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IDF DAIRY SUSTAINABILITY OUTLOOK

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PREFACE

MESSAGE FROM THE IDF DIRECTOR GENERAL

The fifth edition of the IDF Dairy Sustainability Outlook is bringing you once again a variety of inspiring projects and their impacts on how dairy delivers on the UN Sustainable Development Goals. You will find an initiative to foster milk and dairy's role in a healthy and sustainable diet for children and their families in the United States, an innovative animal welfare approach and its relationship with the UN SDGs in the Netherlands, a Swedish contribution to sustainable food and energy systems aimed at setting the basis for future farming, a new approach to determine environmental and economic outcomes of South African Dairy production, the use of manure as a natural fertilizer in India, Arla's initiative to use the sun to cool milk in Nigeria, Dairy Farmers of Canada's commitment to reach Dairy Net Zero GHG emission by 2050, The use of Nonthermal Technologies in dairy processing in Brazil and the Australian Dairy Industry's Sustainability's commitments. The geographical diversity of these initiatives located in five continents prove that dairy's commitment to sustainability and to the UN SDG's is a global one, and that it has no boundaries or cultural barriers.

In fact, some of these initiatives are the result of cooperation practices between countries, between the public and the private sectors, and also with contributions from academia and universities. This shared knowledge, as well as the innovation and technology exchange that it implies, is one of the main purposes of the Dairy Sustainability Outlook in particular and IDF in general. To see them so thoroughly accomplished is a source of pride and joy.

Moreover, the diversity of initiatives described in this DSO edition is not only geographical and cultural: it also appreciates the variety of issues addressed by them, from environmental sustainability to animal welfare and socioeconomic impact. This multiplicity of topics is well aligned with IDF's approach and understanding of Sustainability as a broad and complex concept that addresses many of the challenges that mankind currently faces, as well as IDF's and the Dairy sector's determination to address them.

As part of this determination and commitment, we are already working on a special issue on Climate in preparation of the UN COP27 Summit scheduled in Novemberwhich will also include champions of the Pathways to Dairy Net Zero initiative.

Many of the articles included in this edition of the DSO are outstanding contributions from our stakeholders to those relevant discussions. We hope you find them as interesting as we did. Enjoy your read.

Caroline Emond
IDF Director General

MESSAGE FROM THE SCIENTIFIC EDITORS

Dear Reader,

We are pleased to present the 5th edition of IDF Dairy Sustainability Outlook. Ten countries present case studies from the dairy community, showcasing how the sector is committed to nourishing the global population with safe and nutritious foods through sustainable production systems. Billions of people around the world rely on dairy for nutrition daily.

Through its dynamic nature and forward thinking the sector will be able to continue to innovate to reduce its environmental impact and be part of the solution to tackle climate change. We had several more examples to share but had to make thought choices for this edition. Please visit our website: filidf. org to learn more about IDF work.

We would like to thank the authors, whose written contributions have helped to add value to this report through their insights and analysis.

We wish all of you an interesting and informative read.

Dr María Sánchez Mainar
IDF Science and Standards Manager
msanchezmainar@fil-idf.org

CONTENTS


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AUSTRALIA

The Australian Dairy industry's sustainability commitments in action

AUTHOR
Helen Dornom
Dairy Australia • Australia
helen.dornom@dairyaustralia.com.au

ALIGNMENT WITH SDGS

OUR SUSTAINABILITY PROMISE

At the heart of sustainable development in the Australian dairy industry is a promise: to provide nutritious food for a healthier world. The Dairy Promise is underpinned by commitments the industry has made to:

1. **Enhancing economic viability and livelihoods** – creating a vibrant industry that rewards dairy workers and their families, communities, businesses and investors

2. **Improving wellbeing of people** – providing nutritious, safe, quality dairy food

3. **Providing best care for animals** – striving for health, welfare and best care for all our animals thr
oughout their lives

4. **Reducing our environmental impact** – meeting the challenges of climate change and providing good stewardship of our natural resources.

For each commitment there are goals (aligned with some of the UN SDGs), targets that set our sights for continuous improvement and indicators and metrics for measuring and reporting our progress.

It is 10 years since the Australian Dairy Sustainability framework (ADSF) was established. This year we are reviewing our Commitments, Goals and Targets to ensure we meet our external and internal stakeholder expectations. The Framework is a living, evolving strategy and as we look towards 2030 and beyond, we will need to continue to ensure we stay in tune with what actions we must take to remain a sustainable source of nutrition for the world.

We continue to engage closely with producers and dairy companies to foster the necessary practice changes, and external stakeholders to hear from them what they see on the horizon and show how we are responding to a changing world.

The following provides examples of some of the actions we have in place to support our Commitments - specifically our Commitment to the Wellbeing of people

COMMITMENT 2 – IMPROVING THE WELLBEING OF PEOPLE –– PROVIDING NUTRITIOUS, SAFE, QUALITY DAIRY FOOD SUPPORTS UN SDGS 2 AND 3

Unhealthy diets are not sustainable, yet people are not eating well, the world's leading assessment of global nutrition, (the Global Nutrition Report), concluded in 2021.

Most Australians do not consume the recommended minimum daily intake of any of the five core food groups. Instead, over-consumption of energy-dense, nutrient-poor discretionary junk foods dominates Australian's diets.

Encouraging people to eat nutritious food to improve their health and wellbeing is a challenge for responsible producers, companies, policymakers and health professionals.

Regardless of whether food is made from animals, plants, or in a laboratory, sustainably produced nutritious food will have positive impacts on the wellbeing of both people and the planet.

The dairy industry is committed to producing affordable, nutritious healthy and sustainable, safe quality food.

"It is 10 years since the Australian Dairy Sustainability Framework was established. We are even more committed now to continually improving our practices to ensure nutritious, healthy dairy foods remain an essential part of a sustainable diet over the next 10 years and beyond."

Helen Dornom

EXAMPLES OF WHAT WE ARE DOING:

In 2021, global research led by the University of Melbourne and Austin Health showed that higher daily intakes of milk, cheese and yoghurt reduce fractures and falls in aged care residents. Research in the United States found that eating yoghurt can help older adults who have high blood pressure. While it is critical that the dairy industry continues to produce food in an environmentally responsible manner, the dairy matrix/nutritional benefits of dairy are also important for improving the wellbeing of people.

NEW TOOL HELPS EDUCATE ON FOOD NUTRITION

A first of its kind tool, the Nutrient Rich Food Index enables consumers to compare the nutritional value, affordability and environmental impact of different foods – including milk and plant-based beverages.

The tool not only considers the nutrient density of foods, but also whether the nutrients contained in different foods are over or under consumed by Australian adults. This means the final score for foods is specific to Australian consumption patterns.

Nutrients assessed by the index include protein, vitamins B1, B2, B3, B6, B12, folate, A and C; calcium, phosphorus, zinc, iron, magnesium, iodine, selenium and molybdenum.

Milk scored higher than plant-based beverages for providing nutrients that Australian adults are under consuming – and was found to be the most affordable way to address these gaps.

See the Nutrient Rich Food Index findings on the Dairy Australia website.

Dairy gives voice to world-first nutrition study

Following the outcomes of a detailed scientific study, a campaign has been run by Dairy Australia to raise awareness in the community that an increase in the consumption of dairy foods can reduce fractures by 33% and falls by 11% in aged care residents.

A report on dairy's role in a sustainable diet

An evidence-based report entitled, Dairy's role in a healthy, sustainable diet, has been published specifically for nutritionists and dietitians by the Australian dairy industry.

CONCLUSION

The Australian dairy industry remains committed to its Sustainability Promise – and will continue to refine our goals and targets – and report our progress against our Commitments each year. We are making progress – but still have more work to do. This year, Australian dairy celebrates 10 years since our Sustainability Framework was established.

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See our reports here: www.dairy.com.au/sustainabilityframework

BRAZIL

Nonthermal technologies in dairy processing

AUTHOR

Hugo Scudino[1], Jonas Toledo Guimarães[1], Débora Lemos Lino[2], Pedro Henrique Campelo[3], Erick Almeida Esmerino[1], Mônica Queiroz Freitas[1], Tatiana Colombo Pimentel[4], Marcia Cristina Silva[2], Adriano Gomes da Cruz[2*] • Brazil

[1]Federal University Fluminense (UFF), Faculty of Veterinary, Amazonas, 69077-000, Brazil - [2]Federal Institute of Education, Science and Technology of Rio de Janeiro (IFRJ), Departament of Food, Rio de Janeiro, 20270-021, Brazil - [3]Federal University of Amazonas (UFAM), School of Agrarian Science, Amazonas, 69077-000, Brazil - [4]Federal Institute of Paraná (IFPR), Paranavaí, Paraná, 87703-536, Brazil

Adriano.cruz@ifrj.edu.br (A.G.Cruz)

ALIGNMENT WITH SDGS

ABSTRACT

Dairy products are typically submitted to conventional thermal treatments (pasteurization and sterilization) to guarantee the food safety and shelf life. Other non-thermal treatments have potential to reduce energy and water consumption as well. These technologies can also preserve the quality parameters of the more sensitive products, such as non-enzymatic browning, protein denaturation, altered volatile flavour compounds, vitamin losses, and sensory acceptance. Nonthermal technologies can be attractive to conventional dairy food processing by directly reducing energy and water consumption during processing and the energy impact during storage. Furthermore, they maintain the functional, nutritional, and sensory characteristics of the products. This article aims to overview nonthermal processing technologies, their principles, and examples of adoption by the dairy industry.

INTRODUCTION

Dairy products are positively accepted as their consumption provides health benefits to consumers (1) due to the presence of different nutrients.

Typically, they are subjected to treatments using high temperatures, such as pasteurisation and sterilisation. These technologies ensure food safety, but certain products may be reduced in sensory and functional properties (2). The dairy industry wants to improve its processing techniques to make them more sustainable due to high costs, energy and water consumption (3). The food industry is committed to making healthier and more sustainable products following the Food and Agriculture (FAO) strategy (4). The search for novel technologies that can maintain or increase the concentration of bioactive compounds in processed products is one of the challenges facing the dairy sector.

> "Non-thermal technologies can reduce energy and water consumption during processing and maintain the functional, nutritional and nutritional and sensory characteristics of products."
>
> **Hugo Scudino**

NONTHERMAL PROCESSING: A NEW WAY TO INACTIVATE ENZYMES AND MICROORGANISMS IN DAIRY PRODUCTS

Non thermal processingmay have less impact on the sensory characteristics of the products than some heat treatments (2,5,6, 9, 10). It can meet microbial food safety standards and improve products' physical, nutritional, and sensory characteristics, preserving unstable bioactive compounds and modulating enzymatic activity (3,7,8,9). (9).The idea is to develop applications of novel nonthermal technologies, eventually in combination with advanced thermal technologies, and ensure food safety by satisfying the requirement of a minimum 5-log reduction of the endogenous flora (11).

Figure 1 shows the main nonthermal technologies and their benefits on dairy products quality parameters commonly studied in recent years: high pressure processing, high-intensity ultrasound, cold plasma, supercritical carbon dioxide, and pulsed electric fields.

COLD PLASMA, TECHNOLOGY THAT MAINTAINS THE CONCENTRATIONS OF BIOACTIVE COMPOUNDS OF THE DAIRY PRODUCTS

Cold plasma is an emerging technology that has been extensively studied in the food field, consisting of a cloud of highly energetic reactive species (12) capable of interacting with various food macromolecules, promoting cleavage or modification of these compounds (13–15). In addition to having a good effect on enzyme and microbial inactivation (7,16), cold plasma maintains the concentrations of bioactive compounds of the dairy products (17,18). Depending on processing conditions, the lipid profile can be altered. More drastic processes cause an increase in polyunsaturated fatty acids, while milder conditions can result in higher atherogenic and thrombogenic indices (17,18). The use of cold plasma in dairy products processing requires low temperature (about 25°C), which it has as consequence a direct reduction of energy and water consumption during processing, in addition it is characterized by the absence of water, solvents and residues.

HIGH PRESSURE TECHNOLOGY CAN IMPROVE TEXTURE PROPERTIES

High pressure processing is an important technology in the food sector and is widely used to process dairy products (19,20).

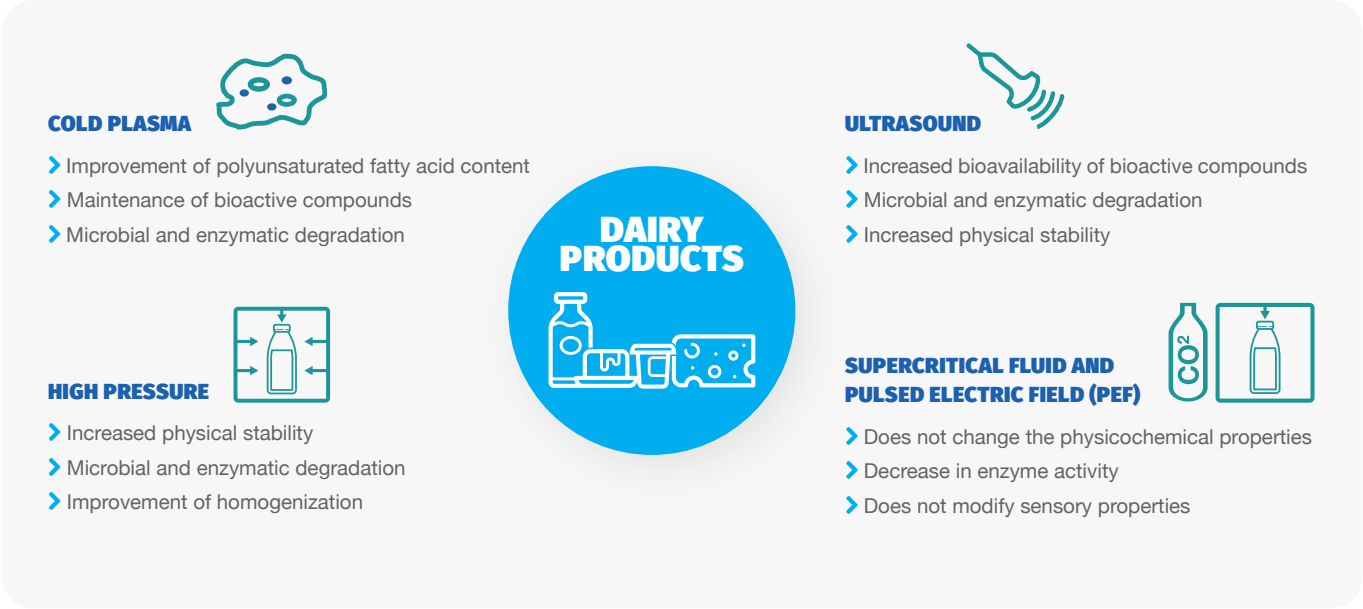

Figure 1. Leading nonthermal technologies and the main benefits of dairy products processing

Its mechanism of action is related to the conformational change of macromolecules, altering their chemical and biological activity due to the high pressure. These alterations can cause enzymatic inactivation and damage to the cell walls of microorganisms (20,21). In addition to increasing the shelf life of products, high pressure processing can impact dairy products' other characteristics, such reduce the fat globules size (22), and improve texture properties (23). Regards the sustentability aspects, HPP requires lower temperature values with direct effect on the energy consumption which it is much lower than thermal process requiring cooling afterwards. However,it is important to mention that the high investment cost has been overcame by increasing the size of the equipment and the capacity of the vessel used.

ULTRASOUND TECHNOLOGY FOR BETTER MICROSTRUCTURAL CHANGES WHILE PROVIDING MICROBIAL AND ENZYMATIC INACTIVATION

The mechanism of action of US is based on acoustic cavitation and acoustic transmission. In a liquid environment, such as milk, the passage of acoustic waves creates areas of compression and expansion, bubble collapse, and increased pressure and temperature at the implosion site. These mechanical impacts generate shear forces and contribute to mass transfer and particle displacement (3). Ultrasound treatment has stood out among nonthermal technologies due to several benefits related to microstructural changes and microbial (24) and enzymatic (25) inactivation in milk and dairy products. Also, ultrasound can increase the concentration of antioxidant compounds (26), reduce the size of fat globules (25) and increase physical stability (27,28). Depending on the treatment conditions, ultrasound can increase the concentration of saturated fatty acids (26) and reduce vitamins (26). One of the advantages of ultrasound are significant energy savings, as the temperature used in always lower than the traditional thermal processing. The use of ultrasound in dairy industry is likely to occur as a continuous flow system (CFS).

SUPERCRITICAL CARBON DIOXIDE TECHNOLOGY EXERTS NO EFFECT ON THE QUALITY PARAMETERS

SCD combines pressure with carbon dioxide to inactivate microorganisms without affecting nutritional content and sensory attributes and is a promising alternative for processing dairy products (8). The main effects of carbon dioxide on enzymes and microorganisms are associated with changes in intracellular pH, causing metabolic disorders since the main biological pathways are very sensitive to changes in pH (8,29). However, the application of carbon dioxide in the processing of dairy products does not affect important properties such as pH, titratable acidity, soluble solids content, and bioactive compounds (30). It can also bring several benefits, such as reducing the size of fat globules (30). Furthermore, the use of carbon dioxide does not affect consumer sensory perception (30). At industrial level, SCD is a sustainable alternative to totally eliminate or greatly reduce the requirement of numerous conventional organic solvent, contributing for a lower generation of residues; furthermore, it operates using lower temperatures when compared to conventional thermal processing.

PULSE ELECTRIC FIELD IMPROVES THE FUNCTIONAL PROPERTIES

PEF is another nonthermal technology with potential to inactivate microorganisms with preservation of heat-sensitive compounds of the food matrix (31). PEF technology is characterized by the treatment of food using two electrodes separated by an insulator. In this method, short pulses are generated by a high voltage pulse generator, which are responsible for functional and structural changes in the cellular membrane of microorganisms, causing their death (32).

PEF is considered as environment-friendly technology that can be applied in food processing for microorganism/enzyme inactivation and recovery of bioactive compounds as it has a high speed to achieve the operational parameters.. However, additional studies are need regards the in PEF equipment to decrease lower the energy costs to achieve results compared to standard pasteurization and transfer PET to the industrial level as more competitive technology

CONCLUSIONS

Nonthermal technologies can be attractive to conventional dairy food processing as they could reduce energy and water consumption during processing and maintain the functional and sensory characteristics of the products. However, the understanding of the application of nonthermal technologies needs improvement at the industrial level.

Most of them currently operate in-batch. Thus, developing devices for the in-flow operation would facilitate their transfer to the industrial manufacture of dairy foods. Therefore, investments and efforts in research are advisable to clarify some side aspects, such as environmental impact and reduction of food waste, that are receiving increasing attention and are not very well documented and need further studies related with each dairy food. Finally, studies covering consumer perceptions are lacking to show the right message to be added to the dairy food's label, and hedonic and descriptive studies that would be interesting to evaluate the optimization of operational parameters.

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CANADA

Dairy Farmers of Canada targets net-zero greenhouse gas emissions by 2050

AUTHOR
Annie AcMoody,
Dairy Farmers of Canada, Ottawa • Canada

annie.acmoody@dfc-plc.ca

ALIGNMENT WITH SDGS

ABSTRACT

The Canadian dairy sector is internationally recognized as a global leader in sustainability, with one of the lowest carbon footprints in the world per litre of milk produced (0.94 kg CO2-eq in 2016). Thanks to increases in production efficiency, from 1990 to 2019, dairy farmers reduced the carbon footprint of milk production by 24% on a per-litre basis. Climate change has affected millions all over the world, and Canadian dairy farmers have not been immune to its impacts. From being forced to evacuate cattle due to wildfires and flooding, to feed shortages due to drought, our farmers have endured many unusual challenges in recent months due to extreme weather. That's why they are proud to do their part to combat climate change.

In February 2022, Dairy Farmers of Canada (DFC) announced a goal to reach net-zero greenhouse gas (GHG) emissions from farm-level dairy production by the year 2050. This aligns with the goals set by the Canadian government and the global dairy sector and was established in consultation with farmers and experts based on the best available scientific evidence. Canadian dairy farmers are efficient and have always been able to adapt quickly to meet new standards. Their flexibility, enthusiasm and ambition put this goal within reach.

INTRODUCTION

Canadian dairy farmers have a longstanding commitment to environmental sustainability and pride themselves on being environmental stewards. DFC's proAction® initiative provides a national quality assurance framework with emphasis in six key areas, including the environment. A critical component of this is ensuring every Canadian dairy farm has an environmental farm plan, which includes an on-farm risk assessment and the development of an individual action plan. Additionally, since 2011, DFC has used a Life Cycle Assessment (LCA) to assess the environmental footprint of milk production.

In 2021, DFC began the development of a sustainability strategy at the direction of its members. Our farmers are dedicated to sustaining and improving the land they use and are committed to continuing to adopt farm practices that mitigate environmental impacts. This initiative encompasses several of the United Nations Sustainable Development Goals, including responsible consumption and production (goal 12), urgent action to combat climate change (goal 13), and the protection and promotion of the sustainable use of land (goal 15).

MATERIALS AND METHODS

To help support the development of a more formalized national environmental objective and build on the work already underway, DFC formed a Sustainability Working Group that included staff membership from each provincial dairy farmer organization. DFC also solicited input from dairy farmers from each province to ensure that regional concerns were being considered and that planned efforts would be feasible nationwide.

DFC started by conducting a materiality assessment, which found that the top priority for stakeholders and consumers alike was to address GHG emissions.

> "Canadian dairy farmers are proud of our tradition of environmental stewardship and our ability to adapt to new realities. Climate change is one of the defining issues of our time, and we are more committed than ever in doing our part to ensure a healthy and sustainable future."
>
> **Pierre Lampron, President, Dairy Farmers of Canada**

Other priorities included biodiversity, soil health and land use, waste, water use and quality, and energy use and efficiency. To develop a strategy to address these areas, DFC engaged consultants at Viresco Solutions, specialists in low carbon and sustainable agriculture. Viresco Solutions carried out an assessment of best management practices that could be implemented on-farm to reduce GHG emissions, considering impact, ease of implementation, and cost-effectiveness. In each province, dairy farmers were enlisted to participate in focus groups to provide input on the feasibility of implementing the strategies in their region.

Based on current adoption rates of various practices and in consultation with experts, Viresco Solutions modelled several reduction scenarios for consideration. Based on previous environmental progress and a commitment to continued improvement, DFC confidently set a goal to reach net-zero GHG emissions from farm-level dairy production by the year 2050.

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RESULTS

The net-zero goal was announced at DFC's Annual Policy Conference in February 2022 and was well-received by farmers, stakeholders and the Canadian public. All dairy farmers in Canada were invited to participate in a Farmer Sustainability Advisory Group to provide input on the implementation plan. This group is supporting the development of the Roadmap to Net Zero, which will be further detailed summer 2022. It was established that the net-zero goal will be achieved through emissions reductions and GHG removal offsets. This process also led to the decision that the Canadian dairy sector will adopt targets related to soil, biodiversity, waste and energy to get closer to their goal. Currently, DFC is working on a roadmap and will monitor progress through a bi-annual questionnaire to all farmers, which is already a part of the proAction initiative, in-addition to the Life Cycle Assessment that is completed every five years. These strategies form the basis of a plan that will continue to evolve over the coming decades as science progresses and new technologies become available.

CONCLUSION

Net-zero can only be achieved through the involvement of multiple actors working together towards one target: a better tomorrow. This commitment represents a continuation of Canadian dairy farmers' ongoing efforts related to environmental stewardship through adopting practices based on science and innovation. Not only does DFC's goal align with the Canadian government's emissions-reduction objectives, but with international targets as well. The Paris Agreement, for instance, aims to foster climate resilience and lower greenhouse gas development while working towards a lower carbon future. Additionally, last fall, DFC also joined Pathways to Dairy Net Zero, a Global Dairy Platform-sponsored commitment towards net-zero GHG emissions.

These shared objectives are part of a larger global effort to reduce the direct costs of emissions on the health, environment and economy of all nations. In Canada, this target has helped further the cooperation and solidarity between dairy farmers as they work towards a common goal and assures consumers that choosing Canadian milk aligns with their preference for sustainable options. Achieving net-zero in a Canadian context will only be possible thanks to the cooperation of members from each provincial dairy farmer organization, guidance from subject-matter experts, and most importantly, through continued consultation with farmers. The on-the-ground experience of our farmers is irreplaceable and invaluable, which has been clearly demonstrated through the insights they provided while developing this ambitious goal for the sustainability of our planet.

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INDIA

Waste to Wealth: GobarDhan

AUTHOR
Meenesh Shah, Chairman,
Member Secretary, INC-IDF, NDDB • India
meenesh@nddb.coop

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ABSTRACT

Carrying forward the idea as presented in the article to actual implementation, NDDB chose two villages in Anand district of Gujarat State to examine the robustness of the Manure Value Chain model. A total of 450 Flexi biogas plants of 2 cubic meter capacity were provided to women beneficiaries in these two villages. The entire process from procurement, processing and sale was benchmarked and standard operating procedures established. On the governance side, in order to manage operations, NDDB helped establish India's first women only manure cooperative. NDDB also extended its trademarked "SuDhan" brand to the cooperative for sale of manure products.

The responsible production as well as consumption of the organic manure promoted circular economy at the village level. During the two years of operations of the manure cooperative, 8.74 Lakh litres of slurry was procured from the farmers. The revenue of the manure cooperative grew by around 350% from INR 18.85 Lakh in 2020-21 to INR 64.34 Lakh in 2021-22. At the individual farmer level, the savings/ additional income accrued was INR 3500 per month. Overall value generation from the entire set of activities was to the tune of INR 237 Lakhs (USD 300,000).

The usage of "SuDhan' products increased grain yield of wheat and maize crop to the tune of 24 and 32 per cent respectively and reduced usage of chemical fertilizers by almost 25%.

"This innovative approach to operate a dairy plant through renewable energy will begin a revolution in the field of green energy consumption in dairy sector enabling reduction in GHG emissions."

Meenesh Shah

Based on the learnings from the small-scale biogas projects, NDDB is also working on a unique model to meet the entire energy requirements of a dairy processing plant through biogas plant.

Reference is cited to National Dairy Development Board's (NDDB) article published in IDF Dairy Sustainability Outlook 2020 which discussed about the initiative towards establishing a robust Manure Value Chain augmenting livelihood security of smallholder dairy farming system.

INTRODUCTION

India's dairy sector has seen a remarkable transformation over several decades, and it has become the largest milk producer in the world, accounting for about 21% of the world output (FAOSTAT, 2021) and growing at 6.2% CAGR with 210 million tonnes milk production in 2020-21. However, it is characterized by a smallholder production system with small herd sizes and low productivity. NDDB decided to leverage and tap the existing potential of the small holder dairying system innovatively. A Manure Value Chain model was developed which focused on establishing "dung" as a commodity by attaching specific value to it. This enabled creation of demand in the small holder dairying system as the model provided avenues for additional income / savings to the farmers. At the same time, the model helped reduce methane emissions.

EXPERIENCE OF THE NATIONAL DAIRY DEVELOPMENT BOARD

In order to understand the social, economic and environmental impacts of the Manure Value Chain model, NDDB studied the results of the actual implementation of the model among 450 women beneficiaries in two villages of Mujhkuwa and Zakariyapura in Anand district of Gujarat.

To manage the operations in a structured manner and to develop a sense of ownership among the beneficiaries, NDDB helped establish India's first women only manure cooperative. During the two years of its operation, the manure cooperative has made great strides in becoming economically viable. During the financial year 2021-22, the revenue of the cooperative was INR 65 Lakh which is an increase of about 350% from last year.

Based on the actual operations of the cooperative, an analysis was made on the

Study Parameters	Grain Yield (kg / ha)	Straw Yield (kg/ha)	Grain Yield Increase (kg/ha)	Grain Yield Impr. (%)
Control : 100 % RDF	5533	7331	-	-
Overall Average of various SuDhan Products (Wheat Rabi 2019-20)	6723	8471	1190	21.5
Control : 100 % RDF	2731	4050	-	-
Overall Average of various SuDhan Products (Maize Kharif 2020-21)	3420	5145	689	25.2

Table 1 – Study results on the efficacy of the "SuDhan" products

incremental benefit being accrued to the farmer. It was found that in the year 2021-22, on an average 3000 Litre of slurry was procured and processed and the farmers earned Rs.1/Litre of slurry in these two villages. Here, it may be mentioned that the total slurry produced from a 2 cubic meter capacity biogas plant of the farmer is about 2000 Litre (varies upon feeding pattern). There are many biogas owned farmers who do not sell the slurry and use it entirely in their own field. The surplus slurry is procured from the willing farmers at least once a month.

The average monthly earning of a farmer in the year 2021-22 was about INR 1000/- from slurry sale. The remaining slurry valuing about INR 1000/- was utilised in their own field. Hence, the bio slurry has actually helped all the Flexi biogas owner farmers reap the benefit of INR 2000/- per month.

Further, the Flexi biogas owner farmers in these two villages saved equivalent to 1.5 Liquefied Petroleum Gas (LPG) cylinders per month on cooking fuel in the year 2021-22 which in monetary terms translates to INR 1500/- per dairy farmer family at current LPG cylinder prices. So effectively, a total of 450 Flexi biogas owned farmers in these two villages have accrued benefits amounting to INR 3500/- per month per farmer from the savings in usage of biogas and sale of surplus slurry.

The slurry procured from the farmers was processed and organic fertilisers were produced. The solid and liquid fertilisers thus produced were used as an alternative to chemical fertilisers or other type of highly priced fertilisers available in the market.

Particulars*	INR (million)
Savings to farmers due to purchase of organic fertilizers	7.6
Savings in terms of Government subsidy for lower use of chemical fertilizers	3.4
Value generated for farmers (gas/slurry sale)	18.9
Direct employment (for seven persons) worth	1.0
Total	**30.9**

Table 2 – Total value generated for the 450 Flexi biogas plant beneficiaries

These products are being sold in the market under the "SuDhan" brand which is a trademark of NDDB for promotion and sale of slurry based organic fertilisers across the country.

NDDB has also conducted a study with Anand Agriculture University- a reputed University in India, on the efficacy of the "SuDhan" products. Summary of the findings in table 1.

EFFECTS OF THE "SUDHAN" PRODUCTS

It also resulted in improvement in quality of grains in terms of protein, micronutrient content, enhanced microbial quantity in soil helping in soil health improvement and reduced up to 25% in use of chemical fertilizers.

Based on the data generated during implementation of the model in these two villages, the total value generated for the 450 Flexi biogas plant beneficiaries in this project in terms of the savings due to usage of low-cost organic fertilisers, savings to Government in terms of subsidies for chemical fertilisers, employment generated etc. was assessed and a summary of the same is provided in table 2.

Therefore, the project was able to create value to the tune of INR 30.9 million working with 450 farmers.

Besides the wealth creation and establishment of the circular economy at the village level, the Manure Value Chain model has many positive social (women empowerment), economic (income & benefits) & environmental (reduction in methane emission) impacts. Some of the areas where NDDB has focused under this model are summarized below:

a) To promote scientific application of Bioslurry by the farmers, indigenously developed slurry applicators have been introduced for providing Bioslurry Application as Service (BaaS) to the farmers on shared basis. These applicators are designed for injection of slurry into the

soil instead of using spraying method. This mode of application helps better absorption of carbon.

b) NDDB is in the process of securing carbon revenues for these projects so as to ensure sustenance of the projects on a long-term basis. Further, efforts are being made to create standard operating procedures/ mechanisms for measuring emission reduction due to application of organic fertilisers as substitute to chemical fertilisers.

Further, a nation-wide study conducted by Japan based Research Institute for Humanity and Nature showed that average per capita Carbon Footprint (CF) of Indians is 560 kg per year. If we extrapolate this value to a typical Indian household of 5 persons then the CF will be around 2800 Kg/year/family. If we consider the fact that with the installation of Flexi biogas plant an average household can reduce 5 tonnes of CO2 emissions per annum, then only the biogas component of the Manure Value Chain model has potential to reduce emissions in a substantial manner, leave alone the impact from replacement of chemical fertilisers. For a test case of 450 households the potential reduction in emission would be to the tune of about 2250 tonnes per annum.

In a country like India, where almost 75 million households are related to dairying, it has huge potential in terms of its social, economic and environmental impact.

COLLABORATIVE APPROACH FOR SUSTAINABLE IMPACT

In Indian Dairy Farming System, the smallholder farmers have very limited resources and in order to mitigate challenges with respect to climate change, the interventions so planned has to be both remunerative to the farmer and easy to adopt.

NDDB is working in this regard both at the policy level with Government of India and the dairy cooperative sector in general. The need to propagate the Manure Value Chain as a viable business enterprise is presently being spearheaded by NDDB through collaboration with Government & philanthropic organisations for scaling up and implementing the manure management initiative across dairy cooperative ecosystem in the country. Presently, the model is being replicated across 8 States in the country. Government of India has also recognised this model under its “Gobardhan” scheme and NDDB as a technical partner will support implementation of the manure management model across the country.

Further, based on the learnings from the small-scale biogas projects and to upscale the concept, NDDB has conceptualized a large scale unique model to meet the energy requirements of a diary processing plant through biogas.

NDDB is implementing one such Biogas Based Energy Generation project at Varanasi Milk Union in Uttar Pradesh which will help meet the electrical and thermal energy needs of the dairy plants. Varanasi dairy will be the first dairy plant in India to run on biogas-based power generated from dung procured from dairy farmers.

The solid & liquid fertilizers produced from this plant will be sold to dairy farmers at reasonable prices through the supply chain used for providing other inputs which will open new avenues for organic farming and help to reduce the chemical deposition in the agricultural fields.

This innovative approach to operate a dairy plant through renewable energy will begin a revolution in the field of green energy consumption in dairy sector enabling reduction in GHG emissions.

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ITALY

A robotic facility for 250.000 Cheese wheels

AUTHOR
Piercristiano Brazzale,
BRAZZALE SPA • Italy

p.brazzale@brazzale.it

ALIGNMENT WITH SDGS

ABSTRACT

Sustainability is doing the right things in the right place. Even before using the best technologies and optimizing processes, what is necessary is to choose where to allocate each of the processing phases to obtain more sustainable results. Following these principles, Brazzale has built the new seasoning warehouse in Sant'Agata di Cogollo del Cengio, a few kilometers from its Italian headquarters. The area guarantees the best conditions thanks to natural ventilation, which comes from the mountains through the adjacent valley. To verify the data, monitor the warehouse and study the aging phenomenon also from the aspect of environmental impact, Brazzale makes use of their collaboration of the University of Milan on their Brazzale Science Nutrition & Food Research Center. At each stage of the design and construction of the innovative robotic seasoning warehouse, the sustainability of the structure and processes guided the choices. In addition to the choice of location, there is an integrated system of shuttles and anthropomorphic robots that takes care of 250 thousand Gran Moravia wheels, which mature in over 8 thousand covered square meters. A double revolution: space optimization thanks to the elimination of corridors, which in the traditional warehouses represented about 50% of the entire buildings, allows maximum stabilization of temperature and humidity. At the same time the reliance on shuttles and anthropomorphic robots for all loading, unloading, brushing and turning operations, guarantees optimum management of the processes and maximum respect for the welfare and safety of workers. Thanks to the photovoltaic panels on the roof and the reduction in consumption, the new structure is also totally self-sufficient from an energy point of view, in a sort of 'perpetual motion'.

A ROBOTIC FACILITY FOR 250,000 CHEESES WHEELS

The facility consists of an air-conditioned storage depot with a volume of about 50,000 cubic meters and a pavilion housing the robotics divided into 2 units, the first for loading and unloading and the second for turning and brushing. The storage depot is equipped with shelf arranged on 4 floors on which are placed about 8,000 steel racks of 32 wheels each, resting on 8 laminated fir boards, sourced only from certified sustainable forests. The 2 processing units are equipped with 4 anthropomorphic robots that select and handle the wheels, as well as temporarily remove them from the racks to allow brushing and turning of cheese and boards. The movement from the storage to the anthropomorphic robots is handled by automated shuttles without batteries, with low power consumption, guided by photocells and powered by induction from the floor. Two shuttles, high-precision elevators, bring these automated shuttles to the desired level, which load and unload the wheels and then return to do their job.

THE REVOLUTION OF THIS SYSTEM IS TWOFOLD AND RADICAL

On the one hand, the elimination of the tares constituted by the aisles, which in the previous generation warehouses accounted for around 50% of the entire warehouse. This allows maximum stabilization of temperature and humidity, benefiting the natural and complex aging process and greatly reducing energy consumption and construction. On the other hand, the entrusting to the automated shuttles and anthropomorphs for all loading and unloading, brushing, and turning operations, controlled by a central computer system, guarantees optimum aging thanks to accurate precision.

> "The automation of the seasoning warehouse allows better performances and greater production efficiency. The robotic operating cycle helps to reduce energy costs, improve the quality of life of employees, as well as improve the efficiency of all activities related to product maturation."
>
> **Piercristiano Brazzale**

In addition to the handling system, the facility also integrates the ventilation system. Excellent maturing is guaranteed thanks to 140 km of ducting in the ventilation and air conditioning system for temperature and humidity control. The warehouse is also environmentally friendly: photovoltaic panels, installed on the roof, guarantee the plant's total energy self-sufficiency.

The huge energy savings, optimisation of space, improved working conditions and more uniform microclimate in which the ripening cheese rests are intuitive.

THE FACILITY IMPROVES EFFICIENCY AND ENERGY USE

The creation of a fully automated system has made it possible to:

1. Optimize space and time. Reduction of 50% of the warehouse area thanks to the elimination of tares in the corridors. This solution, with high storage intensity, allows for the optimization of flows and dimensions, creating a warehouse of

250,000 units (equal to 10,000 tons of product) in a factory that, with traditional systems, would have allowed the storage of about 125,000 units.

2. Improve working conditions. The phases of brushing, turning and handling of the wheels (repetitive actions and heavy loads) are carried out by 4 anthropomorphic robots that can eliminate the hazards and risks for the operators caused by the manual handling that takes place in traditional warehouses. Furthermore, the implementation of automatic systems allows to redirect operators towards other activities of greater added value.

3. Total energy self-sufficiency obtained from 7,000 square meters of photovoltaic panels on the roof of the warehouse (total system power: 747 Kw) (cover image of the IDF Dairy Sustainability Outlook n 5).

4. Using **Smart Technologies** allows:

- **Total control of the conditions of each single operation**. All stages are controlled by a central computer system which identifies and tracks the cheese as soon as they enters the warehouse. In addition, an **X-ray scanner** (low intensity) continuously analyzes the wheels of cheese and classifies them by quality.
- to **Guarantee an optimal maturation** of the cheese by maintaining the ideal conditions of hygrometry and temperature. Thanks to optimal ventilation managed by **140 km of capillary ducts** and the absence of tares in the corridors, the natural ripening process is promoted and energy consumption is reduced.
- **Continuous monitoring** of the weight loss of the cheese through a computerized system designed to record the information at different time scales to allow the adoption of optimal storage conditions and minimizing the physiological loss of the products.

5. Logistic efficiency. Thanks to centralization and optimal localization, about 200,000 km/year of road trips are saved.

Studies are underway on the maturation process, concerning the positioning of the forms, the location of the racks, the turning/brushing times and the air exchange times, to evaluate whether they produce influences on the enzymatic mechanisms of proteolysis and lipolysis, which if guided, they allow to produce a sensory effect characterized by good repeatability.

THE POTENTIAL TO BE APPLIED TO THE WIDER INDUSTRY

The automation system used can be applied to a wide range of dairy products and at every single phase of the process (processing, production, packaging) guaranteeing process improvement and bringing benefits in handling management, product quality and traceability, waste reduction and respect for operator safety.

IT CONTRIBUTES TO INCREASING ENGAGEMENT WITH DAIRY SECTOR

The automation of the cheese ripening warehouse brings (through the use of automated robots, technologically advanced equipment and software) real benefits to the dairy industry in terms of improved performance, working conditions and utilisation of available space, and contribute to a significant reduction in energy consumption. All this with a focus on sustainability and in line with the goals of the SDG sustainable development programme.

THE NETHERLANDS

Animal Welfare: Innovations in animal-based approach in Dutch dairy farming

AUTHOR
J.M.M.
Jansen (ZuivelNL/DZK) & H. van Wichen (DZK) • The Netherlands

jansen@zuivelnl.org

UN SDGs

UN SUSTAINABLE DEVELOPMENT GOALS AND ANIMAL HEALTH AND WELFARE

Though animal welfare as such is not explicitly mentioned in the UN SDGs, Keeling et al (2019) concluded that working to achieve the SDGs is compatible with working to improve animal welfare. This link works in two directions. When analysing this mutual interaction, the impact of improving animal welfare on achieving the SDGs appeared to be, on average, slightly less than vice versa. The exception was **SDG2** ('*Zero Hunger*'). This confirmed an analysis by Bellamy and Bogdan (Rabobank, 2016), who already had concluded that good animal care and welfare in the first place makes a considerable contribution to **SDG 2**, since the improved health of the cow helps to increase cow productivity, thus contributing to a more efficient milk production. Moreover, the direct link between animal care and welfare and the efficient functioning of dairy cattle also relates to feed efficiency, which contributes to emissions reduction, thus delivering on **SDG 7** ('*Affordable energy & clean energy*'). Finally, animal care and welfare are part of a broad set of environmental criteria (including biodiversity, water, soil nutrients and waste) that widely address the **SDGs 12** ('*Responsible Consumption and Production*') and **13** ('*Climate Action*'). In addition to this, one can easily bring in more arguments to broaden the scope of the significance of animal welfare in the context of the UN SDGs, as illustrated by I. Otieno (Civil Society Unit, UNEP) on the occasion of the OIE Global Forum on Animal Welfare (Nairobi, April 2020), who scored no less than 13 of the UN SDGs (**SDG 1-6, 8, 10-15**) as having a relevance in relation to animal welfare.

ABSTRACT

To determine the welfare level on a dairy farm is a complex task, as animals do not speak for themselves. And there is lack of practical, objective methods for accurate and frequent welfare assessments. The European Welfare Quality protocol is the most extensive one, but it takes about a full day to perform. In the Netherlands, where animal welfare is considered a key topic within the context of sustainable farm management, stakeholders of the dairy sector successfully worked together over the past decade to develop a workable, hands-on solution for farmers that is also reliable. This resulted in a Welfare Monitor, that is a practical implementation of the European Welfare Quality®-protocol. This Welfare Monitor can be executed in only 1.5 hour on a farm with 100 cows. By 2020, 96% of Dutch dairy farmers make use of the Welfare Monitor, which is now incorporated in CowCompass. The CowCompass is an on-farm risk analysis on animal health and welfare, that shows what is going well and what can be improved in technical management.

With regard to the development of better objective monitoring methods for the assessment of animal welfare in the future, the Dutch dairy sector is also currently investing into methods based on biomarkers. This is also based on the principle that measuring to the animal itself, more than focussing on its surroundings, is the future. Next to that, it is also in line with the vision of the European Commission, as this implicitly recognizes the integrity of the animal.

SETTING THE SCENE: INTRODUCTION AND BACKGROUND

The Dutch dairy sector considers a good level of animal welfare on dairy farms to be key for sustainable dairy farming. '*A happy cow contributes to an economically healthy farm and a happy farmer*' is a slogan often heard. Moreover, as dairy cattle are at the heart of the dairy business, the dairy farming sector puts a strong focus on the cow and calf, thus operating by using an animal-oriented approach. This is also reflected by the programme of the *Sustainable Dairy Chain (DZK)*, in which sustainability is approached holistically.

DZK is the Sustainable Dairy Chain Programme of the Dutch Dairy Sector, in which farmers and processors jointly work on achieving sustainability goals, to further improve sustainable production in the Dutch dairy chain. DZK operates under the umbrella of ZuivelNL, the organization of the Dutch dairy sector, with membership of both farmers organisations and the processors organisation. Due to its broad coverage, DZK in fact represents the entire Dutch dairy sector.

Striving for continuous improvement of the health and welfare of dairy cows and calves is one of the main goals of DZK, besides several other goals, like climate change mitigation, preserving biodiversity, economic sustainability and farm safety. The dairy sector's approach to animal health and welfare, as presented in DZK, also fits into the way of looking at animals and treating them, as presented in 2021 by the Dutch Animal Affairs Council (RDA). The RDA is a leading advisory body to Government and relevant stakeholders, whose view is widely accepted by

stakeholders in Dutch society. As such, the dairy sector is also well aware that good animal welfare strengthens its license to produce.

However, measuring animal welfare in an objective way is a complex exercise. Asking the cows themselves about their mood and how they feel is quite impossible. Moreover, methods currently in use for monitoring the well-being of dairy cows on farms lack objective observation criteria for 'positive' well-being. And, above all, these instruments are often labour-intensive and therefore relatively expensive. Still, early signalling of a reduced animal welfare status, based on reliable, relevant cow's data, remains of utmost importance to dairy farmers, as it would allow them to manage in a more direct and efficient way on the welfare status of their dairy cattle. For this reason, developing a methodology to measure animal welfare in an adequate, objective way has also become a high priority on the dairy sector's wish list.

Cow Compass. Illustration based on G.A. Hooijer: Example of a septagram generated from the Cow Compass system. The red line represents a medium risk level. The more a blue surface, the less risks were determined in the milk production process.

DEVELOPMENT OF A WELFARE MONITOR

Against this background, the Dutch dairy sector started various initiatives over the past years to monitor and improve the animal welfare status in dairy cattle.

This started with research to compare four existing welfare measurement methods, with the ultimate goal to create one practical measurement method in line with the European Welfare Quality®. This research was funded by the former Ministry of Economic Affairs, Agriculture and Innovation and ZuivelNL and was supervised by the farmers organisation LTO, the Dutch Dairy Association (NZO), the Royal Dutch Society for Veterinary Medicine and the Dutch Society for the Protection of Animals. The research was conducted with extensive involvement of dairy farmers and veterinarians. This resulted in the addition of a welfare monitor to the already existing practical tool CowCompass.

CowCompass is carried out by a trained veterinarian together with the farmer. This management system gives an overview of the animal health and welfare situation and the potential risks at the individual dairy farm. By using this system, dairy farmers also comply with legal requirements for having a Farm Health Plan. The CowCompass clearly shows what aspects go well, in which areas potential risks may occur and which aspects of the technical operational management on the farm leave room for improvement.

The Welfare Monitor that was incorporated in CowCompass closely correlates to the European Welfare Quality® protocol but is much less time-consuming per evaluation. Like the Welfare Quality®, the Dutch Welfare Monitor results in a score on four aspects: nutrition, health, housing and regular behaviour. As part of these aspects, attention is paid to the physical condition, the locomotion and hygiene score of dairy cattle, the human-animal relation as well as the application of dehorning practices. The core of the method consists of looking at cows (clinically and behaviour) and evaluating them, in combination with measuring their (housing) environment (available spaces, cleanliness of available water, etc.). The benefit of the implementation of the Welfare Monitor within CowCompass is that the farmers not only get a measurement of the current welfare level of their herd, but also get advice on what can be improved to increase the welfare level even further.

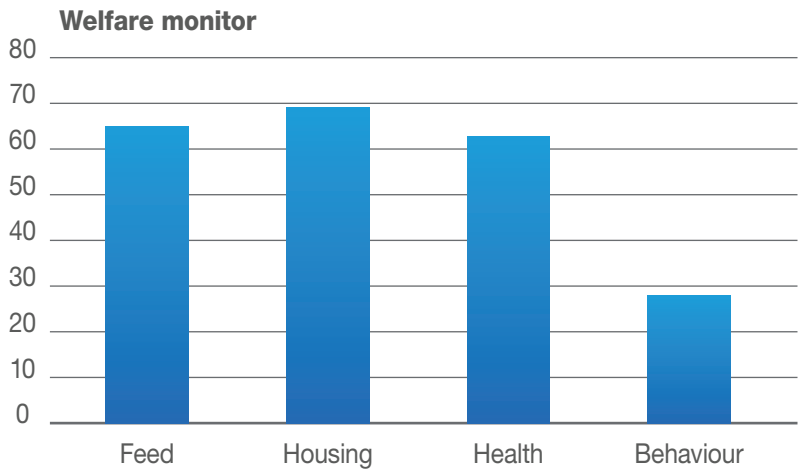

Figure 1. Example of a welfare score of an individual farm - Source: Koemonitor / ZuivelNL (elaborated)

This can be input for discussion among the farmer, his regular vet and other professionals that visit the farm.

WHAT DID IT BRING SO FAR? IMPLEMENTATION PHASE.

After developing the Welfare Monitor, the implementation of the tool as part of the CowCompass management system was effectuated in the period 2016-2017. The translation into the practical monitoring level was done in agreement with the Government and the Dutch Society for the Protection of Animals. In 2016 the necessary ICT infrastructure was put into place and the training of veterinarians took place. In 2017 the first practical field experiences were gained and evaluated. By 2018, around 3,000 Dutch dairy farms (±18%) had implemented the Welfare Monitor. Though encouraging, this number was still too low for making a representative group, suitable for organizing a baseline measurement exercise. In the years after, the participation level of farmers gradually increased, reflecting the success of the approach. By 2019, participation rate of Dutch dairy farms had already increased to 88%. In 2022, the Welfare Monitor has become a widely accepted and appreciated tool amongst dairy farmers, with a participation level of 96%. This situation allows to organise a representative baseline measurement at dairy sector level. Based on that, it is foreseen that in the near future, the Sustainable Dairy Chain (DZK) will investigate the feasibility of setting future national targets for animal welfare, based on the Welfare Monitor tool. With that, the animal welfare aspect will be better secured as a structural aspect in the broader policy of seeking continuously for improvements in the field of animal health and welfare.

DISCUSSION

One of the often reported, positive consequences of applying the Welfare Monitor on the farm in a structural way is that, by using it, farmers in general develop a more animal-oriented view. It is observed that applying the Monitor provides them with a better insight in the animal welfare status of their cattle. Moreover, they also see the economic return of the investment in welfare, by contributing to a better health status of their animals, which also adds to job satisfaction. These are all considered positive outcomes. The current Animal Welfare Monitor thus proves to be a very useful tool that, inspired by the European Welfare Quality®-protocol, allows a practical, less time-consuming way of getting adequate information on the animal welfare status of a certain herd.

Although all veterinarians, who carry out the observations, are being trained for that purpose, in scoring and observing there always remains an element of subjectivity. Moreover, the current instruments in use lack objective observation criteria for 'positive' well-being of animals. It is for this reason that the Dutch dairy sector wished to develop a methodology to measure animal welfare with animal-based measurements in a more objective way.

With this in mind, the Dutch dairy sector, encouraged by the Dutch Government, started a research project on biomarkers to measure welfare of dairy cows. From other research it is known that the 'state of mind' of people, is reflected by a variation in the presence of certain biomarkers. The key objective of this research project is therefore to find out whether it is possible to measure the state of well-being of cows, whether positive or negative, by measuring the level of certain biomarkers. The approach of this research is based on three recent developments in scientific research: 1. The relation between well-being and emotional state and the presence of biomarkers; 2. The measurement of emotional state of animals through behaviour testing; 3. The non-invasive measurement of biomarkers in animals. The search for useful biomarkers comes down to performing behavioural tests in groups of cows that are expected to be in a particular emotional state, while at the same time measuring potential biomarkers in both blood (as a reference) and biological materials other than blood, for example milk. Besides this, existing methods for welfare measuring at farm level are being combined with random measurements of certain biomarkers, to try to identify useful biomarkers for objective animal welfare assessment. It is expected that the study will be completed by the end of 2022, after which a possible follow-up can be determined.

Despite the investment in *animal-based* measurement methods like Welfare Quality® and the EU vision on animal welfare as formulated in the EU Farm2Fork strategy the unfortunate reality is that the focus in policy is still on resource-based measures like housing conditions. It certainly is clear that innovations in housing conditions of cows have increased the welfare of cows enormously in the last decades. And it is also true that, when using animal-based measures, this creates room for innovation to improve even further on housing. However, a good environment is just one out of the six guiding principles the Dutch Animal Affairs Council (RDA) presented as prerequisites for animal worthy livestock management. These are: 1. *Recognition of the intrinsic value and integrity of the animal*; 2. *Good nutrition*; 3. *Good environment*; 4. *Good*

health; *Natural behaviour*; 6. *Positive emotional state*. The RDA states that livestock systems designed on the basis of the six guiding principles are animal-worthy livestock farming systems that enable positive animal welfare. Animal-based measurements give a total view on animal welfare. This also includes farm management as a key aspect for animal welfare.

It underlines the importance of awareness among policy makers to use welfare measurements that always take the animal as a starting point, instead of focussing on secondary aspects that, though important, may offer only part of the solution, and often at a higher cost.

CONCLUSION

Stakeholders of the Dutch dairy sector successfully worked together over the past decade to develop a Welfare Monitor, that is based on the European Welfare Quality®-protocol, but which is faster and more workable for dairy farmers. This tool has now become an integral part of the animal health and welfare management system in use by dairy farmers (*CowCompass*). In 2022 a national baseline measurement is foreseen, which will be the starting point of setting sector goals for further improvement in animal welfare in the future. The Welfare Monitor in the Netherlands is based on an animal-oriented approach.

Taking it a step further, parallel to the practice of implementing the Welfare Monitor, research is being carried out on biomarkers in cows, with the aim of measuring welfare status of cows in a more objective way. This is fully in line with the EU-vision that puts the animal in the centre, as described in the European Welfare Quality®-protocol. In animal welfare, the on-farm management system and way of working by farmers is a key aspect. In view of this, the focus on measuring surroundings and environmental factors, that still often dominates policy measures, brings a risk of missing the point and putting unnecessary (economic) pressure on dairy farmers. Therefore, it is concluded that optimal animal management, based on reliable animal-based data should become the basis for welfare quality in the future.

"CowCompass has become an integral part of the animal health and welfare management system of Dutch farmers."

J.M.M. Jansen

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NIGERIA

Using the sun to cool the milk

AUTHOR
Snorri Sigurdsson, Senior Project Manager
Raw milk supply and production
Arla-Nigeria • Nigeria

snsig@arlafoods.com

ALIGNMENT WITH SDGS

ABSTRACT

In many countries around the world milk spoils because it is not cooled quickly enough after milking. To preserve the quality of its raw ingredient as best as possible, dairy cooperative Arla Foods, recommends that cooling takes place within the first two hours. However, lack of infrastructure, lack of access to cold water, poor access to electricity, for example, limits many farmers' ability to cool the milk down shortly after milking. It has been estimated that around the world tens – if not hundreds – of million litres of milk gets spoiled ever year due to these limitations. One way in which milk spoilage can be greatly reduced is through the use of cooling units, that can be transported and used off the grid – powered by the sun through the use of solar panels.

In Nigeria, Arla Foods is trailing different systems to cool the milk down using the sun to solve this problem. As well as increasing farmers' income as more milk will be of sellable quality, milk spoilage and food waste is reduced as a bigger share of milk can be consumed.

DAIRY PRODUCTION IN NIGERIA

Approximately 95% of the milk produced in Nigeria comes from nomadic herdsmen who move around with their cattle depending on the weather conditions and accessible vegetation. These herdsmen use mainly the White Fulani cattle breed, which is the main breed not only in Nigeria but also in Chad, Ghana, Niger and Togo. This cattle breed is extremely resilient and well adapted to the harsh environment in the Sahel belt south of the Sahara Desert, where drought and heat can be a major issue for farmers. The downside of this cattle, however, is the breed's extremely low yield. Cows often only give 1.5-2.5 litres of milk per day and each herdsman is often only selling 5-10 litres of milk daily.

> "Solar power helps the the nomadic herdsmen on the delivery of cooled milk to an established Milk Collection Centre"
>
> **Snorri Sigurdsson**

MILK COLLECTION CHALLENGE

Because the nomadic herdsmen move around with the cattle, the delivery of milk to an established Milk Collection Centre (MCC) is sometimes not possible because of long distances and lack of proper infrastructure in the area the milk is produced. This has led to a collection system where small volumes of milk are gathered in several places and milk from different herdsmen is combined with other milk. This milk is then transported, often by motorbikes, to the nearest MCC for quality measurements, weighing and cooling. This system of milk collection has one major issue, which is the lack of quick cooling of the raw milk. Because of the small deliveries from each herdsman and long distances from the herds to the nearest MCC the milk is often not cooled down for many hours after milking. This has led to high percentages of spoiled milk, that is, milk that cannot be used for dairy processing as it becomes contaminated with bacteria.

FARMING OFF THE GRID

For most established farmers around the world this issue with milk quality is not a major factor to consider because of higher milk volumes per farm, and for most of them, good access to grid electricity. For the herdsmen in Nigeria this is however a major factor and even if the farmers would like to cool the milk down, that is not possible in most places as there is no access to grid electricity. To compensate for that Arla-Nigeria has now looked into solutions that are based on solar power as Nigeria, placed only 1.500 km north from equator, has many sunlight hours every day, all year round. At the same time the solutions that are sought after need to be portable - with the farmers are moving regularly the system needs to be able to follow the farmers!

3 TRIAL SOLUTIONS

There are many ways to cool down the milk with energy from the sun and some examples are shown in photos 1, 2 and 3. These solutions can both be found as complete produced units, or used as a combined technology where known cooling solutions are powered with energy made by solar panels. No matter what methods are used, the main issue to solve is to find a way to cool down the milk as quickly as possible after milking, to stabilize the raw milk and slow down the growth rate of bacteria in the milk before pasteurization.

PROMISING OUTCOME

To date, one of the 3 methods referenced, has been tested by Arla-Nigeria and first results show that the raw milk quality has improved as expected. The method in question uses a normal freezer that is

Approximately 95% of the milk produced in Nigeria comes from nomadic herdsmen that use mainly the White Fulani Cattle.

Photo 3. Solar powered cooling unit, specially designed for milk jars. © Galactea.

powered by the sun. During the night, when no electricity is generated, the ice in the freezer keeps the unit cold and ready to receive the milk next day. When the milk is delivered and cooled down it is taken to the dairy plant after which, in the middle of the day, a new layer of frozen water builds on the inside of the freeze, ready to cool the next batch of milk. The other 2 methods, which are specially designed and produced methods to cool milk down, will be tested in late 2022 and early 2023 are the ones showed on photo 2 and 3.

Photo 1. Example of a simple solution for milk can cooling. Solar panelled powered freezer, to rapidly cool down milk.

Photo 2. Specialized milk can cooling unit powered by the sun.

NORWAY

The Norwegian animal welfare indicator

AUTHOR
Olav Østerås,
TINE SA • Norway

tone.roalkvam@tine.no

ALIGNMENT WITH SDGS

ABSTRACT

Animal welfare is important in sustainable dairy production. There are many ways to assess animal welfare, and there are different standards. One standard is the Welfare Quality® Assessment protocol for cattle (http://www.welfarequalitynetwork.net/media/1088/cattle_protocol_without_veal_calves.pdf)

Other standards are the OIE standard in chapter 7.11 animal welfare and dairy cattle system (https://www.oie.int/fileadmin/Home/eng/Health_standards/tahc/current/chapitre_aw_dairy_cattle.pdf) and ISO standard ISO TS34700:2016: Animal welfare management – General requirements and guidance for organizations in the food supply chain (https://www.iso.org/standard/64749.html)

The Welfare Quality® Assessment is considered the golden standard in science, however the drawback of this standard is the time needed for proper assessment. The OIE standard is describing what variables that are to be considered in assessment of animal welfare, and ISO is a standard built on the OIE standard, where the industry can set their own goals. In Norway there is a long tradition of animal recording, and the animal recording for dairy cattle also have continuous recording of disease treatments and other parameters as slaughter weights, growth rate, somatic cell counts etc. We recognised that almost half of the variables mentioned in the OIE standard is included in the Norwegian dairy cattle recording system. This gave us the opportunity to have a continuous assessment of animal welfare indicators by extracting these variables from the already existing animal recording system, and thus have a continuous indication of animal welfare at each farm. The Norwegian Animal Welfare Indicator was born. This new indicator is updated every month and includes data from the last 12 months – a monthly rolling 12 months assessment. Data for all indicators are presented to farmers, advisors in TINE SA and the farm's veterinarian if the framers give them access to data.

> "It seems like the Norwegian animal welfare indicator is a good tool for making improvements in general animal welfare, and the tool seems to have good acceptance among the dairy farmers."
>
> **Olav Østerås**

THE TECHNICAL DEVELOPMENT

The technical development of the Norwegian Animal Welfare Indicator (NAWI) started in 2016 by making a prototype in the statistical programme SAS to evaluate how it could work. The baseline year was the annual data for the year 2015. This means that 2015 is considered the baseline year. All herds are therefore compared to the national mean figures for 2015. From these national figures based on the national mean and standard distribution (STD) there was estimated a normalized standard deviation (NSD). The NSD was calculated as the herd mean minus the national mean divided by the national STD. Two distributions were used, normal distribution or poison distribution. As an example, the national slaughter weight for cows was 269 kg with a STD of 30.5 kg, and a specific herd had a mean slaughter weight for cows at 200 kg the estimate of NSD will be (200-269)/30.5 = -2.26. This figure is just the number of STD in difference from the national mean in 2015. If there as a Poisson distribution like for mastitis treatments the calculation is as follows: The national incidence rate per cow-year was 0.22 in 2015. If there is a herd with 40 cows the expected number from the national mean will be 40 x 0.22 = 8.8 treatments. If there in this herd it was 4 treatments the NSD would be (8.8 – 4)/ (square root of 8.8) = 4.8/2.97= 1.62. These NSD will then be a figure from – 3.0 to + 3.0. If the calculation is outside this area the figures will be truncated to -3.0 or +3.0.

The variables included in the indicator is shown in the appendix at the end. For each part indicator like calves, disbudding etc. the NSD's are summed up and adjusted so that this sum for the year 2015 is 0.0. This means that all the part indicators are adjusted so the baseline year is zero (see Figure 1 upper line). Finally, all the part indicators are summed up to the total animal welfare indicator, plus 100, so that the baseline is 100.0 in 2015. There is no weighting between each part indicator, so the indicator is not reflecting the true animal welfare, but is made as a tool for each herd to see if this part of the production at herd level has a higher or lower figure than the country mean in 2015. There is also an indication that herds having figures among the 25% best according to the distribution in 2015 is marked light green and if they are among the 10% best, they are marked dark green. In the same way low figures are marked light red or dark red if they are amongst the 25% lowest or 10% lowest compared to 2015 distribution. The design of the indicator is illustrated in figure 1.

THE INTRODUCTION PERIODE

After the prototype was finished, the indicator was tested among 30-40 herds by advisors in TINE using a questionnaire covering different assessments of animal welfare which was not included in the

Produsent	Dyrevelferds-indikator	Kalver	Avhorning	Ungdyr	Fruktbarhet	Avdrått	Jurhelse	Stoffskifte	Klauv	Livslengde	Døde kyr	Ant. årskyr	Datakvalitet
Landet	107,20	-0,40	2,06	0,22	0,21	-0,11	1,30	1,24	2,26	0,45	-0,04		8,60
Distrikt	107,50	-0,66	2,34	0,02	0,61	0,02	1,16	0,89	2,55	0,62	-0,03		8,60
Produsentlag	109,20	0,06	2,63	0,69	0,29	-0,08	1,11	1,76	2,40	0,56	-0,25		9,00
	114,6	2,0	4,3	0,7	1,2	1,7	2,0	-0,2	-2,7	5,1	0,6	10,7	10,0
	106,5	-0,9	1,5	0,0	-1,2	0,5	6,0	0,6	4,0	-0,3	-3,7	10,4	8,0
	116,7	2,2	2,0	0,9	2,4	1,2	-3,5	3,1	5,9	1,8	0,7	41,0	9,4
	116,5	-4,5	4,1	-1,4	4,9	0,6	0,1	1,2	5,0	5,0	1,4	52,2	10,0
	118,2	2,0	3,7	-1,8	1,6	1,4	2,7	-0,5	7,1	1,2	0,7	12,6	10,0
	101,2	2,0	-1,6	-1,7	-3,4	0,0	0,1	0,0	5,8	-0,6	0,6	10,1	9,5
	105,2	2,9	-2,2	-1,9	-2,0	-1,2	-2,3	1,0	8,1	1,7	1,0	25,6	7,8
	105,9	1,4	0,0	-0,6	0,7	0,9	5,0	-1,5	-3,0	2,1	1,0	23,6	9,0
	117,7	1,9	4,9	4,6	-4,1	0,3	0,2	2,5	7,1	1,9	-1,8	54,1	10,0
	91,7	-0,6	-0,8	0,2	-4,5	-1,0	1,6	2,8	-6,0	-0,8	0,8	16,2	6,9

Produsent	Dyrevelferds-indikator	Kalver	Avhorning	Ungdyr	Fruktbarhet	Avdrått	Jurhelse	Stoffskifte	Klauv	Livslengde	Døde kyr	Ant. årskyr	Datakvalitet
Landet	107,20	-0,40	2,06	0,22	0,21	-0,11	1,30	1,24	2,26	0,45	-0,04		8,60
Distrikt	105,80	-0,58	1,13	0,50	0	-0,14	0,93	1,54	2,19	0,39	-0,15		8,50
Produsentlag	107,60	-0,88	1,83	0,49	-0,37	-0,06	0,44	2,32	3,61	0,33	-0,07		8,50
	128,9	-2,6	10,4	-0,8	0,1	0,6	2,8	9,7	5,3	2,2	1,0	136,6	9,6

Figure 1. Example of the design of the NAWI tool the way it appears on the on the farmer´s (and the advisor´s) website. The columns with the part indicators have different colors to illustrate the level of the indicator.

welfare indicator. The advisors did not know the indicator value. After identifying a significant correlation between the NAWI and these assessments the NAWI was programmed by IT-people into the member`s website for TINE`s farmers at the same time as there were several learning courses for producers on the importance of animal welfare in the production system. During 2019 there were 173 meetings with 4,058 producers, and 838 group meetings with 4643 producers where animal welfare was the agenda for the meeting. In these courses also some of the ideas of the NAWI was introduced. This made a good acceptance among producers on the launching of the NAWI in 2020. When the development on the Internet homepage for producers was finished spring 2020, it was established courses for advisors in TINE how to use the NAWI in the advisory work among producers. After all advisors had been on these courses, they have a one day training by themselves and in groups. Thereafter followed a oneday discussion with the head advisors to understand the figures and calculations as well help to take decisions and have a sound dialog with the producers. These courses are a key when developing new tools, especially in areas as animal welfare assessment which could be quite sensitive. During these courses there were lots of input from experienced advisors on areas where the NAWI could be improved. These improvements were effectuated during spring 2021. After these courses in 2020, the NAWI was launched for producers during the summer 2020.

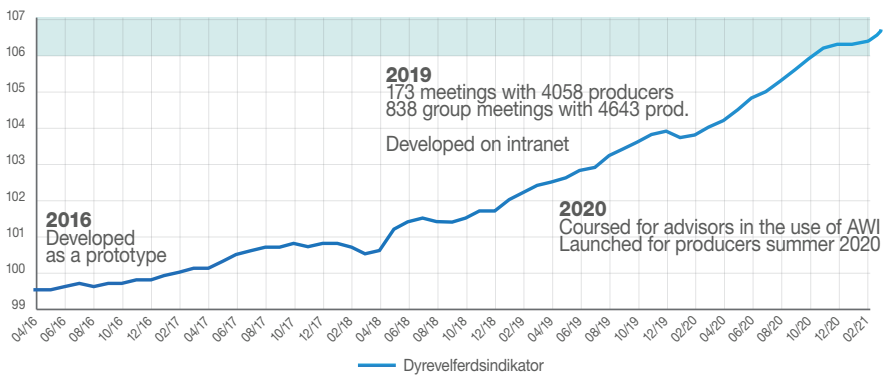

Figure 2. The increase in the Norwegian Animal Welfare Indicator from 100 in 2015 to 107 in May 2021. NB. The national mean is at present among the 25 % best producers in 2015 (indicated by the light green area).

EXPERIENCES AND RESULTS

The NAWI had generally good expectance among the producers. Some producers also came up with some proposal for improvements of the indicator. So this launching turned out to be a very dynamic process with constructive feedbacks and adjustments during 2020 and 2021. Figure 2 illustrate the development of the total indicator.

The first year when the prototype was made, the indicator value dropped from 100 till 99.5 in April/May 2016. Later it increased, and the increase really improved during late 2018 and in 2019 when the courses in animal welfare were running for the producers. Still the indicator value for each producer was not known. After launching the indicator for advisors and producers during the summer 2020, the indicator value really increased, and went from around 103 till 107 in May 2021. Interesting there is a drop in March 2020, and around Christmas in 2020, probably due to lockdown according to COVID-19 in Norway. This would be influenced by less claw trimming activity among others. Looking at the different part indicator we can identify that the best improvement is for claw trimming and disbudding of calves. This is natural as these are routines which are quite easy to correct if the producer is aware of it. It is much more difficult to make improvement in dead cows, growth rate etc, which

Olav Østerås with Norwegian dairy cattle

needs more time to adapt to a better management. We could also see that calf health was not improving, but had lower figures. This is probably due to larger herd sizes and more free stalls, which need more attention in prevention of infectious diseases in calves. It seems like the NAWI is a good tool for making improvements in general animal welfare, and the tool seems to have good acceptance among producers. Introduction courses are very important to prepare and make a good attitude to working with such tools. It is also important to realise that there is a significant relation between good welfare among farmers and good welfare among animals. This is also indicated by the paper of Hansen and Østerås (2019), where the data from the prototype was used to assess this relation. In the future there will be research to evaluate the relation between NAWI and Welfare Quality® Assessment Protocol. If this turns out to be positive, NAWI will be a strong tool to assess animal welfare in dairy production in Norway. The nice thing for the farmer is that this indicator could be made for all herds and updated every month without doing more work than just being a member of the animal recording. Everything is automized from animal recording system. The tool is made to advise and contribute to continuous improvement of animal welfare, and not used for regulatory purposes. For regulatory purposes one must visit the farm and see what is going on in real life. But the tool could be used to advisory work together with the farmer, and it is very easy to identify good and not so good areas in the production.

SUMMARY

The Norwegian Animal Welfare Indicator is developed based on the OIE/ISO standard and using data already existing in the animal recording. It is mainly for documentation and a tool to improve the production system. As such, one should be careful to state that it is directly related to animal welfare, but it is a strong indicator on animal welfare. The tool is made to ease the advisory work at farm level. So far the indicator tells us that in general the animal welfare in TINE production system has improved on a scale from 100 in 2015 to 107 in 2021, and is still on an upward trend.

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Part Indicator	Variable included	Distribution used	Any adjustments
Calves (till 180 days old)	Number abortions	P	
	Number stillborn	P	
	Number dead calves	P	
	Number euthanized calves	P	½ weight
	Number treatments	P	Adj. to N dead
Disbudding	Number pooled calves	P	
	Number disbudded after 42 days old	P	
	Number disbudded after 70 days old	P	2 x weight
Youngstock (from 180 days till calving)	Number dead youngstock	P	
	Number euthanized youngstock	P	
	Number emergency slaughtered youngstock	P	
	Number treatments in youngstock	P	
	Slaughter weight heifers	N	
	Growth rate heifers	N	
	Slaughter weight young bulls	N	
	Growth rate young bulls	N	
	Age at first calving	N	
	Any breed adjustment	Discrete	
Fertility	Herd mean distance first to last I.A. heifers	N	
	Herd mean first to last I.A. cows	N	
	Number culled due to fertility	P	
	Herd mean calving interval	N	
Yield	Difference between mean yield 1st and 2nd parity	N	
	Difference between mean yield 2nd and later parity	N	
	Difference between mean yield 1st and later parity	N	
Udder health	Number of cell counts (CC) above 200,000 pr ml	P	
	Number of mastitis treatments	P	Adj. to parities
	Number of culled cows due to udder health	P	
Metabolic	Number of treatments for milk fever	P	Adj. to parities
	Number of treatments for ketosis	P	
	Number of body conditions scores (BCS)	1	If more than 10
	Number of thin cows < 2.75 (If more than 10 BCS)	P	½ weight
	Number of thick cows >3.75	P	½ weight
	Variation in BCS	N	½ weight
	Slaughter weight cows	N	
	Fat classification cows	Discrete	
	EUROP class cows	Discrete	
	Slaughter weight young cows	N	
	Fat classification young cows	Discrete	
	EUROP class young cows	Discrete	
	Any breed adjustment	Discrete	
Claws	Number of pain full diagnosis	P	
	Number of claw trimmings	P	
	Use of professional claw trimmer	Discrete	
	Number of veterinary treatments	P	
Longevity	Number of cows culled before 15 days in lactation	P	
	Number of cows culled 84 to 290 days in pregnancy	P	
	Number of cows culled 84 to 290 days after last I.A. not pregnancy tested	P	½ weight
	Number of culled cows (not sold for live animals)	P	
	Mean age at culling for cows after 2nd calving	N	
Dead cows	Number of dead cows	P	
	Number of euthanised cows	P	½ weight
	Number of emergency slaughtered cows	P	½ weight

Appendix – The variables included in the Norwegian Animal Welfare Indicator as for 2021. (P =Poisson distribution, N= Normal distribution)

SOUTH AFRICA

Determination of environmental and economic outcomes of dairy production systems in South Africa: a system dynamics approach

AUTHOR
Riana Reinecke, James Blignaut
Asset Research, Pretoria • South Africa

colin.ohlhoff@fruitique.co.za

ALIGNMENT WITH SDGS

ABSTRACT

The dairy sector must demonstrate its positive contributions toward sustainable production through sharing science-supported and evidence-based information. It must do so in conjunction with assisting dairy producers in reducing their on-farm environmental impacts. This should be done in a manner that would lead to a more robust, profitable and resilient farm.

Milk SA recognised the urgency of the dual need for improved on-farm management and the timely dissemination of information that will not only protect the dairy sector and its producers, but also enhance its long-term environmental and financial sustainability. Milk SA therefore initiated a project in conjunction with ASSET Research to develop a web-based system dynamics tool which assists milk producers to calculate and evaluate their on-farm carbon footprint. This tool enables producers to take informed action, and to implement correctional changes which contribute towards lowering their emissions. The tool was tested and calibrated on seven South African dairy farms and proved to be both practical and applicable, with the required data readily available.

The results were calculated, among others, in terms of fat and protein corrected milk (FPCM) produced and expressed in terms of kg CO_{2e}/kg FPCM. Results varied between 0.49 and 1.14 kg CO_{2e}/kg FPCM/kg, using a GWP* of 8 as the warming potential for CH4; the results compare favourably to international standards.

"This online system dynamics tool will assist producers to estimate their emissions, and to track change over time, while indicating several ways in which emissions reductions can be brought about."

Riana Reinecke

INTRODUCTION

Dairy farmers face a variety of daily production realities (such as biosecurity concerns, animal welfare and management issues), the rapid increase in the cost of external inputs and the consequences of erratic climatic conditions, but the producer must also overcome an increase in negative perceptions among consumers concerning dairy per se. These perceptions, especially on social media platforms, have become extremely pervasive in generating a negative sentiment concerning dairy, mostly with respect to the sector's perceived greenhouse gas (GHG) emissions. While the negative, and often false, publicity must be countered it does not exonerate the dairy sector from improving its management to reduce the sector's environmental footprint. Both the producer and the sector must act urgently and do so in a science-informed and evidence-based manner taking cognisance of the complex and dynamic milieu in which it operates.

MATERIALS AND METHODS

The web-based tool is freely available and requires the user to complete the online questionnaire, which is supported by a user manual. The tool is divided into five sub-models which act interdependently and can be applied to analyse various on-farm aspects such as herd management, herd energy use and flows, emissions, etc. An initial assessment is then produced and reported as the baseline footprint of a specific farm. This can be extended with subsequent management scenarios, or by means of revisions over time. Given the interdependency of the various sub-models, all the information flow into the output of this model, including the methane (CH4) emissions which are generated from enteric fermentation processes and manure management, nitrous oxide (N_2O) emissions from soil and manure management, and carbon dioxide (CO_2) emissions from direct sources. Based on the management practices implemented on the farm, different GHG emission trajectories are therefore calculated. Furthermore, the economic sub-model provides additional insight into the potential benefits or impacts any changes may have. To enable this advantage, the model allows the user to create different scenarios to anticipate the effects that specific changes might have on the emissions as well as the associated economic impact thereof. This enables producers to develop effective mitigation strategies, to evaluate the impact of decisions, and to communicate with stakeholders such as consumers, about their real impact on the environment.

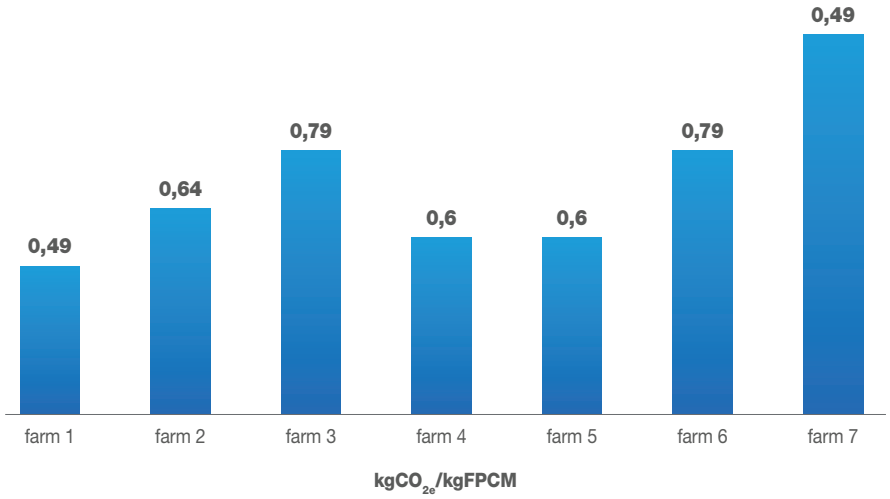

Figure 1. Results from the application of N-fertiliser, both from synthetic and organic sources in terms of fat and protein corrected milk (FPCM) produced and expressed in terms of kg CO_{2e}/kg FPCM.

RESULTS

The model was tested on seven farms in South Africa. The number of productive cows on these farms varied from 260 to 2 460 and the average milk production ranged from 4 500 to 8 150 kg/cow/year. The application of N-fertiliser, both from synthetic and organic sources, ranged between 27 to 600 kg N/ha/year. The results were estimated, among others, in terms of fat and protein corrected milk (FPCM) produced and expressed in terms of kg CO_{2e}/kg FPCM. The results varied between 0.49 and 1.14 kg CO_{2e}/kg FPCM/kg (see Figure 1). A global warming potential of 8 for CH4 is used, which is also called GWP* in accordance with Blignaut et al. (2022). The results compare favourably to international standards.

The research also indicated that the environmental sustainability of a dairy farm and its profitability are not conflicting objectives. The farm that showed the lowest emissions per kg FPCM, Farm 1, also had the highest profit per kg FPCM. These results were confirmed by site visits and on-farm investigation that confirmed that the farm management implemented various measures to improve efficiency before the commencement of the project. The farm management has a policy of implementing strategies to reduce the environmental impact on an ongoing basis.

DISCUSSION

A freely available web-based tool has been developed to assist producers in estimating their carbon footprint and offering guidance towards reducing their emissions. Opportunities for such reduction include improving feed efficiencies rates, improving herd management strategies and increasing productivity. This, in turn, also has an impact on the profitability of the farm. The tool, for example, calculates the protein intake from both procured feed and farm-produced feed. Depending on the forage type, the protein content will be calculated in the model. The evaluated farms indicated that farms with the highest protein intake did not reflect the same results with N-excretion rates. This can be a result of total protein intake and protein percentage in the milk. The opposite was also seen where the average protein percentage on the farm was low, but because of lower milk protein and higher feed intake, the N-excretion rates were slightly elevated in comparison. This suggests possibilities in enhancing the feed efficiency to lower emissions on the farm, and consequently, influencing the economic output of the farm. The same is true for fertiliser application. It was not the farm with the highest N-fertiliser rates that performed the best, but rather where it was applied according to measured recommendations and where more focus was given on precision management.

CONCLUSION

This study indicated that the on-line tool could assist producers to calculate the emissions from a dairy farm, identify the critical environmental indicators and simulate scenarios to determine the best and most profitable mitigation strategies. Producers can also track progress over time which can be used to report on actual data. The tool is, however, not static and is under continual development based on feedback from users and the inclusion of new and improved science. In one such development, the tool will be expanded to include the on-farm carbon capture and storage opportunities that exist.

In conclusion, the dairy industry has an important role to play in both combatting misinformation about the sector, and in advancing the reduction of the environmental footprint of dairy farms. This online system dynamics tool will assist producers to estimate their emissions, and to track change over time, while indicating several ways in which emissions reductions can be brought about. Being environmentally prudent also has financial benefits. The tool embraces the adage that to measure is to know; and knowledge is power – power to assist change and to communicate such change to an increasingly informed public audience.

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SWEDEN

Farming of the Future – How Swedish beef and dairy farming can meet climate targets and contribute to a sustainable food and energy system towards 2050

AUTHOR
Victoria Thuillier
LRF Dairy Sweden, Stockholm • Sweden

Victoria.Thuillier@lrf.se

ALIGNMENT WITH SDGS

ABSTRACT

In early 2020 stakeholders of the Swedish beef and dairy sector set up a project to identify and quantify the potentials to reduce climate impact of Swedish beef and dairy production systems by 2050. The project showed that Swedish beef and dairy production can reduce climate impact in line with the Paris agreement and climate neutral farming by 2050 can be achieved. This can be done without compromising biodiversity, animal health and welfare, while increasing food and bioenergy production. The report and the collaboration is a major contribution to describing the role of cattle in sustainable food and energy production system in Sweden into the future and presents a growth opportunity going forward.

INTRODUCTION

In early 2020 stakeholders of the Swedish beef and dairy sector set up a project to identify and quantify the potentials to reduce climate impact of Swedish beef and dairy production systems by 2050. The collaboration was one of the first of its kind and addressed a knowledge gap where an overall approach handling beef and dairy production simultaneously, as part of an overall system, was missing. While the potentials were identified from a climate perspective, other sustainability aspects were also taken into consideration. The results were published in a report in October 2021 and have been very useful in dialogue with farmers, politicians, research institutes and universities as well as other stakeholders in the food chain. The report and the collaboration are a major contribution to describing the role of cattle in sustainable food and energy production system in Sweden into the future.

MATERIALS AND METHODS

The method for this report included studies of literature, surveys, calculations, interviews with researchers, experts, and stakeholders, as well as workshops. The scope of the study was from field to farm gate.

As the greenhouse gases have different properties and climate impact, potentials were quantified for the three gases separately. The UN IPCC states that between 2020 and 2050, carbon dioxide emissions should be reduced to net zero, methane emissions reduced by about 65 percent and nitrous oxide emissions by around 40 percent. It has also been described that expressing methane emissions as CO2 equivalents, using GWP-100, overstates the effect of constant methane emissions on global surface temperature by a factor of 3–4 over a 20-year horizon (Lynch et al., 2020). As the number of ruminants in Sweden steadily has decreased and productivity simultaneously has increased over time, a 10% reduction over 20 years target for biogenic methane was adopted (Allen et al., 2018).

Besides adopting applicable climate targets, four principles that define sustainable beef and dairy production in the future were set. These are animal health and welfare, planet, productivity, and farm profit. Healthy cattle that can behave naturally in production systems that are ethically sound and broadly acceptable among consumers is key. Livestock farming should be resource efficient and circular maintaining biodiversity and ecosystem services. Long-term sustainable production includes farm profitability and opportunities for the

new investments, initiatives, and talent entry. Sustainable production must be cost effective to yield affordable products that are competitive on the Swedish and global market.

A simulation model was developed to describe the theoretical potentials for climate. Four example farms (small dairy, large dairy, suckler and dairy bull to beef) were defined based on statistics and to be as representative as possible for the Swedish beef and dairy sector. Certain areas were difficult to quantify and to avoid some complexity farm areas were kept intact from 2015–2030–2050, as well as the number of breeding animals per farm.

RESULTS

The dairy example farms:

- Small dairy farm in mixed forestry and agricultural area: 85 ha, 60 cows in production, 9900 kg ECM/year milk yield
- Large dairy farm on lowland: 256 ha, 240 cows in production 10,400 kg ECM/year milk yield

Potentials (kg gas/kg ECM)	CO_2	CH_4	N_2O	GWP
Animal health, lifetime prodcution and breeding	8%	31%	21%	25%
Fossil free farming	25%	0%	4%	5%
Feed production, strategies and ingredients	57%	0%	31%	18%
Methane reducing measures	0%	10%	0%	6%
Manure management and biogas	-4%	10%	15%	9%
TOTAL	**86%**	**51%**	**71%**	**63%**
Carbon sequestration	40%	-	-	8%

Table 1 – Small dairy farm: Weighted improvement potential, all greenhouse gases, relative per kilo product

Potentials (kg gas/kg ECM)	CO_2	CH_4	N_2O	GWP
Animal health, lifetime prodcution and breeding	2%	31%	15%	25%
Fossil free farming	40%	0%	8%	5%
Feed production, strategies and ingredients	47%	0%	30%	18%
Methane reducing measures	0%	10%	0%	6%
Manure management and biogas	0%	9%	15%	9%
TOTAL	**88%**	**50%**	**67%**	**63%**
Carbon sequestration	65%	-	-	8%

Table 2 – Large dairy farm: Weighted improvement potential, all greenhouse gases, relative per kilo product

Quantified potentials and identified innovation gaps on the four example farms. Key areas for development are:

- Animal health and lifetime production
- Breeding for healthy cattle
- Feeding strategy
- Roughage production
- Feed ingredients and feed additives
- Fossil free farming
- Carbon sequestration
- Digitalization, automation, and new technology
- Biodiversity
- Manure management and biogas
- Nutrient losses to air and water

Our results showed that carbon dioxide emissions can reach zero and carbon sequestration increase. Methane emissions can decrease so that no additional climate impact occurs, while nitrous oxide emissions can decrease faster than IPCC advocates.

DISCUSSION

There are great opportunities to reduce emissions in line with the Paris Agreement and achieve climate neutral farming by 2050 in Sweden. By analysing the greenhouse gases separately more balanced conclusions can be drawn in systems involving emissions from cattle

"Using our collective expertise and assumptions the results can be used as a roadmap for future business development as well as a platform for continued collaboration and knowledge transfer to politicians and authorities."

Victoria Thuillier

production. Using our collective expertise and assumptions the results can be used as a roadmap for future business development as well as a platform for continued collaboration and knowledge transfer to politicians and authorities.

To realise the identified potentials, collaboration through the entire value chain is necessary. Management on farm is also key, as well as a more holistic approach to a future sustainable food system and increased farm profitability. While a lot of the knowledge and techniques required already are available, further innovation and development is necessary going forward. More accurate methods to calculate climate impact and sustainability of food are needed. New technology within digitalization and sensors including precision farming of livestock as well as ley and new developments within cattle and plant breeding are necessary. There are also great opportunities within the area of feed ingredients and additives, including methane reducing methods. The area of roughage production harbors large potential from several sustainability aspects. Animal health and lifetime production will continue to be in focus.

The cost of the required on-farm investments must be shared between the stakeholders in the food chain. A smaller price increase for consumers, that goes directly to primary production, can enable technology leaps and further development of the sector.

CONCLUSION

Swedish dairy production is central to sustainable food systems of the future. Climate impact can be reduced in line with the Paris agreement and climate neutral farming by 2050 can be achieved, without compromising biodiversity, animal health and welfare, while increasing food and bioenergy production. Within the framework of the "global methane budget", it is important that a higher proportion of cattle are kept where conditions are most suitable and sustainable, and in all, this can be seen as a growth opportunity for Swedish dairy production in the future.

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Activating the Let's Eat Healthy initiative in schools and beyond: milk and dairy's important role in sustainable, healthy eating patterns for children and families

AUTHOR
Ashley Rosales, Kristal Shelden, Megan Holdaway, Shannan Young, Tracy Mendez
Dairy Council of California, Sacramento • USA

arosales@dairycouncilofca.org

ALIGNMENT WITH SDGS

ABSTRACT

Achieving the United Nations Sustainable Development Goals requires collaborative, multi-sectoral approaches to build sustainable and resilient food systems. With rising rates of food insecurity and malnutrition, solutions are needed to increase diet quality and provide nutrition security, while meeting sustainability targets. Sustainable nutrition focuses on ensuring wholesome, nutrient-dense foods are accessible, affordable and culturally relevant while also preserving environmental resources and supporting local communities. The public health crisis brought on by the COVID-19 pandemic intensified disparities for underserved populations, presenting challenges and opportunities to supporting nutrition security, particularly for children, as childhood nutrition affects the ability to succeed in school and life and can determine future health outcomes. Schools are the heart of communities, providing services and a critical safety net to children and families. Dairy Council of California activated the Let's Eat Healthy initiative to find collaborative solutions to improve nutrition in the school environment by helping increase access to school meals during the onset of the pandemic, innovating to make nutrition education more accessible during extended school closures, and integrating nutrition education and food access together through partnerships. Navigating challenges in a rapidly changing environment requires people and organizations to work together, across disciplines, to leverage knowledge, experience, resources, expertise and creative thinking. Improving access to nutritious foods, like milk and dairy foods, as well as nutrition education will be most effective when done through collaboration, as organizations can discover and scale innovative solutions to ensure children are supported to grow healthfully and reach their full potential.

> "Access nutritious and culturally appropriate foods is a core component of sustainable nutrition and vital to achieving nutrition security."
>
> **Riana Reinecke**

INTRODUCTION

Dairy Council of California is a nutrition organization that collaborates with other local, state, national and international organizations or agencies to elevate the health of children and families through the pursuit of lifelong healthy eating habits. The organization's science-based nutrition education resources, Farm to School assemblies, professional development programs and online resources educate millions of children and families in California and throughout the United States, demonstrating the dairy industry's contribution to community health and sustainable nutrition.

In June 2020, Dairy Council of California launched Let's Eat Healthy, an initiative that brings together educators, health professionals, change-makers, and community leaders to elevate the health of children and families. Let's Eat Healthy invites multidisciplinary coordination, collaboration, and co-creation to champion community health by teaching and inspiring healthy eating habits and making healthy, wholesome foods accessible and affordable to all California's diverse communities.

MATERIALS AND METHODS

The abrupt closure of schools at the onset of the COVID-19 pandemic disrupted meal service for millions of children. To support families and school communities, Dairy Council of California partnered with the California Milk Processor Board to develop a landing page for information on meal sites and a state-wide public awareness campaign. The site provided information on school meal sites across the state and eventually expanded to include food bank locations and distance learning nutrition resources.

Through partnerships with educators, Dairy Council of California adapted its Let's Eat Healthy K–12 curriculum and resources to ensure that children and families were supported with nutrition education during the pandemic. Adaptations included a variety of co-created online resources that easily embed into online learning platforms featuring digital documents, short and informative videos, and grade-appropriate quizzes and games. A new Technology Tutorial Guide walked educators through the process of downloading and

embedding resources into online learning platforms and apps for quick and easy implementation.

The shift to remote learning also applied to Dairy Council of California's Farm to School program, Mobile Dairy Classroom (MDC). MDC is an assembly that brings the farm experience which includes a live dairy cow to students, teaching them how milk and dairy foods get from the farm to the table and how they contribute to a healthy eating pattern. During the 2020–2021 school year, MDC collaborated to begin innovative virtual field trips, combining the traditional experience of an assembly with a virtual farm tour.

RESULTS

The campaign and landing page for information on meal sites became a valued resource for California school districts and communities, supporting 528,797 website visits, including 467,823 unique views. Approximately 40% of viewers sought information in Spanish. This effort to ensure students with the greatest need received healthy meals that include milk and dairy was effective because of the collaborative, innovative efforts of individuals and organizations. Perhaps in part due to efforts such as this, participation in the National School Lunch Program in 2020 declined less in the state of California than the national average.

Shifting to remote education models enabled teachers to continue instructing children and families on healthy eating patterns that include nutritious, high-quality foods. The collaborative effort with educators to adapt resources for online learning and continue teaching nutrition despite the challenge of not meeting in person enabled 4.4 million California students and families to engage with Let's Eat Healthy nutrition resources during the 2020–2021 school year. Over 225,000 students, families, and classrooms engaged with dairy farmers and agriculture instructors through a livestream viewing from the farm.

DISCUSSION

Making sure people are supported and able to access nutritious and culturally appropriate foods is a core component of sustainable nutrition and vital to achieving nutrition security. Schools support children's overall health and well-being by providing nourishing meals, especially for those living in socioeconomically disadvantaged communities or food-insecure homes. Student participation in school meal programs is associated with higher intake of dairy foods, fruits, vegetables, and whole grains. These food groups support the intake of important nutrients that are typically under consumed, making school meals an important source of nutrition for many children.

Teaching nutrition education is also part of the solution to address sustainable nutrition. Teachers can make an important contribution to the knowledge and dietary habits of children and these learned skills and positive health behaviors support physical, social, and emotional health, as well as academic success. Moving forward, it is vital that virtual resources remain accessible to children in both traditional and non-traditional learning environments, as well as those outside of the school environment.

Beyond the pandemic, virtual field trips will continue to be an important tool to increase access to educational opportunities for students who may not otherwise be able to participate. Teaching sustainable nutrition through Farm to School programs helps bridge the knowledge gap between agriculture and the food students eat, resulting in a greater awareness of the role agriculture plays in a healthy diet, while a virtual format makes experiential learning accessible to more students, families, and communities around the world.

CONCLUSION

The Let's Eat Healthy initiative is one vehicle for bringing people together to find creative solutions to address adaptive challenges such as those presented during

the COVID-19 pandemic. Through efforts to improve access to school meals during the onset of the pandemic, innovation to make nutrition education more accessible during extended school closures, and the integration of nutrition education and food access through creative partnerships, Dairy Council of California activated the Let's Eat Healthy initiative to find solutions to improve nutrition and access to milk and dairy foods in the school environment.

Successful multidisciplinary collaboration that focuses on overcoming adaptive challenges with aligned strategies creates opportunities to positively impact the educational, health and wellness outcomes for children and families, supporting their nutritional needs within the school environment and beyond. To navigate the challenges in a rapidly changing environment, people and organizations must work together, across disciplines, to leverage knowledge, experience, resources, expertise and creative thinking. Improving access to healthy food and nutrition education will be most effective when done through collaboration, as organizations can discover and scale innovative solutions to ensure children are supported and have access to the nutritious foods they need.

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INTERNATIONAL DAIRY FEDERATION
70/B, Boulevard Auguste Reyers
1030 Brussels - Belgium
Tel: +32 2 325 67 40
Email: info@fil-idf.org

@FIL_IDF
International-dairy-federation
@international dairy federation
www.fil-idf.org