

## STUDIES OF CUBICLE BED DESIGN IN LATVIAN DAIRY FARMS

Maris Mangalis, Juris Priekulis, Mara Mangale

Latvia University of Life Sciences and Technologies, Latvia

maris.mangalis@llu.lv, juris.priekulis@llu.lv

**Abstract.** The article discusses the experience of Latvian dairy farms in keeping cows in cubicle beds. It has been found that the number of cows kept in this way in the country is increasing every year. If in 2010 about 35% of the total number of dairy cows were kept in the cubicles, now it exceeds 50%. In addition, both high and deep cubicles are common. It was found that the highest milk yields and high milk quality (based on SCC) were obtained using deep cubicle beds in which the cows' beds were filled with sand. If high cubicle beds or deep cubicle beds with other bedding are used, the milk yield of cows is on average 15% lower. The number of SCC, on the other hand, increases by 50% with high cubicle beds and increases by 40% with deep cubicle beds with other bedding. However, this figure depends to a large extent on the frequency of cleaning the cubicle and the frequency of refilling the bedding material.

**Key words:** bedding, cows, cubicles, milk yield, SCC, litter.

### Introduction

Tie stall barns were once the primary type of dairy cattle housing in Latvia. Loose keeping of cows began in Latvia in the 1980s. Then separate experimental barns were built, which used to keep animals in combi cubicles, but sometimes also in cubicles. However, wider use of this type of housing began at the turn of the century, with the introduction of uninsulated or so-called "cold" barns. It has been found that such housing has several advantages over tie stall keeping [1-3]. Firstly, the welfare of the cows is already improving, as the barn has separate feeding and rest areas and the animals can move from one place to another. In addition, cows are milked in a separate hall or barn sector, where more hygienic milking conditions can be provided. Automation and robotisation of technological processes can be introduced more widely, for example, by using AMS (automated milking systems), compound feed preparation and distribution robots, etc. At the same time, the labour consumption of people working in the barn is significantly reduced [4; 5]. If in small barns, where only the water supply of animals and milking of cows is mechanized, the specific labour consumption of workers reaches up to 1000 man-hours per cow per year, then in modern barns this indicator is only 40-60 man-hours. However, in practice, various cubicle construction solutions and cow bedding options are used. Studies have shown [6] that cows tend to sleep 12-14 hours a day, getting up every 1.5 hours. In addition, when lying down, the last 10-15 cm of cows are no longer able to rest on their feet, but fall. Therefore, the cows' bed must be sufficiently soft and must conform to the dimensions of the animal's body. In addition, the bedding must be sufficiently sterile, as it will come into contact with the cow's udder during sleep and may become infected [7; 8] because the animals are not attached to a specific sleeping area and this changes from the specific situation. It is also important that the boxing enclosure must not interfere with the cow's ability to lie down and stand up, otherwise, it may choose a manure passage as a more comfortable place to lie down. The preferred design solutions and dimensions of cubicles, which are recommended depending on the breed and age of the cows or the live weight, are given in the special literature [2; 9; 10]. However, so far there is little research on the preferred design of the cubicles and the layout of the cow beds, based on the milk yields and the quality of the obtained milk. Apart from the bedding type, it is certain that udder hygiene scores are also influenced by other factors, including facilities, bedding and manure management, and parlour procedures [11].

Therefore, the aim of this article is to assess the prevalence of loose cows in Latvia, as well as to obtain information about the cow bedding solutions used in practice and to find out their possible impact on the milk yield and the number of somatic cells in milk.

### Materials and methods

The prevalence of loose dairy cows in Latvia can be assessed according to our [12; 13] developed methodologies. For this purpose, with the help of the expert method, the size of the herd of cows at which the transition from tethered to untethered animals takes place was determined, but then using statistical data [14; 15], the percentage of loosely kept cows is calculated. The formula to be used for the calculations

$$\sigma_x = 100 - \sigma_1 - \sigma_2 - \dots - \sigma_{n-1} - \frac{Z_{nx} - Z_{n\min}}{Z_{n\max} - Z_{n\min} + 1} 100, \quad (1)$$

where  $\sigma_x$  – percentage of loosely kept cows in the country in the relevant year, %;  
 $\sigma_1; \sigma_2; \sigma_{n-1}$  – percentage distribution of cows in the first, second and the respective year;  
 $Z_{nx}$  – critical number of cows in the herd in which the transition from tethered to untethered takes place. According to our studies [11],  $Z_{nx} = 60$  cows;  
 $Z_{n\max}; Z_{n\min}$  – maximum and minimum number of cows in the n-th group with the critical number of cows and the transition from tethered to non-tethered cows in the respective year.

The calculated result  $\sigma_x$  can also be applied to the percentage of cows' cubicles, because, according to our research, other types of keeping for dairy cows in Latvia are used in very rare cases.

In order to find out the most common types of cow cubicles in Latvia, data were collected from individual farms, where the largest herds of dairy cows are kept and also the highest average milk yields obtained. Both the milk yield and the somatic cell count (SCC) detected in the milk were refined according to the data collected by the Agricultural Data Center (LDC). [14; 15]. Initially, 75 farms were included in the studies, but some of them did not answer our calls or refused to provide information during the studies. Therefore, data from 71 farms could be used for the studies. The arrangement of the bedding and the effect of the bedding material on the health of the cow's udder and the quality of milk have been extensively studied by scientists from other countries. [16-18]. Bedding is an important source of teat end exposure to environmental mastitis pathogens. To better control environmental mastitis, we need an improved understanding of the relationships among bedding selection and management, bedding bacteria counts (BBC), and udder health (UH) [17].

For further data processing we used the data analysis program "Descriptive Statistics".

## Results and discussion

The percentage of cows kept in cubicles in Latvia found in the research is shown in Figure 1. It can be concluded that it has gradually increased over the years. If in 2010 34.8% of the total number of cows in the country were kept in the cubicle beds, then in 2020 it already reached 51.9%. So today, more than half of the total number of dairy cows are already kept free using cubicle beds. The cubicles provide a comfortable, injury-free and hygienic environment for cows that promotes growth and increases the milk yield. The Farm Animal Welfare Council stipulates that animals must be kept free of physical discomfort by the appropriate shelter and resting areas [19].

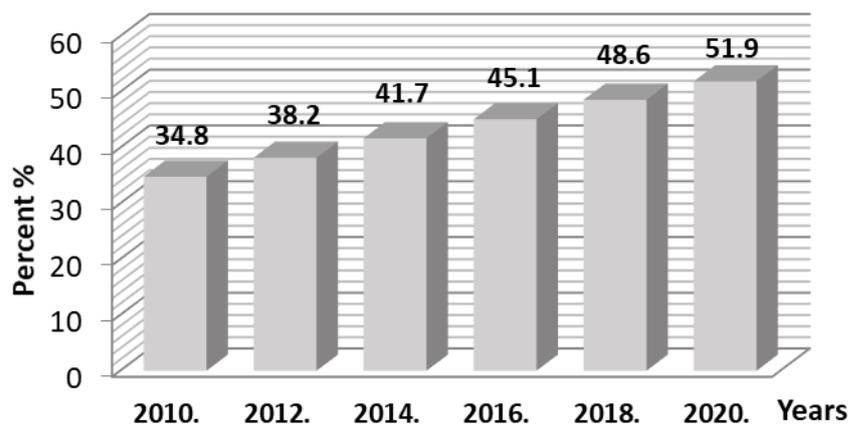


Fig. 1. Use of cubicles in Latvia from 2010 to 2020, % of the total number of dairy cows

Based on the design of the cubicles, the arrangement of the beds and the used bedding material, they can be divided into several types (Figure 2).

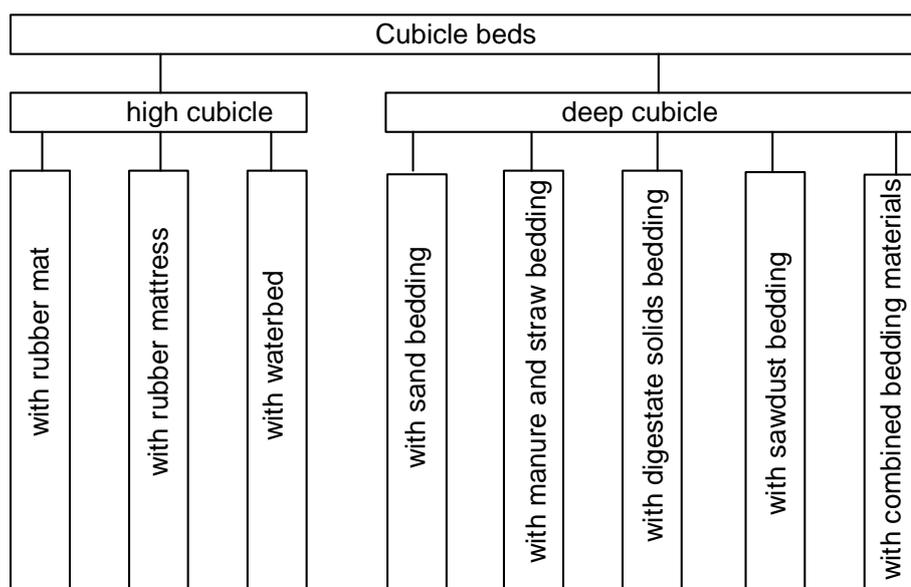


Fig. 2. Types of cow cubicle beds used in Latvia

According to the research data, 44% of dairy herds in Latvia use high cubicle beds, while the rest use deep cubicle beds. Of the high cubicles beds, water beds are the least used (only in two farms), but in all other cases – rubber mats and mattresses. Due to the fact that they require similar care (they are sprinkled 1-2 times a day with disinfectant powder or some other spreading material), the respondents often define these types of high boxes incorrectly, therefore in future surveys both boxes with rubber mats and mattresses were included in one common group. About 56% of farms use deep cubicle beds. The most common (almost 22% of cases) use of so-called manure-straw mattresses, which are formed by filling the cubicle beds cavity with layers of fresh manure and straw, which after compaction are compacted accordingly and, on the very surface, a layer of straw is left. But during the operation of the beds, the straw layer is regularly replenished and renewed. The use of sand is still relatively common (12.5% of cases). Sand is a sterile material that fits well on the cow's body. Clean, deep bedded sand has been associated with the best outcomes for mastitis, cow cleanliness, cow lying times, hock lesions, and cow preference. However, it needs to be replenished regularly and when cows walk, they tend to mix with manure, creating an abrasive mass. Therefore, mobile machinery is often used in practice to remove such manure.

Relatively often (15% of cases) different combined solutions are used to fill the beds of deep cubicles. For example, the lower part of the recess is filled with sand or digestate, while the upper part is covered with a layer of straw. Only digestate or only sawdust is used to fill the deep cubicle beds on farms, but it is not widespread (around 6.5%). Information on the average milk yield of the cows obtained in the research and the type of cubicle beds used is given in Table 1.

Table 1

**Average milk yields of cows and number of somatic cells in milk, depending on the type of used cubicles and bedding material**

Cubicle type	High cubicles	Deep cubicles	
Type of bedding materials	Rubber mats or mattresses	Sand	Straw and manure
Average milk yield, kg · year <sup>-1</sup>	11348 ± 277	13350 ± 498	11323 ± 460
Average level of SCC, 1000 cells · mL <sup>-1</sup>	176 ± 15	111 ± 48	159 ± 28

This table summarizes the total data for all types of high cubicles beds, as they are cleaned daily in a similar way. Data are also given for deep cubicle beds with sand cover, as well as beds with straw-manure cover, when separate layers of straw are bound with fresh manure layers. However, no research

has been provided on deep beds with digestate coating, as well as on combined types of coating, as these solutions are currently used on a small number of farms, so the standard error in processing these

data was well above the 8% tolerable level. The results of the conducted research indicate favourable conditions for the implementation of free-stall housing systems for dairy cattle/cows, in which the lying stalls are covered with sand as the bedding material. Of course, the implementation of this type of solutions requires taking into account the needs related to maintenance, including replenishment of sand as a result of its consumption [20] and sand losses [21]. The level (quantity) of sand in the lying stalls determines the time of lying cows; lowering the level of sand in lying stalls leads to a significant reduction of the lying time of cows [22], which translates into animal welfare [23]. Sand in lying stalls is therefore a valuable alternative in dairy production and is worth systematically introducing in dairy farms, which is also confirmed by our research presented in this article.

According to the data given in the table, quality milk is obtained in all cases of using boxes. In addition, it should be noted that these factors are influenced by many factors, such as the breed of cow, feeding of the animals, the milking technology, the microclimate of the barn, cleanliness of the beds, the frequency of littering, etc. However, these studies show that the highest milk yields and the highest quality milk (in terms of SCC) are obtained when cows are kept in deep cubicles with sand bedding. If high cubicles or deep cubicles with other bedding materials are used, the milk yields of cows are 15% lower. In turn, the level of SCC increases by 50% when using high cubicles, but increases by 40% when using deep cubicles with other bedding material. However, this indicator largely depends on the frequency of cleaning and spreading the cubicle beds, as well as the quality of the bedding material.

## Conclusions

1. The number of keeping cows using cubicle beds is increasing every year, and currently, more than half of the total number of dairy cows in Latvia is kept in this way.
2. In Latvia, both high and deep cubicle beds are used. The high cubicle bed part of the bed is concreted and covered with a rubber mat, mattress or so-called “water bed”, while deep cubicles have a recess in the bed filled with sand or compacted straw, the interlayers of which are bound with fresh manure or filled with digestate, or for different bedding in several layers.
3. It was found that the highest milk yields and the best milk quality (based on SCC) were obtained by using deep cubicles in which the cow beds were filled with sand. If high cubicles or deep cubicles with other bedding materials are used, the milk yields of cows are about 15% lower, but the level of SCC increases by 40-50%.

## Author contributions

Conceptualization, M.M. and J.P.; methodology, J.P.; software, J.P.; validation, M.M. and J.P.; formal analysis, M.M. and M.M.; investigation, M.M. and M.M.; data curation, M.M., J.P. and J.P.; writing – original draft preparation, M.M.; writing – review and editing, M.M.; visualization, J.P.; project administration, M.M. All authors have read and agreed to the published version of the manuscript.

## References

- [1] Laurs A., Priekulis J., Auziņš V. Cold-type cowsheds in Latvia./Materialy na VIII Miedzynarodnowa Konferencja Naukowa “Problemy intensyfikacji produkcji zwierzecej z uwzględnieniem ochrony środowiska i przepisow UE”. Warszawa, 24-25 wrzesnia 2002 r. Cześć II. Pp. 345-348.
- [2] Sindhøj E., Rodhe L. “Manure Handling Techniques on Case-Study Farm in the Baltic Sea Region: Knowledge report”, 2013.
- [3] Gołaś Z. “Determinants of milk production profitability of dairy farms in the EU member states.” Problems of Agricultural Economics 3.352, 2017.
- [4] Priekulis J., Kuplis A. Research in most economically profitable technologies for removal of slurry from cow barns. /Proceedings 5th International Scientific Conference “Engineering for rural Development” Jelgava, May 18-19, 2006, pp.140-145.

- [5] Vegricht J., Doležal O. Automatic milking system and their chances in the Czech Republic. In Proceedings of the international symposium "Robotic Milking", Netherland: Lelystad (17.-19. August, 2000), 239 p.
- [6] Hulsen J. Cow signals: a practical guide for dairy farm management. Roodbont Publishers, 2005.
- [7] Jensen M.B., Pederson L.J., Munksgaard L. The effect of reward duration on demand functions for rest in dairy heifers and lying requirements as measured by demand functions *Appl. Anim. Behav. Sci.*, 90, 2005, pp. 207-217
- [8] Ito K., Weary D. M., Von Keyserlingk M. A. G. "Lying behavior: Assessing within-and between-herd variation in free-stall-housed dairy cows." *Journal of dairy science* 92.9, 2009, pp. 4412-4420.
- [9] Kuhställe clever bauen. Top Agrar Ratgeber. Landwirtschaftsverlag GmbH, Münster-Hiltrup, 2011. 128 S.
- [10] Hulsen J. "Cow signals checkbook.", 2012.
- [11] Lombard J. E., et. all. Associations between cow hygiene, hock injuries, and free stall usage on US dairy farms. *J. Dairy Sci.* 93: pp. 4668-4676.
- [12] Laurs A., Markovics Z., Priekulis J., Aboltins A. Research in farm management Technologies using the expert method. / *Agronomy Research*. Volume 14. Number 3. Saku :Rebellis, 2016, pp. 811-820.
- [13] Priekulis J., Aboltins A. Calculation methodology for cattle manure management systems based on the 2006 IPCC guidelines. / *Proceedings of the 25th NJF Congress*. Riga, 16th – 18th of June, 2015, pp. 274.-280.
- [14] Agricultural Yearly Reports. 20010-2020. (Lauksaimniecības gada ziņojumi) [online] [30.01.2022] Available at: <https://www.zm.gov.lv/lauksaimnieciba/ststistikas...lapas/lauksaimniecibas-gada-ziņojumi?nid=351#jump>
- [15] Latvian Agriculture. Central Statistics Bureau of the Republic of Latvia. (Latvijas lauksaimniecība. Latvijas Republikas centrālā statistikas pārvalde.) [online] [30.01.2022] Available at: <http://scb.gov.lv>
- [16] Bradley A.J., et all. The impact of dairy cows' bedding material and its microbial content on the quality and safety of milk - A cross sectional study of UK farms. / *Int J Food Microbiol.* 2018 Mar 23;269:36-45. DOI: 10.1016/j.ijfoodmicro.2017.12.022. Epub 2017 Dec 19.
- [17] Patel K., Godden S.M., Royster E., Crooker B.A., Timmerman J., Fox L. Relationships among bedding materials, bedding bacteria counts, udder hygiene, milk quality, and udder health in US dairy herds. / *J Dairy Sci.* 2019 Nov;102(11):10213-10234. DOI: 10.3168/jds.2019-16692. Epub 2019 Aug 22.
- [18] Tucker C.B., Weary D.M., Von Keyserlingk M.A.G., K.A. Beauchemin Cow comfort in tie-stalls: Increased depth of shavings or straw bedding increases lying time *J. Dairy Sci.*, 92, 2009, pp. 2684-2690
- [19] Veissier I., Capdeville J., Delval E. "Cubicle housing systems for cattle: Comfort of dairy cows depends on cubicle adjustment." *Journal of animal science* 82.11, 2004, pp. 3321-3337.
- [20] Gaworski M., Garreth Ferraz Rocha Á. Method to monitor sand level changes in free-stall lying area for dairy cows. *Agronomy Research*, vol. 14(4), 2016, pp. 1285-1292.
- [21] Rocha Á.G.F., Gaworski M. Sand losses out the pens in barn with free-stall housing system. *Agronomy Research*, vol. 15(2), 2017, pp. 530-539.
- [22] Drissler M., Gaworski M., Tucker C.B., Weary D.M. Freestall maintenance: Effects on lying behavior of dairy cattle. *Journal of Dairy Science*, vol. 88(7), 2005, pp. 2381-2387.
- [23] Tucker C.B., Jensen M.B., de Passillé A.M., Hänninen L., Rushen J. Invited review: Lying time and the welfare of dairy cows. *Journal of Dairy Science*, vol. 104(1), 2021, pp. 20-46.