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Animal welfare in Norwegian dairy production: a comparison of large and small scale facilities

By

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List of abbreviations

AMS: Automatic Milking System

BMSCC: Bulk Milk Somatic Cell Count

NMCP: Norwegian Mastitis Control Programme

NRF: Norsk Rødt Fe (Norwegian Red)

OIE: World Organisation for Animal Health (Office International des Epizooties)

SARA: Subacute Ruminal Acidosis

SCC: Somatic Cell Count

TMR: Total Mixed Ration

Abstract

This thesis compares large and small-scale facilities through a literature review to better understand animal welfare in Norwegian dairy production. Concern over the well-being of dairy cows has grown globally and continues to do so. This review investigates the effects of various farming methods, farm sizes, and management approaches on dairy cow welfare. The findings paint a picture of how different factors within herd management impact the general well-being of dairy cows and the relevant contrasts between large- and small-scale farms.

The review evaluates important welfare indicators such as living conditions, feeding techniques, pasture access, health monitoring, and stressors by analysing the literature available on Norwegian dairy farms. Large-scale facilities may experience stress from high-density surroundings and less individualized attention. On the other hand, smaller farms often benefit from more up-close monitoring and care. The review's conclusions contribute to our knowledge of how farm size impacts animal well-being in the Norwegian dairy sector by offering critical insights that may direct the creation of policies and best practices to maximize dairy cows' health and welfare in various production systems. These findings might improve the long-term sustainability of dairy production in Norway and impact welfare standards in the future.

Absztrakt

A dolgozat szakirodalmi áttekintések elemzésein keresztül hasonlítja össze a nagy- és kislétszámú állattartó telepek működését, mellyel célja az állatjóllét vizsgálata a norvég tejtermelésben. A tejelő tehenek jóllétével kapcsolatos aggodalom világszerte jelentős, ezért a tanulmány a különböző gazdálkodási módszerek, gazdaságméretek és gazdálkodási megközelítések hatását vizsgálja a tejelő teheneken. Az eredmények képet adnak arról, hogy az állománygazdálkodás különböző tényezői hogyan befolyásolják a tejelő tehenek általános jóllétét, valamint jellemzi a nagy- és kisüzemi gazdaságok közötti ellentéteket.

A tanulmány a norvég tejgazdaságokról rendelkezésre álló szakirodalom elemzésével értékeli a fontos állatjólléti mutatókat, például az életkörülményeket, a takarmányozási technikákat, a legelőkhöz való hozzáférést, az egészségügyi megfigyelést és a stresszorokat. A nagyméretű létesítmények negatívuma a környezeti hatások nagyobb mértéke és a kevésbé az egyed orientált figyelem. A kisebb gazdaságokban viszont előnyt élvez az egyes egyedek gondozása, mindennapjainak nyomon követése. A tanulmány következtetései rávilágítanak, hogy a gazdaságok mérete hogyan befolyásolja az állatok jóllétét a norvég tejágazatban. Olyan javaslatokat nyújt, amelyek megindíthatják a tejelő tehenek egészségének és jóllétének maximalizálására irányuló politikák és bevált gyakorlatok alkalmazását a különböző termelési rendszerekben. Ezek az eredmények a jövőben javíthatják a norvég tejtermelés hosszú távú fenntarthatóságát, és hatással lehetnek a jóllétet befolyásoló normákra.

1. Introduction

As awareness of ethical farming practices grows, the welfare of dairy cows is becoming a critical concern. Proper welfare management in dairy farming is essential not only for the well-being of the animals but also for maintaining productivity and public trust in the industry. In Norway, the dairy industry is strictly regulated with a solid base set by the Norwegian Animal Welfare Act and the EU legislation. The farmers are responsible for following these regulations and treating livestock humanely [1]. The Norwegian dairy industry is dominated by the Norwegian Red (NRF; Norsk Rødt Fe) breed, known for its resilience, milk quality, and disease resistance, and has long been a foundation of Norwegian dairy farming [2].

Furthermore, Norwegian dairy farms follow standards set by TINE, the country's largest cooperative, which conducts regular welfare audits to ensure compliance with national and EU regulations [3]. These regulatory frameworks and Norway's unique climatic and environmental conditions pose distinct challenges to maintaining high welfare standards, especially when comparing large- and small-scale dairy farms. Large-scale farms may struggle to provide individualized care, potentially leading to welfare issues such as stress from high-density environments or inadequate health monitoring [2]. However, small-scale farms provide more individualized care, which may lead to higher welfare results, especially when it comes to environmental conditions and health monitoring [4].

The review will refer to key welfare indicators such as animal behaviour, health, and environmental factors and highlight the variations in welfare outcomes across large and small-scale Norwegian facilities. The objective is to analyse how different farm management practices affect these indicators, contributing to sustainable and humane farming practices by offering insights to inform policy development and raise welfare standards throughout the Norwegian dairy sector.

2. Literature review

2.1. Introduction to animal welfare in dairy farming

Animal welfare has become increasingly important in agricultural practices, especially in dairy farming, where productivity and sustainability are directly affected by the health and welfare of the livestock [5, 6]. According to the World Organisation for Animal Health (OIE) "Animal welfare means how an animal is coping with the conditions in which it lives. An animal is in a good state of welfare if… it is healthy, comfortable, well nourished, safe, able to express innate behaviour, and if it is not suffering from unpleasant states such as pain, fear, and distress" [7]. There are difficulties in putting high welfare standards into practice in dairy production [8, 9]. Despite robust legal frameworks like the Norwegian Welfare Act and EU regulations, Norwegian farmers must compromise welfare gains and financial sustainability [1]. Large expenditures in housing, feed quality, and health monitoring are necessary to maintain high welfare levels, and small-scale farms may find this particularly difficult. Small-scale farms have fewer resources for infrastructure and technology, which might contribute to a financial struggle to maintain good welfare standards. Even though these farms might offer more individualized care, implementing welfare improvements might be expensive [10]. On the other hand, large-scale farms frequently find it challenging to provide each animal with the specialized care that they require since high-density settings can result in problems like stress and improper monitoring, making it more difficult to meet welfare standards [2, 10]. Despite these challenges, it has been demonstrated that improving animal well-being significantly impacts farm sustainability and long-term productivity [2].

2.1.1. Historical overview of dairy farming practices and animal welfare

Dairy farming has experienced major changes throughout the centuries, especially in Norway, where small-scale, traditional agricultural practices dominated the landscape for a large portion of history. Small, family-run farms were the norm in the early days of dairy production. During the grazing season, cows were given access to natural pastures and housed in basic barns [11]. The animals frequently shared space with the farm family in multipurpose barns that provided little distinction between living and working areas [11–13]. Seasonal changes played a significant role in feeding practices throughout this time. While farmers stored hay and other available feed to maintain their animals throughout the winter, cows mostly grazed on open grassland during the summer, taking advantage of the natural vegetation [14]. The limited resources and technologies available at the time were reflected in this seasonal feeding pattern,

which led to inconsistent productivity throughout the year [2, 15]. Due to limited resources and dependence on natural feeds, weather and growth conditions substantially impact production efficiency [16]. Milking and other duties were done by hand, and farmers used little machinery and labour-intensive daily routines. Observation and experience were the foundations of animal care, frequently missing the organized health monitoring procedures used today [17]. Despite these drawbacks, small-scale farms could offer more specialized care because farmers interacted closely with their animals, which enhanced animal well-being by allowing for more tailored attention [5]. However, this individual attention was frequently overlooked due to limited resources, which affected overall productivity and animal health [4].

Industrialization and technology brought about changes in the 20th century which naturally influenced the practice of dairy farming. This way, smaller traditional farms were slowly replaced by larger, efficient operations with robotic milking systems, allowing farmers to manage greater herds with less effort [18]. Mechanization also improved productivity through innovations in feeding systems, manure management, and other processes. However, the scale of these operations led to welfare concerns as individual attention to cows became more challenging to maintain, resulting in overcrowding and increased animal stress [18, 19]. While boosting milk output, this transformation created new challenges in maintaining animal welfare in larger, industrialized systems [18].

In the past, dairy farming focused on addressing the cow's basic physical needs, like food and shelter, with little regard for their welfare beyond that. As the dairy industry developed, new concerns were brought to the surface, especially so in larger farms. Problems such as restricted movement, lameness, and mastitis became more common, particularly in intensive systems [20]. In response, modern welfare principles now emphasize not only the physical health of dairy cows but also their physiological well-being and ability to express natural behaviours [21]. Regulatory frameworks such as the Norwegian Animal Welfare Act aim to ensure that cows have adequate living conditions and health monitoring, reflecting a more holistic approach to welfare [22]. The increasing importance of ethical farming practices has also influenced consumer demand, driving farmers to adopt better welfare standards [23].

2.1.2. Key animal welfare principles in modern dairy farming

Welfare regulations that align with national and EU frameworks strictly govern dairy production in Norway [1]. Giving cows a balanced diet and constant access to clean water is one of the fundamental welfare concepts [24]. High-quality forage, predominantly pasture, and

supplemental feed are prioritized in Norwegian dairy systems to sustain health and milk output, with feeding techniques tailored to the nation's climate [3, 25]. Proper nutrition is essential for preventing metabolic diseases and ensuring that dietary needs are met even in colder months when pasture is unavailable [15].

Housing systems in Norwegian dairy farms are designed to promote comfort and allow cows to express natural behaviour. Free-stall barns are widely used. This allows the cows to move freely, rest, and socialize. This system reduces stress, promotes rest, and improves overall welfare [4, 24]. The Norwegian welfare regulations strongly encourage farmers to provide pasture access during the grazing season. This practice supports physical and mental well-being by allowing cows to engage in natural grazing behaviour [2].

Health monitoring is another vital component of maintaining welfare standards in Norwegian dairy farming. Veterinary care and regular monitoring for detecting diseases like mastitis and lameness are necessary to maintain herd health. Many larger facilities in Norway use automated health tracking systems, while smaller farms often rely on closer, hands-on observation by farmers [4, 17]. Regardless of the farm size, early detection and treatment of health issues are critical to maintaining welfare standards [4]. Programs such as the Norwegian Mastitis Control Program (NMCP) reflect the country's commitment to high welfare standards through structured health monitoring systems [25]. To reduce mastitis, the program monitors milk's somatic cell counts (SCC), a key indicator of udder health. This educates the farmers on preventive measures, emphasizing proper milking hygiene, resulting in healthier cows and high-quality milk [25].

2.1.3. Legal and regulatory frameworks for animal welfare in dairy production

Comprehensive rules for handling animals in Norway are represented by the Norwegian Animal Welfare Act of 2009, which places a strong emphasis on treating them with dignity and giving their welfare top priority. To demonstrate an even greater commitment to animal welfare, this Act substituted the previous Animal Protection Act [1]. According to the Act "Animals shall be treated well and be protected from danger of unnecessary stress and strain". They must be provided with suitable housing, adequate food, and necessary care to meet their physiological and behavioural needs [26]. One of the fundamental principles of the Act covers the idea of animals having intrinsic value beyond their production that brings economic results for humans [27, 28]. Across all forms of agriculture, this sets the requirements to maintain the Five Freedoms; freedom from hunger, thirst, discomfort, pain, and fear [29, 30]. Farmers are

encouraged by this viewpoint to treat their animals with respect. Treating animals with this ethical care has been demonstrated to increase public trust, and even result in higher-quality products [28].

Norway's animal welfare standards, particularly those of dairy cows, are often stricter than those of other European countries. For example, while the European Union (EU) Directive 98/58/EC sets minimum animal welfare standards, Norway frequently exceeds these requirements. For instance, Norwegian farms generally provide more space per cow, which helps reduce stress and health problems, especially in larger farms [31]. A comparison of dairy farms in Norway and Sweden found that Norwegian cows had greater access to outdoor areas and were less prone to lameness and mastitis – two common health issues in confined farming systems [17]. Norway's largest dairy cooperative, TINE AS, upholds even stricter standards through its welfare audits, which check for cow cleanliness, udder health, and adequate space. These checks impact milk quality by maintaining cow health and hygiene. The Norwegian Mastitis Control Program, developed by TINE AS, enforces higher hygiene standards than typical EU guidelines, leading to reduced somatic cell counts, a key indicator of milk quality and cow health [30]. Studies indicate that lower somatic cell counts contribute to a longer shelf life and improved milk quality [32].

The focus on pasture access is a unique feature of dairy production in Norway. In contrast to many European nations where dairy cows are increasingly housed in-doors throughout the year, Norway requires mandatory outdoor grazing, with a specific minimum grazing time [33]. This method gives the cows a more stimulating environment that meets their physical and behavioural demands by promoting their freedom of movement, natural grazing, and interaction with their surroundings [34]. The freedom to exhibit natural behaviours, which is frequently violated in year-round indoor housing systems, is one of the Five Freedoms that this condition directly supports [29, 34].

Studies indicate that access to pasture has many positive effects on dairy cow health [35]. Cows that graze have a significantly lower risk of developing metabolic and digestive issues like acidosis, resulting from high-grain diets often used in in-door feeding systems [36]. The prevalence of lameness, a condition frequently observed in confined housing and often brought on by extended exposure to hard flooring and limited mobility, can be reduced with pasture access [37]. Cows with access to pasture can walk on softer ground, be provided with more room, lessening the strain on their joints and hooves, and lowering the chance of lameness [24, 37].

Norwegian cows‘ access to pasture also contributes to improved milk quality [38]. Milk from pasture-grazing cows often has a better fatty acid profile, including higher omega-3 fatty acids, which benefit human health [39]. This improvement comes from the high-quality grasses and forages cows eat on pasture, adding more nutrients than grain or silage-based indoor diets [40]. In Norway, where consumers value high-quality dairy, these nutritional benefits help meet the demand for milk produced ethically and healthily [41]. Pasture access also benefits cows' mental well-being. Grazing allows cows to forage naturally, reducing stress and improving welfare by lowering aggressive or repetitive behaviours often seen indoors [34].

2.2. General welfare indicators in dairy farming

As previously discussed, Norway has a reputation of its high welfare standards which are supported by strict regulations and effective practices [26]. Observation and monitoring of the cows´ health and behaviour, having regular veterinarian on-site inspections, providing balanced nutrition and prioritising proper housing conditions are important areas for assessing a picture of the welfare of the farm [30, 31]. Evaluating and comparing these practices with those of other European countries helps to clarify in what areas Norway excels, and where there could be room for improvement, additionally highlighting the challenges that arise in the different farming systems of small- and large-scale facilities [6, 41].

2.2.1. Health and disease incidence

Mastitis, lameness and reproductive problems are common challenges in dairy farming, which workers and veterinarians see on a daily basis [42, 43].

In Norway, the focus on disease prevention has led to notable results [30]. Farms implementing targeted programs, such as NMCP, achieve lower somatic cell counts and reduced cases of clinical mastitis [30]. Improved udder health directly affects milk quality and has a positive effect on the profitability of the farm [30]. On the other hand, maintaining such high standards can be challenging, especially so for smaller farms that may struggle with associated costs [41]. Norway´s proactive approach to disease management contrasts with the practices seen in other countries. In the neighbouring country Sweden, where animal welfare regulations are also stringent, the outcomes are somewhat comparable. However, emphasising pasture access and outdoor time in Norway often leads to fewer lameness issues [31]. In the Netherlands, dairy farms benefit from advanced veterinary care, but higher herd densities can contribute to

increased cases of lameness and mastitis, despite strong management practices [44]. In countries like the United States, intensive farming often presents a different set of challenges. Larger herd sizes and confined housing systems can increase the incidence of lameness and reproductive issues due to limited space and reduced mobility [42]. While the U.S. has made strides in disease monitoring and treatment protocols, the higher prevalence of health issues compared to Norwegian farms underscores the impact of Norway´s integrated welfare strategies [45]. Maintaining Norway´s high standards involve significant effort, especially during challenging weather conditions when pasture access is reduced. Farms need to adapt indoor management to continue preventing health problems, which can include implementing advanced flooring materials and enrichment to mimic outdoor conditions [46]. While beneficial, these adaptations can increase operational costs and complexity, posing challenges for small- to mid-sized farms. The impact of robust health management influences the economy in addition to welfare. Healthier cows with fewer instances of disease contribute to longer productive lifespans and reduced veterinary costs, which is crucial for sustainable dairy production. Additionally, improved milk quality marked by lower somatic cell counts, supports consumer trust and market competitiveness [37].

2.2.2. Behavioural indicators of welfare

Since animal welfare is a multidimensional concept comprising both physical and physiological aspects, it is not always easy to establish the welfare status of a farm [47]. Common welfare assessment protocols such as The Welfare Quality Protocol include welfare indicators such as feeding behaviour, housing, health and behaviour [47]. When cattle perform play behaviour and the farm allows and provides appropriate environmental stimulation, positive social behaviour can be seen amongst the cattle [48]. Play behaviour is observed when the young seek partners to play with and entice playing behaviour which is a good welfare indicator especially in young animals [48]. Play behaviour and socialization is more commonly present when the primary needs of the cattle are met [48]. In fact, play behaviour is absent when the animal is ill or injured [48]. It was found that animals kept in open, larger areas showed more instances of social play, increased locomotion like bucking and trotting and social licking when compared to their counterparts in restricted areas [48]. Social licking can be seen in all age groups of cattle; in young cattle, it can be seen as a redirected suckling behaviour; however, in adults, it can point toward the welfare state of the herd as it can indicate boredom or social tension [48]. Reduced grooming behaviour such as self-licking and scratching can reflect poor housing

conditions, such as slippery floors, whereas increased self-grooming is observed when enough flooring space is provided [48]. However, increased self-grooming can also be associated with improper farming techniques, like unhygienic conditions and ectoparasitic infestations [48].

Lameness is an issue arising for multiple reasons and is cattle´s most important welfare problem [49]. Lameness can be detected using locomotion scoring techniques whereby the gait is described and scored numerically based on severity or automated detection systems [49]. Besides observing the gait, cow welfare can also be described by observing the body condition of the cows' hocks, and leg hygiene, contributing to lameness in cattle [49]. Other causes of lameness include infectious origins and poor farriery [49].

Another indication of lameness is the cattle´s lying behaviour [49]. Cows strongly desire rest and spend at least 12-14 hours per day in lying bouts [49]. Hence, an alteration in their total resting time can be associated with lameness and welfare, although multiple factors contribute to lying time [49]. Lame cows would spend longer lying down compared to non-lame cows by increasing the time spent for every lying bout and decreasing the amount of bouts, probably to put less pressure on the lame feet by avoiding the process of lying and standing between the changing of bouts [49].

Aggressive behaviour and fighting can arise when new additions are made to the herd to assert dominance and establish a new hierarchy, usually a process which lasts 2-4 days [49]. With this, animal regrouping and density are important factors regarding animal welfare [50]. Studies show that a high animal density has negatively impacted the herd where decreased growth rate, decreased feed conversion ratio, and lying time have been recorded in dairy heifers [50]. Feeding behaviours can be used to understand how the animal sees the food offered and the level of hunger experienced, additionally providing a reflection of the animals' stress levels [50]. Food accessibility is essential to reduce the stress of competition for resources like feed and water [51]. Abnormal behaviour that can be described as stereotypies appear in the form of functionless and repetitive behavioural patterns and can be an indication of welfare problems [52].

2.2.3. Grazing cattle vs. intensive feeding

Method of feeding and housing in dairy facilities also sets a foundation for the overall welfare of the cows. Grazing and pasture access allows for a more natural way of foraging and leads to less metabolic disorders compared to intensive feeding systems[37]. The consumption of fresh forage in grazing systems promotes rumen function by maintaining a healthy pH balance and

reducing the risk of acidosis, a common issue in grain-heavy diets used in confined housing [53].

Additionally, other natural behaviours of cows, such as exploring and interacting with their environment, contribute to improved mental welfare and lower the incidence of stereotypic behaviours such as repetitive tongue rolling, which often is observed in confined indoor housing [37]. Grazing systems provide the cows with access to enough forage, which minimizes competition and aggression over feed. On the other hand, intensive feeding systems often restrict movement which may result in frustration and stress, especially in case of subordinate cows struggling to access feed at the feeding trough, leading to competition [47]. Pasture grazing cows often consume a more diverse diet of high quality grasses, supporting the milk composition and nutritional quality, providing the farm with decreased SCC numbers [38].

Intensive feeding in indoor housing facilities present several challenges for the welfare of the cows. These systems often rely on energy-dense and high grain diets which are designed to maximize milk yield, and may disrupt the rumen balance which leads to metabolic disorders [53]. Limited movement combined with the typical hard flooring of indoor housing, often promote lameness and other health problems [37]. Compromised behavioural welfare in these intensive systems, often present as aggression and social competition within the herd, as well as boredom and stereotypical behaviour due to lack of environmental enrichment [47]. However, intensive systems offer certain advantages that pasture-based systems cannot always provide [37, 53].

Keeping of the cows in such a restricted manner, allows for controlled and up-close individual monitoring and management of nutrition among other welfare indicators, making more accessible to evaluate the welfare standard of the herd [53]. In the same way, veterinary care is more accessible due to the early detection of disease, giving the farmers a chance to improve housing conditions and treat the animals [43]. There are also nutritional benefits with the intensive feeding system related to colder months, where in contrast the pasture will be of decreased value or simply not available [37].

2.2.4. Environmental and housing conditions

Housing conditions provided by the farmers, together with the surrounding environment of the cows, have a significant impact on the animals' welfare. Factors such as space per animal, cleanliness, ventilation and prevention of overcrowding are crucial for maintaining physical and mental health. Poor housing conditions can exacerbate health issues such as mastitis,

lameness, and respiratory diseases, while also restricting cows' ability to express natural behaviours, which is a fundamental principle of good welfare [47]. Norway´s approach to managing these welfare indicators stands out for its strict regulations, which ensure higher standards of care compared to many other countries.

The amount of space allocated to each cow directly impacts their ability to move, rest, and interact with others. In Norway, loose housing systems must provide at least 6 square meters per cow, as specified in the *Regulations on the Welfare of Production Animals* [33]. This ensures cows have appropriate room to lie down, stand, and move freely without being crowded by herd mates. Additionally, Norwegian regulations have progressively phased out tie-stalls, a housing system that restricts physical movement along with other important needs of a cow in terms of natural behaviour. The construction of new tie-stall barns have been prohibited since 2004, and existing facilities must transition to loose housing systems by 2034 [54]. Norwegian farmers who are still practicing dairy farming with tie-stall barns are required to either renovate their facilities to comply with new standards or fully shut down the operations by this deadline. By contrast, tie-stalls are still permitted and widely used in several other countries, although their prevalence varies. In Canada, approximately 73% of dairy farms employ tie-stall systems, while in the United States, around 39% of farms use this housing type [55]. In Germany, tie-stall housing remains prevalent, particularly among smaller dairy farms. As of 2020, approximately 35% of all dairy farms utilized tie-stalls, accounting for about 11% of the dairy cow population [56]. In Switzerland, around 40% of farms still use tie-stalls, although there is a gradual transition to free-stall systems as part of a movement toward more welfare-friendly housing [57]. These examples highlight the varying pace at which countries are addressing the welfare concerns related to space and housing. Providing more space per cow, as seen in Norway, promotes better hoof health by reducing the time cows spend standing in crowded conditions, which is a common risk factor for lameness. It also allows subordinate cows to avoid dominant animals, minimizing stress and physical conflicts [47]. On the contrary, phasing out tie-stalls can be financially challenging, especially for smaller farms. The renovation which it requires to meet standards of loose housing may not be feasible for all facilities. This is a particular issue in densely populated countries, such as the Netherlands, where high land costs exacerbate the difficulty of expanding housing facilities [58].

Hygiene standards and maintenance of cleanliness in dairy facilities are crucial for preventing diseases such as mastitis, which often is linked to dirty bedding and manure accumulation [59]. Norway´s strict enforcement of hygiene standards by Mattilsynet (the Norwegian Food Safety Authority) plays an important role in maintaining clean and comfortable environments for dairy

cows. Inspections ensure that walkways, stalls, and milking areas are regularly cleaned, and bedding is replaced to minimize bacterial contamination. These measures contribute to the lower SCC observed in Norwegian dairy farms compared to farms in countries with less stringent regulations [30].

The air quality and ventilation systems of farms is an important part of the general foundation of welfare. Improper ventilation may lead to complications such as the accumulation of ammonia and other harmful gases. This further increases the risk of pneumonia and other respiratory diseases in cows [42]. Additionally, the air quality can be negatively affected by the type bedding material used in the facility. Straw or sawdust may be comfortable for the cows to rest on, but can release small dust particles, which can worsen the air quality in poorly ventilated barns. These particles can irritate the respiratory tract of cows, leading to bronchitis or allergic reactions, especially in combination with humidity or ammonia [59]. In Norway, regulations require minimum ventilation rates in dairy facilities, with requirements adapted to barn size and cow density [33, 59]. Most Norwegian farms incorporate natural ventilation systems, which help disperse harmful gases and reduce airborne dust. These systems are cost-effective, environmentally friendly, and particularly suitable for Norway´s moderate climate. This semi-open housing method is often combined with pasture access, where the cows can freely enter and exit.

Figure 1: Typical Norwegian semi-open housing system with natural ventilation, allowing cows to freely enter and exit, supporting natural behaviour and improving welfare.

In contrast, countries with large scale-operations, such as the United States, often rely on mechanical ventilation systems, which provide greater control over air quality but can fail during power outages or equipment malfunctions [55]. Farms in regions with extreme climates,

may face additional challenges in maintaining consistent air quality, particularly in winter when barns are sealed to retain heat, causing an accumulation of gases and dust particles. Norway´s use of natural ventilation offers a variety of advantages; ensuring consistent air quality, reducing risks posed by bedding-related dust particles and simultaneously supporting cows' natural behaviours such as grazing and adequate movement by the open housing solution.

2.3. Large vs. small-scale facilities

2.3.1. Animal welfare challenges in large-scale dairy farms

In Norway, challenges in animal welfare of large-scale dairy facilities are often related to the herd size increasing to meet production demands. Larger farms tend to have economic benefits, but often face difficulties with managing overcrowding, stress factors, prevention of disease and particularly individual cow welfare [60]. These challenges may lead to compromised health and general well-being of the animals and requires strict adherence to Norway´s welfare regulations [30, 33].

Overcrowding is a critical concern in large-scale dairy systems. Higher stocking densities tend to restrict cows´ freedom of movement as well as the access to essential resources. Norwegian regulations require a minimum of 6 square meters per cow in indoor loose housing systems [33], a standard designed to alleviate crowding-related stress. However, larger farms often struggle to meet these requirements, particularly in regions with limited land availability of high costs [31]. In overcrowded facilities, dominant cows often monopolize feeding and resting areas, leaving subordinate animals with limited access, which increases aggression, competition, and chronic stress [47]. Chronic stress impairs welfare, reduces milk yield, and compromises immune function of the cows [41].

Norway alleviates overcrowding through mandatory grazing periods, requiring cows to have outdoor access for a minimum of 8 week per year during the summer months [33]. This outdoor access allows cows to graze freely, interact naturally, and exercise, reducing stress and the risk of lameness associated with prolonged indoor housing [47, 60]. Grazing also facilitates natural behaviours such as foraging and social interaction, which are crucial for cow welfare [37].

Lameness and mastitis frequently occur on large-scale farms. The mechanical and intensive systems ruling the large-scale practice, may increase risk of injury and infection. Mastitis is one of the most commonly occurring diseases in dairy cattle, caused by bacterial infections introduced trough milking equipment, bedding, or environmental contamination. Norwegian studies report mastitis prevalence rates of 20-30% in large herds, with SCC often exceeding

ideal levels when hygiene standards are not consistently met [30]. The NMCP has reduced SCC through regular monitoring, hygienic milking procedures, and early treatment interventions. However, in large-scale farms relying on AMS, mastitis detection can be delayed, as AMS focuses on milk yield and composition rather than physical signs of disease [15, 30, 31].

Figure 2: Severe, recurring mastitis after several antibiotic treatments, worsened by inadequate hygiene.

Figure 3: Separated manual milking of the mastitis cow to prevent contaminated milk from entering the milk tank.

Lameness is often a consequence of intensive systems and usually caused by prolonged standing on hard flooring, insufficient bedding, or inadequate hoof care. Prolonged standing increases the risk of claw disorders, including sole ulcers, bruises, and infections, leading to chronic pain and reduced mobility [42, 59]. Research indicates that Norwegian farms with more than 60 cows report a 30% higher incidence of lameness compared to smaller operations [31].

Figure 4: Decubital ulcer on the hock, likely resulting from continuous pressure from hard or abrasive flooring/bedding.

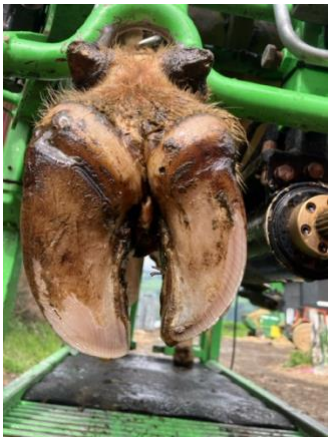

Figure 5: Sole bruising of outer edge of hoof, caused by uneven weight distribution. Often linked to housing conditions such as hard flooring, poor hygiene, improper bedding or limited pasture access.

Figure 6: Septic arthritis in a calf caused by navel infection, exacerbated by damp, dirty bedding and inadequate navel disinfection.

Norwegian regulations require the use of soft bedding materials, such as sand or rubber mats, and regular hoof trimming to be carried out by professionals to improve hoof health and reduce risk of injury [33]. However, maintaining bedding cleanliness in larger herds is challenging due to the high animal traffic, which accelerates bedding degradation and contamination [31, 59, 60].

Free-stall housing systems are the predominant choice in large-scale Norwegian dairy farms. These systems offer cows some movement within confined spaces but lack the natural enrichment provided by pastures, particularly during Norway´s colder winter months. Cows are typically fed a Total Mixed Ration (TMR), a balanced blend of silage, grains, and concentrates designed to maximize milk production [36]. However, TMR diets can pose welfare challenges. High-grain content in these diets is associated with an increased risk of subacute ruminal acidosis (SARA). This metabolic condition negatively affects digestion and milk fat composition [35]. Research comparing feeding systems have shown that TMR can significantly increase milk yield due to its high energy density, however it may compromise rumen health when not combined with adequate fibre intake [36]. The lack of sufficient fibre affects the digestive process and can contribute to conditions like acidosis, which may also lower milk quality [36]. Smaller Norwegian farms, which often include forage-based diets, generally report fewer digestive disorders, reflecting the benefits of balanced roughage for rumen function and overall cow health [35, 36].

Automated feeding systems, a core in large farms, ensure consistent feed delivery but may exacerbate competition at the feeding throughs if space per cow is limited. Norwegian regulations demand a minimum of 70 cm of feeding space per cow to reduce aggressive behaviour and ensure all animals have equal access to food [36]. However, overcrowded feeding areas in large herds remain a concern, possibly leading to stress and uneven feed intake among subordinate cows [35]. Finding the balance between animal welfare and production efficiency remains a challenge for large-scale operations, especially in terms of meeting Norway´s criteria while keeping the farm running economically.

AMS are widely used in large-scale Norwegian dairy farms, while it offers labour savings and operational efficiency. By allowing cows to visit milking stations voluntarily, AMS reduces the stress associated with fixed milking schedules and enables farmers to track milk yield, composition, and SCC in real-time [30]. This precision management approach is particularly beneficial in larger herds, where monitoring individual cows manually can be challenging. However, AMS introduced specific welfare challenges. Overcrowding around milking stations, particularly in herds exceeding optimal system capacity, leads to prolonged standing times,

negatively impacting hoof health and increasing the risk of lameness [15]. Dominant cows may monopolize access to the milking units, forcing subordinate animals to wait longer or visit less frequently. This reduced milking frequency can result in incomplete udder emptying, a known risk factor for mastitis [30]. The study by Østerås and Sølverød emphasized that mastitis remains a major challenge in large-scale Norwegian farms, and while AMS facilitates some monitoring of udder health, it cannot always replace visual inspections for subtle signs of infection [30].

In forced-traffic AMS systems, where cows must pass through milking units to access feed or water, studies highlight disruptions in feeding patterns. Bach et al found that forced-traffic systems often lead to fewer but larger meals, which can predispose cows to SARA due to imbalanced feeding intervals [15]. These systems can also heighten social stress, particularly in subordinate cows, by forcing interactions in confined spaces. Although most Norwegian farms favour free-traffic systems to allow greater freedom, ensuring adequate feeding space and access remains a priority to prevent competition and aggression around feeding areas.

AMS units also influence cow behaviour and movement patterns. The AMS often leads to cows adapting their milking routines to align with an established hierarchy in the herd, where usually higher-ranked cows will benefit from easier access. This social structure may create imbalance in the milking intervals, making the welfare management more difficult. Lower-ranking cows will experience increased stress because of the hierarchy. Additionally, prolonged waiting times for AMS access exacerbate hoof problems, especially in systems with hard flooring that lacks sufficient bedding material to cushion standing cows [15].

Norwegian regulations emphasize farmers to maintain regular hygiene protocols for AMS equipment. For example, the cleaning of teat cups and milking lines is mandated to prevent contamination and reduce the incidence of mastitis. Farms are also encouraged to integrate AMS with natural grazing during the summer months [33]. This practice reduces the time cows spend confined indoors, allowing them to exhibit natural behaviours such as grazing and socializing. Østerås and Sølverød (2009) emphasized that integrating pasture access with AMS helps maintain lower SCC, improving udder health and milk quality while supporting cow welfare [30].

The practice of combining technological innovation with animal welfare distinguishes Norway´s approach from other countries, where AMS is used predominantly in year-round confinement systems. While AMS has proven to increase the efficiency, its successful integration in Norwegian dairy farms reflects a broader commitment to balancing productivity with the welfare of individual animals. The regulations set by Norwegian laws, together with

inspections carried out by Mattilsynet (the Norwegian Food Safety Authority), contribute to maintaining pasture access, hygiene protocols and adequate space for the cows. However, continued innovation and investment are necessary to address the unique demands of large-scale farming while maintaining high welfare standards.

2.3.2. Welfare-benefits of small-scale dairy farms

Small-scale dairy farms in Norway are recognized for their focus on animal welfare. They offer benefits such as close monitoring of individual animals, reduced stress, and opportunities for cows to engage in natural behaviours. These farms generally have fewer than 50 cows [10], with many smaller operations managing herds of fewer than 30 cows [3]. While both sizes provide welfare advantages, the lower end of the spectrum offers even greater opportunities for individualized care and enhanced hygiene. However, small-scale farms do face limitations, particularly in areas where technology may not be as advanced.

Small-scale farms excel in individualized care, which is critical for maintaining high welfare standards. Farmers can observe subtle changes in cow behaviour or milk quality, making easier the early detection of health issues such as mastitis and lameness. Norwegian studies show that farms with fewer than 50 cows have significantly lower disease prevalence compared to larger operations [10]. Specifically, herds with fewer than 30 cows [3] report mastitis rates up to 20% lower than those with more than 70 cows, largely due to improved hygiene and frequent physical inspections [3, 59]. The ability to inspect each cow manually during milking or feeding allows farmers to act quickly, minimizing complications.

Hygiene is another area where small-scale farms have an advantage. The smaller herd sizes allow farmers to dedicate more time to cleaning stalls, bedding, and equipment. Compliance with TINE hygiene standards is over 95% in farms with fewer than 30 cows, compared to 85% compliance in larger herds [3]. This focus on cleanliness reduces the risk of infections and other health problems, directly benefiting cow welfare and milk quality.

Reduced herd sizes naturally decrease competition for resources such as feed, water and resting areas. Norwegian welfare regulations specify a minimum of 6 square meters per cow in loose housing systems [33], but many small-scale farms provide more space, giving cows greater freedom to move and interact. This extra space benefits subordinate cows, reducing aggressive behaviours and chronic stress. The stability of the herd´s social hierarchy in smaller groups also promotes psychological well-being, with fewer signs of anxiety or restlessness compared to larger herds [10].

Human interaction is a unique part in defining the welfare benefit of small-scale dairy facilities. Farmers with smaller herds typically spend more time with each cow, averaging 30 minutes per day on direct care, such as feeding, grooming, and health monitoring [3]. This regular interaction creates trust and reduces fear of humans, making cows calmer during handling and veterinary visits. Research shows that cows accustomed to frequent, positive human contact exhibit lower stress levels and greater overall welfare outcomes [10, 59].

Grazing plays a key role in the feeding practices of Norwegian small-scale farms, particularly during the summer months when outdoor access is mandatory. Farms with fewer than 30 cows often exceed the legal requirement of 8 weeks of grazing annually, providing cows with access to natural forage [3, 33]. Grazing supports rumen health, reducing the risk of metabolic disorders such as acidosis, and enhances milk composition by increasing beneficial fatty acids, such as omega-3s [35, 36]. This aligns with the demands of Norwegian consumers, who prioritize ethically and sustainably produced dairy products [3].

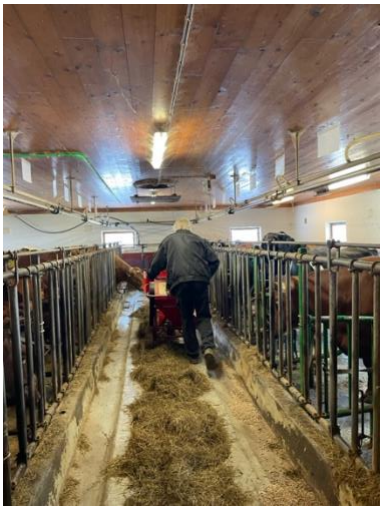

Figure 7: A dedicated small-scale farmer feeding the cows manually for every meal, ensuring individual attention and close observation.

Figure 8: Free-roaming cows during the mandatory grazing period issued by the Norwegian Animal Welfare Act.

Unlike larger operations that rely heavily on TMR diets, smaller sized herds usually feed forage-based diets. These high-fibre diets promote greater digestion and minimize the risk of metabolic imbalances [36]. Additionally, smaller herd sizes ensures that all cows have equal access to feed, reducing competition and associated stress during feeding times. Norwegian regulations mandate a minimum of 70 cm of feeding space per cow, and small-scale farms frequently provide even more, which further minimizes aggressive interactions during feeding [10, 33].

2.3.3. Economic impacts on animal welfare in large vs. small farms

The reality of economic aspects of Norwegian dairy farming has a great influence on the animal welfare. This sets a foundation for how both large- and small-scale farms can address welfare challenges. Each type of farm comes with unique strengths and struggles, particularly as it adapts to evolving welfare regulations. As previously discussed, large farms tend to benefit from their scale, and smaller farms often show advantages with individualized cow care. However, both farming operations face financial pressures that can impact the well-being of their animals.

Large-scale farms often show an economic advantage in that the milk production is more cost-effective overall. Investments in technologies like AMS can help optimize efficiency and is typically seen in large-scale Norwegian farming practices. AMS allow for more flexible milking schedules, while simultaneously reducing labour needs and costs. These systems also provide welfare benefits, such as reduced stress for the cows, as the AMS accommodates their natural milking patterns. However, AMS technology comes with a price tag. Farms with 30 cows or more are better positioned to recover the costs through higher milk yield and labour savings, whereas farms with fewer cows often find the investment impossible [54, 61]. Meeting Norway´s strict welfare regulations add to the financial strain.

The upcoming requirement to transition from tie-stalls to loose housing systems by 2034 is a significant challenge. Research by Halland et al. estimates that the Norwegian industry will need to invest between 18 and 22.8 billion NOK to comply with these new regulations [61]. For many farmers, especially those already managing tight margins, such upgrades are simply not feasible. While larger farms are generally better equipped to make these transitions, the costs remain substantial and can delay other improvements to welfare practices. Additionally, large-scale operations face welfare challenged linked to disease management. High herd densities increase the prevalence of issues like mastitis and lameness, both of which are costly to treat and unfavourable to cow health. Narvhus et al. report that Norwegian farms with herds over 70 cows experience an average annual milk yield loss of 3-5% due to health issues [62]. Even with advanced monitoring systems and regular veterinary care, the scale of operations often limits the individualized attention each cow receives.

Small scale-farms, typically those with fewer than 50 cows, focus heavily on individualized care. Farmers are often able to spend more time with each cow, catching health problems early and reducing stress through regular human interaction [3]. This approach not only supports better welfare but also results in higher-quality milk, particularly in terms of omega-3 fatty acid content, which is valued by Norwegian consumers [3]. As reported in TINE´s Annual Report,

farms with fewer than 30 cows often exceed the legal requirements for grazing time and feeding space, giving cows more freedom, and reducing competition and aggressive behaviour at feeding stations [3, 33]. However, the economics of small-scale farming can be daunting. These farms often face higher costs per litre of milk produced and struggle to compete with larger operations. The shift to loose housing systems is especially difficult. For many farmers managing smaller herds, the required upgrades to barns and facilities are simply not economically viable. Hansen et al. highlight that a significant number of smaller farms are likely to shut down instead of investing in the required infrastructure [54]. Despite these challenges, small farms offer important welfare benefits. Smaller herd sizes tend to present personalized care, improved hygiene, along with reduced stress of the cows due to the greater amount of free grazing. These factors also lower the risk of mastitis and lameness. However, economic challenges often prevent these farms from adopting advanced technologies or expanding their operations.

The economic priorities of large and small farms shape their approach to animal welfare in distinct ways. Larger farms often focus on productivity, using advanced systems like TMR feeding to maximize milk yield. While effective, such systems can increase the risk of metabolic issues, such as SARA, especially when high-grain diets dominate. On the other hand, small farms rely more on forage-based diets, which promote better digestion and overall cow health [36]. Small farms also tend to have stronger human-animal relationships, which reduces stress and improves welfare outcomes. Because larger farms prioritize efficiency over personal attention, these operations find it difficult to provide the same degree of individualized care as smaller farms. Nonetheless, large-scale farms frequently spend money on welfare innovations like climate-controlled barns and precision feeding. Even in large-scale operations, these tools can enhance certain facets of animal welfare.

2.3.4. Farm management practices and their effect on welfare

Farm management practices are setting a foundation for animal welfare and providing farmers with a great opportunity to influence everything from health outcomes to behavioural expressions. In Norway, where welfare regulations are particularly stringent, these practices vary significantly between large- and small-scale farms and between tie-stall and loose-housing systems. Housing type and standards greatly influence health, cleanliness, and overall well-being of the cows. As Norwegian regulations have increasingly shifted farms towards loose-housing systems, cows have been provided with greater freedom of movement and

opportunities for natural behaviour [63]. However, transitions to these systems, such as moving from tie-stalls to loose housing, can initially increase stress and injury rates due to social disruptions and environmental unfamiliarity. Jørgensen et al. observed higher activity levels, increased skin injuries, and reduced rest times during the transition period [63]. Over time, though, cows adapted, with resting behaviour normalizing after one month.

Cleanliness is a critical welfare indicator, influencing both animal health and the quality of dairy products. Ensuring proper hygiene reduces the risks of disease such as mastitis, which is often linked to dirty udders and general poor barn conditions [32]. Proper manure management, regular bedding changes, and adequate barn ventilation are key to keeping cows clean and healthy. In Norway, Mattilsynet (the Norwegian Food Safety Authority) helps ensure high hygiene standards by carrying out regular inspections, often without warning. These surprise visits push farms to stay on track. Dairy farms that fail to meet hygienic standards can face fines, restrictions, or even jail time for serious violations [3, 33, 59]. Studies have also shown that dirty barns are strongly associated with increased SCC and higher risk of mastitis, highlighting the importance of maintaining clean environments [30, 59].

Small-scale farms often have enhanced welfare outcomes due to providing individualized attention to cows. Farmers can monitor health and behaviour more closely, enabling early detection of issues such as lameness of mastitis [30]. However, these farms tend to lack the resources for technologies like AMS or automated health monitoring systems. Compared to larger facilities, this leads to decreased efficiency and the ability to detect subclinical conditions [30]. In terms of diet, small-scale farms frequently emphasize natural feeding practices, including access to grazing during summer and high-fibre diets during winter, which reduces the risk of metabolic disorders such as acidosis [31, 36]. Similarly, findings from Jørgensen et al., showed that cows on smaller farms often benefit from adherence to welfare-oriented approaches [63].

Large-scale operations often present efficiency at the cost of individualized cow welfare [30]. These farms are designed for efficiency and maximizing milk yield, and the welfare challenges differ from small-scale farms. Forced traffic in robotic milking, can improve the milking frequency and reduce labour needs, but may alter feeding behaviour and increase stress for low-ranking cows [64]. Furthermore, overcrowding and competition for resources like feed and resting areas are more prevalent in larger herds, potentially leading to stress and aggression [31]. Disease prevention and cleanliness are also challenging for larger herds. Reneau et al. established a direct correlation between hygiene scores and SCC, with dirtier cows exhibiting

higher risks of mastitis [32]. Effective manure management, regular bedding replacement, and strategic barn design are therefore essential to alleviate these risks in large-scale settings.

Understanding cows´ behavioural responses can be helpful to improve welfare practices among all farming types. Herskin et al. found that cows react with curiosity and alertness when exposed to new stimuli, which can develop into stress [65]. The need for predictable management routines is essential and can reduce stress and other behaviour leading to a hierarchy within the herd. In smaller scale farms it´s easier to maintain consistent routines, also focused on specific cows, when close human interaction has such a large impact on the daily farming practice. However, larger farms can also implement welfare-friendly practices by using technology and standardized procedures to ensure predictability for the herd. Ultimately, the goal is to apply these insights to create better environments for cows, regardless of farm size. Similarly, Hemsworth et al. linked positive human-animal interactions to reduced stress and improved welfare outcomes [28]. These findings highlight the role of educating farmers and workers in low-stress handling techniques, an area where Norwegian farms are increasingly investing. While Norwegian policies demand high welfare standards across farm sizes, striking a balance between productivity and welfare remains a challenge. Innovations like predictive health modelling and targeted training programs for workers have shown promise in enhancing welfare outcomes without compromising efficiency. The study by Østerås & Sølverød demonstrated how proactive mastitis control programs reduced antibiotic use and improved udder health, offering a model for other health challenges [30].

3. Materials and methods

This literature review focused on understanding animal welfare practices in Norwegian dairy farming, particularly comparing the differences between small- and large-scale facilities. To ensure the research was reliable and relevant, a systematic approach was used to analyse and evaluate the sources, either selecting or excluding them from the review. Google Scholar was the main platform for searching for relevant literature, among peer-reviewed articles, journals, reports and books. Search terms included general combinations like "Norwegian dairy farming", "small-scale farms", "large-scale farms", "housing of dairy cows", "dairy cow welfare standards", and more specific wording such as "tie-stall housing", "grazing vs. non-grazing in dairy cows" and "economic sustainability of large-scale dairy facilities". The focus was on finding studies with robust methods and precise results.

The quality of the sources was evaluated by analysing the credibility of their authors and publishers. Preference was given to materials published in well-established journals or by respected organizations in the field. Reference lists of these sources were also reviewed to track down additional studies, ensuring a thorough and evidence-based selection process. Studies specific to Norway were prioritized to acquire insights into its unique dairy industry and additionally focus on the country´s legal framework. Special attention was directed towards research referencing Norwegian laws, like the Animal Welfare Act, and reports from organizations such as TINE AS, whose annual audits provided detailed information about dairy farming practices. International studies were also reviewed to offer comparison. Highlighting welfare practices in other countries, ensured a more rounded view of the topic.

The collected materials were reviewed and compared carefully. Key aspects of analysis included study goals, methods and the reliability of the presented data. Comparisons were made to identify patterns and differences across studies, focusing on welfare indicators like health, behaviour, housing, and feeding practices. Sources that lacked transparency in their data collection methods or analysis were excluded. Similarly, non-academic websites were avoided unless they were official government pages or directly connected to laws or other relevant policies. By combining insights from academic research, government regulations, and industry reports, this thesis offers a thorough exploration of how farm size impacts animal welfare in Norwegian dairy production.

4. Results

This literature review analysed a total of 65 documents to explore animal welfare practices in Norwegian dairy farming, focusing on differences between small- and large-scale facilities. The selected sources were categorized into peer-reviewed articles, books, reports, and websites to ensure a comprehensive and balanced review. Following is a summary of the document characteristics, their findings, and areas of agreement and disagreement.

- Peer reviewed Articles (50): Most of the sources used were academic articles published in reputable journals such as *Journal of Dairy Science, Applied Animal Behaviour Science,* and *Livestock Production Science*. These articles provided valuable insights into welfare topics such as health monitoring, feeding practices, housing conditions and animal behaviour. Their strong research methods and focus on both Norwegian and international perspectives made them essential for this thesis.
- Books (5): Books and certain book chapters were included to provide foundational and historical perspectives on Norwegian dairy farming and animal welfare. These sources added to the discussion with insights into the development and progression of welfare practices and standards over time.
- Reports (6): Industry reports, such as the TINE AS Annual Report and Norwegian welfare audits, provided practical insights into implementing welfare practices. They also included compliance data with Norwegian regulations, such as the Animal Welfare Act, and highlighted challenged faced by farmers in adhering to these standards.
- Websites (4): Government and organizational websites, including those from the Norwegian Food Safety Authority (Mattilsynet) and Lovdata, were used to access legal documents and policy frameworks. Only official websites were included to ensure creditability and reliability.

The selected sources presented various findings on animal welfare in dairy farming. Key insights included:

- Due to smaller herd sizes, small scale farms consistently excelled in providing individualized care. This allowed for better animal health and behaviour monitoring, leading to lower incidence of mastitis, lameness and stress. Grazing opportunities were more frequently utilized in small-scale farms, aligning with welfare regulations and promoting natural behaviours [3, 30].
- Large-scale farms, while efficient and technologically advanced, faced challenges in maintaining welfare standards for larger herds. AMS improved efficiency but often led

to reduced individual attention and issues like overcrowding and competition for resources. Despite these challenges, large farms were more likely to adopt automized technologies for health monitoring and disease prevention [31, 64].

- Legal and regulatory frameworks, such as the Norwegian Animal Welfare Act, were critical in shaping welfare practices. Grazing requirements, housing space mandates and cleanliness standards ensured a high baseline for welfare across farm sizes. Reports highlighted how compliance with these regulations often demanded significant investment, particularly for large-scale farms.
- Comparative perspectives revealed that Norwegian generally performed well in animal welfare compared to international standards. However, studies also pointed out areas where Norway could improve, such as the integration of enrichment practices and the reduction of stress during housing transitions [41, 65].

The reviewed documents showed both consensus and divergence in their findings:

- Areas of agreement: All sources highlighted the importance of grazing opportunities and natural feeding practices in improving cow welfare. The role of stringent Norwegian regulations in maintaining high welfare standards was universally acknowledged. Both small- and large-scale farms were recognized for their unique strengths, with small farms excelling in individualized care and larger farms making effective use of technological advancements.
- Areas of disagreement: The effectiveness of AMS was debated. Some sources emphasized their efficiency and reduced labour needs, while others pointed out potential welfare drawbacks, such as increased competition and altered feeding behaviours [30, 64]. Economic sustainability for small-scale farms under stricter welfare regulations was a challenging issue. While some studies highlighted financial struggles, others argued that consumer demand for ethical farming provided opportunities for small farms to thrive [27, 41].

5. Discussions, conclusions

This thesis sheds light on the challenges and opportunities in Norwegian dairy farming regarding animal welfare, focusing on the differences between small- and large-scale operations. Examining various sources highlights how farm size and management practices can shape welfare outcomes and identify areas where improvements are needed. The results show that small-scale farms often provide more personalized animal care. With fewer cows, farmers have greater opportunity to monitor health and behaviour, leading to lower rates of conditions like mastitis and lameness. Grazing opportunities are also more commonly utilized on smaller farms, supporting natural behaviours and aligning with Norwegian welfare regulations. However, maintaining these standards can be financially challenging. Stricter requirements like transitioning to loose housing systems may lead to operations having to shut down. Previous studies, such as Flaten et al. (2005), highlight small farms' economic strain when balancing welfare improvements with profitability [41]. This remains a significant challenge for smaller farms in the current regulatory environment.

Large-scale farms, meanwhile, often show the advantage of efficiency, technology, prioritizing maximized milk yield. Automated systems, like robotic milking and health monitoring tools, help improve productivity and early disease detection, even in subclinical cases. However, larger herd sizes can lead to welfare issues such as overcrowding and face consequences due to less individualized care. Studies like Simensen et al. (2010) support this, showing that high-density environments can increase stress and risks like lameness [31]. While large-scale farms often have the resources to invest in technological solutions, ensuring consistent welfare improvements across the board is still an area where more work is needed.

Norwegian welfare laws, particularly the Animal Welfare Act, plays a central role in maintaining high standards. Requirements for grazing access and proper housing space, reduce stress and encourage natural behaviours in cows. However, these regulations can be costly to implement, especially for large farms that need to make significant infrastructure changes. Similar challenges were discussed by Almås and Brobakk (2012), who noted the financial pressure on farmers trying to meet both welfare and production goals [27].

Not all sources agreed on specific points. For example, there was a debate about AMSs and its influence on farming practices. Some studies emphasized their ability to reduce labour and improve overall efficiency [3, 30]. Others pointed out negative consequences of AMS like competition, hierarchy, aggression among the cows, and changes to feeding patterns [64]. Another topic of debate was the financial capacity of small-scale farms when adapting to stricter welfare standards. Some studies, like Flaten et al. (2005), highlighted these farms' significant

financial challenges, including the high costs of upgrading facilities and adopting welfare-friendly practices [41]. In contrast, Almås and Brobakk (2012) noted the increasing consumer demand for ethically produced dairy products, suggesting that small farms could use this trend to their advantage by marketing their practices as more ethical and sustainable [27]. These differing views underscore the challenge of balancing economic sustainability and improving animal welfare in the dairy industry.

The findings in this literature review suggest a need for policies and strategies designed to the specific challenges faced by small- and large-scale farms. For smaller farms, financial support, such as grants or subsidies, could help ease the burden of upgrading facilities to meet stricter welfare requirements. For larger farms, investing in welfare-friendly technologies, like better bedding systems or improved ventilation, could help address some of the issues linked to herd density. Further research on the topic is needed to explore the long-term impact of welfare regulations, particularly the transition from tie-stall to loose housing systems, and how these changes affect both welfare and economic outcomes. Analysing Norwegian consumer preferences for welfare-friendly dairy products could also present new opportunities, especially for small-scale farms aiming to market themselves as ethical producers. In conclusion, this thesis highlights the need to balance welfare and productivity in Norwegian dairy farming. Small-scale farms excel in individualized care, while large-scale farms make us of advanced technology, but both practices face unique challenges. By continuing to adapt welfare practices and policies, Norway can set a global example for sustainable and humane dairy farming.

6. Summary

This thesis examines animal welfare in Norwegian dairy farming, focusing on comparing the practices and outcomes of small- and large-scale facilities. Through a systematic review of 65 sources, the study evaluates welfare indicators in dairy farming, such as health monitoring, feeding practices, housing conditions, and behavioural aspects. It highlights key differences between small- and large-scale farms. Small-scale farms stand out due to their personalized care and better use of grazing opportunities, which results in overall healthier cows and lower stress levels. On the other hand, large-scale farms rely on advanced technologies to improve efficiency but often struggle with issues like overcrowding and less individualized attention for the animals. Additionally, the findings emphasize the importance of Norwegian welfare regulations maintaining high standards for farms of all sizes, provided by the Norwegian Animal Welfare Act and the Norwegian Food Safety Authority. However, meeting stricter welfare requirements can be financially challenging for small farms, pointing to the need for policy measures like subsidies to support them. While resourceful in technological adoption, large-scale operations must address issues like lameness and mastitis stemming from herd density. Comparative insights with international standards reveal that Norway leads in some areas, such as mandatory grazing, but can improve further with increased enrichment and stress reduction strategies. The study concludes that balancing welfare and productivity is critical to sustainable dairy farming and brings along unique challenges related to the operational size. Recommendations include financial assistance for smaller farms, investment in welfare-friendly technologies for larger operations, and continued emphasis on ethical production to meet consumer demand. These measures could ensure Norway remains a global leader in humane dairy farming practices.

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Thesis progress report for veterinary students

Name of student: Emma Kristine Vassbotn

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Name and title of the supervisor: Dr. Kiss Annamária, DVM

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Thesis title: Animal Welfare in Norwegian Dairy Production: a Comparison of Large and Small Scale Facilities

Consultation – 1st semester

	Timing			Topic / Remarks of the supervisor	Signature of the supervisor
	year	month	day		
1.	2024	03	13	Discussion of the thesis topic, title, and the content requirements	
2.	2024	03	20	Introduction, checking and discussing the writing of the objectives	
3.	2024	04	9	The process of finding resources, using useful websites and books	
4.	2024	05	14	Discussing how to make the literature background and the materials and methods	
5.	2024	05	24	Improving and discussing the literature review	

Grade achieved at the end of the first semester: 5

Consultation – 2nd semester

	Timing			Topic / Remarks of the supervisor	Signature of the supervisor
	year	month	day		
1.	2024	09	06	Finalization of the literature background, preparation of material and methods	
2.	2024	09	27	Checking material and methods and discussion	

3.	2024	10	12	Discussion of the preparation of results and conclusions	
4.	2024	11	03	Discussion of the summary of the thesis, preparation of the bibliography (Zotero use)	
5.	2024	11	22	Finalization of the thesis, exact placement of figures, correction of captions, checking bibliography	

Grade achieved at the end of the second semester: 5

The thesis meets the requirements of the Study and Examination Rules of the University and the Guide to Thesis Writing.

I accept the thesis and found suitable to defence,

.....
signature of the supervisor

Signature of the student: .....

Signature of the secretary of the department: .....

Date of handing the thesis in: 05./12./2024.....

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