

## A Review on Effect of Climatic Zones on the Milk Production of Holstein Friesian and Jersey Cows

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### ABSTRACT

Dairy farming is emerging as commercial enterprise and milk as the part of dietary food but the milk productivity of the cattle varies with the variation in climatic factors. So, breed selection plays imperative role on maintaining productivity and adoptability in different environments. Holstein Friesian and Jersey being the temperate breeds with high milk producing capacities could not perform well on the tropical and sub-tropical region. With proper feeding, Holstein has higher milk yield and low-fat percentage than Jersey. Milk yield varies by 2.58% in Holstein and 2.09% in Jersey cow with the change in climatic factors (minimum temperature, relative humidity and solar radiation). In hot areas, both breeds suffer from heat stress showing low feed intake, higher body and rectal temperature, high respiration rates and high heart beats. Holstein has high increase than Jersey in rectal temperature and heart beat by 0.55°C and 15.4 inhalations/min respectively which shows Jersey are more heat tolerant than Holstein. It is due to the larger heat dissipating area, short and light hair, lighter body coat and thin fat. Heat stress can be managed by providing shade, nutritious feed and genetic improvements. As the climate change is emerging, it can affect cattle in tropical regions even more in near future. To overcome this future challenge, further research and study must be done for the proper management of Holstein and Jersey in stress condition and heat tolerance breed must be developed by genetic improvement.

**Keywords-** Productivity, Holstein Friesian, Jersey, Climatic factors, Heat stress.

### I. INTRODUCTION

The dairy industry is established worldwide as one of the important sources of financial resources in both developed and developing countries. According to the report of International Farm Comparison Network, 2011, presence of dairy farm is confirmed in 90 countries which consists 98% of global milk production with India, United States, Pakistan, China and Brazil as the highest producer of milk (Doughrati et al., 2013). In some countries like India and Pakistan, cattle rearing is mostly done as subsistence farming while in Europe and United States it is established as a good commercial enterprise. Milk is highly proteinaceous and considered as a part of dietary food.

Although, the local indigenous breeds are highly adopted to the environment but are low in milk production. Thus, for commercial farming, different exotic breeds of cattle and their cross-breeds are reared in different areas with the expectation of increased milk production. High milk producers including Holstein and Jersey are imported by several countries especially of tropical and sub-tropical zones to retain as pure breed or for genetic improvement of local breeds (Usman et al., 2013). The complexity of genetic capabilities of those breeds and the non-genetic factors including the management practices, climatic condition and fodder availability determines the amount of milk production. Climatic parameters include maximum and minimum temperature, relative humidity, wind speed, solar radiation, number of hours of sunshine, precipitation and elevation which affect metabolic activities and productive and reproductive gene expression of cattle (Bull, 1986).

Several research carried out in past shows that variation in performance exists when the same breed of livestock are reared in the different climate and environmental conditions within the country or in different countries (Gomes da Silva, n.d.) (S.S. et al., 2011). Holstein Friesian and Jersey cows are European temperate breeds with high milk producing capacity but their performance varies when they are raised on different conditions. The most favorable climate for dairy farm range from 15-18°C temperature with moderate wind, humidity, amount of solar radiation and proper pasture growth with less chance of parasites attacks (Johnson, 1976). This requirement is somehow fulfilled by temperate region and higher part of tropical zone and considered to be best for cattle rearing.

The change in environmental conditions causes heat stress having negative impact in the lactating cattle (Habeeb et al., 2018). The lactation milk yield is affected from 3-10% by the climatic change. From this change, 1-6% of variation is due to the combined effect of maximum and minimum temperature and relative humidity (Tg & Agropecuarias, n.d.). The environment also affects the physiology i.e. respiratory rate, heartbeat, rectal temperature, hormonal regulation, dry matter intake and evaporative cooling of the livestock, which indirectly effect production capacity. (Muller & Botha, 1993) Holstein and Jersey cows have complications in lactation, reproduction and growth and development in hot and

humid climate than temperate region (Johnson, 1976). Optimum production of milk can be achieved in tropical and sub-tropical zone if the effect of these environmental factors is understood and proper farm management is done. The objective of this paper is to compare the production capacities and the effect of climatic factors on the milk yield of Holstein Friesian and Jersey cows.

## II. VARIATION IN MILK YIELD IN DIFFERENT CLIMATIC ZONES

According to (Muller & Botha, 1993), in temperate condition, the Holstein produces 23.94 kg milk per day while Jersey cow produces 16.74 kg per day, along with proper feed and water consumption. When these two are compared, Holstein has higher milk production but with inferior fat and protein percentage than Jersey.

Total lactation milk yield of Holstein lies in between 8153±1949.24 to 10069 kg of milk in the temperate climatic condition while 2772.76±65 kg to 7454±2134 kg of milk in tropical region. For Holstein, the production of milk is decreased by 40%-60% in tropical and sub-tropical regions than in temperate region (Usman et al., 2013). This difference in production is due to the combined effect of extreme environmental condition and management practices done in tropical

countries.(S.S. et al., 2011) suggested average milk yield of Holstein in semi-dry, Mediterranean, dry desert, Semi-humid and humid climate are 6378.05, 5967.28, 5854.18, 5537.53 and 4873.43 kg respectively in Iran.

(Dinesh et al., 2014) , depicts the lifetime performance in Jersey cows are higher in temperate and sub-temperate conditions than in tropical regions. In the region of Sri-lanka with altitude 1676 masl, monthly mean temperature 18-28<sup>0</sup>C and humidity 75%-85%, the production performance of Jersey is found to be 2187.51 kg per lactation identical to other tropical countries (Fernando et al., 2016). This result is in accordance with result of (5. *Production Performance Thesis.Pdf*, n.d.), which shows lactation milk yield of Jersey cows lies in the range of 1583±434 kg to 4636±25 kg. But, the research by (Adeneye & Bamiduro, 1977) in Nigeria shows the average milk yield 1257 kg which is lesser than other tropical regions.

## III. EFFECT OF CLIMATIC FACTORS ON MILK PRODUCTIVITY

According to the (Tg & Agropecuarias, n.d.), the variation in milk production and composition due to climatic factors (maximum and minimum temperature, relative humidity and solar radiation) is shown in table.

**Table 1: Reduction in yield as percentage of variance in Holstein Friesian and Jersey due to climatic factors**

Breeds	Holstein Friesian (% variance)	Jersey (% variance)
Milk yield	2.58	2.09
Fat%	5.05	10.22
Protein %	8.91	18.07
Fat yield	4.77	3.82
Protein yield	6.33	3.48
Protein/ Fat	1.73	0.45

Source- (Tg & Agropecuarias, n.d.)

Maximum temperature that Holstein can normally withstand is 25-26<sup>0</sup> C but above this temperature specific farm management practice must be carried to maintain the milk production (Berman et al., 1985). According to (West, 2003) when temp is 29<sup>0</sup> C and humidity is maintained at 40%, the milk yield in Holstein is 97% of the production in normal condition but as the humidity rises to 90%, yield decreased sharply to 69% of normal yield while in jersey cows, when temp is maintained at 28<sup>0</sup>C and humidity at 40%, the milk yield is 93% of normal production but as rises to 90% relative humidity, the yield is 75% of normal.

Milk production decreases in cold temperature but with lower rate than in hotter areas. It insights that cattle can tolerate cold condition than high temperatures (Brügemann et al., 2012) (Hansen, 2009). At temperature 40-70<sup>0</sup>F milk production is optimal for both breeds.

Certain decrease in temperature ranging from 10-40<sup>0</sup>F causes slight decrease in milk in Jersey cows but for Holstein it remains same. As the temperature is further increased to 70-100<sup>0</sup>F, the milk production declined by 20% in Holstein and 8% in Jersey cows(Brody et al., 1955).He also suggested that this effect is caused by numbers of hours exposed to high temperatures along with high ambient temperatures. When the number of hours of sunshine increases, the milk yield increases at first but after reaching maximum it decreases. Milk production in Holstein is high up to 24.1 kg at wind speed 9.1 knots and then decreases with further higher speed (Hill & Wall, 2014). (Stull et al., 2008) shows that milk production decreases with increase in precipitation. Milk protein is mostly determined by effect of THI (Temperature Humidity Index), Wind speed, precipitation and number of hours of sunshine while milk yield and fat

is effected by THI and number of hours of sunshine (Hill & Wall, 2014). The effect of climatic factors are more expressed in early to mid-lactating period compared to later period(Sciences, n.d.).

The productive performances in different climatic zones are variably heritable to the offspring in next generation. In semi-dry, Mediterranean, dry desert, Semi-humid and humid climate, the heritability are

0.30±0.07, 0.24±0.05, 0.28±0.06, 0.26±0.05 and 0.29±0.06 (S.S. et al., 2011). It is also shown in research done by (C. L. David, 2008) where the production of imported Holstein and Jersey is found to be different from the farm borne Holstein and Jersey cows due to the environmental effects and the management practices in the sub-tropical region of Punjab, Pakistan.

**Table 2: Lactation milk yield (kg) of Holstein and Jersey (imported and farm-borne)**

Breeds	Imported (kg)	Farm borne (kg)
Holstein	3363.41±100.75	2881.64±88.41
Jersey	3047.51±68.23	1698.39±57.99

Source- (C. L. David, 2008)

#### IV. HEAT STRESS AND ITS EFFECTS

Heat stress is the condition when animal struggle with dissipating heat from the body to surrounding (Kadzere et al., 2002). Cattle are homeothermic and cannot tolerate extreme change in climatic factors. The symptoms of improper heat dissipation are seen as heat rash, heat syncope, heat cramps, heat exhaustion and heat stroke (Habeeb et al., 2018). THI (Temperature-humidity index) is taken as prime indicator of heat stress counting the effect of temperature and relative humidity (Habeeb et al., 2018). According to (Thom, 1959), for farm animals, less than or equal to 74 units THI is normal while 75-78 is alert condition, 79-83 is danger condition and equal to or greater than 84 is emergency condition in terms of heat stress. According to (West, 2003), stress starts from THI of 68 units and become serious from 79-80 units. Threshold value for heat stress is different according to the region because of adoptability of cows and proper farm maintenance. There is inverse genetic relation of productive performance and heat tolerance (Ravagnolo et al., 2000).Cows produces heat as by-product of milk production causing high milk producing dairy breeds to be remarkably effected (Kadzere et al., 2002).

Holstein and Jersey shows low feed and dry matter intake, higher body temperature, respiration rate, heart beat and rectal temperature in hotter region as physiological effect of heat stress.(Muller & Botha, 1993).The change is similar for both breeds but the rate of change differs. Feed consumption is decreased by 20-30% in Holstein but lesser in Jersey when temperature rises to 70-100°F (Brody et al., 1955). Holstein has high

increase than Jersey in rectal temperature and heart beat by 0.55°C and 15.4 inhalations/ min respectively. These differences are due to body color, length and color of hair, thickness of fatty layers and individual milk producing capacities (Muller & Botha, 1993). (Dikmen & Hansen, 2009) reported the inverse relation of wind speed with rectal temperature of cattle. It suggests that moderate wind helps cow to dissipate heat. But high wind and precipitation causes stress. The milk production declines in rainy days due to low feed intake (Graunke et al., 2011). Peculiar fodder and pasture is found according to different climatic conditions and affects the nutrient and diet of cattle reared in different circumstances (Hill & Wall, 2014).

Heat stress leads to sharp decline in milk yield for Holstein and little effect in Jersey while (Smith et al., 2013) found increase of milk yield of Jersey in stress condition. The milk fat percentage drops for both breeds in heat stress while fat-corrected milk (FCM) yield declines in Holstein but no visible effect in Jersey. Holstein Friesian is more sensitive than Jersey because of their size. Holstein is heavier with small body surface providing less area to dissipate heat from the body but Jersey is smaller with larger heat dissipating area (Brody et al., 1955). The THI values are divided as mild, moderate and severe with range of 72-78, 79-90 and greater than 90 by (Smith et al., 2013) and showed that Holstein decreases milk production in moderate and severe condition while Jersey is affected in severe condition suggesting Jersey to be more tolerant to stress then Holstein Friesian cows.

**Table 3: Milk yield and other composition under different heat stress condition of Holstein and Jersey cows.**

Breeds	Holstein			Jersey		
	Mild stress	Moderate stress	Severe stress	Mild stress	Moderate stress	Severe stress
Milk yield (kg/d)	34.8	32.9	30.4	27.1	25.7	23.8
FCM(kg/d)	34.2	33.7	31.1	32	30.8	28.4

Fat%	3.5	3.7	3.7	4.6	4.7	4.6
Protein%	3.2	3.1	3.2	3.7	3.6	3.6
SCS	4.18	4.18	3.84	3.61	4.10	3.31

Somatic cell count (SCC) increases with heat stress in Holstein which may increase chance of sub-clinical and clinical mastitis (Gantner et al., 2017). This effect is more present in summer than spring season (Pascual, 2011).

## V. IMPACT OF CLIMATE CHANGE

Climate change and global warming are rising problem which can create extreme climatic condition and high ambient temperature directly affecting the production and adoptability of different breeds of cattle (Hill & Wall, 2014). Although the milk production is increasing due to genetic improvements at present but in near future climatic change and heat stress can adversely affect those gain (Mauger et al., 2015). The stress hours/day in stressed region is considered to be 13 but expected to increase to 17 hours/day by 2025 (S. E. Valtorta et al., 1996). In United States, the annual loss because of heat stress is expected to be triple i.e. more than \$2 billion by the end of 21<sup>st</sup> century. It is predicted that nationwide dairy production declines by 6.3% at the end of 2080s (Mauger et al., 2015).

Developed countries can somehow cope up with adverse climatic condition as cattle are reared in the advanced farm house with little exposure to weather elements but in developing countries of tropical region, animals are reared in open farm house depending on natural forage and grasses. They are in high chance to be effected by climate change (Rust & Rust, 2013). It also disturbs the fodder, pasture and water availability (Gauly et al., 2013). High temperature favors lesser quality C<sub>4</sub> plants than C<sub>3</sub> plants (Thornton et al., 2007). Low feed and higher feed cost, decreased forages on dry land, less weight gain and feed conversion ratio and occurrence of internal parasites infestation and vector-borne disease effect productivity of cattle (Rust & Rust, 2013)..

## VI. MANAGEMENT OF HEAT STRESS

Temperate breeds cannot withstand the adverse climatic condition of tropical region when imported and sometime failed to survive (P. R. David, 1933). Not only are the climatic factors responsible for low productivity. Inappropriate management of farm, improper nutrient management, inadequate feed supply and lack of advance techniques is also responsible for decline of milk production in tropics and sub-tropics (Usman et al., 2013). According to (Beede & Collier, 1986), the heat stress can be managed by artificial modification of environment, production of stress tolerance breeds by genetic improvement and providing nutritional feeds.

Some methods for management of heat stress in dairy cattle are discussed here.

### 1. Provision of shade-

Proper shading is necessity of both open and close farm housed cattle. In case of open system, trees can be planted for shade. Black globe temperature is found 29.0<sup>o</sup>C- 30.2<sup>o</sup>C in shaded area between trees which is lower than 35.5<sup>o</sup>C in non-shaded area along with decrease in rectal temperature and respiration rates of cattle.(Silvia E. Valtorta et al., 1997) It also increases milk by 0.7 milk/day. While designing barn, it must be east-west oriented rather than north-south as it gives lower exposure to solar radiation. Proper ventilation, establishment of trees around farm and additional shades by cloth roof, metal or wood frame can be supplement to manage heat stress.

### 2. Insulation of roof-

Another method for physical modification is blocking the heat flow by insulating the roof.

Feed consumption increases by 0.2 kg/day whereas milk is increased by 0.6 kg/day in insulated farm house cattle.

### 3. Use of cooling systems-

Different cooling systems can be used like air conditioning, foggers, misters and evaporative cooling pads. Foggers and misters emit the cool air to the body surface of cattle which gives relaxing sensation (Renaudeau et al., 2012). 4% increase in fat-corrected milk is found in air-conditioned animal (Thatcher, 1974) while milk increased by 0.5 kg/day and rectal temperature decreased by 0.5<sup>o</sup>C (G. LeRoy Hahn et al., 1969).

Air movement by using different supplementary fans such as panel or basket fans, big ceiling fans, tunnel ventilation, sprinklers and conductive cooling method can suppress heat stress in farm animals (Fournel et al., 2017).

### 4. Provision of Supplementary nutrient

Plenty of water is required as water intake is increased by 1.2 kg<sup>o</sup>C during stress condition. Feed must include more concentrate than fiber, 3-5% fat and high protein content as ME (metabolic energy) of high concentrate diets have high efficiency. (West, 1999). Some minerals like Na, K, Cl, So<sub>4</sub><sup>2-</sup> are required as a proper balanced diet (Kadzere et al., 2002).

### 5. Genetic Selection and Use of cross-breeds

Milk production varies among different breeds raised on different climates. Breeds with good thermoregulations, energy balance, hormonal balance and water balance must be selected in hotter regions. While importing exotic breeds, cattle with good bio-climatic index should be selected. In between Holstein and Jersey, Jersey is more tolerant to heat stress although the milk production is lower than Holstein. Crossing of Holstein

and Jersey can also be the way to improve tolerance. The genetic correlation of production and heat tolerance is -0.3, so genetic capacities can be improved through combine selection for milk production and tolerance capacities (West, 2003).

## VII. CONCLUSION

To sum up all those literatures reviewed, there is significant effect of the climatic parameters on the productivity of the dairy animals and the effect varies with difference in breeds and management practices. The exotic breeds like Holstein Frisian and Jersey have difficulties in surviving and adopting in new environment so special management should be done to maintain their normal productivity in local condition. Both breeds have higher milk production in temperate regions while moving towards hot and humid region their performance goes on decreasing. Despite these issues, both breeds are highly demanded on tropical and sub-tropical region for their high milk producing capacities than any other local breeds found there. In this case, selection of breed keeping both productive performance and heat tolerance traits plays imperative role to minimize heat stress in cattle. Although the milk production is high for Holstein than Jersey, it is highly sensitive to heat stress thus Jersey can be better option in heat stress condition. If Holstein and Jersey are raised in tropical region, better management of farm, cooling systems and supply of nutrient rich fodder and concentrate should be done. Genetic improvement of the breed by crossing with local breeds is essential in future to cope with changing climate. Further research should be carried out to find the best cross breeds for this situation. Also, the effect of heat stress on milk composition, feed efficiency and occurrence of mastitis need to be clearly studied.

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