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Influence of nutrition on inflammation and mitigating its impact

Undernutrition, or lack of feed consumption, results in weight loss and decreased body condition, impacting reproductive performance. Declines in performance will be registered as delayed puberty, and an increase in the postpartum-to-conception interval in cattle and the wean-to-oestrus interval in swine. It may also reduce ovarian cyclicity, which impacts fertility (*Figure 1*).

Low insulin signals to the brain will downregulate reproductive performance if nutrition is not adequate in livestock. For example, in sows, if amino acids are not adequate, low levels of insulin will signal the hypothalamus to reduce the release of gonadotropin-releasing hormone (GnRH). Generally, due to cost, we do not want to overfeed protein to such an extent that it elevates blood urea nitrogen (BUN) or urea in the bloodstream of livestock. Overfeeding protein or urea have both been shown to have toxic effects on sperm, the ova, and developing embryos.

First-parity animals often do not consume enough carbohydrates daily. Inadequate intake of carbohydrates also signals the pituitary gland to reduce the amount of follicle-stimulating hormone (FSH) and luteinising hormone (LH) released to the ovary, thus reducing the amount of hormone production from the ovaries.

Prioritisation of nutrients

Trace minerals and vitamins are found in the diet in small quantities, but they have a considerable impact on reproductive performance and many other biological functions. Zinc is involved in over 300 enzymatic activities, required for the structural and functional integrity of over 2 000 transcription factors, and is involved in almost every signalling and metabolic pathway of metabolism. The priority for trace minerals in the diet of livestock are needed in the greatest quantity during processes of inflammation and enzymatic activities, followed by maximum reproductive performance and high milk production. Amino acid pathway minerals and consequential inflammatory reduction is important as a metabolic process and in utilisation of feed.

Nutrients are limited based on the nutrient load of a diet and feed intake; the nutrients must therefore be prioritised to meet the specific needs of the animal. Sows prioritise nutrients and energy for metabolism, lactation, growth and reproduction, due to the short duration of a sow's lactation (*Figure 2*).

However, if one examines the priority of the dairy cow, there will be some differences due to the number of lactation days. Researchers prioritised the metabolic use of energy for dairy cows, ranking each physiological state: basal metabolism, activity, growth, energy reserves, pregnancy, lactation,

Figure 1: Nutrition pathways that may impact hormone production in the sow.

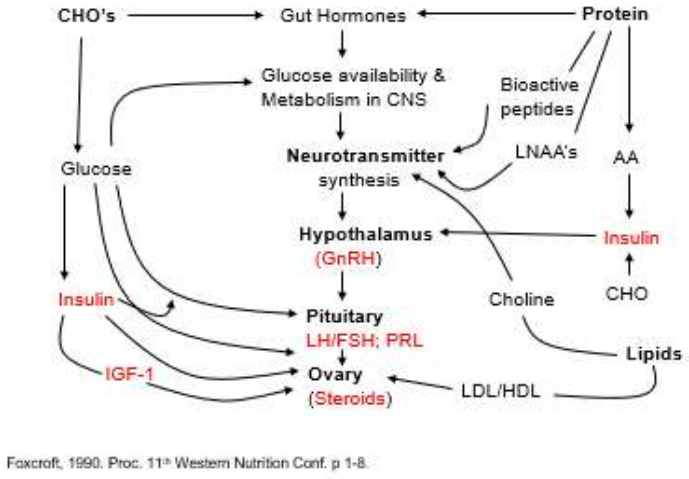
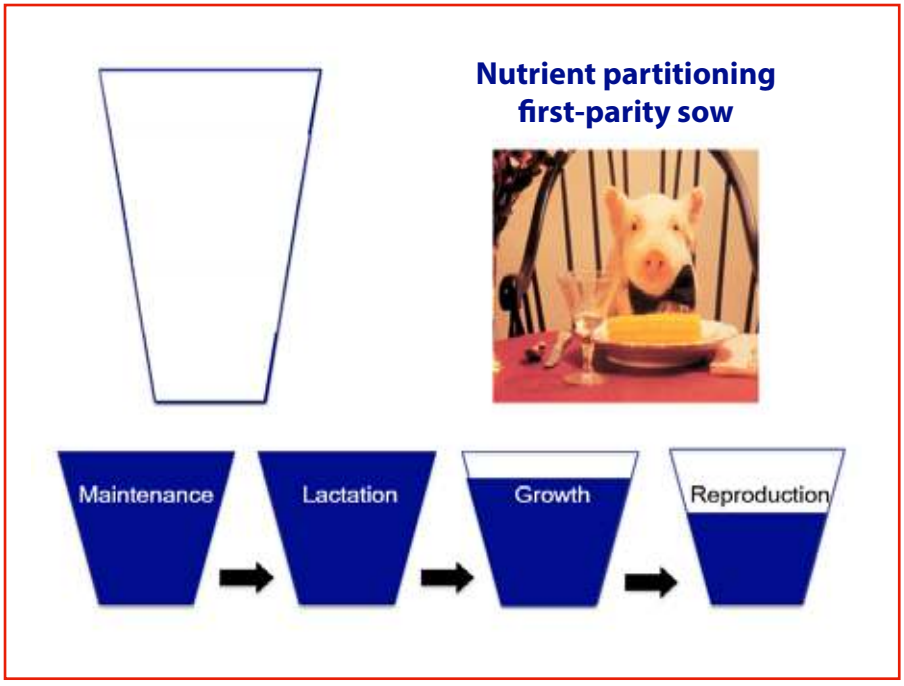


Figure 2: Nutrient partitioning of production priorities.



additional energy reserves, oestrous cycles and initiation of pregnancy, and excess energy reserves. This creates a conflict in terms of reproductive function due to compromising minimum energy reserves and the need for high milk production.

Inflammation and cytokines

The hidden culprit in nutrient utilisation is inflammation. It is therefore important to consider the role of inflammation to protect livestock. Chronic inflammation can be detrimental to the animal due to the continued release of cytokines. In simple terms, anything that causes cellular trauma, disease or injury, as well as any kind of stressor, can cause inflammation.

Proinflammatory signals (cytokines) are released when the body recognises a pathogen, injury, or stressor. Cytokines are small protein molecules that can cause a strong stimulus which will promote inflammatory responses. These signals will reach the brain, which tells the body that something is wrong. The brain will release corticotropin-releasing factor, which will stimulate the adrenal glands to release corticoids, or stress hormones. Its role is to alter nutrient utilisation as this provides energy and a different cascade of amino acids for the immune system to function.

At the same time the liver is stimulated by the cytokines to decrease production, shutting down insulin growth factor 1 (IGF1) and upregulating acute phase proteins for the immune system. The release of corticoids allows the immune system to heighten its priority in terms of nutrients to resolve the inflammatory problem.

Each type of stress may have different releasing factors and processes to heal the problem. Heat stress decreases blood flow to the intestinal tract and lowers nutrient support to the enterocytes. As the respiration rate increases, it creates more reactive oxygen species (ROS), which can damage the protein stitching in the tight junctions. This allows harmful substances from the intestinal tract to enter the bloodstream. In response, proinflammatory cytokines are released, which elicit an immune defence.

Inflammatory reactions and minerals

Many trials have demonstrated improvements in reproductive responses when inflammatory processes are kept to a minimum. Inflammation can have an impact on the intestinal tract, mammary glands, reproductive tract, lungs, skin, eyes and lameness.

When comparing amino acid pathway minerals and inorganic minerals, there are important differences and impacts. Some of the real differences are observed in the gene upregulations of messenger RNA (mRNA) expression and changes that support the immune system. New models are released all the time with the advent of enteroids, which are clones of the actual intestinal tract from pigs where dramatic shifts in RNA signalling between amino acid pathway minerals compared to inorganic minerals can be observed.

A noteworthy dairy study looking at inflammatory reactions of mRNA upregulation at the corium tissue demonstrated that the cow's heel did not mend, and keratinocyte proliferation was decreased in the inorganic mineral treatment. Sow lameness has also proven an issue due to lame sows producing lower amounts of immunoglobulin G (IgG) in their colostrum; the piglets nursed by lame sows grew 7 to 15% slower than the piglets nursed by non-lame sows.

In dairy production, milk production increases when the somatic cell count is decreased. In addition, a difference has been observed in the number of somatic cells in sow colostrum and milk when feed contains amino acid pathway minerals compared to inorganic minerals.

A study done at the University of Barcelona demonstrated that somatic cells were reduced in sows fed amino acid pathway minerals compared to those fed inorganic minerals, when sows received the same amount of feed. Between these two groups of sows, the growth performance at weaning of the sows receiving the amino acid pathway mineral treatment was increased over those receiving the inorganic mineral.

Effect of inflammatory responses

Ovaries in livestock species can be impacted by lipopolysaccharides (LPS) due to gut leakage, *Escherichia coli* in drinking water, and LPS derived from inflammation in the uterus. This inflammatory response impacts the hormone output from the ovary. This is due to granulosa cells detecting the LPS, which then shuts down the aromatase enzymatic pathway that converts testosterone to oestradiol benzoate. Gilts or sows that have this have very poor responses to oestrus stimulation by the boars and are therefore problem breeders.

The greatest impact on reproduction is when livestock are dealing with inflammatory responses. This translates into much poorer reproductive success. Reproduction is a luxury. Inflammation is like a thief in the night that reduces reproductive performance. ❖

References available on request. For enquiries, send an email to Dr Mark Wilson at MWilson@Zinpro.com.