Pilot 1 and 2 Bovaer®

DSM – Agrifirm – FrieslandCampina

Evaluation 2022-2023

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1 Introduction

1.1 Background

FrieslandCampina is aiming to produce net climate-neutral dairy by no later than 2050. The climate plan of FrieslandCampina contains clear targets, with a checkpoint being a significant reduction in greenhouse gas emissions by 2030. For the production of milk at member dairy farms, the target is a 33% reduction in greenhouse gas emissions in 2030 compared to 2015 (The Climate Plan - FrieslandCampina Global - FrieslandCampina). FrieslandCampina is working closely together with member dairy farmers, customers, suppliers, scientists, NGO's and government on meeting the climate targets.

The reduction in greenhouse gas emissions on the farm will be achieved by a package of options, including the use of feed additives that reduce methane emissions from cows. dsm-firmenich has developed such a feed additive, named Bovaer®. Research has shown a substantial potential to reduce methane emissions per day, per kg dry matter intake and per kg milk (see references a-n).

Bovaer® is an enzyme-inhibitor, blocking the final step in methanogenesis in the rumen of the cow. The active component of Bovaer® is 3-nitrooxypropanol (in short: 3NOP). Bovaer® is on the market and its methane reductions can be claimed by the KringloopWijzer (NL) as well as through worldwide accepted certification processes by independent accredited verifiers like VERRA. In this project we have explored the use of Bovaer® in practice by conducting two pilot studies at FrieslandCampina Dutch member dairy farms, in a collaboration with dsm-firmenich, Agrifirm and FrieslandCampina.

Inclusion of Bovaer® in the diet has to be tailor-made for each farm, as the quantity fed is crucial for the optimal effect. In the pilots mineral mixes containing Bovaer® were fed. Feeding via concentrate blends ('meelmengsels') is also possible.

Pilot 1 started in July 2022 and lasted until February 2023. In this period 162 farms participated in the pilot. Pilot 2, conducted on 132 pilot farms, lasted from March to December 2023.

1.2 Objective

The main objective of pilot 1 was to execute a scale-up study of ~200 farms/~20,000 cows by using Bovaer® for a period of 6 months to reduce approx. 10 kton CO_2 eq emissions. Pilot 2 was the continuation, to reduce 10 kton CO_2 eq emissions while at the same time gaining experience with regards to Bovaer® combined with meadow grazing and preparing for full implementation.

Topics assessed by the pilots were:

- Practical consequences of producing feed containing Bovaer®
- Practical consequences of feeding Bovaer® on farm
- Cost of feeding Bovaer®
- Effects on greenhouse gas emissions of feeding Bovaer®
- Effects on milk production and/or cow health of feeding Bovaer®
- Perspective of participating farmers with respect to feeding Bovaer®

1.3 Project team

The team working on the two pilots consisted of the three parties involved:

- Dennis Rijnders – dsm-firmenich
- Gerrit Schilstra / Kees Magré - Agrifirm
- Matthijs Spithoven - Agrifirm
- Sanne Griffioen - FrieslandCampina
- Judith Bezemer – FrieslandCampina
- Jan Dirk van Mourik - FrieslandCampina
- Jeroen Hospers - FrieslandCampina
- Rianne Knippenberg / Joran Huisman / Reinier van der Starre - FrieslandCampina
- Maaike Ruijter / Simon de Ridder - FrieslandCampina

As the participants were FrieslandCampina member dairy farmers, FrieslandCampina took the lead in project management, administration and communication. Furthermore, personnel changes led to various people involved from FrieslandCampina's side.

2. Approach

The two pilot studies had the same overall objective, but a slightly different approach to get there.

	Pilot 1 (July '22 – Feb. '23)	**Pilot 2 (March – Dec. '23)**
Selection of participating farmers	Dutch FrieslandCampina member-farmers that are clients of Agrifirm with a certain feeding system (mixer wagon) and are positive to participate in a pilot	Dutch FrieslandCampina member-farmers that are clients of Agrifirm and are positive to continue to feed Bovaer® and participated in pilot 1
Feeding of Bovaer® for	6 months	+9 months, including the grazing period
Results regarding **practical consequences**	collecting experiences from project team members and participating member-farmers	collecting experiences from project team members
Results regarding **greenhouse gas emission reduction** based on	order and stock information from participating farmers and KringloopWijzer methodology (GWP34)	delivery information from Agrifirm and KringloopWijzer methodology (GWP34)
Results regarding **milk production and/or cow health** based on	monitoring by team members and participating farmers and data analysis by Agrifirm	data analysis by Agrifirm
Results regarding the **farmers' perspectives** obtained by	3 surveys and 2 workshops amongst participating farmers	calls and visits to some farmers that had stopped
Participating farmers **invited for**	2 workshops	-
Communication to participating farmers	a monthly dashboard on CO_2 eq emissions reductions	a monthly dashboard on CO_2 eq emissions reductions

3 Results

3.1 Selection of and communication with participating farmers

The intention was to involve ~200 farmers or ~20,000 cows in pilot 1. This was based on the objective to reduce 10 kton CO_2 eq during the 7-month period of the first pilot. Farmers were recruited by feed advisors from Agrifirm. Selected farms were chosen based on the farmers' view on innovations, the fitness for such a pilot, and practical possibilities to feed Bovaer® (e.g. the feeding system at the farm). In pilot 1, 162 farms (with ~21,000 cows) were selected but 4 farms dropped out. Farms were located throughout the Netherlands. Farm size was on average 130 cows per farm, ranging from 44 to 525.

In pilot 1, two workshops informed participating farmers about the pilot and the way of working during the pilot. Furthermore three surveys were sent out to gather information on the farmer's experience with feeding Bovaer® and to obtain data on orders and stock of mineral feed containing Bovaer® at the farm.

During or at the end of pilot 1, ~18% of the participating farmers stopped due to perceived negative experiences or due to financial reasons. Feedback was analyzed and showed that reasons for stopping the pilot varied and could not be related to a few specific causes/issues. A certain stopping percentage is considered normal for projects like these, and 18% is in the reasonable

range. The individual feedback varied widely, but was mainly related to practical considerations linked to the decision to offer Bovaer® in three standard mineral mixes of 20 kg bags.

- No belief in another mineral mix with different composition (might result in udder issues);
- Bovaer® only available in 20 kg bags and not in a concentrate mix/big bags;
- Not wanting to feed the required amount of 150 grams a day (both due to practical implementation and financial reasons);
- Extra costs for a farmer in case of a customized mineral mix.

This resulted in 132 farmers that continued in pilot 2. In pilot 2 the aim was a reduction of another 10 kton CO_2 eq during 9 months. During pilot 2 FrieslandCampina asked farmers with high meadowing hours (> 10 hours/day) to temporarily stop feeding Bovaer® during the grazing season. The reason behind this is that feeding Bovaer® while grazing is less efficient. That is because Bovaer® is only fed when cows are indoors and the active time of Bovaer® in the rumen is 3 hours, so not sufficiently long when cows are outdoors for more than 3 hours.

Throughout pilot studies 1 and 2, the calculated CO_2 eq reductions were shared with farmers via a monthly Dashboard. This regular moment of contact kept farmers involved so the feeding of Bovaer® stayed top of mind.

3.2 Formulation of diets

Legally it is not permitted to add more than 8% Bovaer® to mineral mixes. In order to achieve the recommended dosage of 12 grams per cow per day, the minimum dosage of mineral mix must be set at 150 grams/cow/day. The original mineral mixes fed on the farms had a lower recommended dose and therefore had to be diluted to a dose of 150 grams/cow per day.

All potential pilot farms were visited by a feed advisor from Agrifirm. During this visit the concept and dosage of feeding Bovaer® was explained and adaptations to the mineral mix that the farmer was used to were discussed.

3.3 Production of feed

DSM produces Bovaer® in bags of 15 kg Bovaer® 10, containing 10% active ingredient of 3NOP (3-nitrooxypropanol). The product was delivered to Nuscience, Agrifirm's mixing location. At Nuscience, the Bovaer® mineral was mixed with other minerals and filled into bags of 20 kg. The finished product mineral mixes contained 8 g active ingredient of 3NOP per 1 kg mineral mix.

Agrifirm chose to premix Bovaer® into three of their common mineral mixes so that the mineral mixes could be called off easily by the participating farmers. However, some farmers requested to keep feeding their customized mix ('maatmineralen') because they were used to it and got the customized mix specifically balanced out for their cows/feed.

During pilot 1 the premixes with Bovaer® were tested on the sufficiency of the active ingredient 3NOP. The conclusion was positive: the average of active ingredient in the tested premixes was 105%. In the beginning of February 2024, a test with Bovaer® in protein meals/blends was done. Being able to supply Bovaer® in protein meals/blends adds another route to include Bovaer on farm which some farmers will find easier to handle. Besides, dilution is not needed anymore.

3.4 Feeding Bovaer®

The mineral mix containing Bovaer® was supplied to the farms in bags of 20 kg. This relatively small package size was chosen to make sure the minerals did not attract moisture, since this was not clear at the start of the project if this might be a risk. Dosing the right amount per day is important in order to retrieve the maximum benefit of CO_2 eq reductions. However, not all farmers were used to feeding 150 grams of mineral mix to a cow per day and often the quantities fed became less precise over time. On average, 1 in 10 farmers indicated that they had to make a change in their management to feed Bovaer®. The main reasons for the change were: feeding more mineral mix, feeding differently (e.g., from big bag to bagged goods) and starting to provide minerals separately.

Feeding Bovaer® in pilot studies 1 and 2 lasted respectively from July/August 2022 to February 2023 and from March 2023 to December 2023. Surveys in pilot 1 showed that the opinion of

farmers about feeding Bovaer® became more positive the longer the farms participated in the pilot. The main positive feedback was that Bovaer® results in CO_2 eq reduction whereby feeding is easy and does not have negative effects on the health of cows or on the quality of milk.

Throughout the pilots only lactating cows were fed Bovaer® because only premixes for lactating cows were put on stock due to their quick turnover rate. However, Bovaer® can also be fed to dry cows.

In both pilots the participating farmers obtained Bovaer® as part of a premix without any costs. Farmers received a participation fee at the end of both pilots and an allowance for attending the workshops in pilot 1.

3.5 Effects on Greenhouse gas emissions

Bovaer® is an innovative feed additive that significantly reduces methane emissions in ruminants, such as cows. By applying Bovaer® in the feed of dairy cattle, the methane emissions of these animals can be reduced by more than 28% (in the KringloopWijzer based on the minimum inclusion rate of 600 mg per kg Dry Matter Intake per cow per day). Reducing methane emissions results in reduction of CO_2 eq emissions. The results on the participating farms in both pilot studies are shown in the figure below. The targets of 10 kton CO2 eq emissions reduction in pilot 1 and another 10 kton CO2 eq emissions reduction in pilot 2 were met. Note that more time was needed in pilot 2 to reach the same amount of CO2 emissions reduction as in pilot 1, because less Bovaer® was fed during the grazing season.

District	Aantal bedrijven	*Gerealiseerde reductie jul '22 t/m dec '23*	*Percentage bespaard*
Achterhoek	2	-197	-23,08%
Drenthe	17	-2826	-26,33%
Flevo-IJssel	12	-1692	-20,84%
Groningen	7	-1132	-19,52%
Holland Zuidwest	14	-1282	-21,96%
Midden-Nederland	8	-766	-19,52%
Midden-Oost Brabant	21	-2120	-19,26%
Noord-Friesland	5	-839	-15,87%
Noord-Holland	14	-1883	-21,60%
Twente-Salland	2	-248	-23,36%
West-Brabant/Zeeland	16	-2893	-24,46%
Zuid-Friesland	25	-4729	-24,23%
Zuidoost NL	19	-1597	-19,02%
Totaal	**162**	**-22206**	

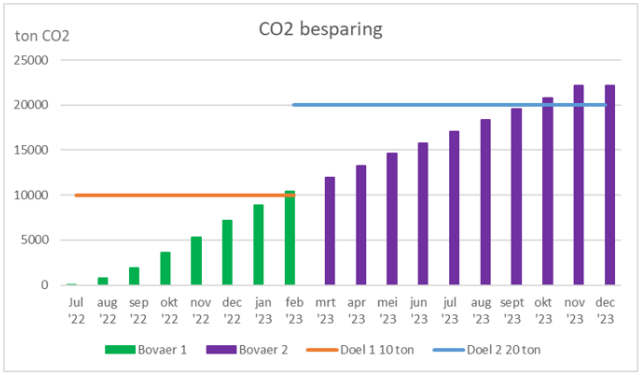

Figure 1 Calculated methane reduction (ton CO2 eq) as a result of feeding Bovaer® on participating farms (pilot 1: July 2022 – February 2023 and pilot 2: March - December 2023)

3.6 Milk production and/or cow health

The effect of Bovaer® on milk production or cow health has not been monitored extensively as various scientific studies showed that no effects on these topics were to be expected. Farmers were asked to signal if they experienced any extraordinary issues in both milk production or animal health. This information was gathered via three surveys. Some farmers had some issues, i.e. as they changed the mineral mix they fed. But these were never directly linked to feeding Bovaer®. No general issues on milk production or cow health were seen.

At the end of each pilot, Agrifirm analyzed a set of parameters regarding milk quality and cow health. In pilot 1, the test group contained 156 farms that received the premix from Agrifirm. In pilot 2 the test group consisted of 132 farms also receiving feed from Agrifirm. In both situations the control group consisted of 300 randomly selected (anonymous) farms buying feed from Agrifirm.

Farms belonging to the test group feeding Bovaer® or farms in the control group had a comparable history of feed intake and milk production over time. In general, feed intake and milk production were lower on control farms than on test farms, which is an indication that the test group is not a fully representative group. The participating farms in the pilot seem to be farms that achieve higher milk production, have more cows and feed more energy. Even when the sample of the control group was changed, the picture remained the same.

Below three comparisons are made, based on the main parameters on milk production, animal health and fertility.

Milk production: Average milk production

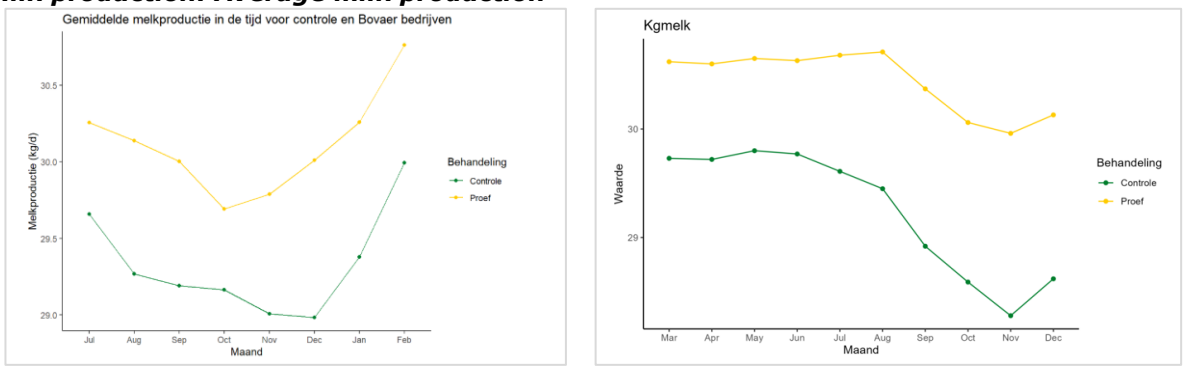

Figure 2 Average milk production pilot 1 and pilot 2

Conclusion pilot 1 and pilot 2:
Farms in the Bovaer® group had on average a higher milk production than farms in the control group. The graph in pilot 1 followed the same pattern over time for both groups. For pilot 2 the course of the milk production is slightly positive for the test group.
As mentioned before, higher milk production seemed to be a characteristic of the pilot farms and not an effect of feeding Bovaer®.

Animal health: Somatic cell count

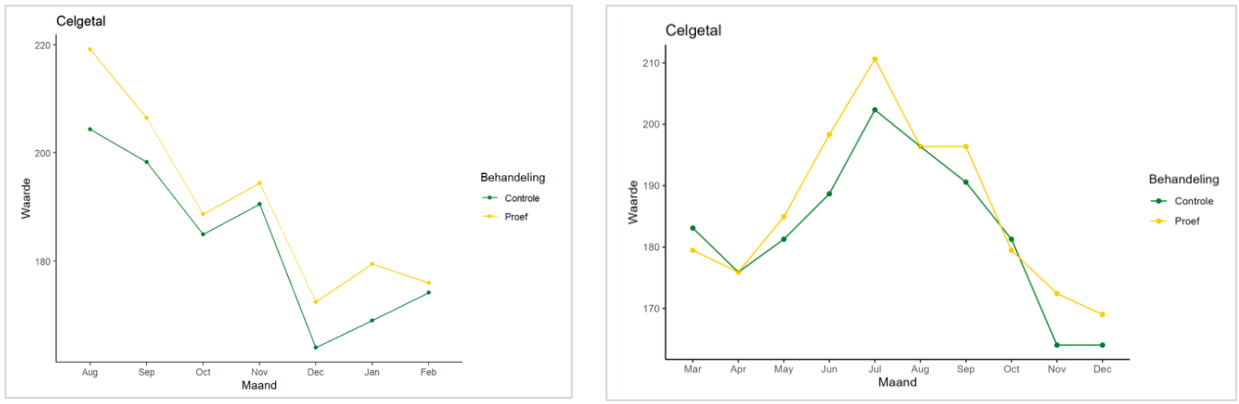

Figure 3 Somatic cell count pilot 1 and pilot 2

Conclusion pilot 1 and pilot 2:
Farms in the Bovaer® group had in pilot 1 on average a slightly higher somatic cell count. For both pilots however, the progression in somatic cell count was comparable for the test and control group.
Differences in somatic cell count are not expected to be an effect of feeding Bovaer® but, rather, a characteristic of the pilot farms.

Fertility: Interval till insemination

	Control group	Test group (Bovaer®)	Standard error	Treatment (p-value)	Treatment X time (p-value)
Farms (number)	300	156			
Cows (number)	109.9	120.9	5.1	< 0.01	0.96
Calves (number)	34.0	36.4	1.6	0.58	0.71
Heifers (number)	28,6	30,1	1.5	< 0.01	0.8
Days in lactation	182	186	2	< 0.01	0.97
Non-return 56d (days)	**54.6**	**54.3**	**0.97**	**< 0.01**	**0.53**

Table 1 Non-return days pilot 1

	Control group	Test group (Bovaer®)	Treatment (p-value)	Treatment X time (p-value)
Farms (number)	300	132		
Cows (number)	111	127	0.03	0.26
Calves (number)	33	36	0.22	0.93
Heifers (number)	30	31	0.58	0.86
Days in lactation	194	192	0.34	0.33
NTR56 %	**56**	**56**	**0.7**	**0.21**

Table 2 Non-return days pilot 2

Conclusion pilot 1 and pilot 2:
Farms in the Bovaer® group pilot 1 had on average a slightly better non-return 56d/NTR56%. However, the difference of 0.3 days in pilot 1 is not considered of practical relevance. In pilot 2 no differences appeared.

Overall conclusions pilot 1 and 2:
Feeding Bovaer® has not shown any negative effects on production, health or fertility during the pilots, in line with results from research experiments.

3.7 Farmers' perspective

To gain insights in the farmers' perspective, during pilot 1 three surveys were sent out and two workshops took place. The aim of these surveys was to learn about the farmers motivations to participate, to find out what factors were perceived beneficial and/or constraining, and to see whether the participating farmers were interested in using Bovaer® in the future. In pilot 2 no structural contact took place. However, several farmers were called in order to get insights in their motivation to continue or why they quitted.

Motivations
Most of the farmers were motivated to participate in the pilots. This can also be recognized by the majority (>80%) that continued from pilot 1 to pilot 2. The fact that farmers were directly contacted by their feed advisors to participate was certainly helpful. Next to this, most of the farmers showed interest in Bovaer® as one of the new measures to reduce methane emissions. And as the product was mixed into the mineral premix farmers were not actively reminded of feeding Bovaer.

About 30 farmers quit during or after pilot 1. Reasons for quitting were various, amongst others: start-up issues with feeding Bovaer®, extra costs as farmers used customized mineral mixes or farmers that during the course of the pilot switched to a new feed supplier or dairy company.

However, most of the farmers continued from pilot 1 to pilot 2. Feeding Bovaer® was easily implemented through feeding minerals. And many farmers were glad they could contribute to the reduction of CO_2 eq emissions by means of these pilots. Also no negative effects and financial compensation were reasons for farmers to continue.

Benefits
The main benefit of feeding Bovaer® is that it's easy to use on farm and that it immediately results in substantial reduction of methane emissions. It does not affect the milk production or the health or fertility of cows.

Downsides
Feeding Bovaer® via/using a mineral feed has limited downsides as farmers are used to feeding minerals to their cows. However, depending on mineral feeding rates per cow and day, mineral feeds may in some cases need to be diluted, due to regulatory requirements, which may come at extra costs if this cannot be done with raw materials that are currently included in the feed ration.

Some farms are not really equipped for feeding minerals from 20 kg bags instead of big bags. These downsides are solved now that Bovaer® is available in concentrate blends ('meelmengsels'). A small trial with concentrate blends was executed on three farms. Samples were analyzed on any deblending of Bovaer in the concentrate blends and showed this was not the case.

Another downside is the application of Bovaer® in the grazing season. Farms with extensive grazing hours will not be able to provide a full day of active ingredient in the cow's rumen. In the KringloopWijzer model the calculated CO_2 eq emissions reduction is such that it is less effective to feed Bovaer® during the grazing season as the methane reduction is not counted for the time spent on grazing.

Future
Both in pilot 1 and pilot 2, farmers were asked if they would continue using Bovaer® and under which conditions. Almost all of the responses were positive with regard to the continuation of feeding Bovaer®; however, only if there are financial benefits. Furthermore, the registration in KringloopWijzer and payout via FrieslandCampina's Foqus planet system should be made as simple as possible. Lastly, making Bovaer® available in concentrate blends may also solve the issue of having separate mineral feeds on site for lactating and dry cows. This will lower the threshold to feed Bovaer® to all cows.

4 Recommendations

Based on the two Bovaer pilot studies, the following recommendations can be made for future pilots and further implementation:

- Do not change farm practices when introducing Bovaer to farms. Mix Bovaer into the ordinary mineral feed or concentrate feed. Using a standardized feed containing Bovaer must be accepted by the farmer and not made a pre-condition when using Bovaer.
- Monitor farms at the start and throughout the pilot to check on amounts of Bovaer® fed. Address questions and issues and keep track on potential stoppers.
- Assess data provided by farmers compared to e.g. ordered quantities of feed containing Bovaer at the feed supplier. Preferably acquire data as close to the source as possible.
- Always keep the feed advisor in close contact with the farmer at the start of using a new feed product on farm. Also workshops are a good way to get into direct contact with farmers and provide them with the right information of something new.
- A product free of charge is a good start but gives no further incentive in applying the correct quantity or applying the product at all. Link the incentive of using Bovaer to the relevant key performance indicator (KPI), in this case: quantities of Bovaer fed or reduction of methane gained.
- Set up a monitoring system for cow health and milk quality during the pilot to quickly objectify issues raised. On the other hand it's also good to weigh the effort with the benefit.

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