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A Report on Microclimate Controlled Dairy Housing Model

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ABSTRACT: The farm efficiency depends on the level of production and reproductive capacity of animals which in turn depends majorly on the optimum microclimate surrounding the animal. Regardless of what breed or pedigree the animals may possess, without the right microclimate conditions, they cannot display their potential for productivity and sustain their health. The complete impact of microclimatic variables on an animal's physiological condition, heat exchange, health, and productivity serves as a marker indicating the influence of these external parameters. There are particular temperature-humidity microclimates for bovines where the animals feel comfortable and will exhibit the best levels of sustained productivity. When maintaining cattle under intensive system in livestock buildings, it is required to maintain the microclimate's essential criteria. These aspects of dairy housing are discussed in this article.

Keywords: Temperature, microclimate, stress, cooling pad, thermometer, hygrometer.

INTRODUCTION

Climate change can affect the productivity and economic viability of the livestock production systems. High ambient temperature affects particularly high yielding, low disease resistant and low heat tolerant crossbred population than the indigenous livestock. To mitigate the adverse effects of extreme weather events, technologies suitable to local conditions and modifications in housing of animals, management and feeding practices need to be designed for future. Environmental modifications aiming at microclimate of the animal to help alleviate heat stress problems are structural orientation, ventilation, use of cooling system along with shade is the best (Sereda and Kostarev 2018). The micro environment around the animal is modified by increasing the heat dissipation and cooling the air around the animal to reduce the heat load and stress on the animal (Ivanov and Novikov 2020).

Although, research in environmentally controlled dairy housing (ECDH) has made significant strides, but there are several key gaps. These include maximizing the integration of automation, ventilation, and cooling systems to raise milk production, cow comfort, and energy efficiency. Long-term research on the effects of controlled conditions on the welfare, behaviour, and health of cows is also required. Furthermore, it is critical to address the sustainability of water and energy consumption, adapt systems to changing climates, and create affordable solutions for varying farm sizes. In order to better adapt circumstances to the demands of individual cows and raise overall farm production, more research is also required to incorporate behavioural data and precision livestock farming technology into environmental control systems.

The future of microclimate-controlled dairy housing may involve more advanced technologies, including artificial intelligence (AI) and machine learning (ML) to optimize microclimate control. These systems would not only maintain ideal environmental conditions but also predict and adjust to future conditions based on data patterns. The use of AI-driven systems to dynamically adjust temperature, airflow, and humidity levels depending on real-time sensor inputs was addressed by Guan *et al.* (2023). Customizing microclimate control systems for particular regions is another focus of recent study. A one-size-fits-all strategy is ineffective; as Li *et al.* (2023) pointed out that the ideal mix of mechanical and passive methods of cooling differs greatly across temperate and tropical climates.

However, the environmentally controlled dairy housing model that was designed at dairy farm of College of Veterinary Science, Tirupati by giving due consideration to orientation of shed, roof projection and micro-environment of the animal by providing cooling system besides comfort to the animal and reducing the labour costs involved in feeding and management is elaborated and discussed in this paper. The various components of the designed model installed are

1. Free stall system
2. Rubberized Mattress
3. Cooling Pads
4. Exhaust Fans
5. Automatic Waterers
6. Automatic Concentrate dispenser system

7. Control unit containing temperature sensor
8. Water tank (outside the shed) for re-circulation of water
9. Drinking water tank
10. Feed bin

Illustration: Model of Microclimate controlled Dairy housing system

1. Free stall system: The standing animal space in the shed was divided into compartments (Free stalls) and one animal was placed in each stall with adequate space for the animal to lie down and space for the milker to milk each animal. The free stall compartment keeps provision to eat its own share of concentrate and green fodder besides preventing to consume other animals share of feed and water. Within the free stall, above the manger for offering green fodder, provision was made for bowl type waterers for drinking water and cup type concentrate feeders for consuming concentrate feed.

The fact that the free stall system gives cows a specific place to rest is one of its key advantages; this is important for both the cows' welfare and milk output. According to Cole *et al.* (2018), cows in well-planned free stall systems rested more, and this was positively connected with increased milk production. Particularly during lactation, rest is essential for recuperation and preserving the ideal energy balance. According to Ames *et al*. (2020), free stall barns that have enough ventilation such as fans and natural airflow can greatly lessen heat stress in the summer.

2. Rubberized Mattress: Rubberized mattress is provided within each free stall for the animal to lie down to have comfort. The rubberized mattress helps in prevention of the udder injuries to high yielding animals beside slippage of animal resulting in lameness. Provision of rubberized mattress is aimed at increasing cow comfort which improve milk production, herd health and longevity of animal (Tikhomirov, 2019). Cows which lie down for 12 to 14 hr/day are more productive than those with lower lying times (Drissler *et al.,* 2005). In comparison of various mattress kinds (rubber, foam, and sand), DeVries *et al*. (2021) discovered that sufficiently thick rubber mats offered better comfort and encouraged more normal sleeping positions. This improves cow comfort, reduces stress, and minimizes the time spent in shifting or adjusting during resting. According to García *et al.* (2021), cows kept on rubber mats produced more milk than those kept on other kinds of bedding. According to the study, this rise was caused by greater sleep, less stress, and fewer health issues, all of which enhanced milk production and energy balance.

3. Cooling Pads: A total of four cooling pads were arranged on one side of side wall which gets moistened once the control unit is switched on. These cooling pads are arranged exactly opposite to the exhaust fans on other side of wall of the shed. Vozmilov (2014) stated that provision of the cooling pads inside the shed helps in cooling of the air around the animal there by reducing the temperature load on animal and prevents stress on animal to maintain the productivity in high yielding animals. According to an experiment by Melo *et al.* (2023), cows kept in barns with cooling pads produced 12% more milk than cows kept in barns with conventional ventilation systems. Better thermal comfort and less physiological stress were cited by the researchers as the reasons for this gain.

4. Exhaust Fans: Exhaust fans were arranged on other side to the cooling pads so as to pump out the hot air from the shed and supply fresh air into the shed with 0.25 HP motor to each exhaust fan installed in the shed. The exhaust fans inside helps in increasing air movement thereby enhancing/improving rate of heat loss from the animal. An integrated approach of exhaust fans and cooling pads is more effective means of reducing the heat load on the animal (Vtoryi *et al.,* 2018). The cooling pads and exhaust fans helps in evaporative cooling and forced ventilation of body surface maximizing the cooling effect on the animal. Venugopal (2011) reported that the economic analysis has shown the breakeven point for fan and mist system is an increase in milk production of 0.81 kg/day. Gao *et al.* (2022) studied the role of exhaust fans in reducing heat stress during summer months and concluded that the use of exhaust fans in combination with cooling pads significantly improved the cows' comfort levels, evidenced by decreased respiration rates and higher milk yield compared to cows housed in non-ventilated barns.

Additionally, several high-capacity fans are required for adequate ventilation in bigger dairy barns. In order to prevent regions of stagnant air that could worsen heat stress, exhaust fans should be positioned and spaced to provide uniform airflow throughout the barn.

Cooling Pads for cooling of air in the shed.

5. Control Unit: The control unit fixed in the middle of the on one side of long-axis of shed controls the number of fans to be operated depending on the temperature outside the shed besides controlling the cooling pads. A temperature sensor is attached to the control unit which helps in reading the internal

temperature of shed / controlling the temperature inside the shed. A hygrometer is placed in the shed separately to know the humidity inside the shed. Research shows that in lactating animal's humidity above 70% effect the milk production besides reducing evaporative cooling adding to head load on animal (El Assaad, 2002).

Exhaust fans for exchange of air inside the shed.

Automatic Temperature control unit.

6. Water tank for re-circulation of water: A water tank of 500 liter capacity is installed outside the shed with a 0.5 HP motor fixed to the shed for recirculation of the water through the cooling pads for better utilization of the water. The water after circulating through the cooling pads again enters the water tank from where the water was pumped into the cooling pads, there by conserving the water (Baymuhanov and Guseva 2020).

7. Automatic Bowl drinkers (ABD/Waterers): A water tank arranged inside the shed is connected to the automatic bowl drinkers placed in each free stall for drinking purpose. The animal can drink the water as and when its likes to drink and once the water bowl fills up, it stops the water automatically preventing the wastage/overflow of water. A study by Grant *et al.* (2010) observed that cattle drinking from automatic bowl drinkers consumed more water per day than those drinking from traditional troughs. According to the study, using ABDs was linked to increased milk production in dairy cows, particularly during heat stress when proper hydration is essential. Additionally, Shao *et al.* (2020) reported that water intake in cattle increased when provided with ABDs due to their ease of access and ability to maintain a clean water source.

8. Automatic Cup Concentrate feeder: A concentrate feeder is arranged in the free stall where provision is made for dispensing of correct quantity of concentrate mixtures for each animal as per the production requirement of animal coming from the fed bin. According to Sharma *et al.* (2018), the precise dispensing of concentrates on buffalo farms that used ACCFs resulted in a notable increase in milk production and a decrease in feed expenses. Farmers benefited economically from the lower labor costs and increased feed efficiency.

CONCLUSIONS

It is clear that dairy animals frequently require protection from short-term weather events in order to survive, as well as from longer-term weather effects in order to function satisfactorily. Yet, the question is how much the animals' surroundings or management need to be changed. The question cannot be satisfactorily resolved by general suggestions; a proper response necessitates a logical analysis of the negative effects of weather and the advantages to be gained from altering the natural environment utilizing cutting-edge technology. This paper has highlighted some simple advances that could be used under intensive rearing for improving the comfort and reducing stress in dairy animals. Of course, rational technology selection will not ensure better performance; rather, by lowering risk, rational technology selection will lessen the likelihood of loss. The most recent advancements in dairy housing with microclimate management highlight the growing application of AI and IoT for real-time environmental control in conjunction with energy-efficient and sustainable technology.

FUTURE SCOPE

Hence, there is future scope where in studies related to micro controlled housing and these developments assist dairy farmers economically and environmentally in addition to improving cow welfare and productivity. In order to ensure sustainable dairy production, it will be even more important to have resilient and adaptable dairy housing systems as the global climate continues to change. The Future of this article could be combining cutting-edge technology like automation, data analytics, and the Internet of Things to make the micro-controlled dairy housing the potential way to completely transform cattle management in the days to come. It is possible to precisely regulate the environment, guaranteeing ideal circumstances for the productivity and well-being of animals.

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