Bedding Strategies in Free-stall Barns

John K. Bernard
Department of Animal and Dairy Science
University of Georgia, Tifton

There are many types of bedding which can be used in free stalls. Although there is no one ideal bedding for all operations, there are several fundamentals that producers should consider when choosing a bedding material to use in free stalls. First, the free stalls must be sized for your cows and maintained in good condition. The bedding material must provide a clean, comfortable surface for the cow to lie down. The choice of bedding also influences daily labor requirements for maintenance and grooming. Failure to maintain adequate amounts of bedding in the free stall will result in stalls that are not as comfortable or result in hock injuries. Also, any soiled bedding must be removed to prevent any buildup of mastitis causing bacteria. Economics of bedding must be considered including initial investment as well as daily maintenance cost. The most common types of bedding include sand, composted manure solids, and mattresses built from materials such as ground rubber, foam, carpet padding, and rubber. This presentation will discuss several bedding strategies that may be used in free stall barns.

Organic bedding

Organic materials used for bedding include sawdust, wood shavings, straw and composted manure solids. These materials contain nutrients required for growth by bacteria and typically have higher concentrations of mastitis causing bacteria than inorganic materials such as sand. When properly handled, these materials have been used successfully by dairy producers. However, if the free stall management is less than desirable bacteria populations can increase greatly resulting in increased subclinical and clinical mastitis. Hogan et al. (1989) reported significantly higher moisture content and concentrations of gram negative bacteria, coliforms, *Klebsiella* species and *Streptococcal* species in free stalls bedded with sawdust or chopped straw compared to those bedded with sand or limestone.

Dehydrated or composted manure solids have been shown to be good alternatives to sawdust for bedding free stalls (Keys et al., 1976). Dehydrating or composting decreases bacterial concentrations compared to the original material, but bacterial concentrations increase after the material has been placed back into the free stall and moisture content increases (Britten, 1994). These results stress the importance of maintaining low moisture concentrations in free stalls to maintain low bacterial concentrations. Limited research has been conducted on the use of composted manure on mattresses, but past research suggests that it should be suitable if the material is kept dry and managed properly.

Sand

Sand is frequently rated highest for udder health, cow cleanliness and cow comfort by dairy producers (Bewley et al., 2001; Stowell and Inglis, 2000). However, it does require a considerable amount to maintain free stalls and manure management can be more troublesome than mattresses. Sand normally does not contain carbon or nitrogen required for bacterial growth. It also has a low water holding capacity and has a loose texture which shifts with the cow and provides good footing. Compared with other bedding materials, most studies indicate greater cow preference for sand than mattresses; however, when cows have a choice between sand and mattresses during the winter in colder climates the preferences for sand decreases (Thoreson et al., 2000). This seasonal effect is related to sand's ability to conduct heat away from the body of the cow, providing a cooler surface which is an advantage in hotter climates.

To reduce the amount of sand in manure, some producers have incorporated equipment or facilities into their waste handling system to collect sand. Recycling sand collected from dairy waste will reduce bedding cost and increase return on investment in sand collecting equipment or facilities. Recommendations of less than 3% organic matter (OM) are commonly cited as the upper limit before bacterial concentrations increase, but data defining the relationship of OM content and concentration of bacteria in recycled sand are very limited. Rates of clinical mastitis caused by environmental organisms are related to bacterial concentrations in free stall bedding (Hogan et al., 1989), so it is important to minimize bacterial populations. No differences were detected in somatic cell counts of cows housed in free stalls bedded with recycled sand collected from a settling basin compared with that of cows housed in free stalls bedded with fresh sand (Meriwether et al., 2000). Bacterial concentrations in the recycled sand were not measured in this study, so it is not known what impact the use of recycled sand had on exposure to pathogenic organisms. One strategy suggested to minimize bacterial concentrations is to bed more frequently so that fresh bedding is always present and solid bedding is not in direct contact with the udder.

Another problem associated with sand is the amount required to maintain desirable amounts of bedding in the free stalls. General estimates of the amount of sand required to maintain free stalls vary from 30 to 50 lb/d. Several sand retaining devices are marketed to dairy producers to reduce the amount of sand required to maintain free stalls and to maintain the desired slope in the free stall. Questions related to the effectiveness of these retaining devices to reduce the amount of sand required and potential for greater retention of OM under normal operating conditions have not been adequately addressed.

We conducted two trials at the Tifton Dairy Research Center to determine the effect of using recycled sand in free stalls fitted with sand retaining devices on bacterial concentrations in the free stall. A second objective was to measure the effectiveness of sand retaining devices on sand usage. Treatments included two sources of sand for bedding (fresh or recycled) and three commercial sand retaining devices plus a control. Two sections of 16 free stalls adjacent to the feed alley in a four-row free stall barn were blocked into groups of four. One section was bedded with fresh sand and the second section was bedded with recycled sand. Within each section of free stalls for trial one, each block of four free stalls was randomly fitted with one of four free stall treatments:

control; Pack Mat® (Promat LTD); Sand Trap™ (Topper, Inc.); and Sand Mizer (Don Themm Enterprises, Inc.). In the second trial, we compared the control with the Agriweb™ (Presto Products Company).

Free stalls were stocked at 90 to 100% of capacity throughout the year with a combination of lactating Holstein (approximately 75%) and Jersey (approximately 25%) cows. Fresh sand was dug from a pit and delivered to the dairy by a local contractor. Recycled sand was collected from a sand settling basin after each flush. This basin is located at the end of a cross alley on the west side of the free stall barn and is approximately 2 ½ inches deep. All flush water runs through this basin before going into a gravity separator designed to collect manure solids and any sand washed out of the sand settling basin. The recycled sand was pushed out of the basin twice daily, allowed to drain, and piled outside until needed for bedding. Free stalls were bedded each week to maintain a constant amount of sand in each stall. The amount of sand used on each block of stalls was recorded weekly for six months. Free stalls were hand raked twice daily to remove any manure or wet sand and to maintain the desired shape of the free stall surface. The free stall barn is equipped with fans and a high pressure mister system that operates when the ambient temperature is above 75? F and the relative humidity is below 80%.

The DM concentration of the fresh and recycled sand used for bedding was similar (Table 1). Recycled sand contained more OM and had greater concentrations of most bacteria than fresh sand. Concentrations of *Bacillus* gram positive were higher during May, June, and July than other months of the year for both fresh and recycled sand, but the increase was greater for the recycled sand. A similar increase was observed for *Coryne* sp. from May through September.

Concentrations of bacteria and OM observed in the fresh sand were minute and should not be considered to be a problem. The settling basin used to collect the recycled sand effectively removed most of the manure based on OM concentrations. As noted previously, all flush water is channeled through this settling basin and the recycled sand is removed from the settling basin twice daily. Although differences in bacteria concentrations were detected, concentrations were less than 1,000,000 cfu/g of sand and would not be expected to increase exposure to mastitis causing organisms.

There were no interactions of sand source and sand retaining device. Free stalls bedded with fresh sand had slightly lower concentrations of DM and OM than the recycled sand (Table 2). It is doubtful that these differences would have any biological significance given the minute difference in actual values. Concentrations of *Bacillus cereus*, *Bacillus subtilis, Bacillus* gram negative, and *Staph. sp*. were higher and *Streptococcus dysgalactiae* and yeast were lower in recycled sand than fresh sand collected from free stalls.

Concentrations of DM and OM were not affected by sand retaining devices in the free stalls and averaged 98.1% DM and 1.4% OM (Table 3). Minor differences in bacterial concentrations were observed among sand retaining devices for *Bacillus cereus*, *Bacillus subtilis*, *Proteus* sp. and *Step. dysgalactiae*. In general, concentrations of these bacteria were highest in free stalls fitted with Pack Mat and lowest for the control free stalls or those fitted with Sand Trap, but differences in concentrations were relatively small. Interactions of sand retaining device and sampling date were observed for *Bacillus cereus*, *Bacillus subtilis*, *Coryne* sp*., Proteus* sp., and *Pseudomonas*

aeruginosa. Concentrations of these bacteria were similar during the initial months of the study and then increased during the warmer months before declining in cool weather. The increase tended to be greater in free stalls fitted with Pack Mat compared with Sand Trap. In the case of *Coryne* sp., concentrations were higher for Sand Trap during March and then declined for the duration of the study whereas concentrations isolated in the control free stalls and those fitted with Sand Mizer were much higher from June through September than the remainder of the study. Similar results were observed in the second trial.

The amount of sand required to maintain free stalls was lower for those stalls bedded with fresh sand (35.7 lb/stall/d) compared with those bedded with recycled sand (39.5 lb/stall/d). The recycled sand had a more crystalline texture which was probably a result of the flush washing out any clay residues that were in the fresh sand. When hand raking the free stalls, those stalls bedded with recycled sand were easier to level than those bedded with the fresh sand.

Control free stalls required 41.5 lb/stall/d of sand to maintain the desired fill and slope. The amount of sand required to maintain the free stalls was lowest for stalls fitted with the Sand Trap (28.0 lb/stall/d) compared to all treatments. Free stalls fitted with the Pack Mat and Sand Mizer required 40.1 and 40.8 lb/stall/d, respectively. In the second trial, the control free stalls required 43.3 lb/stall/d of sand to maintain the desired fill and slope compared with 29.0 lb/stall/d for those fitted with the Agriweb. The amount of savings in sand required for maintaining free stalls with the Sand Trap and Agriweb varies depending on the cost of sand delivered to the dairy, but would range from $12.68 to 35.51/stall/year for sand costing $5 to 14/ton. The savings would be greater for recycled sand depending on the cost of the sand separating equipment or facilities.

These results indicate that recycled sand can be used to bed free stalls without greatly increasing the exposure of cows to mastitis causing bacteria. Sand retaining devices did not greatly affect bacterial concentrations although differences exist among these devices. Of the products tested, only the Sand Trap and Agriweb reduced the amount of sand required to maintain free stalls.

Free Stall Mattresses

There are numerous free stall mattresses available for use in free stalls including those constructed from ground rubber, foam, or carpet padding as well as water beds. Compared to sand and other types of organic and inorganic bedding materials, the initial cost is greater, but labor cost associated with maintenance should be much lower. Most mattresses do require light bedding to prevent hock abrasions and make clean up easier. The major considerations when selecting a mattress are cow comfort and longevity. In general, cows prefer soft rather than hard surfaces (Natzke et al., 1982). The materials used in some mattresses tend to pack or shift over time and lose their softness reducing comfort and increasing leg problems or injuries (House et al., 1994; Rodenburg et al., 1994). Early versions of mattresses using ground rubber covered with fabric without any dividers or cells to keep the rubber in place tended to move resulting in poor comfort or extensive maintenance to move the rubber back under the cow.

One of the more common complaints relates to the durability of the cover. There have been considerable improvements in the covers used on mattresses. I recommend that anyone considering mattresses should visit farms that have had mattresses in place for several years so they can evaluate the durability of the mattress and covering.

Cow preference tends to change over time as cows become acclimated to mattresses. Belgium researchers compared 11 different types of mattresses over four months. There were obvious differences in the preference of cows for mattresses which were softer than most of the other choices and these differences became more distinct over time (Figure 1). The percent of cows using each type of mattress changed from January, when the cows were first introduced to the new mattresses, to April after approximately three months of use. When given a choice, the cows did not use the harder surfaces (A = control free stall with a concrete base covered with sawdust).

We have conducted two studies comparing difference free stall bedding materials. In the first trial we compared free stalls bedded with either Sand Trap™ , Pasture Mat®, Alanta® Waterbeds, or a solid rubber mat (Bernard et al., 2000). Free stalls bedded with sand were used almost 100% of the time. Initial usage of the solid rubber mat was second greatest but usage declined so that by the end of the trial usage was limited. Usage of both the Pasture Mat® and Alanta® Waterbeds was limited initially but increased throughout the trial with equal usage by the end of the trial. In the second trial, we compared usage of free stalls fitted with Pasture Mat ® (Promat LTD), Alanta® Waterbeds (Georgia Duck and Cordage), Comfy Cow Mattress (Sikkema's Equipment) or System 2000 (Don Themm Enterprises, Inc.). The free stalls were stocked at 75% capacity so cows were not forced to use a stall they did not prefer. The percentage of cows laying on each mattress was greatest for the Comfy Cow mattress (54.1%) followed by the System 2000 (41.5%) and Pasture Mat (30.0%) and lowest for the Alanta waterbed (3.8%). Usage of the water bed was much lower than observed in the previous study and may reflect reluctance of the cows to use a mattress that moved when they moved into the free stall (Bernard et al., 2002).

Conclusions

The most important aspect to remember when selecting a bedding material for free stalls is that it must be clean, dry, and comfortable. Failure to meet all of these criteria will result in reduced cow comfort which limits milk yield and increases stress and exposure to mastitis causing organisms. In regards to bedding material, sand is the most desirable but the sand does not work well in most manure handling systems if it is not separated from the waste. Recycled sand can be used for bedding free stalls if the organic matter content is kept below three percent and stalls are properly managed. Free stall mattresses can reduce daily labor requirements, but the initial costs are greater and they do not completely eliminate bedding. There are many mattress systems to choose from and there is no one ideal product for all operations. Producers interested in installing mattresses should visit dairies that have experience with mattresses to get first hand information on cow use, maintenance requirements, and durability.

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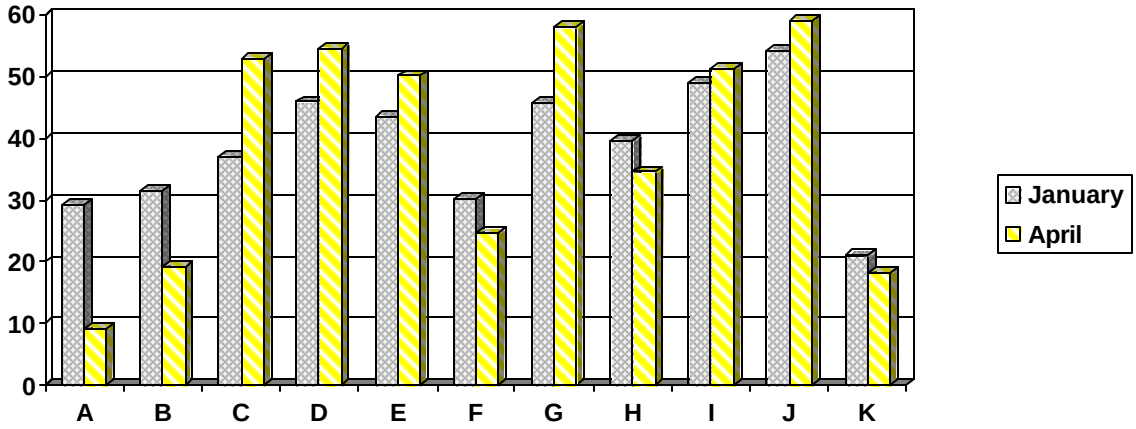

Figure 1. Percent of free stalls fitted with different mattresses when initially installed in January and after approximately 3 months use in April (Sonck et al., 1999).

Table 1. Analysis of fresh and recycled sand used to maintain free stalls.

Item	Fresh	Recycled	SE	P <
DM, %	96.6	96.3	0.3	0.48
Ash, % of DM	99.4	98.9	0.09	0.001
OM, % of DM	0.6	1.1	0.09	0.001
	---------- cfu/g of sand ----------			
Bacillus cereus	3,818	22,898	4,010	0.01
Bacillus subtilis	1,455	9,855	1,806	0.01
Bacillus gram negative	5,271	79,471	10,480	0.001
Bacillus gram positive	32,363	60,663	5,615	0.01
Coliform	0	400	156	0.10
Coryne sp.	23,091	31,191	4,317	0.22
Nocardia sp.	182	0	141	0.34
Proteus sp.	3,817	0	2,976	0.36
Strep. uberis	3,273	4,873	1,329	0.42
Staph. sp.	1,364	7,164	3,815	0.31
Mold	182	982	418	0.21
Yeast	0	800	432	0.22
Klebsiella sp.	1,273	9,673	2,648	0.05

Table 2. Analysis of fresh and recycled sand collected from free stalls.

Item	Fresh	Recycled	SE	P <
DM, %	97.97	98.21	0.08	0.05
Ash, % of DM	98.86	98.36	0.03	0.001
OM, % of DM	1.14	1.64	0.03	0.001
	---------- cfu/g of sand ----------			
Bacillus cereus	14,519	22,734	1,692	0.001
Bacillus subtilis	9,931	12,126	1,009	0.05
Bacillus gram negative	79,888	121,749	9,598	0.05
Bacillus gram positive	272,217	331,123	177,042	0.21
Coliform	40,668	21,062	10,373	0.29
Coryne sp.	76,496	85,731	6,896	0.34
Nocardia sp.	2,607	2,785	339	0.82
Proteus sp.	58	96	67	0.31
Pseudomonas	94	53	51	0.31
Strep. dysgalactiae	5,406	1,498	749	0.01
Strep. faccalis	5,854	1,942	1,827	0.16
Strep. uberis	26,999	23,437	2,385	0.49
Staph. sp.	18,630	30,573	3,367	0.05
Mold	3,028	3,700	598	0.48
Yeast	2,525	1,304	409	0.04
Klebsiella sp.	2,649	4,171	576	0.20

Table 3. Analysis of sand in free stalls equipped with sand retaining devices.

	Control	Pack Mat	Sand Mizer	Sand Trap	SE	P <
DM, %	98.10	98.15	97.95	98.14	0.11	0.52
Ash, % of DM	98.63	98.58	98.56	98.66	0.04	0.25
OM, % of DM	1.37	1.42	1.44	1.34	0.04	0.25
	---------- cfu/g of sand ----------					
Bacillus cereus	14,674[b]	22,875[a]	21,531[a]	15,427[b]	2,404	0.01
Bacillus subtilis	9,489[b]	14,292	10,512[b]	9,822[b]	1,434	0.01
Bacillus gram negative	128,902	87,875	106,960	79,538	13,640	0.25
Bacillus gram positive	332,973	368,708	254,729	250,272	33,422	0.10
Coliform	43,530	18,625	47,861	13,445	14,742	0.27
Coryne sp.	87,191	86,833	86,611	63,820	9,800	0.15
Nocardia sp.	3,524	2,792	2,444	2,023	483	0.27
Proteus sp.	83[ab]	250[a]	0[b]	0[b]	92	0.00
Pseudomonas	26	0	85	185	73	0.13
Strep. dysgalactiae	2,794[b]	5,458[a]	5,506[a]	50[c]	1,064	0.01
Strep. faccalis	3,774	667	8,372	2,790	2,596	0.14
Strep. uberis	22,212	29,500	24,770	24,391	3,390	0.49
Staph. sp.	26,812	30,833	23,394	17,367	4,785	0.13
Mold	4,256	3,917	3,330	1,950	850	0.18
Yeast	1,521	2,292	2,073	1,770	581	0.80
Klebsiella sp.	4,021	2,666	2,293	4,659	819	0.35

[a,b]Means within a row with unlike superscripts differ (P < 0.10)

Notes