Fighting heat stress: diet, gut integrity and gut health

Are our pigs ready for the summer heat?

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The South Africa Weather Service has issued seasonal climate watch on the 31 August 2017 for the rainfall and temperature forecast from September 2017 to January 2017. The El Niño Southern Oscillation (ENSO) phenomenon is now likely to have no specific influence over the coming summer months over South Africa. In addition, as the current and predicted state of ENSO is for neutral conditions, there is currently no confident forecast that can be made for the forthcoming summer rainfall.

Temperatures are expected to be largely above normal for most parts of the country during the spring and early summer periods.

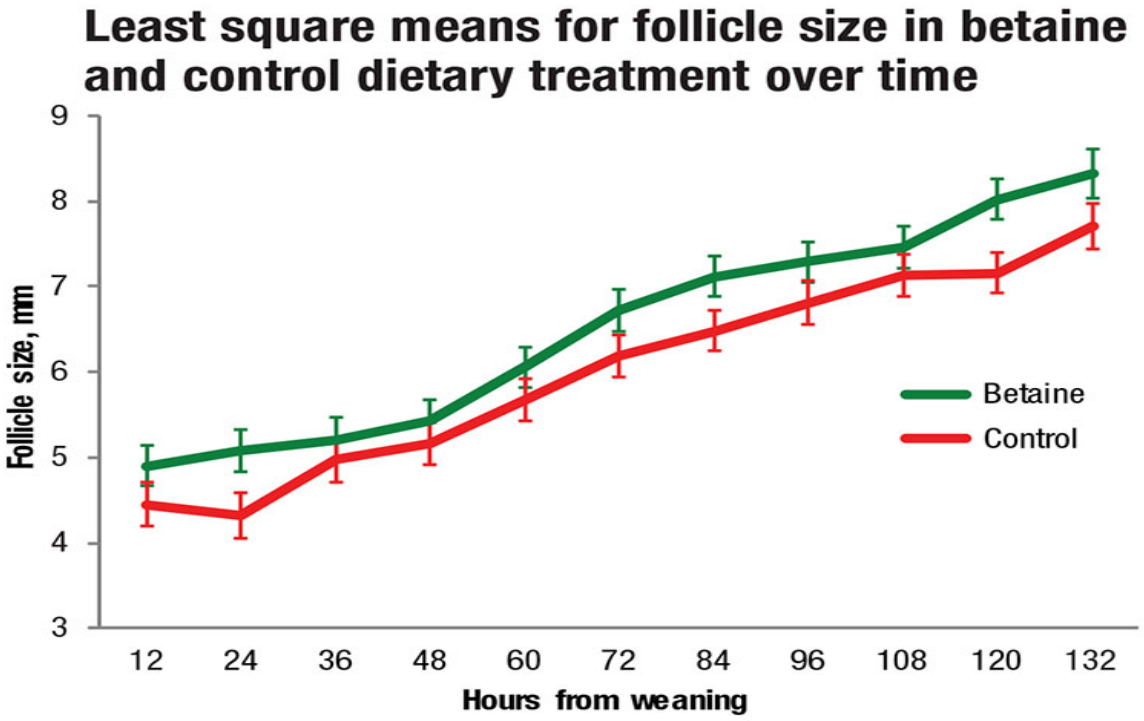
Environmental temperature may not have to greatly exceed the animal's thermal neutral zone in order to have detrimental effects on fertility, and the effects may vary within and between genetic lines of animals. Stress from heat is more than just a fever and results in multiple physiological changes within the animal in attempts to dissipate the heat from its body. Pigs will increase their respiratory rates, decrease feed intake, increase water intake, and divert blood flow to the extremities to aid in heat dissipation. This results in a decrease of blood flow in the gastrointestinal (**GI**) tract, tissue hypoxia, and ATP depletion, ultimately increasing the permeability of tight junctions allowing bacteria and endotoxins to enter into the animal's blood stream. The overall impacts of heat stress on reproduction are decreased milk yield, increased body weight loss, increased wean-to-oestrus intervals, and impairments in embryo development.

Heat stress has multiple impacts on animal metabolism and physiology. These include increased body core temperature, homeorhetic adaptations to dissipate radiant heat, increased respiration rates, reduced intestinal barrier integrity, elevated circulating concentration of stress markers and reduced feed intake as a strategy to reduce heat production. Heat stress can impair the ovarian function, and decreased follicular growth rate, increased occurrence of anoestrus and longer wean-to-oestrus intervals have been reported in sows during high ambient temperatures. The impaired ovarian function can be attributed to the reduction in blood flow to ovaries, since during heat stress more blood flow is directed to the skin to dissipate heat. Therefore, production losses and deaths from heat stress still plague the livestock industry despite many years of research. This fact suggests that our understanding of the problem still may be incomplete. The current paradigm held by animal scientists maintains that decreased production during heat stress is a direct result of an attempt by the animal to decrease its heat load. To lower its heat load, the paradigm maintains, the animal reduces feed intake. The paradigm also maintains that heat stroke is a consequence of heat-induced damage to the brain or dehydration-induced circulatory failure.
Consequently, nutritional strategies for reducing the negative effects of heat stress have been directed at the development of diets that have low heat increments. That is, these diets seek to generate less heat associated with the digestion and metabolism of nutrients. Thus, diets containing elevated dietary fat content have been advocated for hot conditions because the heat increment of fat is lower than that of

any other nutrient. However, several reviews of trials involving the feeding of high-fat diets during heat stress have concluded that evidence for the efficacy of this strategy is inconsistent.

"Research finds betaine reduces heat stress impact on sows and pigs in general".

Betaine supplementation partially reduced the negative impacts of heat stress on the sow, by reducing her body temperature and improving follicular development during the post-weaning period. Betaine is a tri-methyl derivative of glycine, which is synthesized from choline, and it acts as an osmo-protectant by increasing water retention capacity in cells. Betaine has a relevant role in the conversion of homocysteine into methionine, and high levels of homocysteine have been associated with defective implantation and early pregnancy failure in women. Dietary betaine supplementation has been shown to improve reproductive performance in sows when betaine was supplemented during lactation.



Adapted from: *F.A. Cabezón, K.R. Stewart, A.P. Schinckel and B.T. Richert, Purdue University Department of Animal Sciences.*

It is well documented that during the summer months when ambient temperatures are elevated, many reproductive parameters are negatively impacted. One such is a delay in the return to oestrus following weaning in sows as heat will delay follicular development on the ovary following weaning. The wean-to-oestrus interval is a predominant factor in calculating non-productive sow days, which negatively impact reproductive efficiency and profitability. Exposure of mammals to a high ambient temperature results in redirection of blood from the core of the body to the periphery to facilitate dissipation of body heat to the environment. In order to maintain blood pressure, the increased blood flow to the skin is counterbalanced by reduced blood flow to the gut. Gut cells can tolerate a lack of nutrients and oxygen for a limited time, but if deprivation is sustained, as would occur during a heat wave, the lining of the gut is damaged.

Under normal conditions, cells lining the gut are joined tightly together, which prevents foreign proteins from entering the body. The gut and liver are also equipped with a diverse complement of immune cells to destroy any potentially harmful molecules that enter the bloodstream. One of the most virulent foreign molecules is endotoxin, which is produced by bacteria such as E coli and Salmonella species that inhabit the gut of humans and livestock. Less than one millionth of a gram of endotoxin is sufficient to induce an acute immune response in humans. Dietary additives that improve gut integrity and health could make a substantial contribution to reducing the negative economic impact of heat stress in the livestock industry. Such a dietary strategy is supported by comprehensive evidence of diet-induced damage to the gut of all livestock species. However, when a small number of large compounds in the gut are converted into a greater number of smaller constituent molecules, the total concentration of dissolved molecules increases in osmolarity, which exceeds that of the gut cells. Because water flows from solutions of low osmolarity to those of high osmolarity, the digestion of food is accompanied by movement of water out of the blood into the gut. As nutrients are absorbed, the osmolarity of the gut decreases and that inside the gut cells increases, causing water to flow from the gut back into the blood.

Diets for livestock contain high concentrations of feedstuffs that have been processed to increase the rate and extent of digestion. Digestion of these processed feedstuffs can increase the osmolarity of the gut contents to such an extent that the osmotic pressure of water moving from the blood into the digesta can damage the junctions between the cells lining the gut. In recent research, a mixture of osmolytes, which included betaine, increased the resilience of cells to osmotic stress by 42%. Other research showed that gut tissues of poultry supplemented with betaine were better able to cope with an osmotic challenge than those of unsupplemented birds. Dietary betaine supplementation also improved the structure of the gut lining in poultry and increased nutrient absorption in poultry and pigs.

Many of the harmful effects of endotoxin are mediated by tumor necrosis factor- and nitric oxide. Researchers have reported that betaine decreased liver damage caused by endotoxin and reduced the secretion of tumor necrosis factor- by 38% and that of nitric oxide by 21%. A similar suppression of tumor necrosis factor- by a mixture of betaine and taurine was observed when liver cells were exposed to an osmotic challenge. These results suggest that betaine not only protects against gut damage, but enables the liver to cope when gut damage occurs.

Thus, the positive effects of betaine on gut integrity and health indicate that it could play a role in decreasing the susceptibility to heat-induced gut damage of livestock fed diets containing high levels of processed grains.

References available on request.