

# Animal welfare on Argentinean dairy farms based on the Welfare Quality® protocol framework



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**Abstract** Animal welfare is a multidimensional concept that comprises animal health, mental state and natural living conditions and plays an essential role in dairy production. On dairy farms, animal welfare can be assessed with different available protocols. The goal of this study was to describe the animal welfare strengths and hazards of dairy farms in Argentina using the Welfare Quality® protocol as a framework. We conducted a literature search using the Scopus database to find articles related to the measures included in the protocol for Argentinean farms. Furthermore, we included data from national statistics. The data available were grouped according to the four principles of the protocol: good feeding, good housing, good health, and appropriate behavior. The results suggest that cows are well nourished; however, water provision is limited because grazing cows need to walk long distances, between 244 m and 460 m, to access a water point. Heat stress is a notable constraint affecting the welfare of cows, as the temperature-humidity index is greater than 72 for at least 100 days during the year. The prevalence of lameness and downer cows was estimated to be 2.2% and 0.7%, respectively, which are below the thresholds for ensuring good welfare. The annual average somatic cell count was 385,000/ml, close to the cutoff recommended for good health. The mortality rate of the cows was higher than recommended. The main strength of Argentinean dairy farms in relation to animal welfare is access to pasture throughout the year for 90% of the farms.

**Keywords:** dairy cattle, animal wellbeing, dairy systems, Argentina, milk production

## 1. Introduction

Animal welfare (AW) is a multidimensional concept comprising animal health, natural living conditions and affective states (Fraser 2008). It is the state of an animal with regard to its attempts to cope with its environment (Broom 1986). The concept of AW is not new, as farmers have always been concerned about rearing healthy and well-nourished animals (von Keyserling et al 2009). However, over the last two decades, there has been increased concern among consumers and citizens about how animals are treated on farms (Spooner et al 2014; Alonso et al 2020), especially in developed countries but also in emerging nations, such as Argentina (Estévez-Moreno et al 2022).

Argentina is characterized by its large agricultural sector and cattle population, and it is the 6<sup>th</sup> most common dairy exporter worldwide (considering the European Union as a single supplier) (OCLA 2023). During the last 25 years (1997-2022), national dairy milk production has remained stable at approximately 11,000 million liters per year. The dairy cow population was 1.6 million, distributed across 10,076 dairy farms in 2022 (OCLA 2023).

Animal welfare plays an essential role in dairy production. Different methods and programs have been developed worldwide to evaluate dairy cattle welfare and assure consumers that farms are meeting high standards

(Krueger et al 2020). Diverse evaluation programs exist, such as the Welfare Quality® protocol (Welfare Quality 2009), hereafter the WQ protocol, developed in Europe; the FARM animal care program (FARM 2020), used in the USA; and the New Zealand Dairy Cattle Code of Welfare (New Zealand 2019). Most of these protocols use resource or animal-based measures or indicators that are transformed into a scale to interpret the welfare status of animals at the farm. The main welfare concerns regarding dairy cattle worldwide include lameness, mastitis, and cow comfort (Mee and Boyle 2020; Whay and Shearer 2017).

The goal of this study was to describe AW on dairy farms in Argentina based on the available scientific literature using the WQ protocol as a framework. These results may be useful for identifying the main strengths and weaknesses as a previous step toward discussing the most relevant policies to assist farmers and advisors in improving AW on Argentine dairy farms.

### 1.1. Characterization of Argentinean dairy farms and animal welfare legislation

Most dairy farms are managed under grazing conditions, but the percentage of confined cows has grown recently, mainly in the form of dry open lots and compost barns, representing 10% of farms (Lazzarini et al 2019). Approximately 90% of dairy cows are in three provinces:



Santa Fe, Córdoba, and Buenos Aires (Mendez et al 2021). The annual rainfall in this area ranges between 700 and 1,100 mm, and the average air temperatures in summer and winter are 23°C and 10°C, respectively (Lazzarini et al 2019).

The average milk production was approximately 6,000 liters of milk per cow per year, equivalent to 408 kg of milk solids per cow, in 2019 (Lazzarini et al 2019). The average stocking rate is 1.4 cows/ha, and the land productivity is close to 8,000 liters/hectare per year (Lazzarini et al 2019). A favorable milk-to-maize grain price ratio (2.08 average in the last 20 years: OCLA 2023) allows farmers to use large amounts of supplements (concentrates, silage and hay), usually 50% of the cow's diet, on average during the year (Engler et al 2022). A recent review (Lazzarini et al 2019) described the main characteristics of Argentinean milk production and concluded that the main constraints for increasing milk production are a decreasing number of milking cows and problems related to farm infrastructure, such as poor cow roadways, outdated and undersized dairy facilities that affect the efficiency of workers and the welfare of cows.

Apart from poor infrastructure on farms, other limitations include a lack of records and poor training of farm personnel. According to national dairy statistics, 50% of farmers use manual records (Engler et al. 2022), which limits analyses or comparisons of data and makes timely decisions difficult. The training provided to farm staff is usually very limited, and only 65% of personnel inseminating cows have been trained in a course (Baudracco et al 2014).

The first legislation for cruelty in animals in Argentina was established in 1954, with an animal protection act that prohibits abuse and cruelty in animals. Under this act, mistreatment and cruelty against animals are considered criminal offenses (Act No. 14.346 October 1954). Animal welfare falls under the responsibility of the National Service of Health and Quality of Agricultural Food (SENASA), which is dependent on the Ministry of Economy, Agriculture, Livestock, and Fisheries.

In 2015, SENASA developed a code of AW for farm animals. The code establishes good management practices for domestic animals during possession, production, transport, and slaughter (SENASA 2015). Specifically, regarding dairy production, a manual of good practices was developed in agreement with the different representative members of the dairy sector. This guide provides recommendations for good practices to maximize milk production and quality, including the following topics: milking routine and hygiene, dairy facility, animal health, feeding, environment, calf rearing, AW, and labor conditions. An effort was made by Aprocal (a nonprofit association that promotes milk quality) to develop a protocol based on the WQ protocol to certify AW on dairy farms. However, the use of assessment protocols to evaluate AW on farms has not yet been regularly implemented.

## 2. Materials and Methods

### 2.1. Approach for this work

We used the WQ protocol (including its 4 principles, 12 criteria and 30 measures) as a framework to structure our analysis. The WQ protocol categorizes a series of animal-based measures or indicators into four principles for ensuring AW in livestock production: i) good feeding, ii) good housing, iii) good health, and iv) appropriate behavior. The good feeding principle establishes that animals should not suffer from prolonged hunger, i.e., they should have a sufficient and appropriate diet and not suffer from prolonged thirst; i.e., they should have a sufficient and accessible water supply. The good housing principle establishes that animals should be comfortable while resting, thermally comfortable and able to move around freely. According to good health principles, animals should be free of physical injuries and diseases. Additionally, animals should not suffer pain induced by inappropriate management. The appropriate behavior principle establishes that animals should be able to express normal, non-harmful, social behaviors; be handled well in all situations; avoid negative emotions such as fear, distress, and frustration; and promote positive emotions. Within these four principles, there are 12 criteria that comprise 30 different measures for assessing the welfare of dairy cows (Table 1).

### 2.2. Source of information and data selection to describe animal welfare on Argentinean farms

To describe AW on Argentinean dairy farms, we conducted several searches (Table 1) in the Scopus database, and we also used national statistics. The Scopus database allows for the integration of Boolean operators (i.e., AND, OR, NOT) to string together words or phrases as well as truncation symbols (denoted as \*) to designate a range of possible word forms. We conducted separate searches to identify articles related to the measures described in the WQ protocol for Argentinean dairy farms published between 2003 and 2023 in English and Spanish. Table 1 shows the terms used for each search; all searches included the following terms: cow\* AND dairy\* AND argentin\* plus the relevant measure. Seventeen searches that accounted for the 30 measures were conducted in total, as some measures were grouped in one search. For instance, udder cleanliness, leg cleanliness and flank cleanliness are three different measures; however, in our search, we combined them together as "animal\* clean\*" OR "udder clean\*" OR "flank\* clean\*" OR "leg\* clean\*" (Table 1). We performed the same searches three times, and the last was conducted on October 12<sup>th</sup> 2023.

Although measures for thermal comfort (within the good housing principle) have not been developed in the WQ protocol, we included the temperature humidity index (THI; Thom, 1959) in our search, which is the most widely used environmental measure of heat stress in the scientific literature (Galán et al 2018) (Table 1). The THI combines the effects of air temperature and relative air humidity.

After the search in Scopus, the title and abstract of the articles were scanned to select only those studies that simultaneously met the following criteria: a) studies reporting data on dairy cows in Argentina, b) studies reporting quantitative data of the relevant AW measures, and c) studies conducted with at least 10 herds, as proposed

by Thomsen et al. (2023). When the abstract did not provide enough information to accept or reject a study, the full article was scanned. The number of total articles found in all searches and the number of selected articles that met the selection criteria and a brief description of them are presented in Table 1.

**Table 1** Terms included in the literature search (from 2003 to 2023) in the Scopus database corresponding to the different animal welfare (AW) measures within the principles of the Welfare Quality (WQ) protocol (Welfare Quality® 2009); number of articles found in Scopus; number and brief description of the articles that met the selection criteria (a. articles reporting data on dairy cows in Argentina; b. articles reporting quantitative data of the relevant AW measures; and c. articles that reported data for at least 10 herds) and brief description of additional data used.

Principles of the WQ protocol	Criteria of the WQ protocol	Measures of the WQ protocol	Terms included in Scopus for literature search <sup>a</sup>	Articles found in Scopus (n)	Articles that met selection criteria (n)	Reference and brief description of articles selected from Scopus	Reference and brief description of additional data used for describing AW measures
Good feeding	Absence of prolonged hunger	Body condition score (BCS)	1) "body condition score"	7	1	Melendez et al (2020) reports BCS across 22,772 lactations in 28 herds.	
	Absence of prolonged thirst	Water provision, cleanliness of water points, water flow, functioning of water points	2) "water access" OR "water availab*" OR "drink* water" OR "water trough*"	5	1	Lara et al (2019) conducted a survey study that identified the major constraints on milk production in 29 dairy farms with emphasis on farm infrastructure.	Baudracco et al (2014) reports data from a farm survey of 163 dairy farms characterizing productive performance, farm infrastructure and management practices.
Good housing	Comfort around resting	Time needed to lie down, animals colliding with housing equipment during lying down, animals lying partly or completely outside the lying area, cleanliness of udders, cleanliness of flank/upper legs, cleanliness of lower legs	3) "Lying time" OR "lie down" OR "standing time" OR "animal* clean*" OR "udder clean*" OR "flank* clean*" OR "leg* clean*"	-	-		
	Thermal comfort <sup>b</sup>	-	4) "thermal comfort" OR "thermal stress" OR "heat stress"	5	1	Recce et al (2021) reports historical monthly THI average from 2000 to 2013 for Rafaela, Santa Fe province, an important dairy region in Argentina.	National weather service reports historical meteorological data for the country.
	Easy of movement	Presence of tethering, access to outdoor loafing area or pasture	5) tethering OR tie	-	-		

Good health	Absence of injuries	Lameness (loose housed animals), lameness (tied animals), integument alternations	6) lame*	3	1	Brunner et al (2019) reports lameness prevalence in 27 dairy farms for Argentina and other countries in South America.
			7) "integument alteration* or integument lesion*" or integument injur* or "skin alteration* or skin lesion* or "skin injur*"	-	-	
	Absence of disease	Coughing, nasal, ocular discharge, hampered respiration, diarrhea, vulvar discharge, milk somatic cell count, mortality, dystocia, downer cows	8) cough* or "nasal discharge*" or "ocular discharge*" or "vulvar discharge*"	-	-	
			9) diarr*	11	-	
			10) "Somatic cell count" or mastitis	35	6	-
			11) Mortality	4	-	OCLA (2023) is the national observatory of the dairy chain and reports annual milk production, number of cows, milk quality among other data for the whole country. Engler et al (2022) correspond to the national dairy farm survey that includes productive data, management practices, and information of farm infrastructure, from the main dairy region, in 204 farms during 2020-2021.
			12) dystocia OR downer OR "milk fever"	3	1	Brunner et al (2019) described above.
	Absence of induced pain by management	Disbudding/dehorning, tail docking	13) Disbudding or dehorning or "tail docking"	-	-	

Appropriate behavior	procedures					
	Expression of social behaviors	Agonistic behaviors	14) "Agonistic behavio**"	-	-	
	Expression of social behaviors	Access to pasture	15) pasture* and access* and graz*	7	1	Lazzarini et al (2019) reviews Argentinean dairy production, describing the main strength and limitations of dairy farms in terms of infrastructure, natural resources and management.
	Good human-animal relationship	Avoidance distance	16) "Avoidance distance*" OR "human* cow* relation**"	-	-	
	Positive emotional state	Qualitative behavior assessment	17) Behavio* OR emotion* and welfare	1	-	

<sup>a</sup> All searches also included the following terms: AND cow\* AND dairy\* AND argentin\*

<sup>b</sup> No measures for thermal comfort have been developed in the WQ protocol, but we included terms related to thermal comfort in our literature search

We found 81 articles in Scopus using the search strategy described before. After applying the selection criteria, the number of studies was reduced to 12 (Table 1). Even though the search included the terms cow\* AND dairy\* AND argentin\*, many articles from countries other than Argentina or not related to cows appeared in the searches. For instance, an article about Uruguay dairy production mentioned in the abstract the word Argentina. Another example is the case of the measure related to diarrhea; the search identified 11 articles (Table 1), and all of them were related to diarrhea in calves, not in cows. Apart from the articles selected from Scopus, we included data from the main national statistics databases, including the National Observatory of the Dairy Chain (OCLA 2023), the annual national dairy survey conducted by the National Institute of Agricultural Technology of Argentina (INTA; Engler et al 2022) and the National Weather Service (Gastaldi et al 2022). Furthermore, a survey written by two of the authors of this study was used (Baudracco et al 2014). A brief description of the additional data used to measure AW is presented in Table 1.

Finally, the main findings for Argentinean farms regarding AW measures were compared with the recommendations established in the WQ protocol to ensure AW. However, when this figure was not available from the WQ protocol, we referred to the scientific literature to make comparisons possible, as shown in Table 2.

### 3. Results and Discussion

The articles selected from the search conducted in Scopus and the additional literature described above allowed us to describe the following AW measures (Table 2): 1) body condition score (BCS) and 2) water provision within the good feeding principle; 3) THI associated with thermal comfort within the good housing principle; 4) lameness, 5) somatic cell count, 6) mortality rate, and 7) downer cows within the good health principle; and 8) cows' access to pasture within the appropriate behavior principle. Table 2 shows the state of each AW measure for Argentinean farms and the recommendations to ensure AW according to the WQ protocol or other scientific literature.

#### 3.1. Good feeding principle

##### 3.1.1. Body condition score

The BCS is a reliable indicator used to assess the nutritional status of an animal and is included in most welfare assessment programs (Krueger et al 2020). The assessment of BCS is infrequent on commercial dairy farms in Argentina. A study conducted by Melendez et al. (2020) reported that most cows (81%) were dried off with a BCS between 2.75 and 3.5 (using a scoring system from 1 to 5; Ferguson et al. 1994) (Table 2). Roche et al. (2009) suggested that the BCS at drying-off (usually 60 days before calving) should be between 2.75 and 3.0 (5-point scale) and that during the dry period, cows should maintain or gain BCS between 0.25 and 0.50; consequently, at calving, they should have a BCS no greater than 3.0 and 3.5 (5-point scale) (Roche et al. 2013). According to the results of

Melendez et al. (2020), cows may have an appropriate BCS, at least when drying off. This could be a consequence of access to relatively cheap supplements in Argentina.

They also reported that 40% of cows had reduced BCS during the dry period. The loss of BCS in that period of the production cycle has been associated with a higher incidence of metabolic diseases after calving (Roche et al 2013; 2015), which can also affect AW by increasing the risk of disease and associated pain. These results should raise awareness among dairy farmers about the importance of measuring and managing cow BCS, especially during critical moments of lactation, such as during drying and calving periods.

### 3.1.2. Water provision

The importance of drinking water for milk production and AW is widely recognized (Jensen and Vestergaard 2021). In Argentina, water troughs are generally placed in the corners of large paddocks where cows are allowed to graze rotationally on successive pasture plots delimited by electric fences (Miglierina et al 2018). The WQ protocol considers the number of water points available per group of cows, the cleanliness of the water points, and the water flow as measures of good welfare. However, these measures were not found in studies on Argentinean dairy farms. Instead, we used the distance that cows should walk to reach a water trough in grazing systems as a measure of water availability (Phillips 2015). The water trough distance from the grazing area affects cattle social behavior (Phillips 2015), in addition to its obvious effect on the hydration state of cows. Maintaining the water source within 250 m of the animal discourages herd movement and increases water intake (Phillips 2015). Cows were found to walk between 244 m (Lara et al 2019) and 460 m (Baudracco et al 2014) to reach the water trough from the paddock (Table 2). This is a consequence of the limited number of water troughs: one every 19 ha (Lara et al 2021) or 34 ha (Baudracco et al 2014). Thus, on most Argentinean dairy farms, drinking water may not be sufficiently accessible, which compromises the principle of good feeding with regard to water provision.

## 3.2. Good housing principle

### 3.2.1. Temperature-humidity index

In pasture-based systems, as in most farms in Argentina, animals are exposed to environmental conditions and may suffer from heat stress. A THI exceeding the threshold of 72 indicates that cows may be under heat stress (Armstrong, 1994). According to data from the National Weather Service (Gastaldi et al. 2022), in the main dairy region of Argentina (Rafaela, Santa Fe Province), there were at least 77 days with a THI higher than 72 (from December to March; average from 2014 to 2020) (Table 2). If the whole year is taken, this figure can reach up to 100 days with a THI higher than 72. Other studies have shown similar findings in other dairy regions of Argentina (Recce et

al 2021; Table 2). The substantial occurrence of days with elevated THI values implies a potential risk to the well-being of cows, particularly if proactive mitigation strategies are not taken into account.

The provision of shade to cows under heat stress conditions is an essential component of heat management for decreasing body temperature (Kendall et al. 2006), especially under grazing conditions, where cows are easily exposed to solar radiation. On Argentinean farms, although most farms provide natural or artificial shade, the amount of shade available is low, as more than 90% of dairy farms have less than 2 m<sup>2</sup> of shade per cow (Baudracco et al 2014), which is half of what is recommended for minimizing the effects of heat stress (Collier et al 2006). This may explain the decrease in milk production reported every year during the warmest months in Argentina (OCLA 2023).

In addition to providing shade in paddocks or resting and eating areas, waiting yards must also be shaded, as this is where dairy cows experience the most heat stress (Collier et al 2006). Typically, afternoon milking on Argentinean farms starts between 3:00 PM and 5:00 PM, and milking sessions extend for almost 2.4 hours (Engler et al 2022). Only 27% of 204 farms surveyed in Argentina provided shade in the waiting yard (Engler et al. 2022). Other cooling options, such as fans and water sprinklers, are important for reducing body temperature and mitigating heat stress (Polsky and von Keyserling, 2017). National statistics indicate that, in the waiting yard, only 12% of dairy farms are provided with fans and water sprinklers (Engler et al 2022). Dairy cattle in Argentina face the challenges of hot environments and scarce abatement techniques to decrease heat stress in animals.

## 3.3. Good health principle

### 3.3.1. Lameness

It is a serious disease that affects dairy cows worldwide, causing pain and suffering in animals, as well as economic losses associated with the high cost of treatment, decreased milk production and culling of cows (Thomsen and Hue 2008). The prevalence of lameness was estimated to be 2.2% on Argentinean farms (Brunner et al 2019) (Table 2). The latter study also evaluated the prevalence of lameness in other South American countries, New Zealand, Australia, Africa, and Eastern Europe and reported an average of 1.7% (range between 0% and 10.5%) in all the other regions. The prevalence of lameness on Argentinean farms is less than the threshold suggested by EFSA (2019) (Table 2). Furthermore, this percentage is significantly lower than that reported in a recent review across 24 countries, in which the mean lameness prevalence was 22.8% (range between 5.1% and 45%) (Thomsen et al 2023).

### 3.3.2. Somatic cell count

It is the most widely adopted indicator of udder health in livestock worldwide (Costa et al 2020) and is a useful predictor of mastitis (Sharma et al 2011), one

of the most common and economically important diseases related to the welfare of dairy cows. Although 34 articles (out of 80) appeared as a result of the search that included the terms “somatic cell count” or “mastitis”, given that these data are well represented as an average across all dairy farms in Argentina in national statistical databases (OCLA 2023), we opted to incorporate this specific value for the somatic cell count measure (good health principle) over data reported in articles from Scopus. The annual average somatic cell count (SCC) in Argentina in the last five years (2018–2022) was 385,000 SCC/ml according to national statistics (OCLA 2023; Table 2). Several studies performed worldwide have addressed the effects of mastitis on milk yield loss. It has been estimated that a cow with 400,000 SCC/ml will lose approximately 5% of its milk yield (compared with the baseline of 200,000 SCC/ml) (Hand et al 2012). The WQ protocol establishes a threshold of no more than 9% of cows in the herd with an SCC >400,000. Thus, the health principle regarding SCC on Argentinean farms is compromised.

### 3.3.3. Mortality rate

It is defined as the incidence of on-farm deaths and emergency slaughter (deaths/100 animals/year) and is one of the most important indicators of health status (Ortiz-Pelaez et al 2008). Although additional research is needed to determine whether the mortality rate can be used as a sole measure of AW, it is associated with disease and lack of care (Ortiz-Pelaez et al 2008); thus, the mortality rate could be a good estimator of poor welfare on a farm when combined with other measures. The national dairy survey of Argentina reported a mortality rate of 5.7% for adult cows (and 14.6% for the involuntary culling rate), which is above the recommendations of the WQ protocol (Table 2).

### 3.3.4. Downer cows

During the transition or peripartum period, defined as the period from 21 days before calving to 21 days after calving (Grummer 1995), cows suffer important changes that expose them to a greater risk of developing disease (Bruckmaier and Gross 2017). The prevalence of milk fever on Argentinean farms was 0.7% (Table 2); in addition, the prevalence of other metabolic diseases was 2.1% for retained placenta and 15.7% and 4% for metritis and ketosis, respectively (Brunner et al 2019) (Table 2). Appropriate nutritional and environmental conditions are crucial for helping cows cope successfully with the imposed metabolic load and for avoiding negative impacts on health, welfare, and performance (Brunner et al 2019).

### 3.4. Appropriate behavior principle

We discuss this principle in regard to the pros and cons of accessing pasture for cows. In Argentina, approximately 90% of dairy cows are allocated outdoors throughout the year, owing to temperate weather conditions (Lazzarini et al 2019) (Table 2). Regarding natural

behavior, pasture-based systems offer the opportunity to graze, which is one of the main needs of the behavioral repertoire of dairy cows (Mee and Boyle 2020). However, poor weather conditions, such as muddy conditions and heat stress, may present challenges related to cow comfort, health, and production (Bewley et al 2017). Furthermore, most cows spend the night in an open lot (an area with no pasture), as farmers prefer avoiding cows at pasture (alfalfa) during night hours because of the risk of bloating. This situation might create risks for cows exposed to harsh conditions during rainy days, which might affect udder and body cleanliness, thereby affecting AW. Although grazing systems can be very good for ensuring cow comfort, as they allow the expression of natural behavior, in Argentina, pasture access may not guarantee AW by itself, given management and infrastructure constraints. Research that can address the welfare aspects of access to pasture for cows in Argentina is needed, as this is one of the main issues affecting consumer perceptions of dairy production (Stampa et al 2020). Key areas of investigation should include the cleanliness of cows, their exposure to heat stress, and the distances covered during their transit from paddocks to the milking yard. These factors are linked to the impact of grazing systems on the welfare of dairy cattle.

### 3.5. Strategies to improve animal welfare on Argentinean dairy farms

Dairy farmers are being challenged to optimize production systems and produce more milk while meeting increasing pressure from consumers concerning AW. One of the main strengths of Argentinean dairy farms is that cows are in contact with pasture almost all year-round, which is a phenomenon that consumers value positively worldwide (Schuppli et al 2014). However, the data summarized in this study indicate that there is still considerable room for improving AW on dairy farms in Argentina. Implementing management practices to avoid heat stress (Piccardi et al 2011), improving farm infrastructure (Fernandes et al 2021), investing in personnel training (Ceballos et al 2018), and including precision livestock farming (PLF) technology (Aquilani et al 2022) are all available strategies for improving AW.

#### 3.5.1. Implementation of management practices to avoid heat stress

Apart from the negative effects on welfare and production, heat stress has consequences for the reproductive performance of cows, as indicated by an increased number of days open, a reduced conception rate, and a greater number of cows suffering from different types of anestrus (De Rensis et al 2015). Seasonal calving is common in grazing systems, such as New Zealand and Ireland, where cows' highest feed requirements (peak of lactation) are matched with those of the highest pasture production season (spring). In Argentina, due to the high temperatures between December and March, the strategy

of concentrating mating and calving would avoid mating and calving during the hottest months of the year rather than matching cows' requirements and pasture supply (Baudracco et al 2022). This strategy can improve feed intake, milk production and reproductive efficiency (Piccardi et al 2011). However, seasonal calving is still performed by a small proportion of farmers, with more than 80% of farms implementing year-round calving (Engler et al. 2022).

The effects of heat stress can also be reduced by choosing dairy breeds that are more tolerant to hot climates (Gantner et al 2017). Within the *Bos taurus* cattle, Jersey cows are more resistant to heat stress than Holstein cows are (Collier et al 1982; Sharma et al 1983; Smith et al 2013). However, in Argentina, 83% of the dairy herds are Holstein breeds, while a small proportion are Jersey crossbred cows (6%) (Engler et al 2022). The inclusion of a greater proportion of Jersey genetic species would increase the tolerance to heat stress. The adoption of seasonal calving and the selection of more tolerant breeds are long-term strategies. However, the inclusion of environmental management techniques can be adopted immediately to reduce heat stress. Shading construction should generally be made available on dairy farms, especially on dairies with grazing cattle. The purpose of this approach is to minimize

the solar load on animals, especially in the afternoon (Ji et al 2020), to reduce the overall heat load on the animals. Furthermore, the installation of fans and water sprinklers has proven to be advantageous for cooling cows and is the most cost-effective heat stress mitigation approach (Ji et al 2020).

### 3.5.2. Improvements in farm infrastructure

Improving AW often requires changes in infrastructure (Fernandes et al 2021). An intensification process of dairy farms, with a greater number of cows per farm, took place over the last 20 years in Argentina and caused an increase of 49% in herd size (Lazzarini et al 2019). Larger herd sizes are often associated with increased stocking densities, longer walking distances on the farm, reduced ability to examine and treat cows individually, and longer milking times (Beggs et al 2015), which altogether compromise AW. In addition, there is evidence that the increased herd size in Argentina was not accompanied by larger farming facilities (Lazzarini et al 2019). Increasing water provision infrastructure will likely manifest in animals' physiological functioning, boosting AW (Jensen and Vestergaard 2021).

**Table 2** Animal welfare (AW) measures for Argentinean dairy farms, grouped according to the four principles of the Welfare Quality (WQ) protocol (Welfare Quality®, 2009) and recommendations to ensure animal welfare from the scientific literature.

Principles of the WQ protocol	Measures of the WQ protocol	AW measures for Argentinean dairy farms	Recommendations to ensure AW from scientific literature
Good feeding	Body condition score	-Between 2.75 and 3.5 at drying off (Melendez et al 2020)	Between 2.75 and 3.0 at drying off (Roche et al 2009)
	Water provision	-Distance from water troughs to cows in the paddock: between 244 m (Lara et al 2019) and 460 m (Baudracco et al 2014)	Distance from water troughs to cows in the paddock < 250 m (Philips 2015)
Good housing	Temperature-humidity Index (THI)	-THI >72 for more than 100 days per year (National weather service, Gastaldi et al 2023). -THI >72 (monthly average) for at least 3 months per year (Recce et al 2021)	THI: <72 (Armstrong 1994)
Good health	Lameness	-2.2% (Brunner et al 2021)	<10% (EFSA, 2009)
	Somatic cell count	-385,000 SCC/ml (OCLA 2023) <sup>a</sup>	<9% of cows in the herd with SCC >400,000 SCC/ml (Welfare Quality®, 2009)
	Mortality rate	-5.7% (Engler et al 2022)	<2.25% (Welfare Quality®, 2009)
	Downer cows	-0.7% (prevalence for milk fever; Brunner et al 2021)	<5.5% (Welfare Quality® 2009)
Appropriate behavior	Cows' access to pasture	-Unrestricted access to pasture all year round in 90% of the farms (Lazzarini et al 2009)	At least 6 hours a day during at least 120 days a year (Pro Weideland 2018)

<sup>a</sup> National average from 2018 to 2022

SCC=somatic cell count

### 3.5.3. Training of farm personnel

Animal welfare requires investment in the training of people responsible for the care and handling of animals (Fernandes et al 2021). A study conducted in Brazil

confirmed the importance of training and revealed that the implementation of training on beef farms reduced the number of miscatches with the head bail by 45% (Simon et al 2016). Similarly, Ceballos et al. (2018) demonstrated that,



compared with trained people, nontrained farm workers had poorer quality animal handling, leading to more undesirable animal behaviors during handling. Furthermore, another study showed that when people do not use good handling practices during vaccination procedures, the animals are more stressed, display more undesirable behaviors, and consequently suffer more welfare problems (Chiquitelli Neto et al 2015). Thus, training farm personnel is an effective and practical strategy for promoting positive human–animal interactions.

### 3.5.4. Inclusion of precision livestock farming

These technologies have been developed with the intention of improving animal surveillance and assisting farmers in refining their management while minimizing handling practices (Silva et al 2022). Better farm management may improve animal production efficiency and welfare. However, sensor technologies may not be taken as a replacement for the farmer but only to support him or her in the daily control of animals (Berckmans 2017; Stygar et al 2023). A recent review (Stygar et al 2021) described the PLF technologies that can be used to monitor AW. Examples of PLF technologies that can contribute to the improvement of AW are the automatic detection of lameness and mastitis and the assessment of BCS, among others. The proportion of farms using PLF and the type of PLF used were not quantified for Argentinean dairy farms. There are only reports about the use of automatic feeding systems in dairy parlors and automatic cup removers; approximately 12% of the cases involved both technologies (Engler et al. 2022).

Some AW issues can be improved through better farm management practices. However, improving infrastructure in dairy systems and increasing the use of PLF require access to proper financing, which has been described as one of the most important limitations of the Argentinean dairy industry (Lazzarini et al 2019).

### 3.6. Limitations and scope of this study

The description of AW was based on a low quantity of articles and aided by national statistics, which may limit the extension of this analysis to all farms in Argentina. Due to the current state of the art, many AW measurements could not be addressed in this study. However, we were able to describe and discuss the greatest welfare concerns regarding dairy cattle: lameness, mastitis (somatic cell count) and cow comfort (pasture access). Furthermore, we were able to discuss the four principles of the protocol: good feeding, good housing, good health and appropriate behavior. To our knowledge, this is the first study that aimed to describe AW in dairy farms in Argentina by analyzing the available scientific literature.

## 4. Conclusions

The main strength of Argentinean dairy production systems regarding AW is year-round access of cows to pasture on 90% of the farms, promoting the natural

behavior of cows. Dairy cows are generally well nourished, given the common use of affordable supplements. Based on the thresholds of the WQ protocol and other scientific literature, we can conclude that the main aspects that need to be addressed to improve the welfare of dairy cows are the inclusion of heat stress mitigation techniques, the improvement of water provision at grazing and the reduction of SCC. The implementation of policies aimed at promoting the training of farm personnel, together with initiatives facilitating access to financial resources for farm investments, appears to be important strategies for improving the welfare of dairy cows.

### Ethical consideration

Not applicable.

### Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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