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REVIEW: EUROPEAN COMPOST BEDDED-PACK BARNS FOR DAIRY COWS

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ABSTRACT - There is increasing interest in the use of continuous housing systems for dairy cows, with various reasons put forward to advocate such systems. The objective of this review was to examine existing scientific literature assess the main benefits achieved by the Compost bedded-pack barns (CBP) for housing dairy cow throughout Europe. Although summarizing existing work, knowledge gaps and directions for future research are also identified. The scope of the review is broad, examining relevant topics under three main headings: design, bed management, and composting process. Regarding main headings, some European CBP system does not appear to be similar to the US CBP but producers developed different design and management styles to adapt to the several microclimates that exist in each country. CBP systems had benefits for dairy cow behaviour, in terms of grazing and improved lying/resting times. In summary, the results of this review highlight that there are considerable benefits to animal welfare and animal productivity when housed in Compost bedded-pack barns.
Keywords: lactating dairy cattle, design, comfort.

INTRODUCTION

Housing can deeply affect the welfare of dairy cows and consequently their performance. Actually, free stall barns (FS) represent the most widespread housing system in European dairy farms. However, recent findings showed that this system can severely compromise animal welfare, especially as regards feet and leg health. *compost-bedded pack barns* (CBP), also known as compost barns, are relatively new housing option for dairy cows that seems to offer improved cow comfort. The CBP system has

elfare and increasing agronomic value of effluents produced. Experiences with CBP are reported in European literature from the Netherlands, Denmark, Austria, Switzerland, Spain and Italy. More recently, farms in Germany, Sweden, Slovenia, Slovak Republic and Norway also adopted this system. Although all CBP in Europe share similar characteristics, noticeable differences can be found among the systems developed in different countries and climates. Thus, the objective of this review was to examine existing scientific

literature assess the main benefits achieved by the *compost bedded-pack barns* for housing dairy cow throughout Europe.

CBP IN THE NETHERLANDS

In 2007, a group of Dutch dairy farmers started looking for a barn in which cows can become older without problems and out of which excellent fertilizer for the land proceeds. In that year researchers inspired dairy farmers through experiences from Minnesota (USA) with Compost Dairy Barns. There they used a bedded pack consisting of wood chips and sawdust, but the sawdust was becoming more and more expensive. Therefore, a number of Dutch farmers went on a study trip to Israel in 2008, searching for a cheaper bedding material. In the Israeli climate farmers succeed to keep the cows clean on a bedded pack of dried manure. However, that is not possible in the humid climate in the Netherlands. Therefore, at the end of 2008, experimental farms of Wageningen UR started to experiment with three principles of drying the top layer of the bedding, namely: drainage, evaporation and absorption of moisture. Moreover, limiting the emissions was also a significant challenge. The CBP system spread in commercial dairy farms in the Netherlands since 2009. In early 2014, about 40 bedded pack barns have been built in the Netherlands (Galama et al., 2011).

With the aim of enhancing the composting process, automatic systems that blow (or suck) air into the pack have been employed in some Dutch CBP. Aeration systems mainly consist in perforated tubes that are installed in the concrete floor below the pack and are connected to an external air pump. In this kind of barns the pack is stirred mostly once a day and the main bedding material used is wood chips (Galama, 2014). To keep the pack sufficiently dry in the humid Dutch weather and limit the amount of wood chips needed, a pack density of 15 m^2/cow is recommended even though, with aeration systems and optimal management, 12 m^2/cow appear to be adequate. In the Netherlands, this type of CBP is known with the name composting bedded pack.

The other CBP system developed in the Netherlands is quite similar to that employed in Israel and it is not based on the production of heat into the pack. The main material used in this kind of CBP is compost from organic wastes. For this reason this housing system is known in the Netherlands as compost bedded pack although differences with the North American CBP are substantial (Galama, 2014). The pack is stirred once

daily and the recommended pack density in this type of CBP ranges from 15 to 20 m^2/cow in barns provided with scraped or slatted feeding alley and up to 30 m^2/cow.

Due to restrictive regulations, most Dutch research on CBP focused on environmental footprint. Results indicate that the bedding material enriched with manure has advantages and disadvantages. It is primarily a soil improver as it adds more organic matter. That is an important advantage for the improvement of the soil fertility and reduced nutrient leaching. However, the nitrogen is released more slowly in the soil. For the short term this is a disadvantage, because the crop yield will decline. For the longer term a portion of the nitrogen will still be released. In addition, part of the active nitrogen is permanently lost due to the higher nitrogen losses from the barn. For both types of bedded packs developed in the Netherlands, nitrogen losses appeared to be higher than in free stall barns. This is due to the additional supply of nitrogen via the bedding material and because of larger emitting surface than in a free stall barn. However recent research found that an actively composting bedded pack can fix most of the nitrogen and thus limit ammonia emissions to a level that is comparable or lower than in free stalls.

Regarding the building structure, in the Netherlands a common solution used for compost barns is given by greenhouses (Figure 1). These structures allow obtaining an interesting reduction in the building costs for the light bearing structures and the simple plastic coverings, having bright inside environments and reaching an good ventilation during summer. particular care has to be put in the control of sun radiation to avoid heat stress.

A.

B.

C. D.

Figure 1. A. In the Netherlands a common solution for the structure of the barn is given by greenhouses; B. An inside view of a compost barn realized under a greenhouse; C. The greenhouse structure allows to open the roof during the summer season in order to create a natural environment; D. Dutch compost barns are often realized in laminated timber.

The TAS/XTAS issue

In recent years, an important Dutch dairy cooperative noticed that milk from CBP can cause some spoilage problems in long-life dairy products that were considered to be microbiologically sterile. Further researches demonstrated that the use of green waste compost and composting wood chips as bedding for dairy cows can cause milk contamination by thermophile aerobic spore-forming bacteria (TAS) and by a subpopulation of bacteria that produces extremely heat-resistant spores (XTAS). Spores produced by TAS and XTAS bacteria can survive standard milk sterilization processes causing problem in the shelf life of some dairy products (Galama et al., 2014). For this reason, the Dutch Dairy Company decided to forbid the use of compost as bedding for dairy cows starting from the 1st January 2015. Actually, the prohibition does not regard composting wood chips although this material also represents a matter of concern.

Research investigated the presence of TAS and XTAS in various types of beddings and in milk from CBP. Spores of both TAS and XTAS were detected in beddings while only TAS were found in milk. Concentration of XTAS cannot be determined in tank milk because concentrations were below the limit of detection. High concentrations of TAS and XTAS spores were detected in compost and composting wooden chips. From the bedded pack, TAS and XTAS bacteria can contaminate the cow's teats. Although they are not believed to produce intramammary infections in cows, TAS and XTAS from contaminated udders are transferred in milk. Due to the high concentration of spores in compost and composting wood chips beddings, teat cleaning operations have shown to be insufficient to avoid milk contamination (Galama et al., 2014).

Other bedding materials such as sawdust, straw and separate manure solids showed very limited concentration of TAS and XTAS compared with compost and composting wood chips. For this reason, in the last few years, many producers tried to use wheat straw in CBP that was originally developed for compost or wood chips. Results appear to be encouraging. In a study carried out in the Netherlands, milk quality as well as performance and welfare of cows housed in CBP using compost, composting wood chips and straw were compared. In CBP using straw, lower concentrations of TAS and XTAS were found in milk. Furthermore, cows housed on straw bedding had the lowest SCC (Somatic Cell Count) indicating that straw can represent a viable alternative to compost and wood materials in CBP.

The Cow Garden/High Welfare Floor

The "High Welfare Floor" is still experimental, but a very challenging concept. The working principle of the floor is based on immediate separation of animal waste. To allow the separation, the artificial floor is composed by several layers (Figure 2). Liquid drains through the floor into a drainage layer below and removed from the barn. Solid manure remains on the floor surface, to be automatically cleaned by a robot. The availability of two different kinds of manure allows a flexible fertilization.

A. B.

Figure 2. A. The High Welfare Floor allows to separate urine and feces. The surface is cleaned by means of a robot; B. The solid manure collected by the robot can be stored separately allowing a better use in the fields.

In "Cow Garden", the "High Welfare Floor" is used mainly in the resting area of the animals, but in this innovative housing system low trees and shrubs are placed inside the barn with the aim of providing a more natural living environment to the animals (Figure 3).

Figure 3. An inside view of a "Cow Garden" in the Netherlands. The "High Quality Floor" is used in the resting areas. Trees and shrubs are planted among the alleys.

Alternative use of the compost barn

In the Netherlands some dairy farmers are using the barn for alternative uses, especially in cases of organic and bio-dynamic production. The Figure 4 show a barn where the resting area is closed to the cows during the grazing season. From spring to autumn, the animals go outside to graze and come back to the building only for milking and supplement feeding. In this way the cows can use the feeding alley, but not the resting area. The compost bedding is employed to produce vegetables, like tomatoes, peppers, zucchinis (Galama et al., 2011).

A. B.

Figure 4. A. In this organic farm, the resting area with compost bedding is used from spring to autumn to cultivate vegetables; B. Cows in the feeding alley. The resting alley is closed to the animals and used for vegetable cultivation.

CBP IN AUSTRIA

The first types of CBP system have been built in Austria around 2011. Each of these housings is special, because it has been adapted to the dominating microclimate in the several regions. The system should continuously be adapted to the prevalent climatic

and economic situations, which means that it needs some time so as to be able to manage a compost barn at best (Burgstaller et al., 2016). At present (2018) there are about 80 – 85 compost barns in Austria, being managed by means of the most different materials (Figure 5).

Figure 5. An Austrian compost barn with timber structure.

Admittedly, there are regions in Austria, where the management of these systems is badly or even not feasible at all, for example in too humid climatic conditions during the whole year.

In order to achieve the nearly pasture-like conditions in the housing system, regular support measures, the choice of optimal bedding material and a considered arrangement of facilities (e.g.: drinkers, concentrate feeders, scrapers, etc.) in the housing are important. The next important constructional detail is represented by the transition area between lying and feeding area. Too high ground sills are a handicap for the cattle, being too low they lead to a lot of dirt in the walking alley (Burgstaller et al., 2016).

To start a new bedded pack, 20 – 25 cm high bedding-mattress is taken to get started (1.8 – 2.5 m³/animal). Thereon a litter-amount of about 0.4 – 1.3 m³/animal is strewed every 2 – 7 weeks. The material for the lying area is loosened up to a depth of 15 to 25 cm by means of a grubber or rotary tiller once or twice a day, and the accruing excrements and urine are being worked in. In this way air attains the mattress, so that the excrement-urine-litter mix can rot by means of aerobe and facultative anaerobe microorganisms. A loose-crumbly lying material will evolve (Ofner-Schröck et al., 2015).

Temperature in the bedding increases through the composting progress. It should be between 30 and 45 °C for a quick conversion of the organic substances and for the support of useful germs. Twice a year (spring and autumn), when the compost mattress has achieved a height of 50 – 60 cm, bedding removal has to be organized. The setting of

a new pack should not be carried out during the cold season, because the composting process hardly establishes in cold weather.

An important item concerning welfare, cleanliness and profitability is the size of lying area. Austrian researchers recommend a minimal area of >7 m² (for high yielding cows: up to 15 m²)

The mostly utilized bedding substances are sawdust, wood shavings and wood chips. These substances advance biological activity, are well to be mixed thoroughly and are therefore better aerated.

CBP IN ITALY

In Italy, use of CBP has spread since 2006; currently, there are around 50 CBP, mostly located in the Po Plain, northern Italy. Although in other countries this housing system has evolved mainly with the aim of improving cow comfort, in Italy it was initially developed to reduce the risk of mastitis in conventional straw yards (Leso, 2015). As a matter of fact, the first CBP in Italy resulted from retrofitting of conventional straw yard housing systems and had limited space per cow (6.7 m^2/cow on average). Italian farmers soon saw the advantages in the CBP in terms of udder health. A few years later, also the positive effects on cow comfort and lameness became evident, and more farmers shifted to CBP. However, just in recent years (since 2014-2015) the first barns specifically designed for the CBP housing system have been constructed in the country. Newly constructed CBP have a space per cow comprised between 10 and 15 m^2/cow (resting area only). The increased space allowance allowed achieving further benefits, especially concerning cow cleanliness and ease of management. Most commonly used bedding materials in Italian CBP are sawdust, wood shavings and straw.

Italian research on CBP showed that, if properly managed, this housing system can represent an effective solution for housing dairy cows. Compared with FS, CBP showed to improve cow's longevity, indicating better cow comfort and health. Producers indeed identified animal welfare as the main benefit of CBP and overall they appeared to be very satisfied. Nevertheless, concerns about the cost of bedding remain to be addressed (Leso et al., 2013).

In Italy construction waste management has become extremely important due to stricter disposal and landfill regulations, and a lesser number of available landfills. Design for Deconstruction (DfD) is a new concept in building science based on the use of

recyclable, renewable, locally available and environmentally friendly raw materials, with low environmental and economic impact according to six main principles for sustainable construction: to minimize resource consumption; to maximize resource reuse; to use renewable and recyclable resources; to protect the natural environment; to create a healthy and non-toxic environment; to pursue quality in creating the built environment (Leso et al., 2018). The Figure 6 shows a prototype of a building realized applying the DfD principles for a compost barn in the region of Piedmont. The entire facility can be completely removed (and most materials recycled) when obsolete (expected life time 20 years).

A. B.

C. D.

Figure 6. A. A large herd kept in a compost barn in North Italy (Mantua province); B. A compost barn with a structure realized in steel and laminated timber. Emmer husks are used in the ban as bedding material; C. The compost barn is always realized with large openings. The walls are not provided also in mountain areas with cold winter. The building in the picture is placed in North Italy (Vipiteno, Bolzano); D. Concepts of Design for Deconstruction are applied in the compost barn shown in the picture.

CONCLUSION

From the present results, the Compost bedded-pack barns can be seen as an animal-friendly system to European dairy producer. Further investigations are desirable to analyze other factors affecting animal health and to resolve any outstanding issues concerning economy and alternative litter materials.

In dairy operations, milk yield can be affected by several factors so quantifying the effect of housing system alone is challenging. Results reported in literature indicate that high levels of milk production are possible in CBP. Further, as CBP has the potential to improve cow comfort, increased milk production compared with other housing systems such as Free Stall might be expected.

REFERENCES

BURGSTALLER, J.; RAITH, J.; KUCHLING, S.; MANDL, V.; HUND, A.; KOFLER, J. Claw health and prevalence of lameness in cows from compost bedded and cubicle freestall dairy barns in Austria. The Veterinary Journal, v. 216, p. 81-86, 2016.

GALAMA, P. J.; DE BOER, H.; VAN DOOREN, H. J.; OUWELTJES, W.; POELARENDS, J.; BOKMA, S.; DRIEHUIS, F. Vrijloopstallen voor melkvee in de praktijk. Lelystad: Wageningen UR Livestock Research, 2014.

GALAMA, P. J.; BOKMA, S.; VAN DOOREN, H. J.; OUWELTJES, W.; SMITS, M.; DRIEHUIS, F. Prospects for bedded pack barns for dairy cattle. Lelystad: Wageningen UR Livestock Research, 2011. 33p.

LESO, L.; CONTI, L.; ROSSI, G.; BARBARI, M. Criteria of design for deconstruction applied to dairy cows housing: a case study in Italy. Agronomy Research, v. 16, n. 3, p. 794-805, 2018.

LESO, L. Performance and design of an alternative housing system for dairy cows. Tese de Doutorado. Thesis of PhD (Sustainable management of agricultural and forestry resources). 2015, 123 p. Università degli Studi Firenze, Firenze–IT.

LESO, L.; UBERTI, M.; MORSHED, W.; BARBARI, M. A survey of Italian compost dairy barns. Journal of Agricultural Engineering, v. 44, n. 3, p. 17, 2013.

OFNER-SCHRÖCK, E.; ZÄHNER, M.; HUBER, G.; GULDIMANN, K.; GUGGENBERGER, T. Compost Barns for Dairy Cows - Aspects of Animal Welfare. Open Journal of Animal Sciences, v. 5, n. 2, p. 124, 2015.