

The intestine as a critical target of heat stress: a nutritional strategy to protect swine productivity during summer

Introduction

Heat stress is one of the major challenges facing modern swine production. Rising temperatures associated with climate change are increasingly exposing animals to conditions that exceed their adaptive capacity, negatively affecting growth, feed efficiency, reproductive performance, and farm profitability.

Beyond reducing feed intake, heat stress causes physiological, metabolic, and immunological alterations that directly **impair** productive performance. In this context, nutritional strategies complement management and housing measures, helping to reinforce the animal's defense mechanisms. Among these, plant-derived bioactive compounds stand out due to their ability to modulate inflammation, reduce oxidative stress, and improve resilience under heat stress conditions.

When heat exceeds the pig's adaptive capacity

Pigs are particularly susceptible to heat stress due to their limited ability to dissipate heat, resulting from the scarcity of functional sweat glands, their high metabolic heat production, and the presence of subcutaneous fat. When ambient temperature exceeds the thermoneutral zone, pigs activate adaptive mechanisms such as increased respiratory rate, reduced activity and feed intake, as well as redistribution of blood flow toward the periphery to facilitate heat dissipation. However, when these conditions persist, physiological disturbances develop that compromise productive performance.

The intestine: a key organ in the physiological response to heat stress

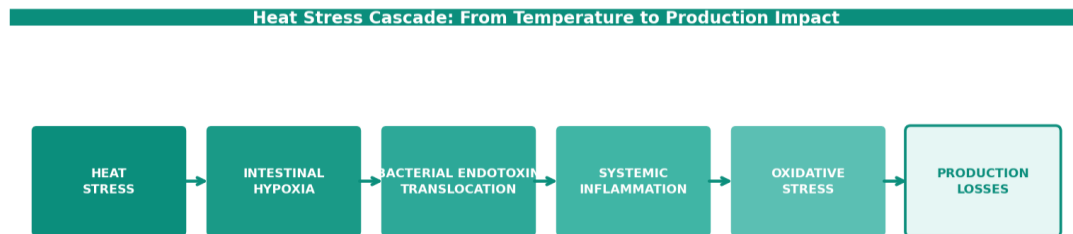
During periods of heat stress, a significant proportion of blood flow is redirected from internal organs toward the body periphery to facilitate heat dissipation.

Consequently, the gastrointestinal tract receives less oxygen and nutrients, creating a state of intestinal hypoxia that compromises intestinal mucosal function (Pearce et al., 2013; Pearce et al., 2014).

- Reduced intestinal blood flow may lead to: Disruption of tight-junction integrity
Increased intestinal permeability.
- Reduced nutrient absorption.
- Increased translocation of bacterial endotoxins into the bloodstream.

The translocation of endotoxins into the bloodstream triggers a systemic inflammatory response, redirecting energy and nutrients toward maintenance

and immune defense. As a result, fewer resources remain available for growth, milk production, and reproduction (Lance et al., 2013).



Adapted from: Pearce et al. (2013, 2014); Lance et al. (2013)

Figure 1. Heat stress cascade: from elevated temperatures to impaired production performance

Oxidative stress: the hidden damage caused by heat

Intestinal hypoxia and systemic inflammation promote the excessive formation of reactive oxygen species (ROS), generating a condition known as oxidative stress.

- When free-radical production exceeds the body's antioxidant capacity, oxidative damage can affect: Cell membranes.
- Structural proteins.
- Metabolic enzymes.
- DNA.

Even small daily reductions in weight gain can translate into significant economic losses by the end of the production cycle.

The economic cost of heat stress in swine production

Heat stress has economic consequences throughout the production cycle.

Piglets

Young animals are particularly sensitive due to the immaturity of their physiological adaptation mechanisms.

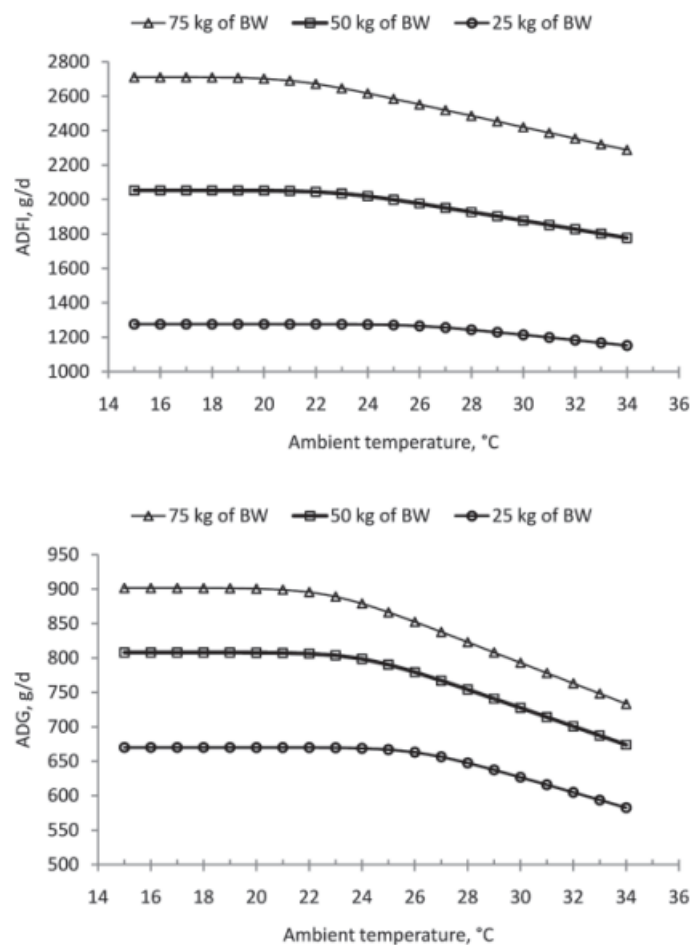
- Key consequences include: Reduced feed intake.
- Lower average daily gain.
- Poorer batch uniformity.
- Increased susceptibility to digestive disorders.

Growing and finishing pigs

At this stage, high temperatures cause:

- Reduced voluntary feed intake.
- Poorer feed conversion efficiency.
- Reduced growth rate.
- Lower slaughter weight.

Figure 2. Effects of ambient temperature on ADFI (Average Daily Feed Intake) and ADG (Average Daily Gain) at different body weights



Source: Renaudeau et al., 2014

Sows

- Sows are among the animals most susceptible to heat stress, particularly during lactation. Key consequences include: Reduced feed intake during lactation.
- Greater loss of body condition Reduced milk production.
- Lower piglet weaning weight.

- Hormonal disturbances
- Poorer colostrum quality.
- Reduced subsequent reproductive performance.

Impact of Heat Stress Across Swine Production Stages		
Piglets	Growing & Finishing	Breeding Sows
- Reduced feed intake	- Reduced voluntary feed intake	- Reduced feed intake during lactation
- Lower average daily gain	- Poorer feed conversion efficiency	- Greater body condition loss
- Poorer batch uniformity	- Reduced growth rate	- Reduced milk production
- Increased susceptibility to digestive disorders	- Lower slaughter weight	- Lower piglet weaning weight
		- Hormonal alterations
		- Poorer colostrum quality
		- Reduced subsequent reproductive performance

Source: Article text — The intestine, a critical target of heat stress (Igusol-Produmix, 2026)

Figure 3. Impact of heat stress across swine production stages

Polyphenols and capsaicin: a nutritional strategy against heat stress

Plant-derived bioactive compounds have attracted increasing interest as nutritional strategies to improve animals’ resilience to heat stress. Among them, polyphenols from grape extract (*Vitis vinifera*) stand out due to their antioxidant and anti-inflammatory properties, helping to reduce oxidative stress, modulate inflammation, protect intestinal integrity, and support immune function.

In swine, supplementation with polyphenol-rich grape extract has shown relevant effects in sows exposed to heat stress. Wang et al. (2019) observed an improvement in antioxidant status, increased IgG and IgM concentrations in colostrum, higher piglet survival at birth and weaning, as well as reductions in rectal temperature and respiratory rate, indicators directly related to thermal load.

Capsaicin, the main bioactive compound of peppers belonging to the *Capsicum* genus, complements this action through activation of the TRPV1 receptor, promoting thermoregulation, heat dissipation, and peripheral blood flow. In addition, it contributes to modulating oxidative stress and inflammation, helping to maintain feed intake and intestinal function during periods of intense heat.

In heat-stressed growing pigs, supplementation with *Capsicum* spp. has been associated with increased feed intake, improved feed efficiency, greater thermal tolerance, and reduced body temperature (Cervantes et al., 2024). Improvements in intestinal integrity have also been reported, with increased

expression of tight junction proteins and improved post-absorptive metabolism (Cervantes et al., 2025). In addition, Kroscher et al. (2022) described that capsaicin may partially prevent metabolic alterations induced by heat stress, particularly in parameters related to energy metabolism.

Taken together, these results support the use of ingredients rich in polyphenols and capsaicin as nutritional tools to reduce the physiological and productive impact of heat stress in swine. Based on this scientific evidence, IGUSOL has developed HeatCalm, a nutritional solution specifically designed to help animals cope with the challenges associated with heat stress.

Conclusions

Heat stress is a complex physiological challenge that affects intestinal integrity, promotes inflammation and oxidative stress, and compromises animal productive performance. In this context, nutritional strategies play a key role in complementing management measures. The combination of polyphenols and capsaicin allows simultaneous action on antioxidant protection and thermoregulation, helping to maintain animal welfare, preserve productivity, and reduce the economic losses associated with heat stress.