Spanish Journal of Agricultural Research
18 (1), e0501, 9 pages (2020)
eISSN: 2171-9292
https://doi.org/10.5424/sjar/2020181-15287
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)

RESEARCH ARTICLE

OPEN ACCESS

# Comparing welfare indicators in dairy cattle under different loose housing systems (deep litter *vs* cubicle barns) using recycled manure solids for bedding

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## Abstract

*Aim of study:* Dairy farmers in Southern Spain are continuously investing in the modernization of their facilities and frequently ask technicians about the type of housing they should choose for their farms. Although some studies have analysed the economic impact of different housing systems, there are no reports evaluating the impact of these systems on animal wellbeing. To remedy this deficit, a study was carried out to analyse animal welfare status in two types of loose housing conditions: deep litter (DL) and cubicle (CU) barns.

*Area of study*: This study was conducted in Cordoba (Spain).

*Material and methods*: A total of 1,597 cows from nineteen commercial dairy farms were involved in this study, of which twelve had CU barns and seven had DL barns. Welfare Quality assessment was used to evaluate animal wellbeing, inn order to compare both housing systems.

*Main results*: The study found some weaknesses for feeding and health indicators of animal welfare in both types of housing systems. The overall welfare assessment based on feeding, housing and health indicators showed no differences between farms with DL or CU barns.

*Research highlights:* A good welfare status could be reached under any type of housing system.

**Additional key words:** dairy cow; wellbeing; feeding; housing; health.

**Abbreviations used:** BCS (body condition score); CU (cubicle barns); DEH (dehorning method); DL (deep litter barns); DLL (dirtiness of lower leg); HR (hampered respiration); ND (nasal discharge); OLA (outdoor loafing area); SCC (somatic cell count); TNLD (time needed to lie down); VD (vulvar discharge); WQ (Welfare Quality assessment protocol for dairy cattle).

**Authors' contributions:** Conceived and designed the experiment: CCPM and EIA. Performed the fieldwork: LM. Analysed and interpreted data: FMM, LM and CCP. All authors drafted and approved the final manuscript.

**Citation:** Molina, L; Agüera, EI; Pérez-Marín, CC; Maroto-Molina, F (2020). Comparing welfare indicators in dairy cattle under different loose housing systems (deep litter *vs* cubicle barns) using recycled manure solids for bedding. Spanish Journal of Agricultural Research, Volume 18, Issue 1, e0501. https://doi.org/10.5424/sjar/2020181-15287

**Supplementary material** (Tables S1-S3) accompanies the paper on SJAR's website

**Received:** 10 Jun 2019. **Accepted**: 25 Mar 2020.



**Funding:** The authors received no specific funding for this work.

**Competing interests:** The authors have declared that no competing interests exist.

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## Introduction

The different types of housing systems aim to offer the most comfortable environment for dairy cows, among other reasons, in order to safeguard animal welfare. In this context, it is worth measuring the wellbeing indicators of cows housed in distinct systems, because poor welfare can induce suppression of the immune system and other disturbances, which are likely to increase the risk of disease (Abeni & Bertoni, 2009).

Dairy cattle are usually accommodated in tie or loose housing systems, with numerous variations within each system according to the type of bedding, the presence of stalls and the size of the resting area, among others. In Southern Spain, dairy farms exclusively utilise loose-housing systems, defined as a system where cows are kept untied in the barn, usually comprising a lying area, a feeding passage, a standing and walking passage and a milking area (Zappavigna *et al*., 2014). The loose-housing systems predominantly used in Southern Spain are deep litter (DL) barns (which have unobstructed lying areas for every group of cows) and freestall or cubicle (CU) barns (which have individual spaces or stalls for lying down). Deep litter barns are usually built on dairy farms with relatively few cows, but when cow density is increased, farmers tend towards CU construction. In order to choose one over the other, farmers consider numerous factors, the available area per farm and the investment capacity being some of the most important.

Ethograms need to be analysed in order to determine how cows behave, enabling better decisions to be taken for designing appropriate housing for cows. In this regard, Grant (2004) determined how much time dairy cows dedicate to their basic activities over the day, reporting around 5 to 5.5 hr for eating, 12 to 14 hr for lying/resting (including 6 hr of rumination), 4 hr for rumination while standing and 30 min for drinking. It is evident that cows' predominant activity is resting, suggesting that special attention should be devoted to the impact of the different housing systems on the resting of cows. It has become generally accepted that housing for dairy cattle should be constructed in accordance with the five freedoms needed to ensure animal welfare (Capdeville & Veisser, 2001).

Farmers frequently invest to improve and modernise their farms in order to enhance productivity. Nowadays, they are also aware of the importance of providing good conditions to optimise animal wellbeing. Technicians are frequently asked about the type of housing system they recommend, and the answer is not easy since many factors may impinge on the decision. Considering the great impact that the housing system has on animal wellbeing, the present study was conducted to compare welfare assessment based on feeding, housing and health principles in dairy cows reared under two different loose-housing systems: deep litter barns and cubicle barns.

# Material and methods

## Animals and housing

This study was carried out on a total of 1,597 cows from 19 commercial dairy farms located in Cordoba (Spain), with a herd size ranging from 33 to 189 cows. Dairy cattle farming in this region exhibits some singularities linked to the climate, such as the relative absence of grazing. This area has two marked seasons: a cold, moderately rainy winter and a dry, hot summer. Rainfall is irregularly distributed throughout the year, with maximum rainfall in the autumn-winter period and minimum rainfall in summer, exceeding the annual average of 500 mm in the wider region, but with very marked local differences.

Farms using DL barns (n=7) and CU barns (n=12) were studied. The total resting area for DL barns ranged between 4.6 m$^2$ and 13.1 m$^2$ per cow. Regarding freestalls or cubicles, the width was between 1.15 m and 1.25 m, and the length between 1.7 m and 2.0 m (from rear curb to brisket board), which is equal to 1.9-2.5 m$^2$ per cow. Cubicles per cow range from 0.7 to 1.5 m$^2$, with an average value of 1.1 m$^2$. In all cases, cows were milked twice a day and a total mixed ration was used. The bedding material used in all the farms was recycled manure solids. In relation to bedding management, both in DL and CU barns, bedding material was aerated twice everyday using a cultivator or a chisel type of equipment to dry the surface and make it comfortable for dairy cows. In CUs, new bedding material was added every 12 days on average, although this period can vary from 7 to 21 days, depending on weather conditions. In DL barns, bedding material was completely replaced twice a year.

Regarding reproductive management, 57% of farms with DL barns and 50% of farms with CUs used oestrus synchronization protocols. On the other hand, only 14% of DL barns had automatic heat detection systems, while 42 % of CU barns had them.

## Wellbeing assessment

Welfare based on feeding, housing and health freedoms was assessed in accordance with the Welfare Quality assessment protocol for dairy cattle (WQ) (Welfare Quality, 2009). All the farms participating in this study were assessed during October and November 2015. They did not participate in any animal welfare certification scheme. The day before the on-site farm evaluation, each farmer was given a brief questionnaire on topics such as number of milking cows, presence of tethering, access to OLA, dehorning method, percentage of tail-docked cows and use of anaesthetics and/or analgesics for dehorning. Regarding somatic cell count (SCC), as these data were not available at individual cow level, the worst-case scenario was considered (SCC>400000 for 17.5% of cows). During the morning of the day welfare assessment was conducted, the cows were held at the feeding rail after milking (never for more than two hr). This was when the evaluation of the body condition score (BCS), dirtiness of lower leg, hindquarters and udder (DLL, dirtiness of hindquarters and dirtiness of udder, respectively), nasal discharge (ND), ocular discharge, diarrhoea, vulvar discharge (VD), and integument alterations was carried out. Afterwards, lameness was assessed and scored. Drinkers were evaluated while the cows were in the shed. Finally, evaluations were made of how long the animals took to lie down in their resting area, whether collisions with housing equipment occurred and the number of cows lying completely or partly outside the rest area. During this time, hampered respiration (HR) and coughing were also quantified (Table S1 [suppl]). Farms were classified for the different principles of welfare as excellent, enhanced, acceptable or not classified.

Several indexes relating to reproductive performance were obtained for each farm. Average values for the year preceding the day of the visit to the farm were used. These data were obtained using ReproGTV software (Grup Tècnic Veterinari, Girona, Spain).

### Statistical analysis

Descriptive statistics (mean, standard error, minimum and maximum) were calculated for the assessed feeding, housing and health measurements and for the global scores of each criterion. The comparison of data obtained from the two different housing systems was conducted using an analysis of variance (ANOVA) for quantitative variables and a Chi-square test for qualitative ones. It is important to note that, although some of the WQ measurements on individual cows are qualitative, *e.g.* DLL can be 0 (no dirt or minor splashing) or 2 (separate or continuous plaques of dirt), we used herd level data, *e.g.* the percentage of cows with separate or continuous plaques of dirt, which are quantitative. The correlation of different welfare measurements was described using the Pearson correlation coefficient. When $p$-value was lower than 0.05, differences were considered significant. All statistical analyses were performed using SPSS v18 for Windows (SPSS Inc., Chicago, USA).

## Results

With regard to the feeding principle, farms with CU barns showed significantly ($p$=0.016) higher percentage of lean cows than those with DL barns. Malfunctioning of watering troughs was rare in both housing systems, but the water showed a tendency to be dirtier ($p$=0.054) in DL barns.

With respect to the housing principle, cows in both types of barns needed similar time to lie down. Significant differences were observed in the percentage of animals colliding with equipment and the presence of dirty animals (Table 1). The percentage of collisions between animals and equipment was significantly higher ($p$<0.05) in farms with CUs. It was noted that CUs were more effective than DL barns to maintain cows clean. Significant differences were found in hindquarters ($p$=0.03) and lower legs ($p$=0.03), and a tendency for udder ($p$=0.06). Regarding OLA, 85.7% of farms with DL barns had them, but they were available in only 16.7% of farms with CUs. No access to pasture was available in any farm. The overall housing classification showed good values, since all the farms were classified as “enhanced” or “excellent” (Table S2 [suppl]).

The comparison of welfare indicators linked to health principles between DL and CU barns showed no significant differences ($p$>0.05), except for nasal discharge that was higher in CUs (Table 1). Also, a tendency ($p$=0.06) for higher vulvar discharge incidence was observed in cows housed under CU system (Table 1). The presence of horned cows was significantly higher in farms with deep-litter barns (Table 1). A tendency ($p$=0.09) for a higher use of thermocautery for disbudding instead or caustic paste was observed in farms with CU barns. All the monitored farms, both DL and CU barns, were classified as “acceptable” for the health principle, *i.e.* the welfare of animals associated to this principle is above or meets minimal requirements.

No significant differences were observed for reproductive parameters or milk production comparing animals housed in DL or CU barns (Table 2). Nevertheless, a larger variability in reproductive performance was observed in CU barns.

The partial welfare assessment based on feeding, housing and health did not reveal major differences between farms (Fig. 1, Table S2 [suppl]). The correlations between the welfare measurements were also analysed (Table S3 [suppl]).

## Discussion

Consumers are increasingly concerned about how the food they eat has been produced (Cembalo *et al.*, 2016). It has been argued that the type of housing impacts on cows’ resting time and therefore on their comfort (Haley *et al.*, 1999). Aspects such as overcrowding, uncomfortable bedding, insufficient space and a long distance to feeders, among others, can negatively affect cow welfare. Prompted by the interest

**Table 1.** Significance of differences between welfare indicators of deep litter (DL) barns and cubicles (CU) barns using ANOVA and chi-square test.

| Principle | Measurement | DL | | CU | | *p*-value |
|---|---|---|---|---|---|---|
| | | Mean±SEM | Min-Max | Mean±SEM | Min-Max | |
| FEEDING | very lean cows (%) | 8.0±1.1 | 3.0-15.2 | 17.2±3.2 | 4.5-32.7 | 0.016 |
| | length of trough per cow (cm) | 6.4±0.7 | 3.5-9.2 | 6.3±0.9 | 1.6-11.4 | 0.930 |
| | clean water points (%) | 85.7±7.0 | 50.0-100.0 | 100.0±0.0 | 100.0 | 0.054 |
| | malfunctioning of water points (%) | 14.0±10.9 | 0.0-100.0 | 8.0±10.9 | 0.0-100.0 | 0.703 |
| HOUSING | time needed to lie down (s) | 4.6±0.1 | 4.2-5.5 | 4.8±0.3 | 3.6-6.4 | 0.597 |
| | animals colliding with equipment (%) | 0.0±0.0 | 0.0 | 15.2±6.2 | 0.0-50.0 | 0.027 |
| | animals lying outside resting area (%) | 0.0±0.0 | 0.0 | 1.5±1.5 | 0.0-13.8 | 0.332 |
| | animals with dirty lower legs (%) | 49.8±8.6 | 20.0-81.8 | 30.8±5.3 | 11.5-59.1 | 0.033 |
| | animals with dirty hindquarters (%) | 33.9±7.1 | 13.0-76.6 | 13.9±5.1 | 0.0-47.7 | 0.033 |
| | animals with dirty udder (%) | 20.4±3.8 | 6.7-45.5 | 9.2±4.1 | 0.0-40.9 | 0.060 |
| | access to outdoor loafing area | 85.7 (yes) | yes/no | 16.7 (yes) | yes/no | 0,006 |
| | access to pasture | 0.0 (yes) | yes/no | 0.0 (yes) | yes/no | - |
| HEALTH | animals with severe lameness (%) | 3.5±0.8 | 0.0-7.0 | 5.7±1.0 | 0.0-9.4 | 0.101 |
| | animals with no integument alteration (%) | 91.7±2.0 | 79.8-100 | 85.6±5.3 | 47.7-100 | 0.298 |
| | animals with mild integument alteration (%) | 8.3±2.0 | 0.0-20.2 | 11.1±3.6 | 0.0-34.1 | 0.507 |
| | animals with severe integument alteration (%) | 0.0±0.0 | 0.0 | 3.3±1.9 | 0.0-18.2 | 0.107 |
| | n. of coughs per animal | 0.1±0.1 | 0.0-0.7 | 0.2±0.2 | 0-1.3 | 0.694 |
| | animals with nasal discharge (%) | 16.8±3.4 | 3.0-39.4 | 30.9±4.7 | 12.7-50.0 | 0.026 |
| | animals with ocular discharge (%) | 5.0±1.2 | 0.0-12.1 | 8.8±3.2 | 0.0-29.1 | 0.288 |
| | animals with hampered respiration (%) | 0.0±0.0 | 0.0 | 0.8±0.6 | 0-5.5 | 0.226 |
| | animals with diarrhoea (%) | 4.5±1.9 | 0-18.2 | 3.4±1.5 | 0-12.8 | 0.717 |
| | animals with vulvar discharge (%) | 0.0±0.0 | 0.0 | 1.5±0.7 | 0-4.5 | 0.057 |
| | animals with somatic cell count above 400,000* | 17.5±0.0 | 17.5 | 17.5±0.0 | 17.5 | - |
| | horned cows (%) | 5.0±1.9 | 0.0-11.8 | 1.0±0.3 | 0.0-5.8 | 0.018 |
| | procedure for disbudding/dehorning | 42.9 (thermocautery) 57.1 (caustic paste) | no/ thermocautery/ caustic paste/ dehorning | 83.3 (thermocautery) 16.7 (caustic paste) | no/ thermocautery/ caustic paste/ dehorning | 0.094 |
| | use of anaesthetics/analgesics | 0.0 (yes) | yes/no | 0.0 (yes) | yes/no | - |
| | tail docked cows (%) | 0.5±0.3 | 0.0-2.5 | 0.6±0.2 | 0.0-4.5 | 0.794 |
| | procedure for tail docking | 100.0 (rubber rings) | no/rubber rings/surgery | 100.0 (rubber rings) | no/rubber rings/surgery | - |
| | use of anaesthetics/analgesics | 0.0 (yes) | yes/no | 0.0 (yes) | yes/no | - |

* Data not available due to the lack of official milk records. The worst-case scenario (17.5% of cows with SCC>400,000) was considered, according to WQ protocol (2009).

**Table 2.** Average value of reproductive and productive measurements in deep litter and cubicle barns.

| Measurement | Deep litter | | Cubicle | | *p*-value |
|---|---|---|---|---|---|
| | Mean±SEM | Min-Max | Mean±SEM | Min-Max | |
| Calving interval (d) | 432.2±8.5 | 408.1-465.1 | 463.8 ±16.7 | 398.1-535.0 | 0.266 |
| Calving to conception (d) | 157.2±8.4 | 133.1-190.1 | 181.5 ±15.0 | 122.9-235.0 | 0.343 |
| Calving to first service (d) | 73.7±0.3 | 73.0-74.7 | 84.8 ±5.0 | 69.0-107.0 | 0.180 |
| Services | 3.2±0.1 | 3.0-3.6 | 3.2 ±0.4 | 1.9-5.4 | 0.950 |
| Fertility (%) | 32.0±1.0 | 28.7-35.2 | 34.3 ±3.9 | 18.5-52.6 | 0.712 |
| Heat detection (%) | 57.3±2.9 | 47.8-67.5 | 51.5 ±3.6 | 37.0-67.0 | 0.355 |
| Milk production (kg/d) | 35.9±0.1 | 35.7-36.0 | 36.4 ±1.1 | 29.3-40.5 | 0.788 |

of farmers and society at large in aspects related to animal welfare in dairy cows, the present study was conducted to compare the welfare status of two different housing systems in southern Spain, in order to assess the wellbeing of animals reared under these housing systems and to determine differences between farms.

Most studies conducted in this field establish a set of welfare indicators using a limited sample of animals, although these measurements are different between studies. Recently, new welfare assessment protocols for dairy cows have been developed offering more consistent, standardised and comparable animal-based measures at farm level, which are related to the five freedoms, as in the case of WQ, the most popular protocol.

The overall welfare assessment did not reveal differences between farms with DL or CU barns. In a holistic approach to this assessment, it was found that farms exhibited low scores in terms of health indicators, while housing parameters exhibited good scores. As far as feeding indicators are concerned, inappropriate scores were detected in some cases, showing huge differences between farms for this principle. These results suggest that great attention should be focused on the health and feeding parameters in order to increase the welfare of these farms.

Most welfare measurements based on feeding and housing indicators showed differences when they were assessed on different farms, but not linked to the type of barns used (*i.e*. DL or CU barns). Health indicators did not vary between the assessed farms. In relation to this, Popescu *et al*. (2013) affirmed that the different housing systems (including the controversial tie-stall farms) offer good welfare conditions for cows, and that it is not the design or type but incorrect management practices that are ultimately responsible for deficient animal welfare.

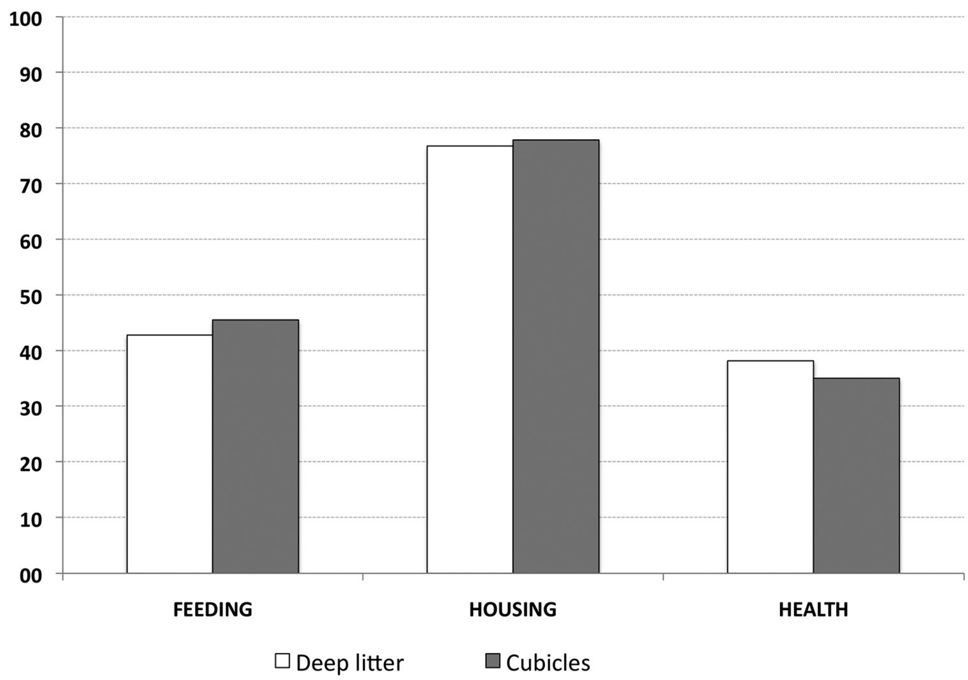


**Figure 1.** Average scores (%) for feeding, housing and health principles depending on the housing system.

With regard to the feeding principle, BCS deficiencies in intensive dairy farms have been associated with reduced welfare, which is usually linked to diseases or deficient facilities. In the present study, the percentage of very thin cows showed significant differences between the two housing systems (8.0% and 17.2% in DL barns and CU barns, respectively). These values were higher than those reported by Ostojic-Andric *et al.* (2011) in Serbia (5.1% and 2.2% in loose housing and tied housing systems, respectively), but lower than described by Bugueiro *et al.* (2018) in different types of housing (freestall and tied systems) in North-Western Spain (19.4%). A high percentage of lean cows has been associated with severely lame animals (Bugueiro *et al*., 2018), but in the present study no correlation was detected between these parameters (Table S3 [suppl]). Such lack of correlation is probably due to the fact that WQ only considers very lean and very lame cows, which might not be a good representation of the lameness status and body condition of all the animals in the farm. Average farm size was approximately double for CU than for DL barns (105 *vs* 51 cows per farm). A lower feeder length per cow in larger farms due to space constraints, and the correspondent larger competition for feed, could be suggested as a factor involved in the differences between CU and DL farms regarding the percentage of very lean cows. However, no correlation was observed between such percentage and farm size. The percentage of very lean cows was also not related to the space or the number of CUs per cow. As de Boyer *et al.* (2014), we found that the percentage of very lean cows had a large variability among farms. It could be interpreted as differences in the number of cows in the first third of lactation, which are more likely to be tagged as very lean (BCS < 2.5), even when there were no significant differences among farms in the average number of days in milk (199 days in CUs and 233 days in DL barns).

Regarding water availability, cows suffering from insufficient access to water (associated with pathologies or due to insufficient troughs) may have several consequences, such as a decrease in feed intake and milk production (Steiger *et al*., 2001). It has been reported than cows with a restriction (around 50%) of water intake suffer a reduction in their milk yield of around 74% and exhibit more aggressive behaviour (Little *et al*., 1980). In the present study, the cleanliness of water points was slightly worse in DL barns. However, there were fewer lean cows in DL than in CU barns and milk production was not affected. Probably, the assessment of water cleanliness on the basis of punctual visits, as established in WQ, is not adequate. It could be better to ask the farmer about water point management (number of daily cleanings and moment when they are performed).

Consistent differences between DL and CU barns were detected when welfare indicators based on housing measurements were analysed. Cleanliness is a key welfare indicator, since cows have been shown to prefer clean, dry and soft surfaces for resting (Rushen *et al*., 2007). In this study, cows housed in DL barns exhibited more dirt compared to animals housed in CUs, in line with the findings of Fregonesi & Leaver (2001). This difference may be explained by deficient bedding maintenance, while inadequately designed barns can also affect cow cleanliness. The way barns are oriented is essential for preventing rainwater from entering and ensuring that the rest area is appropriately ventilated and dry. Cubicles were associated with cleaner animals, which may be attributable to the automated cleaning systems incorporated into this type of housing.

This study also showed that cows housed in CU systems suffer a significantly higher percentage of collisions with equipment than in DL barns. Colliding with the physical elements of the barn can also occur when the animals are trying to avoid placing excessive weight on a painful leg (Cook & Nordlund, 2009), which may be indicative of discomfort during rest in dairy cows (Hörning, 2003). While no collisions were recorded in DL barn systems, cows housed in CUs had a collision rate of 15.2% (<20% is deemed to be normal), lower than that reported by other authors in cattle reared in a tie housing system (Ostojic-Andric *et al*., 2011; Popescu *et al*., 2014).

One of the most important factors influencing the choice of the housing system is the softness of the bedding material (Fregonesi & Leaver, 2002). Recycled manure solids, used as bedding material in all the farms involved in this study, can provide economic benefits without affecting herd health when they are properly managed (Husfeldt *et al*., 2012). Poor bed maintenance, involving for example inadequate bedding thickness, can result in a too hard resting area, which makes it difficult for the cow to lie down, increasing the time required (TNLD). However, in the present study, TNLD was similar for both systems (4.6 and 4.8 sec in DL and CU barns, respectively) and both fit the Welfare Quality optimum (<5.2 sec).

Almost all the farms with DL barns had an OLA, whereas it was present only in few farms with CUs. This is probably due to CU barns being a preferred option when the available area to place the farm is limited. An OLA may provide better welfare conditions for cows, since the frequency of medical treatments has been found to be reduced on farms where animals engage in regular outdoor exercise (Regula *et al.*, 2004). However, in this study, there were not significant differences in any health measurement between farms with and without an OLA. It could be interpreted that the available space per cow was not a limitation for animal welfare in any farm, including those without OLA.

With regard to health indicators, Fregonesi & Leaver (2001) observed a higher percentage of SCC and mastitis in cows housed in strawyard barns, which was attributed to higher levels of exposure to dirt. In the present study, no significant differences were detected in most health measurements comparing the two types of loose housing system (DL *vs* CU barns), and all the farms were classified as acceptable, *i.e.* around minimal requirements. ND and VD exhibited significantly higher percentages in CU than in DL barns. Oltenacu & Algers (2005) argued that dairy cows are particularly susceptible to stress and metabolic, physiological and immunological disorders due to the genetic selective pressure to obtain high milk yields, something that underlines the importance of providing dairy cows with exemplary management. In this context, Trevisi *et al.* (2006) conclude that if cows of high genetic merit are managed properly, it is possible to obtain high yields and provide good welfare conditions simultaneously. The present study shows similar milk production in cows regardless of whether they are housed in DL or CU barns, which is consistent with the findings of Haley *et al*. (1999). The higher percentage of nasal discharge in CU barns observed in this study could be due to dust produced by new bedding material impacting the metal parts of CUs, which could reduce the cow resistant to infections and allergies (Zappavigna *et al.*, 2014). It is added every 12 days on average while, in DL barns, new bedding material is added twice a year. Although cows are not usually present in the barn when new bedding material is added, they are in nearby areas, and dust may be persistent in dry climates such as the study area. On the other hand, as there is also a higher percentage of vulvar discharge in CU barns, a lower activity of the immune system in these farms could be suggested as a reason for differences in both nasal and vulvar discharges.

A higher number of horned cows were detected in those farms with DL barns, which used thermocautery in 43% of them and caustic paste in the remaining 57%. Farms with CUs however used mainly thermocautery procedure for dehorning (83%). Aspects associated with disbudding or dehorning (as the type of procedure or the use of anaesthesia or analgesia) have important impact on the welfare assessment. In this sense, if thermal dehorning is carried out using anaesthesia and analgesia, the punctuation obtained by WQ will be around three times higher. In this case, no farmer used anaesthesia or analgesia. Although dehorning method is independent of housing system, the higher percentage of horned cows and the common use of caustic paste in DL barns could indicate that these farmers are less aware of animal welfare.

It has been reported that housing systems affect the reproductive performance of dairy cows (Barberg *et al.,* 2007). For example, it has been demonstrated that preventing cows from lying down produces variations in the hypothalamic-pituitary-adrenal axis (Munksgaard & Simonsen, 1996), which supports the suggestion that better housing systems, involving better resting conditions, will enhance reproductive and other parameters. Cows housed in DL barns spend more time lying or ruminating than those in CUs, and Phillips & Schofield (1994) described reduced calving-to-conception intervals in cows housed in deep strawyards compared to those housed in CUs, which may be attributable to better welfare conditions. In the present study, no differences for reproductive parameters were observed when DL and CU barns were compared, in accordance with Fregonesi & Leaver (2001), who found no difference between housing systems for calving-first oestrous intervals or fertility. Nevertheless, reproductive values in CU barns presented much more variability than in DL barns. This probably prevents differences to be significant, even when for some parameters, *e.g.* calving interval, mean values for CUs are quite higher than for DL systems. These differences are probably due to the use of automatic heat detection systems, not to the housing facilities, as a tendency was observed for farms using these systems to have larger calving intervals (487 *vs* 443 days, $p$=0.06) and lower heat detection rates (43.3% *vs* 57.3%, $p$=0.002). An opposite result would be expected. We hypothesize that, in this case, farmers having automatic heat detection system relied solely on this technology, eliminating the time for cow behaviour observation. This could have a negative impact on reproductive indexes if the technology was not working perfectly.

In general, society seems likely to continue making increased demands for food produced in a way that minimises harm and maximises wellbeing for animals (Croney & Botheras, 2010), so it is necessary to continue undertaking this type of studies to provide both farmers and technicians with the information they require.

To conclude, all the farms showed a good housing assessment, while feeding and health evaluations offered immense scope for enhancement. One of the proposals for increasing the welfare score in these farms should be conducted towards the implementation of anaesthesia and analgesia for carrying out the dehorned in young animals, among other interventions. On the other hand, both DL and CU barns have strengths and weaknesses in terms of animal welfare. Deep litter barns were inferior in terms of cleanliness of animals and water points, while CUs had some problems related to animals colliding with equipment and nasal discharge, the last probably associated to dust or deficiencies in cow immune system. Reproductive performance was similar for both systems. Management practices, such as the space per cow seem to have a greater impact on animal welfare than the type of facility. In this sense, WQ protocol presented some limitations to evaluate animal welfare, as management information is not included, and data refer to punctual visits to farms, which might not be representative.

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