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Dairy cattle welfare – the relative effect of legislation, industry standards and labelled niche production in five European countries

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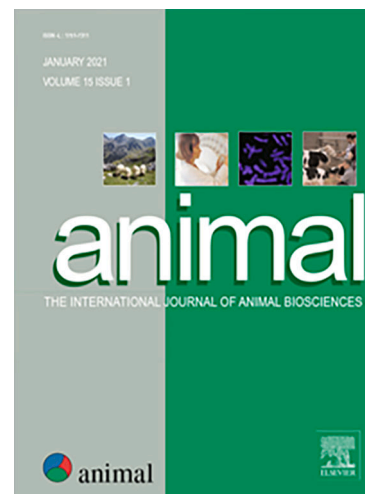
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Dairy cattle welfare – the relative effect of legislation, industry standards and labelled niche production in five European countries

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Abstract

The only common European Union (EU) legislation set up specifically to ensure the welfare of dairy cattle is for calves. As a consequence, there is wide diversity in how dairy cattle welfare is ensured in EU countries. A few countries have legal requirements for dairy cattle welfare, while in others it is left to industry standards or niche production requirements, typically linked to various premium labels. In this paper, we compared animal welfare provisions in dairy cattle production across five countries with different combinations of legislative and other approaches: Denmark, Germany, the Netherlands, Sweden, and the United Kingdom. Firstly, we aimed to map the diversity of animal welfare initiatives. Secondly, we used the Benchmark method of expert valuations and weightings of the relative importance of individual welfare provisions. We found that Denmark and Sweden have the highest level of dairy cattle welfare provisions as measured by the Benchmark method, partly due to

high legislative welfare requirements, followed by the United Kingdom, which has an extensive industry standard with very high uptake. Germany and the Netherlands, on the other hand, have lower levels of documented welfare provisions, and correspondingly a Benchmark score closer to a baseline defined by legal requirements at EU level. We also found differences in what elements of animal welfare were focussed on. Some initiatives emphasized fulfilling the social needs of cattle, while others focused more on space and freedom to move. Also, the countries with the highest Benchmark score had a relatively high level of production of organic and other specialty dairy products. We found the effect of national legislation or ambitious industry standards on dairy cattle welfare to be much larger than previous studies have found in either pigs or poultry. At a time when the EU is considering stepping up its efforts to improve animal welfare in terms of common minimum standards, the results of this study could have important policy implications. The diversity in the level of dairy cattle welfare standards found across countries may speak in favour of having shared minimum standards, both at EU level and globally. However, even among countries with a similar Benchmark score we found a difference in the kinds of welfare provisions at work, which may make full harmonisation of standards more challenging.

Keywords: Animal welfare, dairy cow, policy, marketing, Benchmark

Implications

Animal welfare legislation for cattle in the European Union is only laid down for calves, resulting in a wide diversity in welfare provisions for dairy cattle across countries. By mapping this diversity across five countries, and assessing the welfare implications by using the Benchmark measure, the present study can feed into European policy discussions concerning dairy cattle welfare. Differences in the *level* of dairy cattle welfare requirements found across countries may speak in favour of shared minimum standards. However, diversity in the *nature* of the standards highlighted in this study may make achieving full harmonisation more difficult, both within the European Union and globally.

Introduction

Three kinds of initiatives exist to counteract welfare problems in animal production. The first is animal welfare legislation, where all production systems in the relevant country or region must comply with legally defined welfare requirements. The second consists of private initiatives, which can be part of quality assurance schemes set up by industry or may be part of sustainability or welfare standards defined by a non-governmental organization (**NGO**), a retailer, a fast-food chain, or the like (More et al., 2021). The products of private initiatives may be sold with a particular label, typically at a price premium or, if they dominate the supply side of the market, may effectively define the minimum welfare standards for the country/region (e.g. Red Tractor, United Kingdom (**UK**)). Thirdly, there are hybrid initiatives where the state

defines standards for animal welfare labels which may be used by the industry, retailers, etc. In all three kinds of initiatives, production must meet specific welfare standards. These standards typically prescribe certain provisions in terms of, for example space, quality of flooring and lying area, or availability of different kinds of feed. There may also be prescriptions about management procedures such as regular hoof trimming or the need to register certain health problems and act on them if the prevalence is above a certain threshold. In addition there are requirements for inspection and monitoring of legislation in each country, and sometimes this also applies to private or hybrid initiatives, by independent bodies through third party auditing, to guarantee that the welfare standards are delivered.

For pigs and poultry in the European Union (**EU**), there are common minimum welfare standards that must be reflected in the animal welfare legislation of the member countries. In the case of cattle, besides general requirements (Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes as mentioned above), there is no specific EU legislation set up to ensure common minimum standards – apart from for calves for which there is an EU directive (Council Directive 2008/119/EC of 18 December 2008 laying down minimum standards for the protection of calves). This means that there is large variation between EU countries regarding how dairy cattle can be housed, taken care of and managed, which all affect welfare. This is a situation that both creates opportunities and risks in relation to animal welfare (Lundmark et al., 2018).

A few countries defined additional specific legal requirements covering several aspects of dairy production beyond housing and care of calves, while in other countries a combination of the mentioned private and hybrid initiatives may be applied to a larger extent, depending on the specific development and strategy of the country in relation to animal welfare policy (Keeling et al., 2012). However, there are specific concerns about the efficiency, transparency and oversight of the private initiatives (More et al., 2017, 2021), and there are debates about how best to target these initiatives to relevant groups of consumers (Veissier et al., 2008; Vanhonacker and Verbeke, 2014). Furthermore it has been argued that not enough is known about the actual contribution of legislation and various private initiatives to the prevention of welfare problems and the promotion of good welfare for dairy cattle (Ingenbleek et al., 2012, 2013; de Olde and Busch, 2022). How to combine legislation and private initiatives in policy-making is also not well understood (Vogeler, 2017). More such research has been conducted on initiatives to promote sustainability in other agricultural sectors (Traldi, 2021; Dietz et al., 2022).

If the knowledge gap we have described were to be filled, this would enable various stakeholders, e.g. farmers, dairy industry, retailers, (animal welfare) NGOs and ultimately politicians, not only nationally but also at EU level and beyond, to find new ways to align dairy cattle welfare requirements. Different ways forward would be to implement these requirements in legally defined minimum standards, or to develop various private or hybrid initiatives for the benefit of dairy cattle welfare. This in turn would serve to meet the expectations of many consumers who are known to care about farm animal welfare (European Commission, 2015).

In this paper we compare animal welfare standards in dairy cattle production across the following five countries: Denmark, Germany, the Netherlands, Sweden, and the UK, the first four EU member states, the latter a former EU member state that still

largely complies with EU animal welfare law. These countries were chosen to reflect a diversity of approaches. Denmark and Sweden have elaborate animal welfare legislation for dairy cattle (the legal requirements are dispersed over several legal documents the most important of which in the case of Denmark are the Animal Welfare Act (Danish Veterinary and Food Administration, 2021) and the Order on minimum animal welfare requirements for the keeping of cattle (Danish Veterinary and Food Administration, 2020) and in the case of Sweden are the Animal Welfare Act (Government Offices of Sweden, 2020), the Animal Welfare Ordinance (Government Offices of Sweden, 2022), and the Swedish Board of Agriculture's regulations and general recommendations on cattle husbandry in agriculture (Swedish Board of Agriculture, 2019). Besides separate animal welfare legislation for England, Northern Ireland, Scotland and Wales (with underlying codes of recommendation for the welfare of livestock) the UK has a well-developed industry standard known as the "Red Tractor" assurance scheme that also covers dairy cattle production (Red Tractor, 2022). Germany and the Netherlands have no specific animal welfare legislation for dairy cattle, apart from what follows from the EU directive on calves and from the general provisions of their respective animal welfare laws, but have a relatively large number of private initiatives, in the case of the Netherlands often as part of sustainability programmes. In Denmark, Sweden and the UK there are also private initiatives with specific animal welfare requirements, including organic dairy production.

In the current study, we first aimed to map the diversity of animal welfare legislation and initiatives found in these countries. Secondly, we aimed to assess the welfare provisions of these initiatives by means of the Benchmark method (Sandøe et al., 2020, 2022). This is a method to estimate uptake of animal welfare provisions for production animals at the national level and to evaluate the welfare outcome based on expert valuation and weighting. Using this method, it is possible to compare the aggregated effect of different animal welfare initiatives, whether legislative, private or hybrid. The results of applying this method to pigs (Sandøe et al., 2020) and broiler chickens (Sandøe et al., 2022) are published, but this is the first publication to present results of applying the method to dairy cattle. We found that Denmark and Sweden have the highest level of dairy cattle welfare provisions as measured by the Benchmark method, partly due to high legislative welfare requirements, followed by the United Kingdom, which has an extensive industry standard with very high uptake. Germany and the Netherlands, on the other hand, have lower levels of documented welfare provisions, and correspondingly a Benchmark score closer to a baseline defined by legal requirements at EU level. The results of this study may serve to increase transparency about the diversity of animal welfare provisions in dairy cattle production. Further, it may improve our understanding of the relative role and effect of legislation, private, and hybrid animal welfare initiatives in different countries and thus may help to underpin efforts to improve animal welfare policy in these areas.

Material and methods

As dairy production results in a variety of dairy products, it presents a rather complex case compared to other animal production systems. For example, while the sole product of broiler production is various cuts of chicken meat, dairy production results not only in fresh milk that is turned into a wide array of dairy products, including different forms of drinking milk, butter, cheese, a number of fermented products, and

particularly in exporting countries milk powder for use in baby formula and sports/fitness products, but also veal and beef. To limit the complexity, we focus on primary production, i.e. how the milk is produced on-farm in the five countries, both in the standard and in the various alternative production systems. Thus, with respect to the animals, we focus on the welfare standards for heifer calves, heifers and dairy cows on farm and during transport to slaughter, and do not include the aspects of production that concern veal and beef.

Mapping animal welfare initiatives

To map the diversity of animal welfare initiatives found in the five countries, legislative initiatives, private initiatives by the dairy sectors, NGOs, retailers, etc., and hybrid initiatives involving both governmental and private actors in the five countries were identified. We did this with the help of a network formed from colleagues in academia in each of the five countries, in the dairy sector, in relevant branches of government, and via sources publicly available on the internet or in the literature. We focussed on animal welfare initiatives that covered at least 1% of milk production in each country.

To analyse the animal welfare provisions in each initiative, we first developed a framework that describes various dimensions of welfare provisions for cattle at different stages of their lives. For each dimension, different levels were defined. For some dimensions, it was logical to include more than two levels (e.g. a number of levels of indoor space per animal), while others were dichotomous by nature, e.g. whether tethering is allowed or not. This resulted in a generic framework with 47 specific dimensions that cover different kinds of welfare provisions relating to the different stages of the lives of the animals (see Table 1). Each specific dimension had at least two levels, where the lowest level was “no requirements”. Not all distinctions between levels exactly fitted how levels were defined in the existing initiatives, but the grid was constructed so that all initiatives could reasonably fit in.

Furthermore, the 47 specific dimensions were grouped into 20 intermediate dimensions and six general dimensions (comfort and rest, space and freedom to move, social needs, feeding and drinking, health, and procedures) (Table 1). For a full description of all dimensions and levels, and an overview of how included initiatives are categorized according to the most suitable level within the 47 dimensions, see Supplementary Table S1.

The 47 specific dimensions, with the exception of ‘Mortality and disease load’, concern resources provided to the animals that are considered to matter for their welfare, but they do not report the actual welfare outcome for the animals. This contrasts with so-called animal-based measures, which focus on how the animals respond to what they are provided with and how they are being cared for (EFSA Panel on Animal Health and Welfare, 2012). This choice was made in light of existing welfare initiatives for dairy cattle which, like initiatives for other farm animal species, are nearly all concerned with resources.

Assessing welfare effects of the initiatives using the Benchmark method

The aim of using the Benchmark method was to evaluate and aggregate the combinations of levels in the welfare dimensions that are found in legislation and in

the various animal welfare initiatives. More specifically, each level within each of the specific dimensions was evaluated, for example within the specific dimension 'bedding in lying area for heifers', three levels were evaluated (Slatted floor or solid concrete floor (no requirements as per EU standards); Soft bedding required (e.g. thin rubber mat); Soft bedding that can take form after the shape of the animal (e.g. sand, plenty of straw, rubber mattress, water bed)). Subsequently, each specific dimension, for example 'bedding for heifers', was assigned a weight. The evaluations and assignment of weights were carried out by a number of academic experts in dairy cattle welfare as described in more detail in the next two sections.

Questionnaire to evaluate levels within each dimension and give weight to dimensions

We developed an online questionnaire that allowed experts to give values to each level within the 47 specific dimensions. This was done on a scale from 0 to 10, where the respondents were instructed that 0 represents minimal welfare for the animal in a commercial production system; and 10 represents the best possible welfare for the animals in an existing commercial production system. The importance of each specific dimension was subsequently scored on a scale from 1 to 5. The full content of the questionnaire can be found as Supplementary Material S1.

When deciding on the choice of scales, it was important to strike a balance between being easy to understand and likely to be used in the same way by different respondents, and being nuanced enough to capture differences in opinions. We chose the 0–10-point scale as it is often used in pain-scale assessment tools (Karcioglu et al., 2018), whereas the 1-5-point scale, ranging from 1-not important to 5-very important, is inspired by the Likert scale, which is often used in sociological and psychological research (Jebb et al., 2021).

Eliciting expert opinion

Through a snowball sampling method using the network of the Danish welfare experts in the project team (BF, SSN, and PS) we aimed to identify as many experts as possible in dairy cattle welfare, mainly professors and senior researchers working at universities and other research institutions in Europe, North America and Australasia – areas where typical dairy cattle production systems are similar to those found in the countries being studied in this paper. We identified 65 such experts, who were informed about the aim of the project by mail from the first author of the paper and were invited to fill out the online questionnaire. The invited experts came from Denmark (6), UK (3), Sweden (2), Germany (1), Netherlands (4), Austria (2), France (2), Italy (4), Spain (2), Canada (11), USA (9), Australia (8), New Zealand (6), or were officers from the European Food Safety Agency (**EFSA**) (5).

We received complete responses from 38 of these (response rate 58%). The remaining 27 did not provide valid responses due to one wrong mail address, eight who did not consider themselves as experts, one that did not like the concept, eight that never responded, and nine that only answered some of the questions. By mistake, one question was missing in the online survey, and we therefore subsequently had to get responses to this in an extra request afterwards (we received 32 responses to this question). The survey was conducted in the period from February 14 to March 25, 2022.

Assessing the initiatives using the Benchmark method

For every animal welfare initiative, we calculated Benchmark scores for each of the three groups of animals involved: heifer calves, heifers and dairy cows. For each group of animals, the score was calculated as the sum of the weighted valuations of the relevant levels within each specific dimension. Thus, the problem of aggregation (Sandøe et al., 2019) was handled by a simple additive approach. The three groups of animals contribute to the total Benchmark score with the following relative contributions: heifer calves (1/8), heifers (3/8) and cows (4/8) based on the estimated, respective length of each phase in the life of a dairy cow.

Based on the weighted contributions from the three groups of animals, the total Benchmark score achieved for each animal welfare initiative was calculated on a scale from 0 to 100. Given the values and weights provided by the experts, it is, however, not logically possible to get a Benchmark score below 20.1 and a score above 74.9. Thus, an animal welfare initiative that has the worst possible set of values in each of the 47 specific dimensions will, given the expert valuations and weightings, get a score of 20.1; and an animal welfare initiative that has the best possible set of values in the 47 specific dimensions will get a score of 74.9.

By combining Benchmark scores for animal welfare initiatives found in each country with the shares of the production in each country under each initiative, we calculated the total Benchmark score achieved for dairy production in each country. Thus, the national Benchmark score is a function of the scores of the different animal welfare initiatives found in each country, where each animal welfare initiative weighs in relative to its share of the production in the country. The scores for the animal welfare initiatives in the five countries provided by each expert were compared using generalized linear models with the `lmer`-function in the `lme4`-package (Bates et al., 2015) in R (R Core Team, 2023), using the national Benchmark scores as the outcome variables (see above). The technical replicates were the 38 expert scores. “Country” was included as a fixed effect, and “Expert” was included as a random effect, to take into account the B score for all countries calculated based on each of the responses of each expert. The difference in national Benchmark scores between countries was compared using the `emmeans`-package (Lenth, 2020). The Tukey posthoc test was used and adjusted for multiple comparisons, and an adjusted *P*-value of 0.05 was considered statistically significant. Model fit was assessed through the standardized residuals, which should be independent, identically distributed Normal (0, σ^2).

A baseline level was added to illustrate how much the achieved Benchmark is above the lowest level for the dimensions presented in Table 1, with the exception of measures relating to calves, where the requirements set out in the EU directive regarding calves (Council Directive 2008/119/EC of 18 December 2008 laying down minimum standards for the protection of calves) serve as the baseline. The requirements of the directive include artificial light during daytime in winter to mimic natural light and max 5 lux for at least 8 hours between 6pm and 6am, group housing with at least 1.5 m² per calf, calves may be kept for a maximum of 8 weeks in a single box where they can see and touch other calves, and access to roughage.

Finally, we made a comparison of the relative effects of legislation and various private or hybrid initiatives. Also, we compared the differences in the relative degree

to which each of the six general dimensions had an effect in achieving dairy cattle welfare measured by the Benchmark score beyond the baseline level in commercial production systems in the five countries.

Measure of consistency of ranking between the experts

Finally, we compared how the different experts (based on their valuation and weighting) would rank the five countries to get an assessment of how much the experts agreed. The latter was also estimated using Kendall's coefficient of concordance based on the individual experts' scores.

Results

In Table 2 we present the main groups of animal welfare initiatives found in the five countries and the extent to which they include different types of requirements that go beyond the baseline.

In Figure 1 we provide the aggregated Benchmark scores for dairy cattle production in each of the five countries studied compared to the baseline in 2021 – and with the contribution divided into whether it follows from legislative requirements or from requirements of private and hybrid initiatives that go beyond the legal minimum. In Supplementary Material S 3, there are figures for each of the five countries comparing the Benchmark values for the included welfare initiatives.

[Insert Figure 1 around here.]

The figure shows that the aggregated Benchmark scores differ between countries. A test of whether the experts agreed on whether the aggregate Benchmark differs between countries was carried out. Apart from Denmark and Sweden (adjusted $P=0.07$), and Germany and the Netherlands ($P=0.99$), the countries were pairwise significantly different, all with $P<0.0001$. The common standard error for all bars in the plot was 1.68.

The figure also shows differences in the relative contributions to the Benchmark score from various private or hybrid initiatives. Not surprisingly we found that in the three countries with limited dairy cattle welfare legislation there is a larger effect from private and hybrid initiatives. Such initiatives are also found in the two countries with extensive dairy cattle welfare legislation but here less is added from these initiatives beyond what is covered by the legislation.

Information on the Benchmark scores for the individual initiatives for each of the five countries presented in Table 2 are given in the Supplementary Material S 3.

In Table 3, we aim to map how each country fares in the six general dimensions compared to the average Benchmark score for that general dimension for all five

countries. For example, compared to the average Benchmark score for 'Comfort and rest', the positive numbers for Denmark, the UK and Sweden indicate that these countries place more emphasis on 'Comfort and rest' while the initiatives in Germany and the Netherlands place lower emphasis on this, which in turn generates a lower than average contribution to the Benchmark score.

Finally, in Table 4 we give an indication of the consistency in ranking between observers by showing how the five countries would rank based on the responses of the 38 experts who filled out the full questionnaire. For example, in their valuations and weightings, 35 of them ranked Denmark as having the second highest aggregated Benchmark score, while 2 ranked Denmark highest and 1 ranked Denmark third. Kendall's coefficient of concordance was estimated at 0.91

Discussion

As far as we know, the current study is the first to comprehensively map animal welfare initiatives in dairy cattle production across different countries. We describe combinations of welfare provisions required by standards found in national animal welfare laws, private, and hybrid initiatives and assess the relative uptake of each animal welfare initiative. It is also the first study to present an assessment and comparison of the potential welfare contributions of these initiatives for dairy cattle by means of the so-called Benchmark method. There are other so-called benchmark studies published for dairy cattle (Trillo et al., 2017; Warner et al., 2020; Dachrodt et al., 2022), but unlike this study, they do not aim to present welfare outcomes that enable comparisons across animal welfare initiatives and whole countries, but instead focus on giving the individual farmer a tool to compare and improve practices at the farm.

We found large differences in animal welfare legislation across countries. Most notably, Sweden and Denmark have welfare legislation for dairy cattle that is not found in the other three countries, with the exception of legislation about calves in accordance with the relevant EU Directive (UK is no longer covered by this but still complies). The United Kingdom has an extensive industry standard for dairy cattle, which covered 95% of dairy production in 2021. In comparison, Germany and the Netherlands have much lower protection in terms of legislation than Sweden and Denmark, and lower industry standards than the UK for dairy cattle. On top of this, there are differences in labelling schemes and other private or hybrid initiatives to promote good animal welfare which are found in the market for milk in all five countries but which have a higher uptake in the three countries with the highest level of legislation or industry standards.

Our study found differences not only in the number of welfare provisions, but also in their kind and level. For example, some initiatives put very little emphasis on provisions relating to health such as availability of hospital and sick pens, while other initiatives emphasised their importance (see Table 2). Also, when looking at the Benchmark effects there are interesting differences between countries that are close to each other at the aggregated level. For example, in Denmark there is much less impact from the dimension 'Space and freedom to move' compared to Sweden (see

Table 3) – most likely due to the fact that access to summer pasture is mandatory according to the Swedish but not the Danish animal welfare legislation.

The differences in legislation or other welfare initiatives are reflected in the aggregated Benchmark scores for dairy cattle welfare standards in the five countries. The group that, comparatively speaking, has the highest level of uptake of welfare provisions in legislation, consists of Denmark and Sweden followed by the UK with a Benchmark level well above the baseline. At the other end, Germany and the Netherlands have lower levels of welfare provisions in legislation or private initiatives and a Benchmark level closer to the baseline. Thus, the two countries without national legislation on dairy cattle welfare or ambitious industry standards achieved a markedly lower Benchmark score than the other three. Also, a relatively high level of production of organic and other specialty dairy products of 16-23% in the three countries with the highest Benchmark scores played some, but not a major, role measured in terms of an improved Benchmark score.

It is important to underline that it cannot be concluded from our study that dairy cattle in the two countries with a lower Benchmark score have a lower level of welfare than the others. It could be the case that dairy cattle farmers in Germany and the Netherlands do in practice what the farmers in the three other countries do, even though their practices are not ensured through legal or industry standards. However, in the absence of standards, there is a risk of very uneven welfare levels across farms. In addition, it is important to emphasize that standards cannot stand alone, they must be supplemented both with efforts to control compliance and, not least, efforts to engage and motivate farmers to see the point of complying, thereby developing a good culture of care in the dairy sector. Furthermore, even countries with relatively high Benchmark scores may have room for improvement regarding dairy cattle welfare provisions, both concerning the minimum standards defined in legislation and regarding the ambitions set in the various private and hybrid initiatives.

An important conclusion of our study is that national legislation in the case of Denmark and Sweden and ambitious industry standards in the case of the UK for dairy cattle have played the major role when it comes to dairy cattle welfare provision as measured by the Benchmark method. Here there is a striking contrast to what was found in other Benchmark studies, notably for broiler chicken (Sandøe et al., 2022), where private and hybrid initiatives in some countries played a very large role. At a time when the EU is considering stepping up efforts regarding common minimum standards for animal welfare (European Commission, 2020; EFSA Panel on Animal Health and Animal Welfare et al., 2023) the results of this study may have important policy implications. Firstly, we show that currently there is diversity in the level of dairy cattle welfare standards found across countries that geographically and economically are not very far apart. This may speak in favour of having shared minimum standards at EU level. Secondly, however, even among countries with a similar level of standards, such as Denmark and Sweden, there is difference in the *nature* of these standards in terms of which aspects of welfare are emphasized. And this may give rise to some caution when it comes to the idea of full harmonisation of welfare requirements. If different countries use different means to achieve comparable levels of dairy cattle welfare, it may appear arbitrary and counterproductive to impose one set of means rather than the other.

The Benchmark approach as applied here, of course has both strengths and limitations:

A strength of the study is that there is a high interobserver reliability regarding the underlying valuations and weightings by the experts (see Table 4), as also suggested by the Kendall's coefficient of concordance, which showed a very high agreement between experts.

The use of a single Benchmark score based on the sum of scores of individual parameters builds, as previously noted in Sandøe et al. (2022), on an assumption that poor welfare in one dimension can be compensated for by good welfare in another dimension. This could be viewed as ethically problematic. On the other hand, by having a weight for each dimension it becomes clear that some dimensions can have a greater impact on animal welfare than others. Furthermore, the additive approach to aggregating input from the 47 specific welfare dimensions may give rise to the risk of double counting. Thus, connected dimensions are treated as independent, where for example the effect of no outdoor access (specific dimension 16) is treated independently from access to pasture via a good driveway (specific dimension 15). If the experts made their scores for 'access to outdoor with no requirements for pathways' then there is in principle no double counting, but if the experts had a good driveway in mind when they scored 'outdoor access' then there is double counting. The formulation of specific dimensions as independent was chosen to ease presentation for the experts. Alternatively, a very large set of questions would have to be asked where each combination of specific dimensions would constitute a separate question. Unfortunately, there is no simple solution to this problem about aggregation; the only real option is being fully transparent about it (Sandøe et al., 2019) or not doing it at all.

The Benchmark method, as previously noted in Sandøe et al. (2022), primarily considers *resource-based* measures of animal welfare – that is, what is provided to the animals in terms of space, enrichment etc. – rather than looking at the actual reactions of the animals to the housing and management to which they are subjected, measured in terms of so-called outcome- or *animal-based* measures. These direct welfare measures of animals' reactions can give a more accurate account of welfare than indirect resource-based measures. However, the measures used in the Benchmark approach are scored by experts able to translate the resource-based measures to proxy outcomes or potential welfare risk factors for the affected animals; and therefore the difference may not be that large. However, to strengthen the Benchmark, it may be a good idea in the future to include measures of other major animal welfare challenges for dairy cattle, such as mastitis, lameness, and dirtiness (Lundmark Hedman et al., 2018, 2021). It may also be an idea to include measures relating to health management. For this to work it would, of course, also be required that the measures are used in actual initiatives to promote dairy cattle welfare. Furthermore, it is also important to be aware of different ways of managing and monitoring compliance with standards (Lundmark et al., 2016; Lundmark Hedman et al., 2022).

Even though no fewer than 47 dimensions are included in the current dairy cattle Benchmark, it may be discussed whether some important dimensions are missing. A specific area of concern could be the conditions for cattle on pasture. While the dimensions cover many aspects of the provisions for cattle while indoors, when it

comes to pasture, the focus is only on whether the animals have access to pasture during the summer season, whether there is shelter and shade, whether there is grass of good eating quality and on the quality and length of the outdoor driveway to pasture. We could for example also have included density at pasture, water provision at pasture, provision of supplementary feed and the like. This limitation reflects that in the five countries studied most dairy cattle spend most of the time indoors. However, this may change in the future and more emphasis may be put on the quality of pasture for dairy cattle in legal requirements, industry standards or niche production requirements for dairy cattle welfare. If this happens the Benchmark measure must be amended to cover more dimensions relating to conditions on pasture.

The experts as noted in previous applications of the Benchmark method (Sandøe et al., 2022) only reported on typical welfare outcomes for the provided resources, not about variations in outcomes across farms or countries due to differences in the quality of management.

A further disadvantage of the Benchmark approach, as previously noted in Sandøe et al. (2022), is that it presupposes that farms are complying with welfare legislation and requirements or market initiatives, rather than investigating actual compliance. In practice, farms may only comply partially with welfare legislation, private and hybrid market initiatives, and the degree of compliance may also vary between different kinds of initiatives (Berg and Lundmark, 2020). Also there may be differences regarding the training of farmers or farm workers that may have an effect on the welfare of the animals.

Still, we think that the Benchmark method stands out as a feasible way to make meaningful and comprehensive comparisons of the welfare provisions delivered to farm animals – now also including dairy cattle.

Ethics approval

The ethical standards of the survey study were assessed and approved by the Research Ethics Committee for the Health and Sciences Faculties at the University of Copenhagen, permission number 504-0243/21-5000.

Data and model availability statement

All data on which this study is based is made available in repository files: Repository R 1: Scores on dimension values and weight on dimension from 38 international experts; Repository R2: Country Benchmark scores from 38 international experts

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The authors did not use any artificial intelligence assisted technologies in the writing process.

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P. Sandøe: Collaborates with employees from different branches of Danish animal production, and with various animal welfare NGOs, typically via externally funded

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Table 1. Dimensions included in the dairy cattle Benchmark

The second column from the right lists the 47 specific dimensions informing the Benchmark. In the two columns to the left, the dimensions are synthesized at an intermediate (20) and a general (6) level. In the rightmost column, the number of levels used to describe each dimension is specified.

General dimensions	Intermediate dimensions	Specific dimensions	Number of levels
Comfort and rest	Air and light	1. Indoor air quality (calves, heifers, cows)	2
		2. Light (calves, heifers, cows)	3
	Cubicles/bedding	3. Cubicle size (heifers)	2
		4. Cubicle size (cows)	2
		5. Stocking rate (cubicles per heifer)	4
		6. Stocking rate (cubicles per cow)	4
		7. Bedding in lying area (heifers)	3
		8. Bedding in lying area (cows)	3
	Brushes	9. Access to brushes (heifers)	4
		10. Access to brushes (cows)	5
	Waiting time/transport	11. Waiting time before milking (cows)	2
		12. Transport time to slaughter (cows)	5

Space and freedom to move	Floor/ground	13. Floor (heifers)	4	
			14. Floor in walking area (cows)	4
			15. Outdoor driveway to pasture (cows)	3
		Tethering	16. Indoor production systems (heifers)	2
			17. Indoor production systems (cows)	2
		Indoor area	18. Area single box (calves)	3
			19. Group housing total area per calf	3
			20. Total indoor area (heifers)	3
			21. Total indoor area (cows)	3
		Outdoor/pasture	22. Outdoor production systems (heifers)	6
			23. Outdoor production systems (cows)	6
Social needs	Positive social interaction	24. Single box time (calves)	4	
			25. Calf-dam time (welfare of calf)	5
			26. Cow-calf time (welfare of dam)	5
	Avoidance of social	27. Feeding table (heifers)	3	

	stress	28. Feeding table (cows)	3
		29. Walking area behind feeding table (cows)	2
		30. Walking area between cubicles (cows)	2
		31. Calving pen	2
Feeding and drinking	Water	32. Access to water (calves, heifers, cows)	2
	Suckling/ weaning	33. Weaning (calves)	3
		34. Suckling satisfaction (calves)	4
	Roughage	35. Roughage (calves)	3
		36. Roughage while indoor (heifers)	3
		37. Roughage while indoor (cows)	3
	Drying off (feed restriction)	38. Methods of drying off cows	3
Health	Mortality and disease load	39. Mortality and disease load (calves, heifers, cows)	2
	Hospital /sick pens	40. Hospital /sick pens (heifers)	4
		41. Hospital /sick pens (cows)	4
	Hoof care	42. Hoof care (heifers)	3

		43. Hoof care (cows)	3
Procedures	Disbudding	44. Disbudding (calves)	4
	Forced feeding	45. Forced feeding of colostrum (calves)	2
	Repro techniques	46. Use of other repro techniques (heifers)	3
		47. Use of other repro techniques (cows)	3

Table 2. Comparison of different dairy cattle welfare initiatives (with at least 1% share of national production) found in Denmark, Germany, the Netherlands, Sweden and the United Kingdom

The share of national production is shown for each initiative as well as an indication for the six general dimensions in Table 1 of how many go beyond the baseline. For example, the Danish legislation offers some improvements over the baseline in 9 out of the 12 specific dimensions related to ‘Comfort and rest’ (corresponding to 75% of the specific dimensions in that category). Note that it is only recorded whether there is an improvement, not how large it is. “Organic” will ensure compliance with EU standards for organic dairy production plus in some cases various national requirements. See Supplementary Material S3 for documentation of the different initiatives.

Country	Initiative	Share of volume (%)	Comfort and rest (% of 12)	Space and freedom to move (% of 11)	Social needs (% of 8)	Feeding and drinking (% of 7)	Health (% of 5)	Procedures (% of 4)
Denmark	Legislation	77	75	36	50	86	80	50

	BW 1 heart ¹	3	83	45	100	100	100	50
	BW 2 hearts	7	83	64	100	100	100	50
	Organic	13	92	82	100	80	80	100
Germany	Legislation	10	17	18	13	29	0	0
	QM ²	84	25	18	13	29	40	50
	Pasture-based	2	25	45	13	29	40	50
	Organic	4	58	91	50	71	100	100
Netherlands	Legislation	35	17	36	13	29	0	50
	Pasture-based	14	17	55	13	29	0	50
	Sust. prog. ³	49	42	64	13	43	20	50
	Organic	3	67	82	25	43	40	100
Sweden	Legislation	83	75	82	63	71	80	25
	Organic	17	75	100	100	100	100	100
United Kingdom	Legislation	5	25	18	25	29	0	0
	Red Tractor	83	67	73	63	43	60	25
	First Milk	6	67	91	63	43	60	25
	Organic	5	67	91	75	57	60	75

RSPCA 1 92 91 63 43 100 75

Abbreviations: ¹BW=Better Welfare ²QM=Quality Management ³Sust. prog.=Sustainability programs, RSPCA=Royal Society for the Prevention of Cruelty to Animals. See more on these in Supplementary Table S3.

Table 3. Benchmark score contributions by country and dimension for dairy cattle

Contributions to the total Benchmark score of each country within the six general dimensions of dairy cattle standards in 2021 – compared with the average of the five countries in %.

Country	Comfort and rest	Space and freedom to move	Social needs	Feeding and drinking	Health	Procedures
Denmark	3.6	-7.2	4.8	8.7	3.4	-6.4
Germany	-6.0	-12.7	-17.0	-13.1	-2.5	6.9
Netherlands	-15.5	-0.9	-18.7	-7.1	-13.6	-0.6
United Kingdom	7.7	10.5	6.2	-1.3	1.1	-0.1
Sweden	10.2	10.3	24.7	12.8	11.6	0.2

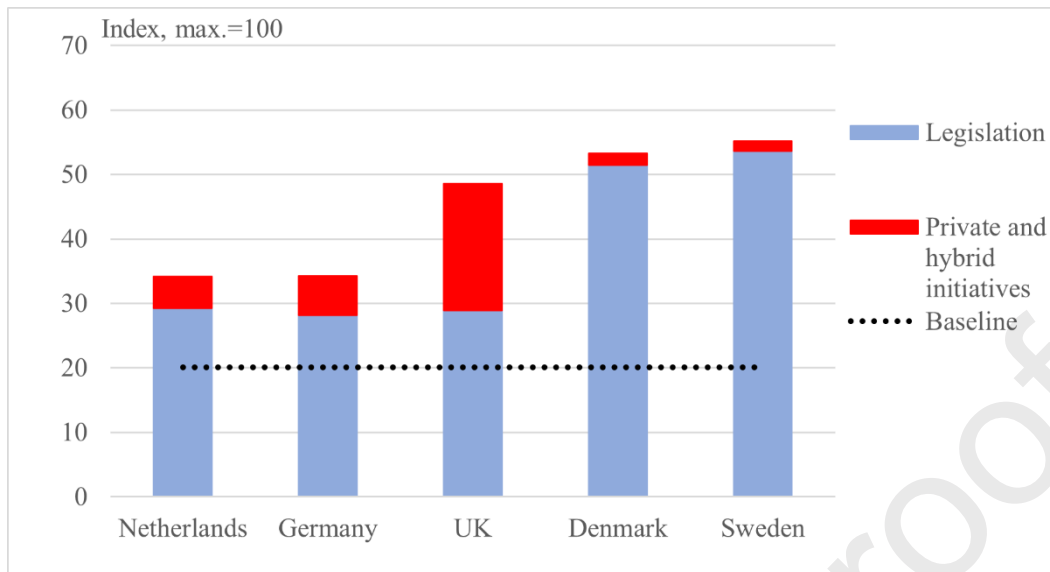
Table 4. The ranking of the countries based on the responses of the 38 experts to the questionnaire regarding dairy cattle

Rank	Denmark	Sweden	Germany	Netherlands	United Kingdom
1	2	36			
2	35	2			1
3	1				37
4			20	18	
5			18	20	

Figure captions**Fig. 1.**

Aggregated Benchmark scores for dairy cattle production in Denmark, Germany, the Netherlands, Sweden, and the United Kingdom in 2021 presented in ascending order and compared to the baseline of the legal minimal standards in the European Union. The effect on the Benchmark score is divided into whether it follows from legislative requirements or from requirements of private and hybrid initiatives that go beyond the legal minimum.

The baseline level illustrates how much the achieved Benchmark is above the lowest level for the dimensions presented in Table 1, with the exception of measures relating to calves, where the requirements set out in the European Union directive regarding calves (Council Directive 2008/119/EC of 18 December 2008 laying down minimum standards for the protection of calves) serve as the baseline. Abbreviations: UK=United Kingdom; Max.=Maximum



Highlights

- Benchmark tool used to compare dairy cattle welfare provisions in 5 EU countries
- Differences in legislation and other initiatives aimed at improving dairy welfare
- Sweden & Denmark found to have highest level of welfare provisions
- Countries differed in prioritizing social needs vs. space and freedom to move
- These differences may make full harmonization of standards challenging