



A clean and comfortable cow, resting on a dry manure solids composting pack in Queensland

Bedding Pack Shelters

(Including Compost Bedding Packs)

An Information Sheet for Australian Dairy Farmers

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The following information has been collected by visiting and interviewing twelve dairy farmers in Queensland, Southern NSW and Victoria, who have built, and are now managing bedding pack systems. Most of these systems are actively composting, but some are not, yet are still successful. A review of the literature has been conducted, and highlighted information mainly from USA, Britain, Holland and Israel, much of which is not relevant to Australian conditions. The average North American system is designed to house less than 100 cows fulltime, mainly to improve cow comfort, but also to protect cows from winter sub-zero weather conditions.

It must be pointed out that this is not a scientific paper, but is a summary of findings of Australian farmers' experiences and is designed to be read in conjunction with the Case Studies, and assist farmers' appreciation of the bedding pack dairy shelter systems that are currently being utilized in Australia, as well as their issues, limitations and management requirements.



Definitions (not scientific)

A Bedding Pack (non-composting) system supplies bedding for the cows to lay on as well as absorb manure and urine and keep the cow comfortable and dry. The bedding is usually, but not always organic, for example it can be sand. This pack needs to be partially or fully removed and replaced on a regular basis. Some of these systems do actively compost from time to time.

A Compost Bedding Pack system always utilizes organic bedding and the pack is allowed to ferment through bacterial activity in the pack, utilizing the carbon from the bedding and nutrients from the faeces and urine, producing heat, carbon dioxide and moisture. This system must be managed, monitored and maintained in this active composting phase through aeration by cultivation, to maintain the appropriate bacterial activity (resulting in heat) and moisture below the surface, as well as moisture evaporation from the surface following tilling. It is possible for compost bedding packs to be managed so that most of the effluent is continuously decomposing, and the pack can last for many years without being removed. Examples of the organic bedding material used in these systems are; sawdust, wood shavings, wood chip, rice hulls, dry manure and compost.

Compost, is the final material that results when addition of nutrients to the fermenting pack ceases, and the bacterial activity utilizes all the remaining nutrients in the organic matter. The bacteria then die and the material cools. Compost is often then used as a soil conditioner. Organic bedding pack material can be removed and allowed to compost completely, while being turned, then utilized as soil conditioner or even as new bedding.

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Planning a new dairy shelter

Firstly, why are you considering building a shelter? There are many reasons, and the reasons will dictate your expectations, as well as what solution is best for your situation.

Reasons; are generally related to some degree of intensification, and will include;

- System change – going from full grazing to PMR and some grazing (Part time usage) or from grazing or PMR, to TMR (Full time usage). This is generally used to increase cow numbers, improve cow management and will also reduce walking and energy expenditure.
- Improve annual pasture utilization in Southern Australia, by protecting winter pastures more from damage by grazing when the weather is wet.
- Shelter cows in the winter, to reduce stress and improve cow comfort
- Heat mitigation for cows in the summer
- Improve cow comfort and cow health, especially mastitis and lameness
- Improve dry matter intake, as cows spend more time eating
- Lack of water availability and pricing in irrigated dairy areas to sustain pasture systems
- Access to cropping and significant fodder areas to support TMR
- Ability to segregate herds based on production potential and age
- Opportunity to upgrade old dairy infrastructure to fully housed robotic milking systems incorporated in housing systems
- Mitigate climatic variables to minimise production fluctuations in high yielding herds

Now consider the important issues

- Number of animals to be sheltered (will all or part of the herd be housed in the shelter?)
- Is the shelter to be utilized full-time or part-time?
- Sites available, especially for airflow (breeze), drainage and orientation to support shade and pack drying
- Shelter space required
- Loafing area space required
- Pack management, including labour and machinery necessary for pack tilling etc
- System must be able to handle the maximum stocking density that will occur during the year
- Environment, incl. temperatures, humidity, wind/breeze/airflow, rainfall and distribution, storms
- Capital and operating cost
- Feeding options to be considered (eg internal, external)
- Availability of bedding material
- Access to good quality labour
- Management capacity and focus required (is there sufficient capacity to monitor well and act quickly)
- What flexibility does the system need/have (eg changing animal numbers, new dry bedding etc)
- Statutory planning and suitability of desired location
- Effluent system designed to accommodate solid manure/bedding and possibly also liquid effluent
- Access to adequate and reliable water supplies of appropriate quality

The success of this transition to semi or full confinement depends on each farm's implementation of all the critical components necessary to make their system work, and seasonal variations may impact more on over-simplified facilities than on fully planned systems.

Farms that "copy" what another farm has done, without fully understanding the underlying principles of the system, may get into difficulties.

Now consider the options for developing bedding pack shelters, keeping in mind that; **LESS COMPLEX IS USUALLY BETTER AND EASIER.**

1. Shelters with internal feeding options

Single bay bedding pack shelter.

This is a simple system, is limited by the space available to have a long and narrow shelter, but generally will have better airflow. The feed alley generally dries out well, allowing dry scraping. The feeding area can be open or covered



Single bay compost shelter with uncovered feeding area

Double bay bedding pack shelter

This system is wider and some airflow will be restricted, but they can make efficient use of a central feed lane and can be built in two stages. The feeding area can be open or covered. The alleyway with the unroofed feeding lane, generally dries faster and allows for dry scraping and all manure to be managed in a solid state. Alleyways with the roofed feeding lane often don't dry well, and liquid effluent must be managed, by wet scraping or flood washing. It is common to have sprinklers over feed alley, to cool cows while feeding.

Compositing double bay—bedding pack examples;



Double bay with uncovered feeding lane



Double bay with covered feeding lane

Non-composting double bay—sand bedding pack example;



Double bedding pack shelter with covered feed lane that has a sand bedding pack (non-composting)

Four bay bedding pack shelter

The four bay housed bedding pack systems must be designed extremely well, and its description is beyond the scope of this paper. Indeed these systems require a very high capital investment, are high risk and have not been highly successful in Australia to date. This is mainly due to poor airflow and resulting high ammonia levels and high incidence of mastitis, especially in times of high ambient humidity. In general, the narrower the shelter, the better the airflow across the bedding pack and the cows.

2. Shelters with external feeding options

Dry lots with bedding pack shelters

Shelters can be erected in dry lots or large loafing areas. These shelters can be large high-roofed structures, or be small specialised low-roof structures that are designed to increase air speed under the roof. The bedding in these shelters can be non-composting bedding packs, composting bedding packs, or packs that only actively compost occasionally. It is necessary to supply feed on a separate feed alley, generally well away from the shelters.

Dry lots are generally more successful in a dry climate, built with the correct slope and must also be well managed, including regular scraping of the lot. Care needs to be taken if using gravel as a base for dry lots or loafing areas, and many farmers find that the dry scraping will bring up small stones that may cause lameness.



Low roofed drylot bedding pack shelter



Drylot feed alley being dry scraped



High roofed drylot bedding pack shelter and associated



Double feed alley between two drylots

Large single roofed bedding pack shelters

Simple stand-alone bedding pack shelters with external feedpads and loafing areas and watering points, are simple to build and operate, but the external loafing area and feedpad can be problematic during wet conditions. that may cause lameness.



Steel roofed compost pack shelter



External feedpad and feed trough



Plastic roofed compost pack shelter and its associated external feedpad and feed trough



Design and Construction

Composting and Non-composting Packs

Site selection and preparation;

Often, the site and orientation is predetermined, due to conversion of a previous structure, or limited space availability. The most important aspect of site selection is access to a year-round breeze, to encourage the bedding pack to dry (especially compost bedding packs), for air exchange, to maintain air quality, as well as to provide cow cooling and cow comfort.

The shelter site should be elevated to allow water to drain from the site adequately, and not pool on-site and wet the bedding pack. The site should also have a low risk of seepage and strategies to mitigate runoff of effluent into the environment, including the subsoil. Care should be exercised when excavating/cutting and filling the site, with respect to exposing water draining onto site during wet times, as well as restricting natural airflow.

If the bedding pack is well managed, seepage below the pack is usually not an issue, but in any case, the pack base needs to be stable and solid, and can be either clay, gravel or concrete. This will also depend on local building regulations.

An East–West orientation of the long shelter axis is preferred in USA, so that no sun enters and over-dries the pack, limiting fermentation in composting packs. However, many farmers in Australia prefer building in a North-South orientation, to allow the sun to enter to help dry the pack, for composting as well as non-composting shelters.

But one must be aware that cows will be exposed to morning and afternoon sun in North – South orientation shelters, especially with full-time shelter use, and if the cows have no free access to a surrounding loafing area to follow the shade. This may also force cows to utilize a smaller shaded area of the pack during these periods, and wet patches may develop. It is possible to utilize retractable sunblock blinds on the western side in this situation. For an East - West orientation, no sun enters to pack, but there must be a high airflow to dry pack, and a need to possibly cultivate more.

Design and Construction;

Bedding area required; The recommended bedding area requirements for full-time use of composting bedding packs is approximately 10m²/cow. In facilities for sick or calving cows, producers should provide at least 12m² of resting space. Bedding area requirements for non-composting shelters are similar, but the bedding may need to be removed earlier if the cow density is higher.

Structure; The 1.2- to 1.5m retaining walls designed to surround the packs in the barns in USA, will limit airflow across the pack under Australian conditions. Most farmers in Australia agree that no wall, or a only a very low wall to stop the pack moving, is desirable at the edge of the bedding pack. To maintain adequate ventilation, roof supports need to be a minimum of 3.5m in height with no side walls in place. Roof overhangs should be no less than 1m and preferably a length of one-third of the height of the sidewall, to prevent entry of rain (and possibly sun) onto the pack. It is preferable to install gutters to reduce roof runoff from blowing into the pack. For iron roofed structures, a minimum roof pitch of 4:12 is recommended, as shallow roof pitches may create still air pockets and limit air movement up under the roof and into the air vents at the top. For gable roofed structures, for example a double bay shelter, a continuous ridge vent opening must be considered, with an opening of at least 7.6cm for every 3.0m of roof width, with a minimum opening width of 30.5cm. One Australian drylot farmer is using specialised narrow, low roofed structures with a shallow roof pitch, that acts as an aerofoil to increase airspeed below the roof and across the cows. The use of shade cloth as a roof for these structures has been considered by a number of farmers. However this is highly risky and inadvisable, as this would allow rain to enter, wetting the pack, decreased composting activity (in a compost packs) and increased moisture levels in all packs, resulting in increased mastitis and lameness. Cow will continue to use these wet areas, as it is cool under the shade, and this scenario would generally have worse animal health outcomes than no shelter at all.

Orientation and sunlight; As mentioned earlier, the prevailing wind direction should be taken into account when considering orientation, striking a balance between limiting or maximising solar radiation entry (possibly using greater roof overhang) and prevailing wind directions entering the shelter. The proposed utilization of the shelter will also affect the design. If the cows will have free access to an external loafing or drylot area adjacent to the shelter, or if the shelter will not be utilised in the afternoon in the summer, then the issue of the sun entering the pack and forcing the cows to move, is not as relevant, and orientation can be North- South.



N/S shelter with adjacent loafing area where cows can follow the shade



Cows confined to N/S shelter, being forced to one side as the afternoon sun enters the pack

However, if the cows are forced to remain on the pack, then an East-West orientation should be considered, as a North-South orientation may force the cows to congregate in a smaller area of the pack to avoid the sun, effectively increasing the stocking density in that area, and wet patches may develop.

Sidewall curtains help minimize the effects of winter winds and inclement weather on cows and compost temperatures, but will not generally be necessary under Australian conditions, especially in the subtropics. These are generally only necessary to prevent excessive winter wind cooling (in cold climates, eg Northern USA).

The access to and from the bedding pack from the loafing area or the feed alleys and water, should be as open as possible and preferably open from the sides, to prevent high traffic areas and the resulting wetting and compaction of the pack. If the cattle will be leaving and entering the bedding pack regularly through a narrow entrance at the ends, either from wet pasture or an external wet loafing area, they will often bring mud in on their hooves and wet the pack. Farmers in Australia are addressing this issue by building a cleanable concrete apron outside the narrow end entry to the pack. However, this may become an area where cows slip and the concrete must have a non-slip surface and must be cleaned regularly.



Wet area on end of the pack where cows enter



Cows enter pack from full alleyway length, no wet areas

Alleyways, feed-bunks and headstalls are the same design as per free-stalls, with the exception that the watering points will be in the cross-overs in the free-stall systems, and in the alleyways or the loafing areas in the bedding pack systems. Feed bunk/trough width per cow should be 46 to 76cm. Water troughs should supply approximately 0.91m of water access space per 15 to 20 cows.

Additional ventilation and cooling is not being supplied in most of the current Australian bedding shelters, however, it is being considered by a numbers of farmers in Queensland and Victoria, mainly to supply extra cow cooling in summer, and not to dry the pack. Milking parlour and holding yards need good cooling capacity.

Machinery access; Provision must be made for easy machinery access for pack tilling, bedding filling and emptying.

Effluent Management; In well managed and actively composting bedding packs, faeces and urine are decomposing, and the bedding packs are handled as solid waste when cleaned out. Traditionally the compost bedding packs have been changed each 6 – 12 months. Many Australian farmers are now not cleaning out their compost bedding packs for many years, and some farmers are questioning if it is necessary at all, if the pack is continuously composting well and not increasing in volume. Alleyways, feedpads, loafing areas and dry lots, where the manure dries, can be dry scraped and the manure stored outside as dry manure solids.

Internal concrete alleyways will often not dry out well and may need to be wet scraped or are flood washed, generating the need to manage slurry/liquid effluent management on some farms. One farmer who uses flood wash to clean the internal alleyways, is separating the solids by using a simple weeping wall system within a trafficable solids trap.

In non-composting bedding pack shelters (eg sand beds), the material must be extracted on a regular basis, and can be used directly as fertilizer. One farmer using sand bedding, can have his pack successfully functioning in place for nine months, before replacement with new sand. The frequency of pack replacement will depend on the level of shelter use.

Composting; A number of farmers are mixing dry manure solids with the extracted organic (not sand) bedding from the shelters, and composting this material outside in rows, using a turning machine, and selling the finished composted material or using it as a soil conditioner, or even reusing it on the bedding pack.



Manure solids bedding that has been removed from a composting bedding pack shelter, now being turned and allowed to compost completely (heating up then cooling down) in rows for sale/use as a soil conditioner

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Bedding Material

Composting shelters must use organic bedding and not sand, as this bedding is an important carbon source for the composting bacteria.

Traditionally, sawdust and wood shaving have been the bedding of choice, however these materials are beginning to be less available and becoming more expensive. The material of choice in USA is a mixture of sawdust and wood shavings. Kiln dried sawdust is preferred, but many Australian farmers are using green sawdust, and finding that this material dries well when spread over the pack. However, there is an increased risk of environmental bacteria being present (and possibly causing clinical mastitis) when using green sawdust.

Woodchip is commonly used, but some farmers find that new woodchip beds cause lameness and cows are sometimes reluctant to lay down in it initially. This will also depend on chip size and shape.

One farmer in Australia is successfully using timber mill waste, which is cheap, and contains some woodchip, small sticks, sawdust, wood shavings and some soil. A farmer in Southern NSW is successfully using rice hulls, as he is in a rice growing region. However, rice hulls are expensive to transport long distances.

Examples of well composting bedding pack materials in Australia



Woodchip



Dry manure solids



Rice hulls

Most of the composting pack system sighted in Australia started with woodchip or sawdust, but now they are mainly (or completely) dry manure solid (DMS) packs and are generally working well, if managed properly. They are also developed at no extra cost to the farmer. However, most of the farms sighted had low humidity, and the ability of DMS bedding packs to function well in high humidity and high temperature environments is unclear. A new compost bedding pack system is being developed in coastal Queensland and its progress will be followed closely.

Other materials that have been used in USA include processed corncobs, chopped soy straw, chopped flax straw, ground through a 20mm screen.

Materials that have shown not to be effective in compost packs include chopped wheat straw, as the waxy layer tend to slow water uptake and release. Peanut hay and sugar cane bagasse have also been used, but decompose very quickly and tend to provide too much Nitrogen to the pack, resulting in higher ammonia levels. Coarse hay and cereal grain straw produce a pack that is difficult to cultivate. Processed corn stover does not maintain a coarse particle size, decreasing air incorporation. Paper and cardboard absorb a lot of water, but do not retain a structure well when tilled, and do not compost well. Oily and fragrant wood sawdust, shaving and chips should not be used, as they may contain antibacterial agents that interfere with the composting process.

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Non-composting bedding pack shelters commonly use sand, and if managed well, they seem to be generally functioning effectively, but the complete bedding pack must be removed before they become too wet. Many bedding pack systems in USA and Britain use whole straw as the pack, but are extremely difficult to aerate, as they are difficult to cultivate.

The extracted sand/manure material from these systems can be applied directly to pasture, and one farmer in Indonesia is allowing the sand/manure mix to ferment outside in stacks, and then reuses the sand as bedding, however, this is not a recommended practice.

Compost Bedding Pack Management

The aim of the management, is to keep the pack surface dry, fine, loose and comfortable. Tilling is important for composting and non-composting beds.

To start a compost bedding pack, generally a layer of bedding from 25 to 50cm deep is laid down. The pack soon becomes infused with moisture from faeces, urine as well as moisture from microbial activity. Most pack in Australia are 30-50cm deep.

Compost Bedding Pack management. The bedding must then be monitored and managed daily, to maintain appropriate moisture level and microbial activity (heat), through; cultivation (aeration); adding bedding; or reducing cow numbers as the moisture content increases.

If the moisture level gets too high (>55 %), the bacteria die and composting activity ceases, the temperature drops and no more urine and manure are composted, so the pack quickly becomes wetter, and increases the risk of lameness and an environmental mastitis outbreak. In Australia, most farmers monitor the pack by assessing the particle/lump size and looseness after cultivation, as well as monitoring the cell count. The cleanliness of cows and udders is also used to monitor pack moisture, with cows becoming dirtier as pack moisture increases. If the pack is fine and has a dry surface following cultivation, the moisture is considered to be acceptable. If the cultivator is bringing up clumps of firm moist material, the pack is generally considered too wet or cultivation is too deep.

Cultivation/Tilling. This incorporation of manure and urine, mixing of the pack and aeration, is the most important management tool to maintaining compost bedding as well as non-composting packs. In composting packs, steam is often seen to rise after tilling. Occasionally non-composting packs, including sand, will also show some composting activity. Tilling must be conducted at least once, but preferably twice daily. Most Australian farmers use a chisel plough. However, in the USA, rotary hoes are commonly used to approx. 20cm, twice daily and produce a fine particle and comfortable pack. Many of these farmers also use a tined implement to cultivate deeper, once to twice per week.

If the pack is too wet, the moisture content can be decreased by tilling more often, adding new dry bedding (which can include dry manure solids) or decreasing the number of cows on the pack, possibly be removing some of the lower production cows. Sometimes, especially in times of continuous rainfall, it is necessary to have more cows on the pack than is optimal, and many farmers have a few weeks of the year when this is the case. Generally the pack will recover within one week, if managed well. If the pack has no cows on it for a period of time, most farmers find it advantageous to keep tilling at least once per day, and the pack will usually begin to compost again 1 – 2 weeks following the re-introduction of cows.

Labour. Most Australian farmers who were interviewed, have not increased labour units when converting to bedding pack shelters, but utilize labour differently. For example instead of bringing cows in from the pasture, they are tilling the pack and cleaning.

Staff training; All farmers (using composting and non-composting packs) emphasised the need to have staff who are trained well in, and understand the reasons for;

- Pack moisture monitoring
- Action to take if the pack moisture is too high
- Pack management, especially tilling
- Milking management, especially cow preparation and many use mechanical teat scrubbers/washers
- Post milking management, including effective teat dipping/spraying and keeping the cows standing post-milking



Fine & dry manure solids compost bedding pack



Fine & dry manure solids compost bedding pack



Tilling a composting wood chip bedding



Chisel plough used to till a large compost bedding pack

Cost Estimates

Capital cost. Australian farmers report a range of between \$500 - \$1,800/cow to build a bedding pack system, depending on the structure type as well as the amount of self-build and construction labour supplied by the farm.

Operational cost, include the cost of tilling equipment and ½ to 2 hrs labour/day as well as the cost of any added bedding material. Some farms have a dedicated tractor for tilling. Bedding costs vary from nil (dry manure solids) to \$7,000/year (export quality softwood chip in Case Study 1.) (See case studies for bedding costs and availability).

Outcomes in Australia

IF WELL MANAGED, it has been shown that composting and non-composting bedding pack systems in Australia can be very successful, and result in;

- Improving cow comfort and health. Reported by most of the farmers interviewed
- In Victoria, better annual pasture utilization and annual DM production
- Higher per cow dry matter intake and production per year
- More even milk supply throughout the year
- Better cow comfort, including cooler conditions for the cows in summer, in Qld and Victoria as well as having cows out of the cold/wet conditions in the worst of the winter
- A significant reduction in clinical cases of mastitis
- A significant reduction in lameness cases
- Better body condition scores
- Little change in somatic cell count levels
- Little change in reproductive parameters
- Little change in labour units, but most staff were generally happier

Bedding Pack Issues

Larger herd sizes, (eg > 800 cows) require larger sheds, more labour and equipment and have higher risks, especially in more humid and hotter environments. Larger sheds generally have poorer air exchange and airflow, and generally require a well-designed fan forced ventilation as well as excellent monitoring and management.

Milking management is critical. It has been shown in the USA, that if cows are not prepared properly in the milking parlour, the level of clinical mastitis cases will increase in bedding pack systems. Effective milking management, especially teat preparation is considered very important. The use of teat scrubbers/washers/dryers should be considered in these systems.

Effective post milking treatment is also very important, with no water/mud splashing on return to feed bunk and keeping cows standing for 1hr following milking is also advisable. One Australian farmer with a very wide composting shed with poor airflow, reported a sudden increase of environmental mastitis during humid (and cool) environmental conditions.



Sawdust, wood chips and wood shaving. These bedding materials are becoming more scarce and more expensive

Wet bedding packs. Some farmers report that storms sometimes blow rain in and wet the pack, while others have issues with high traffic areas, including narrow entry to the pack or the sun causing cows to congregate in smaller areas of the pack.

Hot and high humidity regions. It is still unclear how effective compost bedding pack systems will be in hot humid areas of Australia, such as coastal Queensland, especially when using dry manure solids as compost bedding.

Heat stress. This issue has decreased on most of the bedding pack shelter farms visited, however, some farms have cows that are still experiencing some heat stress (in Victoria and Queensland) and some farmers are considering using fans in hot periods.



Hand held pre-milking teat, scrubber, washer, chlorine steriliser and dryer



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