving in autumn 2012 the overall sellable milk production per cow per day averaged 4 to 5 litres, an amount that was disappointingly low for the farmers' expectations. The farmer was reluctant to physically separate calves from cows for long periods of time. To increase the amount of the sellable milk the farmer decided to start milking the cows twice a day while maintaining the free access of the calves to their mothers 24h. The addition of the afternoon milking did not affect considerably overall milk production. On the 7th March 2013 calves were partially separated from their dams and restricted suckling was introduced. Under this regime the calves were kept separated from their mothers as the cows went for the morning milking and were allowed unrestricted access to their mothers from after the afternoon milking onwards. During the day, the cows and calves could still see each other and interact through gates. Partial suckling did not allow for sufficient milk yield recovery and the overall milk yield still remained below the expected level, which caused a significant impact on the farm's economy. The overall monthly milk production and quality from bulk tank analysis is shown in Table 3.1.

Table 3.3. Monthly milk production and quality from bulk tank analysis

Month	Cows in milk	Milk produced [a]	Milk Sold [a]	Fat %	Protein %	SCC [b]	Bactoscan [c]	Urea %
Oct 2012	68	30203	29963	4.75	3.63	269	23	
Nov 2012	81	30685	25365	4.76	3.65	285	25	
Dec 2012	76	38502	26642	4.52	3.56	312	35	0.012
Jan 2013	60	41360	21272	4.25	3.35	307	40	0.008
Feb 2013	48	30078	11926	4.18	3.27	318	36	0.008
Mar 2013	63	27817	16657	4.19	3.34	278	35	0.012
Apr 2013	92	50964	44904	4.19	2.97	136	9	0.013
May 2013	94	65748	58618	4.16	3.08	194	14	0.012
Jun 2013	94	65656	64156	3.80	3.19	197	9	0.007

[a] *Total litres*

[b] *Somatic Cell Counts, measured as thousand cells/ml*

[c] *Number of bacteria present in milk expressed as thousand bacteria/ml*

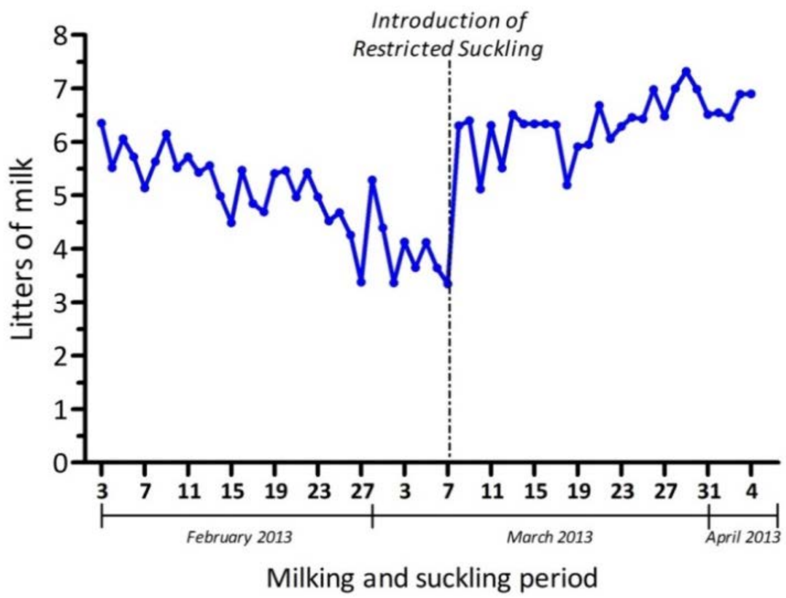


Figure 3.1. Daily milk production retrieved at the parlour of cows that were suckled by their calves during the period 1st February 2012 to 4 April 2012.

In an attempt to reduce milk intake by the calves and increase milk yield in the parlour, the farmer offered creep feed (i.e. concentrate supplemental feed in a designated area) to calves. A short observational study was carried out to evaluate whether creep feeding would be adopted by the calves. The number of calves eating creep feed was recorded at half hour intervals from 09:00 to 12.00 over two consecutive days (December 2012). Only 7 out of the 30 different individuals were observed eating the creep feed over these particular two days. To encourage calves to enter the creep area the farmer provided haylage and introduced some objects to appeal to the calves' interest in exploring. While calves had unlimited access to their mothers' milk the estimated concentrate intake averaged from 0.3 – to 0.5 kg per calf per day but following the partial separation of the calves from their mothers on the 7th of March, individual concentrate intake increased to approximately 2 kg/day.

3.5.4 Behaviour of cows and calves

Maternal suckling was introduced at the same time as the herd had moved into a new housing system. The way in which the cows could lay down in this area resulted in some soiling of the beds. The cows rarely lay in adjacent cubicles, and often their bodies overlapped into the adjoining cubicle, underneath the divider. To rise, the cows generally lunged to the side, over the cubicle division. The farmer considered that the low stocking rate of the cubicles (2-3 cubicles per cow) encouraged the calves to stay in the adult cow areas, because of the high availability of lying places, particularly as the calves could lie in any position, not being restricted by the cubicle design. When the cow numbers increase calves may be more likely to enter the creep area for rest and consume more feed while they are there.

Calf-cow behaviour was assessed at the time the cows were going to the milking parlour and observations took place in December 2012. Calves were somewhat unruly, but as calf numbers increased, the majority of them were content to remain in the cubicle area and await their mothers' return. Some calves were occasionally eager to go to the collecting yard, possibly even pass through the parlour, but this did not cause problems. Human appearance (i.e. herdsman arrival) did cause disturbance among the cows and calves. The most common time for suckling was after the morning milking and feeding while cross-suckling was also observed occasionally; for example five different cows were observed to have two calves suckling them at once. The "roving" calves generally approached the cow from behind, when her own calf was suckling.

3.6 Results from the study trip to The Netherlands

3.6.1 Summary of interviews and study trip

Two researchers from Aarhus University visited one farm where cows and calves were together 1½-2 hrs after each milking, and five farms where the calves were part of the milking herd night and day, although in some of the herds, the calves were kept inside when the cows walked to the pasture, for security reasons (e.g. a motorway close to the farm). In most farms, the bull calves were sold off at an age of 3 weeks. Heifer calves were normally with their mothers until an age of about 2-3 months. Amongst other things, the experiences also pointed to:

- Bonding should be ensured from the very start, but was normally not a problem. Some had the cows and calves isolated in a calving box for few days before they were let into the milking herd, others just kept a close eye to them. It was normally uncomplicated, although some had to be helped to suckle at the start. It was paramount to ensure that it worked well within the first day or two, no matter which system was applied.
- The major challenge was the process of de-bonding. One farmer let the calf stay with its mother but with a 'nose-ring' that hindered suckling. Others made various versions of fence-line weaning, meaning that the calf had to suckle through a fence, which limited it and made the calf more aware of presence of humans – who then should make positive contact with the calf and feed and pat it, as well as other calves. It would be an advantage to have more calves together.
- Most herds had a continuous calving pattern throughout the year, which on one hand could be a challenge for the 'peace' in the herd – both in the calf group and the cow group, and with regard to behaviour as well as hygiene issues. On the other hand, seasonal calvings would require quite a lot of extra space used only during one period of the year.
- The design of the housing system needs to be considered carefully: minimum metal bars, corners, narrow places and blind ends, and maximum overview, space to move and equipment for calves like lower water troughs and feeding tables which they can reach.
- A special area for calves, unreachable for cows, could be desirable, but only a few had this.
- The very young calves often preferred to stay with their mothers – sometimes they walked with them to the slatted floor areas and were lying there while the mother was eating. Solutions to this, i.e. offering mothers of young calves feeding in a more 'calf friendly' area were not really developed.
- Calves normally preferred to eat the feed offered for the mothers. The farmers would offer calves special calf concentrate, but the calves would still prefer the cow feed.
- The learning element in systems where calves were allowed to be together with grown-up cows, was emphasised by all farmers. They had made observations which made them think that the calves were much better equipped to come into the cow system when they grew up, which could be explained by them being 'used to the system' from a young age. They ate roughage and had social contact with fellow calves and grown-ups, which also gave them a good start as ruminants and as social animals.
- The calves could have diarrhoea caused by 'over-drinking', and it was seen occasionally but was not regarded as life threatening.
- All farmers had experienced a calf that was damaged or had died, but it was a very rare. One farmer took out cows in heat from the herd as a result, and others emphasised the design of the housing system.
- With regard to milk consumption and weight, they all realised and accepted that the calves drank much more milk this way, than when being restricted in a twice-a-day-milk-feeding program, but they were also ill less and their weight curves were normally about 1½ in front of their age.

3.7 Discussion, conclusions and recommendations

Observations in the Danish dairy herd during one calving and calf rearing season showed that the health of cows and calves was good, and the management seemed to work well on a daily basis, judged by observing animal behaviour.

It was clearly demonstrated that skills and adaptation to the herd conditions is paramount for the success of this system, and it requires observation and deep knowledge of cow and calf behaviour, as well as quick action and reaction to all observations made. The interviews in The Netherlands supported this.

Generally, the biggest challenge in the cow-calf system is clearly the de-bonding process, and to less extent also the bonding. Further literature studies suggest different ways to meet some of the challenges of creating bonds between cows and their calves, as well as to de-bond at weaning.

4. Farmer Field Labs: farmers doing research together to improve animal health and welfare and reduce antibiotic use

4.1 Background and motivation for the study

The Farmer Field Lab programme "Duchy Originals Future Farming Programme", organized by the Soil Association with participation from the Organic Research Centre (ORC) provided an ideal framework to form a discussion group and thus, a proposal to create a local farmer group focusing on antibiotic reduction in dairy herds was put forward. The farmers involved were keen to improve the health of dairy cows with the aim of cutting down on antibiotic use, with benefits for animal welfare and farm profitability as well as contributing to efforts to preserve antibiotics for life-or-death situations.

This study was a combination of two studies: the Farmer Field Labs themselves was one study of interest, as a means of social innovation in potential work for the future on antibiotic reducing strategies. The other study was the trial itself, and this is treated below, as section 5 of this report.

4.2 Aims, research question and methodology

The main focus of the discussion group was to share experience and management practices regarding the use of a commercial liniment cream containing 35% mint oil (Uddermint®) as an alternative or complementary approach to the use of antibiotics to treat mastitis on organic dairy farms. Some of the participating farmers were already using this practice as standard, while others were keen to explore or to question the potential benefits. Consequently, the farmers identified the need to gather more robust data on the effectiveness of the use of Uddermint® in containing cows' somatic cell count (SCC) and six farmers committed to -but only four succeeded in- participating in an on-farm trial during 2014. The meetings were co-ordinated by a livestock consultant from the Farm Consultancy Group, UK, while the set-up of the on-farm trials was formulated with input from a livestock researcher from ORC.

4.3 Results

4.3.1 Meeting practices of the farmer group

The farmers met on a regular basis and the meeting was held at a different farm each time, providing the opportunity for the host farmer to share current issues, problems and production data and benefit from other farmers' feedback on cow health, herd management and mastitis treatment.

4.3.2 Focus and results

Each Field Lab was attended by 8 to 12 farmers or farm managers. On every occasion the meeting was held at a different farm (host farm). From September 2012 to June 2014, 8 field lab meetings occurred.

Meetings 1 to 5

The initial meetings discussed the use of antibiotics on the farms and the practicalities of using Uddermint® as part of any treatment plan for mastitis in dairy cows. There was an investigative discussion with an individual group member whose herd required higher amounts of antibiotics than the average (i.e. around 18% of lactating cows) of the group in 2011 - 12. The research identified that the spring block calving herd had encountered problems during the dry period in 2012 which could have been linked to the very wet, mild conditions in January 2012. Participants visited a new parlour development where the farmer was keen to trial Uddermint® in the future. Four farms in the group were using Uddermint® to some degree already, but not under trial conditions.

Meetings 6 to 8

Discussions revolved around the current use of Uddermint® regarding practicalities and potential benefits. Some of the farmers were using it as a complementary method for treatment of clinical mastitis in the early stages, although some were using it to treat cows with rising cell counts. However, it was too early for the farmers to report conclusively whether the strategy of treating cows with rising cell counts was working. In December 2013 six farms agreed to run a controlled field lab trial from January to April 2014 (udder mint trial – described below). The trial ran from January to June. In June, after completion, the group had their first chance to review all the raw data. The discussion focussed on optimum drying off and *Orbeseal* application, as well as methods of barn and grazing management. Some of the discussed issues mattered for the farmers and their management, but had no real connection to the conducted trial.

Farmer group meetings were held quarterly from September 2012 to June 2014. The on-farm trials took place from January to June 2014. A final wrap-up meeting was held at the ORC in November 2014.

4.4 Discussion and conclusions

Participating farmers have commented that although they considered their management prior to this discussion group and the on-farm trial was quite good, they have benefited from the process of coming together to discuss the various methodologies the other farmers employed.

Field Labs have been developed in the UK through the Duchy Future Farming Programme, now known as Innovative Farmers (www.innovativefarmers.org). The initial partnership behind the programme comprised the Soil Association (UK-based NGO), the Organic Research Centre, Waitrose (UK retailer) and the Prince of Wales's Charitable Foundation (funder). Other experiences from different places in the UK, regarding 'Field Labs' show that their approaches to trials have ranged from informal split-field comparisons to multi-site experiments following a rigorous protocol. The groups are supported by a facilitator and a researcher, and they both help the group devise a practical trial that builds on the existing evidence. In size, groups have ranged from five to over 20 participants, who met monthly, seasonally or at appropriate milestones in a farm trial. The Field Labs were evaluated in 2014 by the Countryside and Community Research Institute, which found that the majority of farmers consulted were very positive about the Field Lab approach and their experiences. Farmers reported that Field Labs had inspired them to change farm practices. They valued learning how to formulate research questions, and the learning experience together in a group. They highlighted openness and sharing as important in instilling confidence and a sense of empowerment, gaining knowledge that informed their farming in general. Farmers who had hosted trials generally reported gaining a lot, especially when the learning had been of direct relevance to their farm.

The so-called Stable School method has been practiced to a wide extent in Denmark (where the initiative started in 2004), as well as Norway, and it has been included in research and development projects in England, Switzerland, Austria and Germany (Ivemeyer et al., 2012). Evaluation and research on participating farms and with the farmers, showed that it was a powerful way of reaching goals – both the groups' common goals such as phasing out of antibiotics, and the individual farmers' own goals. The emphasis on farmers' ownership over the process and their way of taking responsibility for phasing out or at least significantly reducing antibiotics on their farms, was paramount. The method built on mutual trust and respectful dialogue where the farmers explored each other's farms and daily routines in-depth.

Based on this and multiple other studies with farmer groups, forming farmer groups for different purposes, can strongly be recommended as a priority.

In this particular project, the focus was on low-input and organic management strategies. Much knowledge exists already, and much knowledge exists among farmers, which can be made use of. Farmer Field Labs could also offer a systematic way to generate knowledge where there are gaps. The fact that a lot of 'traditionally educated' vets and advisors often are not focusing much on low-input strategies, supports this argument further: in cases where farmers need to develop novel strategies, they need to collaborate more , working together on strategies , and lean less on 'traditional advice'.

4.5 Future recommendations

The recommendations below are based on the learnings of the group from this process and backed-up by results and conclusions from other projects with farmer groups. The results of the trial will be presented as a separate study below in section 5. The recommendations are:

- Be clear about the purpose of the group. Is it to exchange knowledge? Is it to work towards a common goal? Is it to generate knowledge? The purpose of the group will guide the structure and ways of communication. The communication should for example, be guided so that everybody are encouraged to speak, e.g. by taking rounds.
- All farmers should be equally participating. That is, for example open up all of their farms, so that everybody sees where all others come from, and all farms create basis for common learning.
- Keywords identified in other projects as crucial for farmer group success are : 1) ownership, 2) working towards a common goal, 3) create mutuality in the group, 4) take the starting point in every participants practical conditions and goals, and 5) make clear appointments.
-

5. Use of udder mint liniment to reduce SCC

5.1 Background and motivation for the study

There is a great interest amongst dairy farmers in reducing the use of antibiotics on their farms and the level of antibiotic use for the control of mastitis is of particular concern, because most antibiotics used in dairy farms is used for mastitis cases.

Bovine mastitis is the inflammation of the mammary gland and udder tissue and is one of the main animal health problems both in conventional and organic dairy herds (Hovi et al. 2003; Ruegg, 2008; Haskell et al., 2009). It usually occurs due to bacterial invasion into the teat canal but also can occur as a result of chemical, mechanical, or thermal injury to the cow's udder.

In clinical cases of mastitis the cow displays definitive symptoms of the disease, mainly associated with abnormalities in the udder (i.e. swelling, heat, hardness, redness, pain) and in the milk (i.e. watery appearance, flakes, clots, or pus). Other symptoms, depending upon the severity of the illness and how systemic it has become, also include reduction in milk yield, fever, anorexia, diarrhoea and dehydration. The disease can also be present in a herd sub-clinically, where the affected cow displays few or no obvious clinical symptoms of the illness, just showing a reduction in milk yield and can in some cases – depending on which pathogen - certainly represent a possible source of infection for other cows, who can become subclinically affected themselves, or may go on to show clinical signs of the illness, due to differences in immune status between cows, as well as the type of pathogen. Subclinical infection can only be indicated indirectly by a high individual cow SCC, or bacteriological examination.

In the UK, the main bacterial species that cause mastitis in dairy cattle are *Streptococcus uberis*, *Staphylococcus aureus*, and *Escherichia coli (E. coli)*, although more than 200 organisms have been identified as mastitis-causing pathogens. The major pathogens associated with incidences of contagious or environmental mastitis are summarised below in Table 1. The consequences of the disease and its control result in major losses to the dairy industry in the UK, and considerably impair the welfare of the dairy cow in the cases of clinical mastitis. Some of the main causes of these losses are due to milk being unsuitable for human consumption, reduction in milk yields, extra labour, costs of veterinary care and medicines and costs of reduced longevity due to premature culling.

Over the past years, organic dairy farmers have shown increasing interest in the use of a commercial product called Uddermint® in an attempt to mitigate the use of antibiotic treatments for controlling mastitis in dairy cows. According to the manufacturer, Uddermint® is a specially formulated liniment cream containing 35% mint oil, designed for easy massage and absorption into the udder. In organic and low-input dairy farms this cream is used for softening swollen and inflamed udders and also from prevention of oedema at calving time. Because mint oil is known to improve blood flow by dilatation of the capillaries, it is likely that the application of Uddermint® to the udder can enhance the transportation of white blood cells (neutrophils and macrophages) to the site of infection and thus, to combat infection. However, there is a complete lack of scientific data or case studies to support this hypothesis. This study presents data from on-farm trials on the effectiveness of a liniment cream containing 35% mint oil in reducing somatic cells counts in organic dairy cows.

Table 5.1. Major pathogens associated with incidences of contagious or environmental mastitis.

Mastitis-causing Pathogens	Type of mastitis	Signs	Response to antibiotics
Contagious pathogens			
Staphylococcus aureus	contagious mastitis pathogen, and has a good ability to adhere to teat and udder skin	characteristic in chronic cases	notoriously difficult to treat with antibiotics
Corynebacterium bovis	causing subclinical disease / contagious	raised Somatic Cell Counts	sensitive to the majority of antibiotics
Mycoplasma	highly contagious		responds poorly to antibiotics
Streptococcus agalactiae *Streptococcus dysgalactiae*	very contagious mastitis / it can either give acute, febrile disease or sub-acute, more chronic disease	common cause of mastitis in heifers and dry cows and implicated in cases of Summer Mastitis.	responds well to antibiotic treatment / prophylactic treatment can prevent early-onset disease
Environmental pathogens			
Escherichia coli	biggest environmental cause of mastitis / being present in large numbers in faeces	very acute, painful and potentially fatal forms of mastitis	Vaccines are available, but their use is heavily compromised by the fact that several strains of the bacterium may be present
Streptococcus uberis	Environmental	very acute, with a sudden onset	particularly responsive to a range of antibiotics
Coliformbacteria	environmental mastitis	severe, toxic mastitis	

5.2 Aims and Research question

The aim of this study was to evaluate the effectiveness of a commercial liniment cream containing 35% mint oil in reducing cows' somatic cell counts, as an alternative practice to the use of antibiotics on organic dairy farms.

5.3 Material and methods

5.3.1 The participating farms

Participating farms were located in south west of England (i.e. Wiltshire, Oxfordshire, Gloucestershire and Berkshire) and one farm was located in the south east (Kent).

5.3.2 Decision to enter into a controlled trial

The trial took place within the framework of a Farmer Field Lab, which is explained in chapter 4 above. Each of the meetings was attended by 8 to 12 farmers or farm managers and held on different farms in the period from September 2012 to June 2014. As explained above, the first 5 meetings focussed on the use of antibiotics on the farms. The farmer group quickly identified a focus on Uddermint® as part of any treatment plan for mastitis in dairy cows, and discussed how they used it.

In December 2013 six farms agreed to run a controlled field lab trial from January to April 2014, and they reviewed the collected results in June 2014. This discussion furthermore focused on optimum drying off and *Orbeseal* application, as well as methods of barn and grazing management.

5.3.3 Set up of on-farm trial

To test whether the use of liniment mint oil cream can maintain cows' SCC at optimum levels in practice, six farmers committed to participate in an on-farm trial during 2014, where they should apply the following simple protocol:

- Every second newly-calved cow was treated for 4 consecutive days with the commercial liniment mint oil cream Uddermint® (treatment UT).
- The cream was applied in a quantity of 5 ml and the whole udder was massaged for a minimum of 2 minutes each day before the morning milking.
- The control group (treatment C) consisted of untreated cows.
-

5.3.4 Data collection and analysis

An experimental procedure was set up as explained above, and the outcome variable was simply the number of cows with SCC above 200.000 and 1 million, respectively, because the participants found these thresholds relevant. Somatic Cell Counts from all cows in the trial group and the control group were recorded every month for 4 months after application of the treatment through National Milk Records.

Data were analysed by means of a two sample t-test assuming unequal variances. A cow was considered "above the cut-off values" if she had SCC over 200.000 or 1 million, respectively, at one or more out of the 4 monthly samplings. The number of cows included in the trial on each farm, the total SCC observations obtained and the percentage of the cows with above 200,000 or 1,000,000 SCC are shown in Table 5.2.

Table 5.2: Overview of the data obtained in each participating farm.

	Farm 1		Farm 2		Farm 3		Farm 4	
Uddermint treatment:	Yes	No	Yes	No	Yes	No	Yes	No
Cows (n)	29	36	18	15	14	11	22	32
Total SCC Observations	115	142	69	58	49	42	82	117
Cows with SCC > 200.000	17.4%	24.6%	17.4%	22.4%	18.4%	7.1%	19.5%	32.5%
Cows with SCC > 1 million	2.6%	2.8%	1.4%	0.0%	0.0%	2.4%	2.4%	11.1%

5.4 Results and Discussion

Out of the six farmers committed to participate in the trial only four succeeded in carrying out the experimental procedure. Two farmers voluntarily withdrew from the study shortly after the start of the trial and no data were collected from these farms.

Due to differences in the size of the farms and farm's calving management, the number of cows included in the trial as well as the SCC observations obtained differed between the four participating farms, see below in Table 5.2.

The results show that in Farms 1, 2 and 4, the percentage of cows with SCC > 200,000 is higher in the group of cows that were not treated with Uddermint® compared to the Uddermint® treated group, which suggests that untreated cows are prone to get mastitis infection. This notion is not supported by the data in Farm 3. The high percentage of cows with SCC > 200,000 within the Uddermint® treatment group in this farm, is likely due to the fact that the farmer uses Uddermint® as a complementary method for mastitis treatment and deliberately selected cows with high SCC to be included in this treatment, and in this way not following the guidelines for the study.

The average SCC over the monitoring period, which was 4 months following calving, in both treated and untreated cows on each farm, is shown in Figure 1. As expected, average SCC varied across the participating farms. On average, Uddermint® treated cows in Farm 3 had significantly lower SCC compared to SCC in Farms 1 and 4 (Figure 1, panel i). The same farm differences were also noted in the untreated cows, with the addition that SCC in the untreated cows in Farm 4 were significantly higher compared to all other farms.

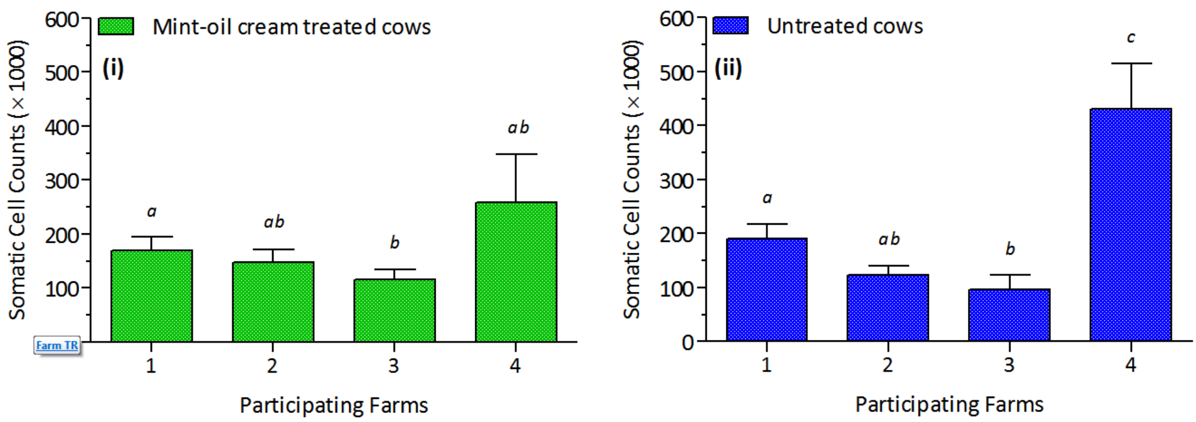


Figure 5.1. Average Somatic Cell Counts per farm in Uddermint® treated [panel (i)] and untreated [panel (ii)] cows in the participating Farms (in each panel, means with different letters indicate statistical differences). In figure (i) SCC in Farm 3 are statistically lower than Farm 1. No difference between 1, 2 and 4. In figure (ii) SCC in Farm 4 is statistically higher than Farms 1,2 and 3, and SCC in Farm 3 are statistically lower than Farm 1. No differences were found between 1 and 2, and between 2 and 3. In figure (ii) SCC in Farm 4 is statistically higher than Farms 1,2 and 3. And SCC in Farm 3 are statistically lower than Farm 1. No difference between 1 and 2. No difference between 2 and 3, i.e. 'a' mean that does not have the same letter with another mean is stat different from that mean.

In all recording months SCC of the Uddermint® treated cows were lower than in the untreated cows but a statistical significant difference was noted only in the 3rd recording (Figure 2a). As can be seen in Figure 5.2a below, differences in SCC between Uddermint® treated and untreated cows for each month post partum show that SCC across all farms were numerically lower in the Uddermint® treated cows compared to untreated cows. However, statistical differences were only observed in months 2 and 3 post partum in Farm 4. Somatic Cell Counts from each treatment were combined across the farms for each recording month and differences between Uddermint® treated and untreated cows were tested. The results show that on average, SCC in the untreated cows remained relatively constant and above the critical threshold 200,000.

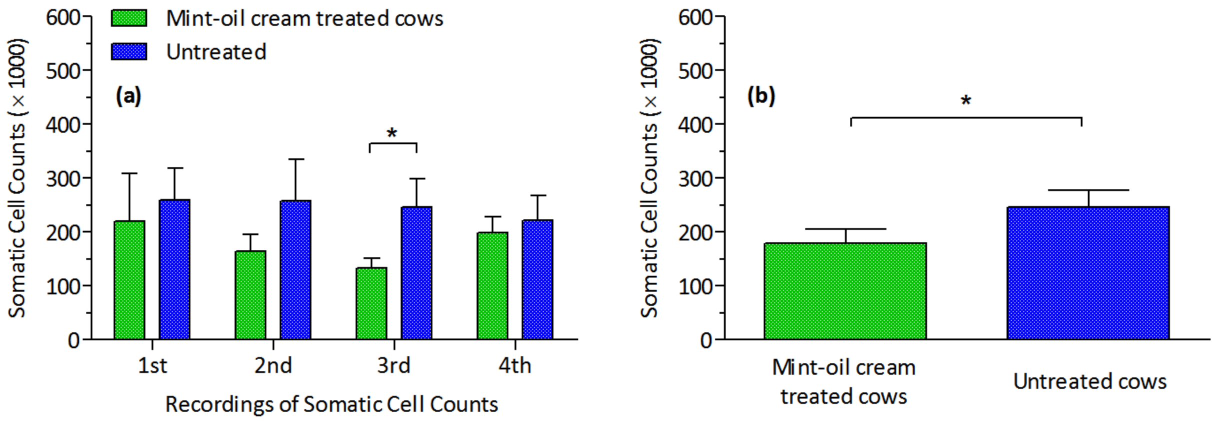


Figure 5.2. Average SCC in each recording month combined across the participating farms [panel (a)] and average SCC combined over the recording periods and over farms [panel (b)] (in each panel, means marked with * indicate statistical differences).

When SCC data from each treatment were combined across the farms and across the recording months a statistical difference between Uddermint® treated and untreated cows (Figure 2b) was observed. This indicates, also in view of the individual farm data, that treatment of the udder with a liniment cream containing 35% mint oil has the potential to reduce SCC in dairy cows.

Effect of cow lactation year and calving month on SCC: Across farms the cows included in the trial calved from February to April 2014 and the number of cows calved in each of these months in all participating farms is shown in Table 2. The cows were assigned to one of two groups based on whether the lactation year of the cows falls within year 1 to 4 or 5 to 8 (Table 2). These data enabled testing of the effect of calving month on SCC in both treatments, although it was not possible to include interaction terms between risk factors, such as farm X lactation number or calving month. Results of the simple comparisons are shown in Figure 3.

Table 5.3: Number of cows in each group of lactation-year and in each calving month, in both treatments, across the participating farms.

	Year of lactation		Calving month		
	1 to 4	5 to 8	Feb	Mar	Apr
Uddermint Treated Cows (*n*=)	209	106	96	129	90
Untreated Cows (*n*=)	237	122	155	115	89

In line with the previous findings, the average SCC in the treated cows was systematically lower compared to the mean SCC of the untreated cows, irrespective of the lactation-year-group or calving month; however, due to large variation of the SCC in each group no statistical differences were noted. The results also showed that mean SCC were not affected by the year of lactation, nor by calving month.

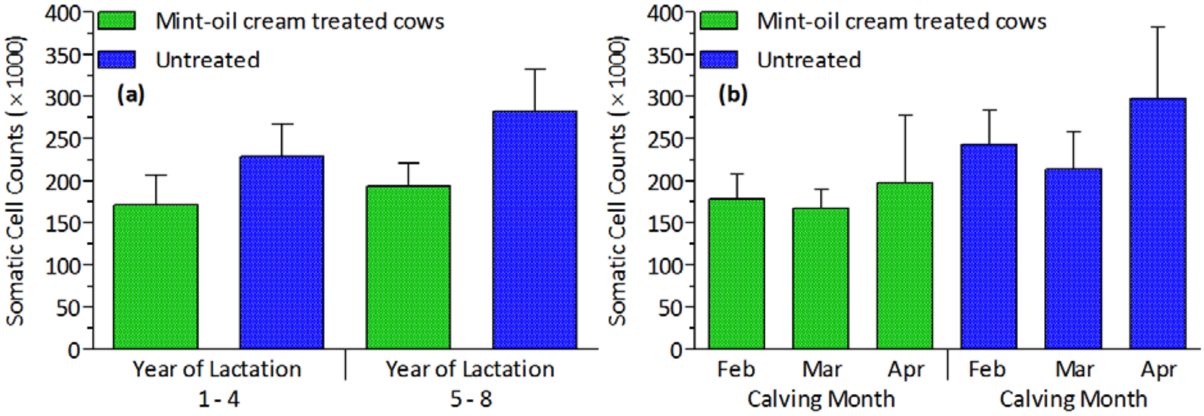


Figure 5.3. Effect of year of lactation (panel a) and calving month (panel b) on SCC in mint-oil cream treated or untreated cows, across farms.

5.5 Conclusions/Recommendations

A farmer who uses mint-oil cream treatment as a standard practice commented that "It is difficult to pick up trends as yet [in 2013] but it has made us aware of our treatment protocols compared to other farms in the group". Although some of the farmers voluntarily withdrew from the study, the on-farm trials conducted on the four farms indicated that liniment mint oil cream treatment of the newly calved-cows could act as a complementary on-farm practice to reduce mastitis incidences as indicated by its effect on cows' SCC. Future studies will be needed to determine the mode of action as well as the optimum volume and massage duration for an effective treatment and an acceptable cost:benefit ratio to animal welfare and farm performance.

6. Summary of a study investigating forage's influence on iodine content in milk

6.1 Aim and research question:

The aim of this study was to investigate the relationship between iodine concentrations in bulk milk samples with iodine concentrations in forage on organic dairy farms. The reason for this study was in reality that there were claims that the level of iodine in organic milk was 'too low'. This study was set up to investigate whether this had to do with the farm management practices on organic dairy farms. The results show that the use of iodised post-dip teat disinfectants has a major effect on milk iodine concentrations, which is in accordance with the current literature. This result has nothing to do with animal health and welfare aspects of iodine use, and will not be further presented and discussed in this deliverable report.

As becomes obvious from the above, this study was initiated because of human health concerns (low iodine content in organic milk), and since this report is dealing with innovative strategies mainly for animal health and welfare, we only summarise it below for the purpose of reporting what could be of relevance from an animal health and welfare perspective.

The cow's need for iodine: The iodine requirement for dairy cows is estimated to be about 0.33 mg/kg DM or about 0.6 mg dietary iodine/100 kg of body weight (NRC, 2001). Pregnancy does not increase the requirement for iodine for thyroxine production to any significant degree (Miller et al., 1988). Late gestation cows incorporate about 1.5 mg iodine/day into thyroid hormone while during lactation thyroid hormone production is increased, especially in high producing cows and iodine incorporation into thyroid hormones may reach 4 to 4.5 mg iodine/day (NRC, 2001). In diets with adequate iodine content, about 20 percent of the dietary iodine is incorporated into the thyroid gland; when not, up to 65 percent of the dietary iodine is taken up (Miller et al., 1988). Dietary iodine that is not taken up by the thyroid gland is excreted in urine and milk making the iodine content of milk a reasonable indicator of iodine status (Berg et al., 1988): milk normally contains from 30 to 300 µg iodine per litre (Berg et al., 1988).

The levels of micro and macro elements in milk depend largely upon the content of these elements in soil (which affects levels in pasture) and animal feed, which varies considerably among and within countries. In general, the mineral content of milk is not constant through the lactation period of a cow and can be influenced by both genetic and environmental factors. Variation in the reported concentrations of many minerals in milk can also be due to analytical errors and contamination from milk collection and processing equipment and procedures (Cashman, 2006, Flachowsky et al., 2014).

In addition to the iodine intake, the most important influencing factor seems to be the use of iodine-containing teat dips (Flachowsky et al., 2007; Borucki et al., 2012). The content of iodine in iodine-based teat dips varies between 1-10 g/L and the use of these disinfectants can increase milk iodine concentration by 11 to 150 µg /kg (Flachowsky et al., 2007). Iodine-based teat-dipping spraying solutions increase milk iodine concentrations more than pre-dipping iodine-based sanitizers and according to Borucki et al., (2012) their use should be avoided to maintain milk safety (i.e. <400 µg iodine /L). There is some debate in the literature about how the stage of lactation influences the iodine content of the milk, but it was shown that colostrum generally features considerably higher milk iodine contents than later milk (see PhD thesis of Franke, 2009).

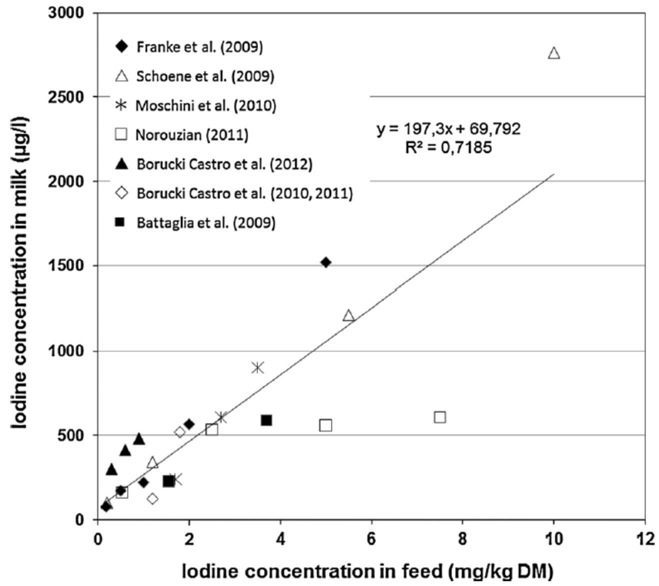


Figure 6.1: Influence of iodine concentration in the feed of dairy cows (mg/kg DM) on the iodine concentration of milk (µg /L) by various authors [Source: Flachowsky et al., (2014)]

The iodine content of the milk can also be influenced by breed, as at the same level of dietary iodine, there are differences in milk iodine between breeds. However, breed differences, although significant, cannot be used to control iodine concentrations of milk (Franke et al., 1983).

6.2 The SOLID study

Twelve case-study farms were selected to conduct a study on iodine and other mineral concentration in milk, blood, urine and forage samples from June 2014 to January 2015.

For each farm, blood and urine samples from 10 milking cows were obtained under normal vet visits in three occurrences over the study period. To obtain an overview of the management and practices of the case-study farms, the farmers were asked to fill in a questionnaire.

Monthly averaged milk iodine concentrations over the 10 study farms indicate that iodine concentrations in organic milk drop from early spring to late summer and increase again from autumn towards winter. As expected there was variation in urine iodine concentrations between farms but urine iodine also fluctuated considerably within farms across samplings. Determination of iodine in urine is a reliable parameter for the assessment of the iodine supply and reflects shortfalls of iodine intake. Urine iodine concentrations were above optimal levels (i.e >100 µg/L) in most of the farms, except 2 farms.

Data on forage/diet mineral concentrations are missing from three farms, as samples were not collected. Over the study period only two farms submitted four samples for mineral analysis and three farms submitted one sample for mineral analysis.

The forage analysis results (Table 6.1 below) show that across the study farms, copper, zinc, cobalt, iodine and selenium were relatively low but molybdenum levels were above optimal levels.

The relatively low average iodine concentrations of the forage samples in the case-study farms can reflect the notion that British soils are low in iodine.

Table 6.1: Average mineral concentration of forage/diet in each participating farm.

Mineral[1] *Macro-elements (% DM Basis)*		Optimal levels	Farm									
			1	2	3	4	5	6	7	8	9	10
Calcium	Ca	0.5 - 0.7	-	0.9	-	0.8	1.1	0.9	0.9	-	1.0	1.5
Phosphorus	P	0.3 - 0.4	-	0.1	-	0.3	0.4	0.3	0.3	-	0.4	0.4
Magnesium	Mg	0.15 - 0.25	-	0.1	-	0.2	0.2	0.2	0.2	-	0.3	0.3
Potassium	K	1.5 - 2.5	-	2.3	-	3.0	3.2	2.3	2.4	-	1.8	2.4
Sodium	Na	0.2 - 0.3	-	0.1	-	0.2	0.1	0.1	0.2	-	0.1	0.4
Chloride	Cl	0.6 - 1.4	-	0.7	-	1.4	0.9	0.7	0.8	-	0.6	1.0
Sulphur	S	0.15 - 0.25	-	0.2	-	0.3	0.2	0.2	0.2	-	0.2	0.2
Micro-elements (mg/kg DM)												
Manganese	Mn	75 - 125	-	32	-	72	102	92	80	-	258	100
Copper	Cu	08 - 12	-	6.8	-	13.3	8.9	8.3	8.3	-	21.0	61.2
Zinc	Zn	40 - 80	-	31	-	39	26	33	34	-	73	194
Cobalt	Co	0.2 - 0.3	-	0.1	-	0.2	0.1	0.1	0.1	-	0.1	0.9
Iodine	I	0.5 - 1.5	-	0.3	-	0.8	0.4	0.2	0.5	-	0.7	1.5
Selenium	Se	0.1 - 0.2	-	0.0	-	0.1	0.1	0.1	0.0	-	0.3	1.0
Iron	Fe	100 - 200	-	59	-	561	252	296	377	-	197	551
Molybdenum	Mo	0.35 - 1.25	-	1.5	-	1.4	2.5	1.6	2.0	-	1.3	1.5
Forage samples submitted for analysis			0	1	0	4	3	2	4	0	1	1
Farm Iodine in milk[2]			O	O	O	H	L	H	L	L	H	H

[1]*Laboratory analyses were carried out by the Thomson & Joseph Ltd, Albion Laboratory Services, Hoveton, NR12 8QN, UK except for farm Number 2 for which samples were analysed by Sciantec Analytical Services, Stockbridge Technology Centre, Selby YO8 3SD*

[2]*L=Low, O=Optimal and H=High with milk iodine concentrations below 60 µg/L, between 60 to 120 µg/L or above 120 µg/L, respectively*

A comparison both in milk iodine and urine iodine concentrations was performed between farms with low, average and high iodine concentrations in forage. Results show that urine iodine concentrations were significantly higher in the farms with average or high forage iodine compared with the farms with low forage iodine ($P \leq 0.001$), adding to the existing body of evidence that iodine excreted in urine is indicative of dietary iodine intake.

Six out of the 10 case-study farms use iodised post-dip teat disinfectants, while the remaining 4 farms do not follow that practice. The results of how this influenced the milk are reported elsewhere.

6.3 Conclusions

The results show that the use of iodised post-dip teat disinfectant is the most important influencing factor for the iodine concentration in milk. In this respect, the iodine concentrations in milk do not serve as a robust indicator in identifying shortfalls in iodine intake or dietary iodine deficiencies especially on farms that use iodised post-dip teat disinfectants. It is important to feed the optimal level of iodine to maintain animal health and welfare, and dietary iodine supplementation is recommended to the farms in which iodine concentrations in forage are below 0.5 mg/kg. Over the course of the study average iodine concentrations in organic milk remained within or above optimal levels defined in the current literature (i.e. >120 µg/L).

7. Overall discussion on the general methodological approach

In WP1, we attempted to use a farmer-led participatory approach to identify the most interesting issues – from 'things relevant to' to 'important problems of' organic and low-input farming – and develop and evaluate some potentially innovative practices and solutions. In addition to research partners (from institutes and universities), the project also directly involved enterprise partners (small and medium size milk companies such as buyers or processors (SMEs)). The participatory approach ideally progressed in in four steps.

- Step 1: identifying topics where farmers feel knowledge or innovation is needed.
- Step 2: developing appropriate research approaches and experimental procedures to test innovative solutions for topics identified in Step 1. In the presented cases related to animal health and welfare and low-input of antibiotics, some of the approaches were more case-studies to discuss and learn from,
- Step 3: carry out the proposed research with a small number of farms or groups of farmers, and
- Step 4: reporting on the lessons learned and communicate the result to both for farmers, consultants and researchers and also.

It proved to be quite challenging to go through all the steps in the participatory processes, which could be explained by many external factors, such as challenges related to milk prices and other economic constraints, which meant that farmers obviously focused on 'survival' more on 'innovations', time constraints e.g. leading to learning from past experiences with herbs rather than starting long term projects with stripes of herbs in grass, for example.

In terms of methods chosen in relation to animal health and welfare, farm case studies were used in relation to mother-rearing of dairy calves, based on monitoring certain aspects on two individual farms in DK and UK, using a variety of data collection methods both quantitative and qualitative. In the case of herb studies in Denmark, we used comparative case studies, where this approach was extended to several farms and observations could be compared between different farms. The on-farm trial with udder mint liniment introduced a specific treatment, which was compared with a control group or with performance before the treatment was introduced. This project was carried out partly using a group discussion as the common learning ground. It was a conscious process, facilitated by a facilitator, aiming to generate knowledge and draw out experience and knowledge among participating farmers. In this case the UK developed field labs (MacMillan and Benton, 2014) were used. In Denmark, approaches like the concept of stable schools (Vaarst et al., 2007) could be similarly used, and both approaches are inspired by the Farmer Field Schools (Sones et al., 2003). These structured ways of experience exchange in both Stable Schools and Field Labs offered a formal and systematic structure to go through the whole process of participatory research, from identifying topics to applying the research and discussing it.

A researcher or research team is absolutely crucial, if the learning is going to be extended beyond the farmer group. In this context, it is absolutely crucial to reflect on who will benefit from this type of innovation in organic or low-input agriculture. Some types of innovation will generate benefits for individual organic farmers, but other types can generate public benefits - for example, lowering the use of antibiotics will lower the general risk of creating antibiotic resistance, and of getting products with antibiotic residuals. Some types of innovation – or insights, as were created through the case-studies – can also be shared among other farmers in the general farming community, for inspiration. This means it is important to disseminate farm specific experience and knowledge e.g. through this SOLID project, and via open-access sources such as Organic Eprints (e.g. http://orgprints.org).

Innovation in this respect is far from being only connected to 'private benefits' such as economic benefits like patents and 'something going into production'. Innovation can be seen as a crucial and necessary part of sustainable development, because it is not only about 'products', but a reflected part of a continuous process, which involves creative thinking and knowledge sharing through learning in communities. Buckwell and co-authors (2014) argue that the 'knowledge per hectare' should be intensified if we want to intensify European agriculture sustainably, like, for example, in the case of the types of innovation discussed in this deliverable report: a broad range of ways to improve wellbeing of cows, focus on health, disease prevention and exchanging knowledge about issues that would enable individual farmers to create low-input strategies of antibiotics. This type of innovation and strategies, in the organic sector for example, has been relatively ignored by formal research investment.

This type of innovation, which can be formalised through systematic processes related to identification, carrying-out the research, adjustments along the way, and communication and discussion of the results, can happen in farmer groups, and it can become very powerful when framed by structures like dairy companies and other organisations. This allows farmers to work together and make decisions as a group and to develop approaches to innovation which align with the values and priorities within the organic movement, and in accordance with e.g. low-input-antibiotic strategies. Again, these structures are largely ignored as potential and relevant actors for research based innovations and knowledge generation.

8. Conclusions

- Growing herbs in long-term pastures showed that farmers, who had started growing herbs in pastures were consistently and persistently continuing developing their systems and experimenting, e.g. with herbs in stripes versus herbs sown into the pasture. Even though the actual benefits for animal health and production were not possible to document through these studies, they still felt encouraged to offer their animals herbs either in grass or silage, and they believed that it had some good effects on animal health and welfare. According to the farmers' observations, the cows favoured herbs, which alone could create an argument that it had animal welfare benefits, in addition to the fact that it had additional benefits for biodiversity, pollinators and the farm environment, and it can be seen to be in accordance with the organic principles.
- Maternal suckling carried out in two studies in UK and DK, respectively, following farmers who tried out the system for the first year versus the 21st year (Dk), clearly demonstrated the importance of development of context relevant, farm specific and experience based management routines for such systems, which requires a lot of skills, attention and appropriate action.
- Farmer Field Labs was used as a method to identify, carry through and demonstrate as well as discuss innovations relevant to organic farming. The farmers emphasised that they had experienced benefits by meeting, discussing and seeing each other farms. In addition they carried through a trial on four of the farms with udder mint liniement, which added to knowledge generation and created results which could be interesting beyond the context of these specific four farms.
- Udder mint liniment was tested in a trial, which took place at four farmsparticipating in the Field Labs. The four farmers engaged in testing a certain udder liniment with the aim of keeping SCC low after calving, and due to the results which came out of this study, the difference between treated and untreated cows was significant on an overall scale.
- A UK based study aimed at studying human health effects of low iodine content in milk, and therefore the reasons for low iodine content in organic milk, in chapter 6. The aspect of animal health was whether low milk-iodine content was reflected in poor animal health. This connection could not be demonstrated based on data in this study.

A general observation made by the research teams, although not systematically investigated as a part of the studies, is the challenge of involvement, taking ownership, in combination with allowing all actors in a process to define their challenges, potential solutions, methodologies and ways forward. Generally, the lesson learned from setting up smaller innovation studies - which ideally should be farmer driven - in collaboration with researchers, is that it needs a systematic approach at all stages, and a very integrated approach between farmers, researchers and other stakeholders and actors. It also requires resources; assuming that researchers can enter into processes of on-farm innovations 'which will be carried out anyway because farmers are innovative' is definitely a wrong assumption. The collaboration requires mutual respect, sense of ownership, - and thereby responsibility for its success - from everybody involved, and constant interaction throughout the process.

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