

Sustainable livestock buildings – a challenge for the future of organic farming

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Abstract

The function of livestock buildings is mainly to give shelter for confined animals and protect against predators. Up to date, most buildings used for organic livestock farming are mainly constructed using concrete, steel or wood elements. Thus, negative environmental impacts have to be considered. Annual world production of cement as one of the main building raw materials implies 4 % of annual CO₂ emissions. Sustainable livestock buildings can be more environmentally friendly and cost-efficient, if renewable raw materials of local resources and even waste materials are used.

Key words: renewable raw materials, organic livestock buildings, energy saving,

Introduction

Straw bales from rice, wheat or other cereals can be used to build simple insulated livestock buildings which require only minimum of energy and can be easily recycled at the end of the life span. In countries, where straw is still burned on the fields, it is evident, that CO₂ emissions can be reduced drastically by using those materials substantially. Straw structures for livestock buildings can be used in all climate zones, for example in arid regions to protect heat sensitive livestock like poultry or rabbits. Consequently, the energy consumption for cooling and heating can be reduced by more than 80 %. Load bearing constructions using straw bales do not require any wood or steel frame within the wall.

A more sophisticated approach uses straw or plants like miscanthus to produce natural sandwich boards. In contrast to fibre boards which are mainly used for constructions, this invention uses whole stems of straw and/or miscanthus perpendicular between two plywood layers for ultra-light and loadable sandwich boards. Natural sandwich boards can be used for mobile shelters for small ruminants, calves, pigs and poultry. Our experimental work shows advantages regarding climate and heat load compared to fibre reinforced plastic shelters. Durability is given for more than ten years.

In areas, where reduction of heat stress for animals is a main topic, green roofing of livestock buildings can be an alternative to energy intensive cooling and fans. Results of our study of the natural cooling effect of marshland plants on a dairy cow building indicates a 5 °C lower temperature compared to the same building without green roof.

Straw bale buildings

Burning of straw or other crop residues is a common practice in developing countries (IPS 2009) as well as in industrialized countries like Canada (Comeau 2007). Together with CO₂ emissions from cars and industry, burning of crop residues is an environmental, health and safety risk. Burning crop residues on the fields may have negative effects on biodiversity and soil fertility (Virto et al. 2007).

Amongst other alternatives to burning, use of crop residues like straw as building materials has several advantages: Less environmental pollution, less energy than producing concrete or other building materials and good insulation properties. A wholistic evaluation of a straw bale building has been conducted by Ashour et al., 2011. Fig. 1 shows the temperature evolution inside the wall at different locations of the straw bale wall. The temperature gradient increased from outside (low temperature) towards the inner side of wall. Outside temperature peaks were smoothed by the straw bale wall (Ashour et al. 2011).

Buildings with straw bale walls can be an effective way to use crop residues. With good insulation properties straw bale walls can play a major role in the future of energy saving and environmental friendly building concepts.

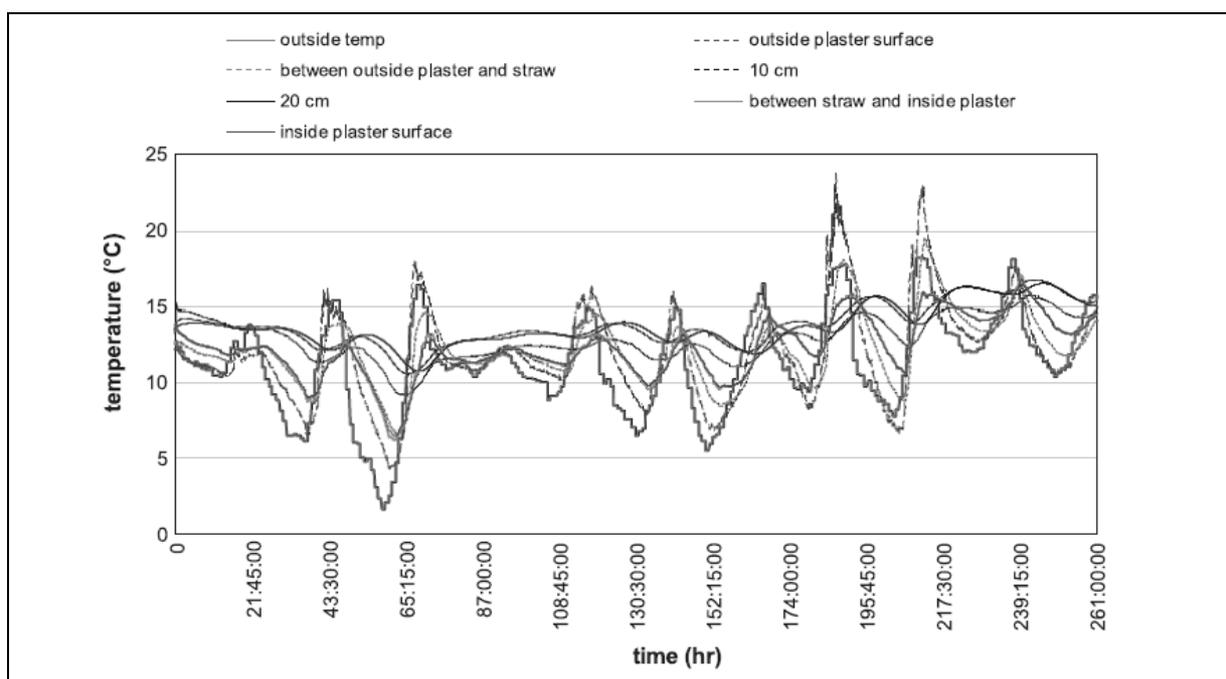


Figure 1. Temperature inside and outside of a straw bale wall (from Ashour et al. 2011)

Light Natural sandwich boards (LNS)

Livestock housing even in moderate climate need to provide shelter from heat stress in summer and prevent from condensation inside during winter time. Building materials used to house calves and small ruminants tend to be made out plastic materials, either reinforced with fibre or by construction. Recent studies have shown, that plastic used as building material has increased indoor temperatures in summer and show condensation at the inner surface in winter. Thus, a superhutch from renewable raw materials was developed, as easy to set aside as superhutches made of fiberglass reinforced plastic (GFK). The building material of the new hutch was light natural sandwich (LNS), a light panel material from renewable raw materials (see fig. 2). The LNS-Panels were used to form a load-bearing superhutch of 16 m² area without framework but moveable with a tractor. For a comparison, two LNS and two GFK- hutches with same size (16 m² area) were investigated. Groups of six calves (3 months old) each were housed till an age of 6 months in the period from February 2003 to February 2004 in the hutches. In total, 96 calves were housed in the hutches. Temperature and relative humidity was recorded in every hutch as well as reference values for both parameters outside in the shade.

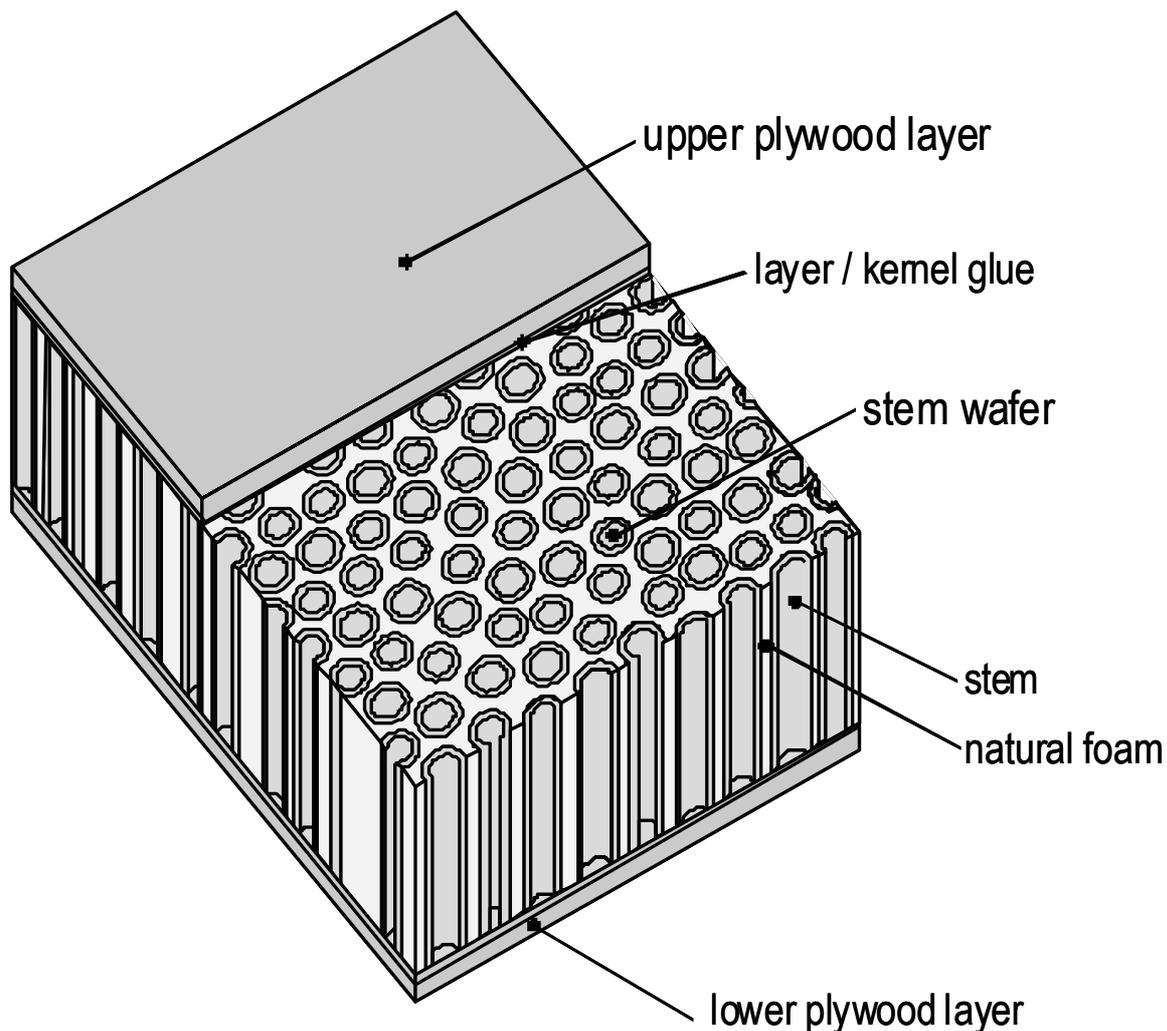


Figure 2. Principle design of Light Natural Sandwich Boards (Möller et al. 2001)

Results

During summer 2003 mean indoor air temperature as shown in figure 3 in LNS hutches was 5 to 6 °C lower than the value in the plastic hutches (measured between 10 a. m. and 4 p. m.). The temperature in LNS-hutches was close to the outdoor temperature in the shade, whereas the indoor temperature of GFK-hutches was higher than 30°C for several hours.

Green roofing with marsh plants

The reduction of summer heat stress for dairy cows is an important question for the design of dairy buildings in many climate zones. Parallel to an increasing milk yield metabolic energy production of cows is rising as well, inducing the necessity for additional energy transfer. Heat stress for dairy cows starts with 20 to 21 °C ambient temperature and has negative effects on milk yield when exceeding 25 °C. Changes regarding the lying behaviour indicate heat stress at 21 °C. Lying time for cows at a thermo-neutral climate is significantly longer, this may be another reason for a reduced milk yield as well.

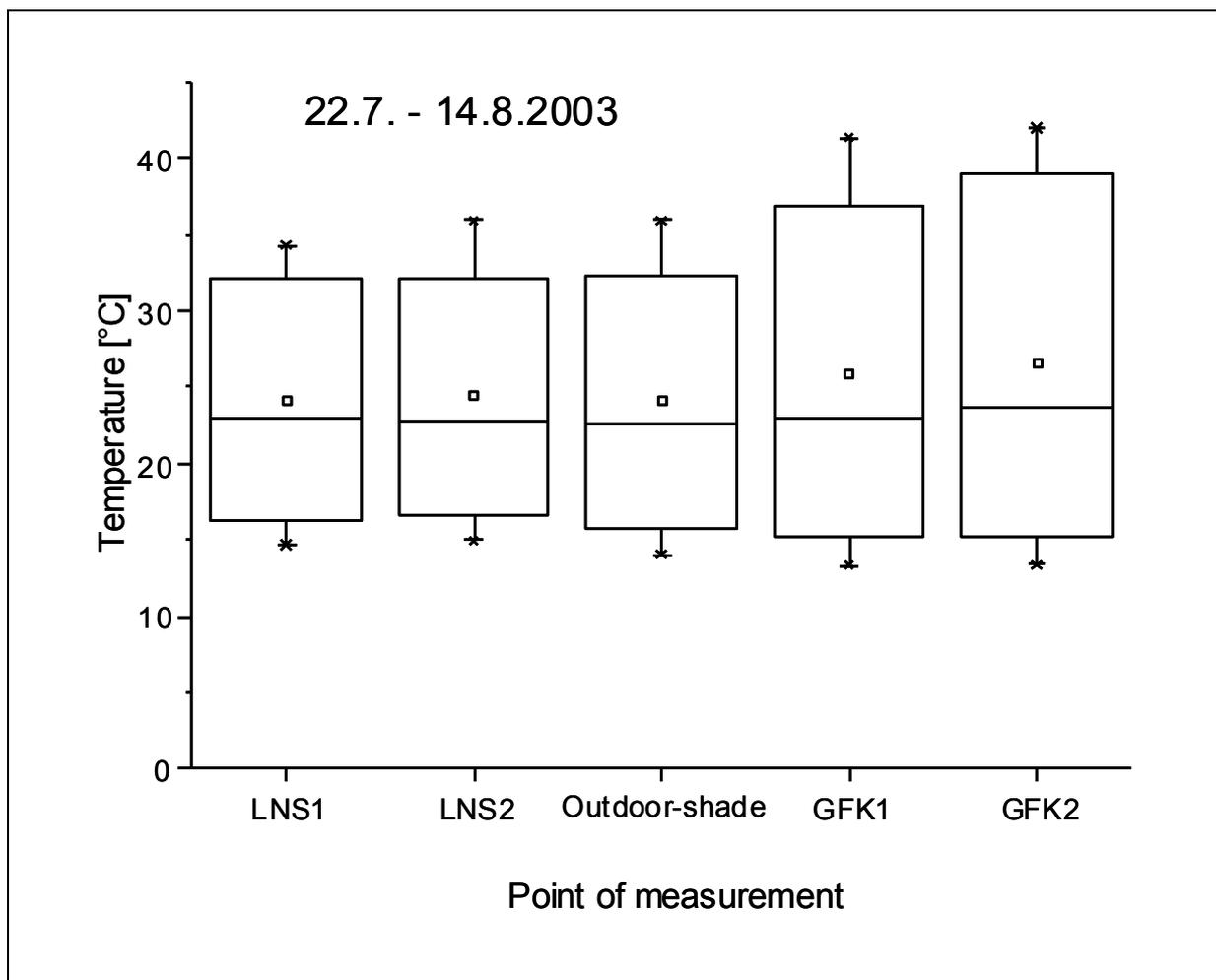


Figure 3. Temperature distribution inside LNS and GFK hutches compared to outdoor situation

One of two identical dairy buildings was equipped with the marsh plant green roof. Both dairy buildings had measuring devices for ambient temperature and humidity. A meteorological station was placed close to the buildings to record outdoor climate parameters. Within a second configuration level it is planned to collect the water for irrigating the roof in a storage basin beside to reuse it. The water may be elevated to the roof by a solar powered pump. The marsh plants consist almost of sedge varieties (*Carex*), *Mimulus luteus*, *Lythrium salicaria*, *Iris pseudacorus* etc. A foil was placed between roof (fibre cement) and the mats carrying the plants to prevent roots from growing between the roof tiles. The watering of the plants is controlled by an irrigation micro-computer, the water overflow is collected using the eaves gutter.

Results

Analysis of ambient temperature in both dairy barns demonstrates that a reduction of ambient temperature by 5° C could be realized using marsh plant green roof. The ambient temperature in the green roof barn did not exceed 25°, whereas the control building temperature came up to 30 °C during afternoon. The difference of -5 °C could be achieved from June to September, too. A comparison of the temperature under the roof of both, green roof and fibre cement, gave us a difference in mean temperature (on the surface) of 25 to 30 °C. The green roof acted as a shield to protect from solar radiation. The marsh plants were stimulated by the solar radiation to evaporate more intensively, which may lead to an additional cooling effect.

Conclusions

The presented alternative way of cooling down a dairy building by green roofing could reduce ambient temperature by 5 °C, compared to a fibre cement roof.

Suggestions to tackle the future challenges of organic animal husbandry

Why do we still use conventional building materials for organic livestock buildings? Future development should consider ecological functions of buildings like biodiversity, life cycle, appearance and energy saving. Natural and local building materials should be used to build green livestock buildings in the future.

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