COW COMFORT

By Jackson Wright and Tim Shelford

Research is underway in NYS to evaluate performance of LED fixtures under barn conditions and the implications of light spectrum on milk production.

Light Spectrum and its Implications on Milk Production

Life on earth has evolved under the influence of the sun's daily light and dark cycles. As a result, many species have developed the ability to detect changes in daily light exposure or photoperiod. Consequently, seasonal variation in light exposure can result in changes in physiology. To illustrate this, consider these examples:

- In poultry, manipulating photoperiod can facilitate year-round egg production.
- In horses, increasing light exposure can accelerate the return to reproductive competency.
- In dairy cows, increasing light exposure can increase milk production.

The ability of animals to detect photoperiod was likely an evolutionary benefit as changes in photoperiod could predict seasonal changes in their environment. In dairy cows, it is likely that shortening day length signaled the cow to store more nutrients in preparation for winter. Whereas, lengthening days signaled the cow to divert more nutrients to milk production, and thereby improved the likelihood of reproductive success.

Manipulating photoperiod to increase milk production has occurred since the 1970's, and several studies show that supplementing lactating cows with 16 to 18 hours of continuous light can increase milk production from 5 to 16 percent above cows exposed to less than 13.5 hours of continuous light. In these studies, light had to be sufficiently intense, greater than 15 foot-candles, with 6 to 8 hours of sustained darkness. To put this in perspective, full daylight can be 1,000 foot-candles, dusk 10 foot-candles and twilight 1 foot-candle. Dairy lighting recommendations are 20 foot-candles for freestall feeding areas and general lighting. Typical office lighting is usually between 50 and 75 foot-candles.

The mechanism behind the increase in milk production is unclear. However, it is known that for many mammals, light patterns influence the secretion of melatonin from the pineal gland. At night levels of melatonin are high. During the day, light exposure suppresses melatonin secretion. This creates a rhythmic pattern of melatonin secretion connected to day length and establishes a circadian rhythm. Further investigation suggests that mimicking the longest days of the year for dairy cows suppresses melatonin secretion, which increases circulating levels of prolactin and insulin-like growth factor (I). Both are associated with improved mammary function. In the dairy industry, this management strategy is commonly referred to as long-day photoperiod or LDPP.

Previous research shows that metal halide (MH), high pressure sodium (HPS) and fluorescent light fixtures can increase milk yield. These light fixtures are commonly used in dairy barns because they are cost effective in terms of electricity use, when compared to incandescent lighting. However, it appears that not all light is created equal to suppress melatonin. For example, research shows that in humans blue light between 446-477 nm wavelengths is the most effective region in the light spectrum to suppress melatonin secretion. Why is this important? Because different light fixtures produce light with different characteristics and wavelength distributions.

Recently a study that compared light from white fluorescent (4000K) and blue light-emitting diodes (LEDs) suggested that narrow bandwidth blue LED light more strongly suppressed melatonin in humans. In this study, the blue LED light significantly suppressed melatonin secretion, whereas a white fluorescent light fixture with double the energy input did not significantly suppress melatonin secretion.

FYI

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Moreover, spectral power distributions of white fluorescent fixtures, the power per unit area per unit wavelength of an illumination, show peaks in relative power at the 425, 540 and 600 nm regions of the light spectrum (**See Figure 1**). In other words, white fluorescent (4,000K) light fixtures lack relative power in the 446 to 477 nm region of the light spectrum. Similarly, other lighting types such as metal halide and HPS, also lack power in this region (**See Figure 2**). On the other hand, blue LED lights peak in relative power between the 450 and 500 nm regions of the light spectrum (**See Figure 1**). This concept agrees with previous publications that identify the 446 to 477 nm wavelength region of the light spectrum as the most effective light to reduce melatonin levels in humans. In addition, LED lights offer several other unique characteristics that may make them desirable to dairy producers. Among these are high energy efficiency, increased durability and a reported 100,000 hour operating life.

Take home messages for photoperiod manipulation, blue LED lighting and dairies:

- Current studies on the effect of blue LED lighting on melatonin production are limited to human and rat models. More research is needed to establish if this region of the light spectrum is more effective to suppress melatonin secretion in cows.
- The reported 100,000 hour operating life for LED lights are estimates based on lab studies and don't represent the effects of farm conditions. The unique environment of a barn will have to be considered. Excessive heat, moisture, dust and corrosive manure gases could affect the somewhat sensitive LED circuitry.
- A key requirement identified in research farm studies is that the light period must be followed by an uninterrupted period of dark. This condition could complicate operations where dairies milk three times per day.
- Milk increases due to photoperiod are not as rapid as with other practices such as rBST. Cows take time to become conditioned to long day lighting. Once conditioned, milk increases are additive with other management strategies, such as frequent milking or rBST.

Although more research needs to be done before we can recommend a dairy invest in blue LED lighting in their barns, blue LED lighting does seem to be a very promising means of implementing long-day photoperiod.

Currently, the North West New York (NWNY) Dairy, Livestock and Field Crops Team is investigating the effects of photoperiod manipulation using T8 fluorescent and blue appearing LED lights on a farm in western New York. In the NWNY study, three nearly identical barns under the same management were updated with T8 fluorescent or blue appearing LED fixtures. The study was designed to compare implementing LDPP with LED and T8 fixtures versus a control group.

Throughout the study, NWNY, NYSERDA and RPI Lighting Research Center will monitor milk production, energy usage and light brightness at cow eye level in each experimental barn. An economic analysis will be performed to account for the initial cost of the fixtures, fixture performance, operating life, expected energy savings and milk production, to determine which lighting system is the most cost effective for dairy producers. Results from this study should be available July, 2014. Hopefully results from this study will provide dairy producers with more information regarding performance of LED fixtures under barn conditions and the implications of light spectrum on milk production.

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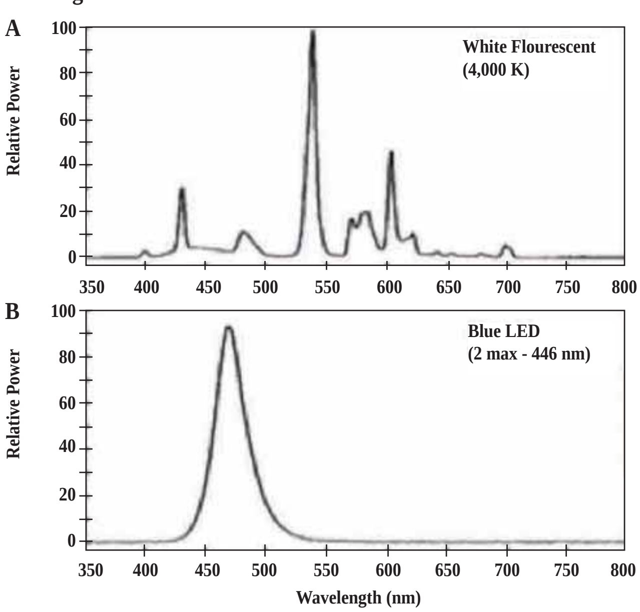
Reference:

K. E. West, M. R. Jablonski, B. Warfield, K. S. Cecil, M. James, M. A. Ayers, J. Maida, C. Bowen, D. H. Sliney, M. D. Rollag, J. P. Hanifin, G. C. Brainard. Blue light from light-emitting diodes elicits a dose-dependent suppression of melatonin in humans. J Appl Physiol. March 2011 110:(3) 619-626.

Figure 1. Special power distribution corresponding to polychromatic white light source.



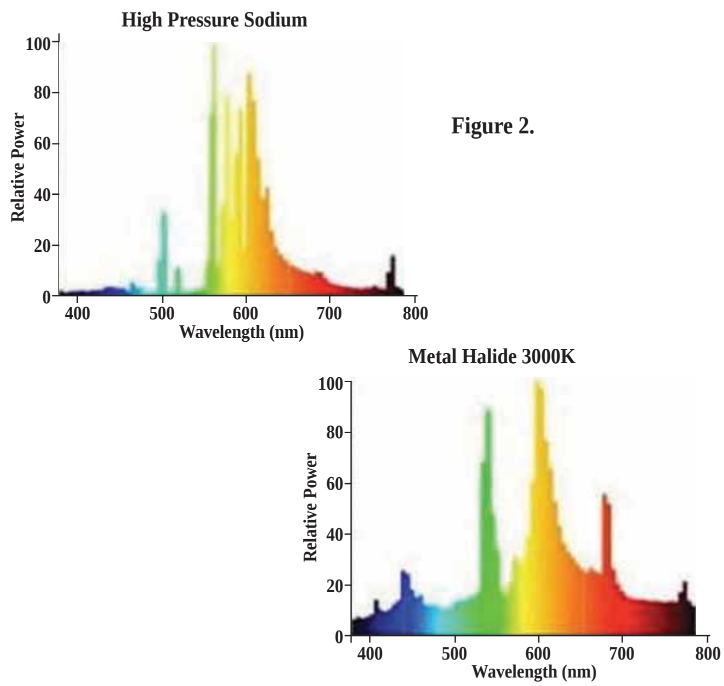


Figure 2.