

- PILOT COWSHED: A YEAR MONITORING CLEANLINESS, ANIMAL WELLBEING, AND CHEESE PRODUCTION

Stabilized separate, bedding material that “works”

The results from a pilot study cowshed with stabilized separate bedding showed good standards of animal cleanliness and a prevalence of lameness comparable to other cowsheds with stalls using traditional bedding materials. The level of health and hygiene of the milk and the sanitary condition of the udders were fully compatible with the norms in the Parmigiano Reggiano cheese production area.



Stall with stabilized bedding

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In Emilia-Romagna the majority of dairy farms buy their bedding materials directly from the market because their land cultivation is organized almost entirely around production of fodder crops. However, in recent decades **agronomic motivations have led numerous medium to large size farms to set up mechanical manure separation plants, and some of these have experimented with using the solid fraction obtained from separation, known as “separate”,**

as bedding in freestall barns.

The advantage is obvious, especially for very large barns, but there are also health and hygiene implications that have to be carefully assessed, especially for the production of milk destined for Parmigiano Reggiano cheese making. **One of the most problematic aspects of the use of untreated separate as bedding for cows housed in stalls is its high humidity (75-80%),** which encourages the development of microbes and adhesion of the finest separate particles to the skin of the udders, acting as a vector for pathogenic micro-organisms. Nevertheless, a Dutch study has shown that a high presence of bacteria in the bedding does not

necessarily cause problems of clinical mastitis or milk contamination (Valacon-Diary, 2012).

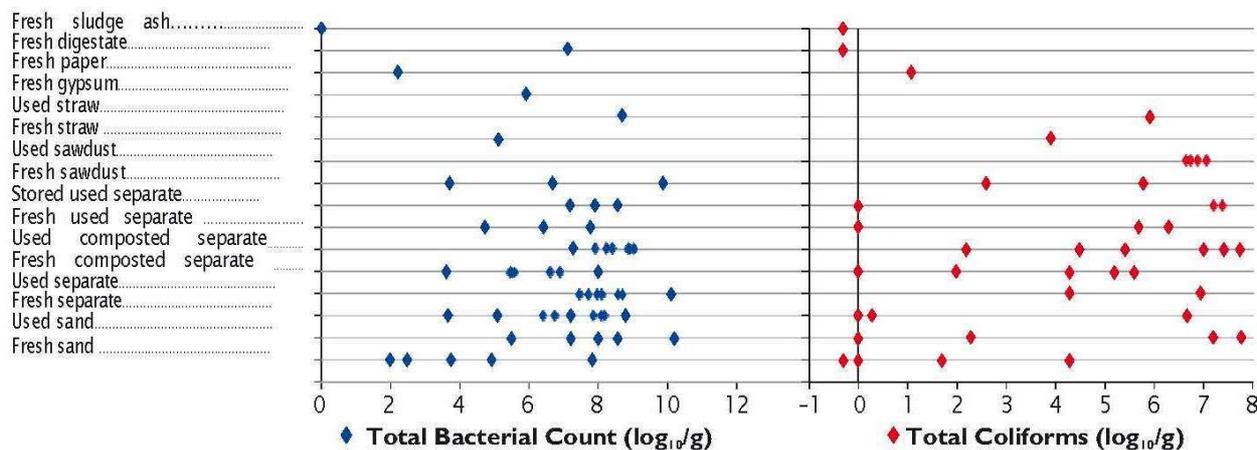
There are relatively few farms successfully using this system in Emilia-Romagna. Some have tried in the past but later abandoned it, returning to traditional bedding materials.

Based on regulation (CE) 1069/2009, cowshed manure is classed as a category 2 animal by-product and so can be utilized for technical purposes, as long as this does not constitute an unacceptable risk for public and animal health. Two studies were conducted in the United Kingdom and Holland into the use of separate as bedding for dairy cows, leading to the publication of a number of recommendations (Defra, 2017, Green *et al.* 2014, Valacon-Diary, 2012).

Monitoring “stabilized bedding”

The crucial factor for the successful use of separate as bedding depends on its chemical, physical, and microbiological composition, which can all vary on the basis of the type of manure being treated, the type and calibration of the separator, and the subsequent handling of the separate. Graph 1 shows the bibliographic reference values for Total Bacterial Count (TBC) and Total Coliforms (TC), expressed in “units forming colonies” on a logarithmic scale (log base 10 Ufc/g) for different types of bedding, demonstrating a wide variability from material to material and even for the same materials. The term “used” materials means those already used as bedding.

GRAPH 1 - Total Bacterial Count and Total Coliforms present in different bedding materials



The different stall bedding materials exhibit wide variability from material to material (and even for the same material). The term “used” materials means those already used as bedding.

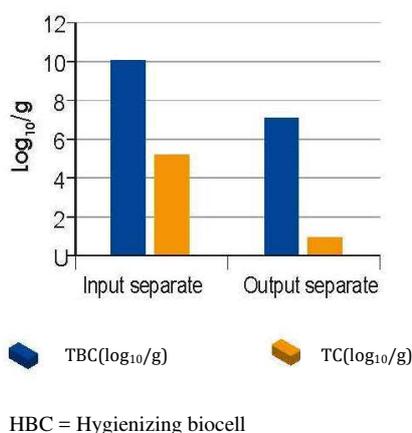
The Total Bacterial Count values for fresh separate vary from 10^4 to 10^8 Ufc/g. Past experience has demonstrated that static or dynamic (with periodic overturning) accumulation of bedding or similar materials causes the development of aerobic processes that can raise the internal temperature up to 60 or 70 °C. This is the minimum condition required to hygienize the product from a health and hygiene perspective. Based on this knowledge a Work group for innovation (Wgi) was set up called “Stabilized Bedding”, within the context of the Regional Rural Development Program 2014-2020 (operation type 16.1.01) for groups operating in the European partnership for innovation: productivity and sustainability for agriculture - Focus area 2A.

The Wgi “Stabilized Bedding” tested a prototype dynamic hygienizing biocell plant, developed by Cri-Man of Correggio (Reggio Emilia) for stabilizing separate for use as bedding. The effects on the cleanliness and wellbeing of the cows, hygiene of the milk, cheese making process and maturation of cheese, company costs, and environmental sustainability were monitored for one year at the Giaroli dairy farm in Reggio Emilia. On the strength of this experience, CRI-MAN developed three biocell models with different operating capacities, referred to as the HBC500, HBC1000 and HBC2500 (HBC = Hygienizing BioCell).

Monitoring hygiene and wellbeing

Throughout the monitoring period for the stabilization process, from December 2016 to November 2017, the retention time of the separate in the biocell was on average 1.2 days. Graph 2 shows the **average Total Bacterial Count and Total Coliforms values for the separate on input and output from the biocell, highlighting a marked reduction in bacterial load which resulted from the pasteurizing effect on the material during the time inside**

GRAPH2- Total Bacterial Count (TBC) and Total Coliforms (TC) n the separate before and after the stabilization process



There was a marked reduction in bacterial count in the output separate derived from the hygienizing pasteurizing effect during the time inside the hygienizing biocell.

the hygienizing biocell.

On the pilot farm the stabilized bedding was unloaded directly into a mixing trailer towed by a tractor and then distributed in the stalls once a week. Subsequently the material was “smoothed out” with a horizontal scraper fitted on a tractor to form a soft layer of bedding of about 10 cm in thickness. As a precautionary measure the pilot farm applied a carbonate and calcium sulphate based additive, mixed for half an hour in the trailer before distribution.

Microbiological analyses revealed that the mixing and consequent aeration of the separate had a counterproductive effect, triggering a rapid increase in microbial load. Furthermore, various bibliographical sources have highlighted the very limited effect of these types of additives for reducing bacterial load in fresh separate.

Consequently, mixing and aeration of separate before distribution in stalls is not recommended. In all cases, microbiological analyses revealed that after distribution the separate exhibited a marked increase in microbial load, partly attributable to contamination with urine and manure from the cows.

Comparison with reference cowsheds

The animal health and hygiene data (degree of soiling and %

of lameness) from the pilot shed were compared to data from other reference sheds using different stall systems and bedding management in the rest area. Table 1 shows that the average **degree of soiling** of the cows in the pilot shed was **low overall** and comparable with that of stalled sheds using straw in quantities equal to or greater than 2 kg/head/day (sheds B, G, and I), or mattresses of 0.7 kg/head/day of wood sawdust (shed D). The **good state of cleanliness of the cows in the pilot shed derived from the relatively high total proportion of solids in the stabilized bedding (38%)**.

Conversely, in shed A using “fresh” separate with a total solid content lower than 30%, the degree of soiling was higher. The **average prevalence of lameness in the lactating cows in the pilot shed (4.3%)** was also below the warning threshold of 10% indicated by Efsa (Efsa, 2012) and was intermediate relative to the levels recorded for the other stalled sheds with solid walkways in Table 1 (from 1.9% to 7.3%). It should be noted that lameness is not only influenced by stall comfort due to type of bedding, but also other factors like the flooring in the walkways, nutritional issues, and foot care for the cows (for example washing, disinfection, hoof trimming).

Milk quality for Parmigiano Reggiano cheese

Parmigiano Reggiano is a hard, cooked curd, long seasoned, PDO cheese obtained from milk that

TABLE 1 – Degree of soiling and % of lameness in the pilot shed with stabilized bedding and comparison with 9 sheds with different types of bedding

Shed	Type of stalls	Type of bedding (°)	Bedding consumption (kg/head/day)	Degree of soiling (°)	Lameness (%)
Pilot	Inset in 3 rows, solid floor walkways	Stabilized separate (TS= 38%)	5	2.59	4.3
A	Inset in 3 rows, solid floor walkways	Unstabilized separate (TS<30%)	9	3.46	4.1
B	Inset in 3 rows, solid floor walkways	Long straw	2	2.74	4.3
C	Inset in 3 rows, solid floor walkways	Chopped straw	1	3.45	7.3
D	Matrasses in 3 rows, slotted	Wood shavings	0.7	2.65	11.4
E	Inset in 2 rows, solid floor walkways	Wood shavings	0.4	3.95	6.9
F	Solid floor in 3 rows, slotted floor	-	0	4.68	17
G	Inset in 3 rows, solid floor walkways	Long straw	3.3	2.38	1.9
H	Solid floor in 2 rows, solid floor walkways	Long straw	0.5	3.70	5.8
I	Inset in 2 rows, solid floor walkways	Long straw	2.3	1.92	2.7

(°)TS=total solids.(°) Degree of soiling = Average score of at least 50% of the animals in the shed with degree of soiling calculated for 5 anatomical regions, when 1 indicates very clean and 10 very extensive soiling.

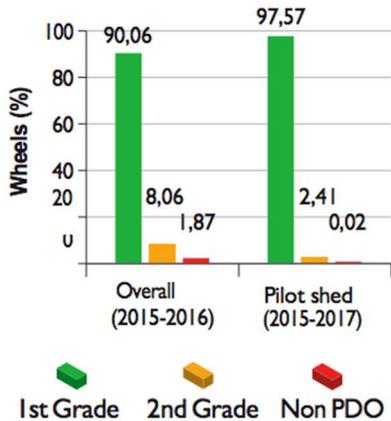
The average degree of soiling in the pilot shed was overall low and comparable to that of stalls with straw bedding (2 kg/head/day, stalls B, G, and I) or mattresses (stall D) as a consequence of the relatively high solid content (38%). Stall A used “fresh” separate (solid content below 30%) and the degree of soiling was higher.

TABLE 2 – Chemical composition, physical-chemical properties, and health and hygiene parameters of the milk in the pilot barn

	N	Mean	DS	Minimum	Maximum
Lactose(g/100g)	44	4.90	0.06	4.71	5.03
Fat (g/100g)	44	3.39	0.25	3.01	3.95
Protein (g/100g)	44	3.19	0.11	3.02	3.51
Casein(g/100g)	44	2.48	0.09	2.36	2.73
CaseinIndex(%)	44	77.88	0.86	76.43	79.82
Urea(mg/100mL)	37	25.92	2.73	2	31.90
pH	44	6.69	0.05	6.55	6.85
Titrateable acidity (°Sh/50 mL)	43	3.27	0.12	3.00	3.50
Total bacterial count (103Ufc/mL)	44	87	235	7	1.591
Somatic cells (103 cellule/mL)	44	320	34	248	396
Spores (n./L)	44	55	48	30	200
Aflatoxin M1 (µg/kg)	12	0.006	0.002	0.005	0.011

In cases of mastitis the somatic cells increase (> 400,000 cells/mL), with a reduction of lactose (about 5 g/100 g) and casein (< 77%). The somatic cell content in the milk samples were on average 320,000 and the average values for lactose and casein were entirely physiological, indicating a good state of health.

GRAPH3- Results of analysis of the cheese wheels produced with the milk from the pilot shed compared with the wheels from the cheese Consortium



Over the period 2015 (first quarter) to 2017, expert assessment (Graph 3) classified 97.57% of the wheels as 1st class (average score for the production area was 90.06%), 2.41% as 2nd class (average score for the production area was 8.06%), and only 0.02% of the wheels were not marked (average score for the production area was 1.87%).

does not undergo any thermal hygienizing treatment (unprocessed milk). For this reason the progression of the cheese making process and the textural and sensorial characteristics of the finished cheese depend closely on the chemical, physicochemical, and microbiological characteristics of the original milk. It is therefore important to assess any effects of the stabilized bedding on the characteristics of the milk, with particular reference to the levels of microbial contamination (total microbial count, presence of coliforms and butyric clostridia spores) and the somatic cell content. For example, **butyric clostridia spores are the main microbial agents responsible for the most serious defects in Parmigiano Reggiano**, like early or late swelling. An increase in cells, in addition to having a negative effect on the quantity of milk produced, also causes a net deterioration in the

DYNAMIC HYGIENIZING BIOCELL PROTOTYPE

The pilot farm is home to about 480 lactating Friesian cows, housed in cowsheds with three rows of stalls and solid floor walkways cleaned with scrapers.

The biocell (photo below) is an upright, all stainless steel structure. Solid separate with a total solid fraction not less than 31%, is loaded in at the top and hygienized material is released from the bottom. Along its transit the biomass is constantly mixed with vanes that rotate slowly around a central vertical shaft.

In addition to mixing there is also forced ventilation from the outside with a fan drawing air into the central shaft and blowing it out through the vanes. An even distribution of air is ensured by nozzles positioned along the profiles of the vanes. The blown air carries the oxygen required for the exothermic process of oxidization while at the same time as it travels upwards it becomes saturated with H₂O, partially drying the biomass and increasing the total solid content on average by around 3%. The cooling of the biomass caused by the ventilation is compensated by a heat recovery system from the exhaust air extracted at the top of the biocell. The heat is used to raise the air input temperature. It is important to note that untreated input material never comes into contact with material at the lower levels that has already completed the hygienization process. The process is monitored with suitably distributed temperature and weight transducers that enable constant monitoring of the amount of material present and the stage of the hygienization and drying processes. The readings from the transducers are processed by a PLC (programmable logical controller), which regulates the air input. A program enables management of an entire separation and hygienization plant. The biocell management system is designed to ensure complete hygienization of the output material, and output is not enabled until the required hygienization conditions have been fulfilled (the reference is a continuous temperature of 70 °C for at least 1 hour).



technical features of the milk, with negative repercussions on the cheese yield and quality.

Therefore, one of the project aims was to assess the possible effects of the use of stabilized bedding on the quality of milk destined for Parmigiano Reggiano production.

Good results with stabilized bedding

Over the course of a year from

December 2016 to November 2017, 44 cowshed milk samples were collected on a more or less weekly basis from morning milking, along with 42 milk boiler samples destined for transformation into Parmigiano Reggiano cheese. The boiler milk in the dairy was derived by mixing, in a proportion of about 1:1, milk from the previous evening, now partially skimmed due to natural rising of cream during the night, and the unskimmed



The stabilized bedding is unloaded directly into a mixing trailer towed by a tractor, for distribution in the stalls once a week. It is then "levelled" with a horizontal scraper fitted on a tractor to form a soft layer of bedding of about 10 cm.

milk from the morning milking sampled previously.

The values for somatic cells, lactose, and casein index shown in Table 2, are closely linked to each other and are important indicators of the state of health of the mammary gland. In conditions of mastitis an increase in somatic cells is observed (over 400,000 cells/mL) together with a reduction in lactose (about 5 g/100 g) and the casein index (less than 77%). The somatic cell content in the morning milk samples was on average 320,000 cells/mL (min 248,000 and max 396,000/mL), without ever exceeding the value of 400,000 cells/mL.

The average lactose values (4.90 g/100 g) and the casein index (77.88%) were also entirely physiological, indicating the good state of health of the herd.

The average value for the Total Bacterial Count in the morning milk was 87,000 Ufc/mL (min. 7,000 and max 1,591,000/mL).

The very high maximum value observed can be considered as episodic, given that the

already returned to normal (46,000/mL). Analysing the individual data it emerges that only 4 samples out of 44 had values above 100,000 Ufc/mL. Furthermore, the mobile geometric mean of the total microbial count, calculated over two months with two samplings per month, never reached 100,000 Ufc/ml (max 93,000/mL).

The average contents of butyric clostridia spores in the morning milk samples and in the boiler milk were respectively 55 and 61 spores/L, both within the norm. Regarding the individual samplings, 8 samples exhibited contents above 100 spores/L (threshold value for the production of Parmigiano Reggiano), both for the morning and boiler milk samples (about 19% for both). This percentage is in line with bibliographic data and can be considered normal in a region that for some time has been striving to solve the problem of milk contamination by butyric clostridia spores.

The spore content of the milk did not influence the quality

of the cheese. Over the period 2015 (first quarter) to 2017, expert assessment (Graph 3) classified 97.57% of the wheels as 1st class (average score for the production area was 90.06%), 2.41% as 2nd class (average score for the production area was 8.06%), and only 0.02% of the wheels were not marked (average score for the production area was 1.87%).

Finally, the content of aflatoxin M1 (measured in 12 samples with one sampling per month) was on average 0.006 µg/kg with a maximum value of 0.011 µg/kg, which is considered low.

In conclusion, the values measured for the stalled cowshed using stabilized bedding indicated that the health and hygiene of the milk and the sanitary condition of the mammary glands of the cows were fully in line with those observed in the Parmigiano Reggiano production area in previous studies.

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