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Maintaining the performance of broilers under heat stress

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Broiler lineages currently used in the poultry industry result from a continuous selection for improved efficiency to convert feed into body mass and growth performance. However, one of the outcomes of such assisted evolution is less resistant individuals that are highly susceptible to heat stress, which occurs when broilers are unable to balance body heat production and body heat loss. As heat stress is a recurrent problem in the poultry industry that often results in continuous economic losses, it is critical to take preventive measures to address the negative zootechnical consequences of heat stress, while simultaneously improving animal health and welfare.

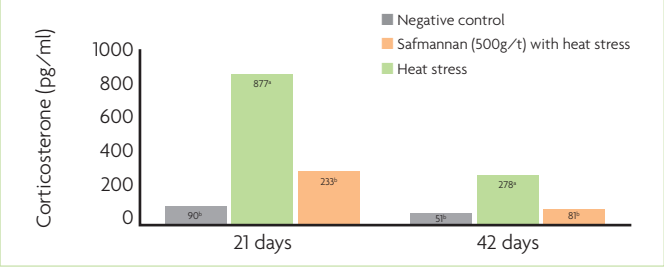
Physiological response to heat stress

Broilers under heat stress need to increase heat exchange between their body and the environment. This is achieved by diverting blood and nutrient flow from internal body organs, such as the liver, kidneys, and intestines, to peripheral tissues, such as skin. This process leads to hypoxia in the intestinal epithelium, which compromises intestinal integrity and facilitates the translocation of bacteria and bacterial products such as lipopolysaccharides into the internal environment, a process known as 'leaky gut syndrome'. As a consequence, an immune response is triggered together with the activation of the neuroendocrine system and the concomitant secretion of adrenal corticosteroids to attenuate the immune response of the animal. In turn, corticosteroids will decrease the release of thyroid hormones (T3 and T4) responsible for controlling body temperature and metabolism, thereby increasing broiler's susceptibility to heat stress and negatively affecting feed intake. Ultimately, the combination of heat stress, a weaker immune system, and lower feed intake increases the risk of inflammation, morbidity and mortality.

How to tackle heat stress?

Nutritional supplements are available to address heat stress in broilers. Particularly, feed supplementation with yeast cell wall compounds, such as, mannan-oligosaccharide and 1,3/1,6 β-glucan, has been shown to modulate immunity, preserve gut function and improve growth performance. This scientific knowledge is the foundation of Safmannan, a selected yeast fraction rich in mannan-oligosaccharides and β-glucans (1,3 and 1,6). High levels of serum corticosterone are an indicator of heat stress in broilers, as recorded in a scientific trial performed by Sohail et al. However, broilers grown under severe heat stress but given feed supplemented with Safmannan

Fig. 1. Corticosterone concentration (pg/ml) of broilers. Trial carried out in Mexico during which Cobb 500 birds were kept at a high temperature (35°C) from the age of 1 to 42 days old.



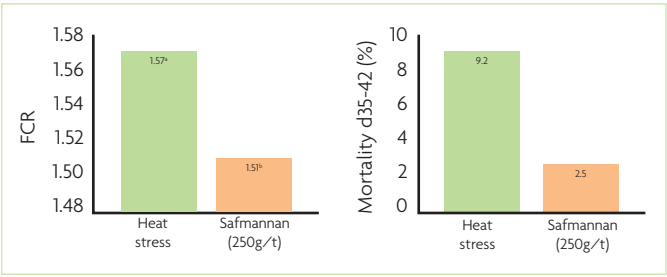


Fig. 2. Brazilian study 2017 to evaluate the effect of Safmannan on broiler performance under severe heat stress (THI: 32 at D42) conditions.

showed corticosteroids levels statistically similar to those under no heat stress, and also significantly lower than the heat-stressed group (Fig. 1). Feed supplementation with Safmannan contributed to normalise the serum corticosterone probably due to its ability to bind pathogens, thereby minimising inflammation and normalising hypothalamic-pituitary-adrenal axis function. The hormonal action of Safmannan extends beyond corticosterone. The levels of the hormones T3 and T4 usually drop under heat stress, thereby reducing feed intake and metabolic rate in order to decrease body temperature. This can be reversed by feed supplementation with Safmannan. Results from a scientific trial done in Mexico has shown that Safmannan stimulates the production of these thyroid hormones, which is a clear indication of reduced stress levels in feed supplemented broilers. The hormonal processes previously described have a direct effect on zootechnical performance of broilers. This can be prevented by using Safmannan feed supplement, as proven in a scientific trial carried out in Brazil that shows a reduction in FCR and mortality of broilers exposed to heat stress when the selected yeast fraction is used (Fig. 2). These results are likely driven by a reduced intestinal inflammation and by the overall gut health improvement.

An integrated heat stress management strategy

It is widely accepted that heat stress affects broiler performance and health. In particular, heat stress has detrimental impacts on gut integrity as it reduces the natural physiological capacity to address inflammatory processes caused by pathogens such as salmonella and E. coli. Safmannan is a premium sustainable nature-solution based on a selected yeast fraction that has been scientifically validated to improve the natural defences and the intestinal mucosal integrity. Moreover, Safmannan decreases the levels of the stress hormone corticosterone, and increases thyroid hormone concentrations, thereby contributing to normalise the hypothalamic-pituitary-adrenal axis function.

This feed supplement further contributes to mitigating the negative zootechnical consequences of heat stress, such as improving FCR, growth performance and survival. Safmannan is, therefore, a biological approach to address the physiological alterations induced by heat stress in broilers and improve their zootechnical performance, health and welfare.

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A selected yeast fraction to consistently address heat stress in broilers

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The selection for high growth performance broiler lineages has led to less resistant individuals. Modern poultry genotypes are less resistant to heat stress as well as to pathogenic infections. This issue has been frequently addressed by using yeast-based feed supplements in order to preserve gut function and, consequently, improve the overall health and growth performance of broilers. Positive results have been observed particularly when Saccharomyces cerevisiae yeast cell wall components are included in broiler diets. Although yeast cell wall (YCW) is comprised of glucans, glycoproteins, mannans (MOS), and chitin, the benefits of YCW feed supplementation have been mostly associated with the presence of mannan-oligosaccharides (MOS) and β-glucans (1,3 and 1,6). Dietary supplementation with yeast-based products to broilers is widely acknowledged to improve their nutritional and growth performance. These beneficial responses are a result of the ability of MOS to adsorb and bind with certain micro-organisms and their metabolites in the gastrointestinal tract, such as pathogenic bacteria, thereby improving the integrity of the intestinal mucosa and modulating immune response. However, such zootechnical and immunological benefits differ with the relative composition and structure of mannans and β-glucans, which in turn vary yeast strain, growth stage, and the biotechnological process used to prepare the yeast-based product.

Different sources of yeast cell wall products

Currently, the main yeast sources for the animal feed industry are waste products from various fermentation processes, such as brewing and the bioethanol industry. Consequently, yeast by-products differ from batch to batch, resulting in unpredictable outcomes and efficiencies. Furthermore, the choice of an appropriate extraction technique also affects the product's quality, quantity, structure, and other functional properties of the extracted mannans and β-glucan. As most YCW-based products commercially available are simply a by-product of one or several strains used for other industrial processes, it is essential to develop reliable yeast fractions prepared especially for the purpose of improving broiler growth performance, health, and welfare. Safmannan feed supplement is the result of scientific developments that have culminated in a premium yeast fraction rich in mannan-oligosaccharides and β-glucans (1,3 and 1,6) obtained by controlled primary fermentation of a Saccharomyces cerevisiae proprietary bakery strains, autolysis, and purification.

Safmannan shows superior results

A scientific study carried out in China compared the effects of Safmannan and another YCW additive on broiler performance under severe heat stress conditions. Safmannan was added to feed at 250g/t, whereas the other YCW product was added at the recommended dosage of 1kg/t. Broilers supplemented with Safmannan showed an average daily feed intake similar to broilers under no heat stress, and significantly higher than both the heat stress group and heat stress group supplemented with the other YCW product (Fig. 1). This positive effect of the feed additive Safmannan resulted in an improvement in broilers' daily average gain as compared to results observed for broilers supplemented with the other YCW product. The same study also showed a 100% survival rate of broilers in the Safmannan experimental treatment after 42 days under severe heat stress, which contrasts with the 4% mortality recorded when the other YCW product was used.

A high performance premium yeast fraction

Yeast cell wall products are a sustainable solution to strengthen the immune system and reduce pathogenic pressure in the gastrointestinal tract, thereby improving animal health and productivity. However, the reliability and consistency of such positive results depend on the cell wall fraction composition which, in turn, depends on the yeast strain, growth conditions, and extraction and purification process. Safmannan efficiency was higher than the generic YCW, even when used at notably lower dosages (250g/t of Safmannan as compared to 1kg/t of the other YCW product). By protecting gut integrity, reducing translocation of bacterial pathogens and limiting production of proinflammatory cytokines like IL-6, which can activate the HPA axis, Safmannan can mitigate the detrimental effects of heat stress in broilers, maintaining bird growth performance and survival under heat stress conditions. Safmannan is a unique product prepared using biotechnological processes designed to address the physiological consequences of heat stress in broilers. The batch-to-batch consistency and high concentration of active ingredients allows for a consistently superior performance.

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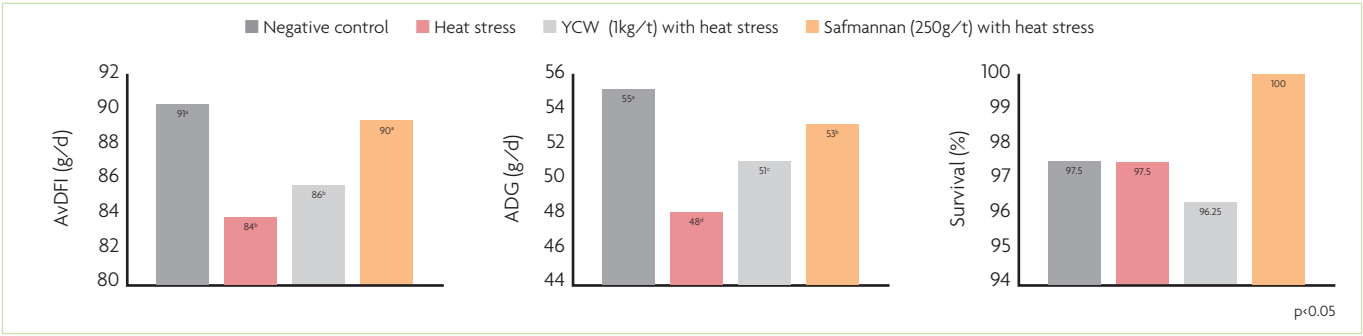
Fig. 1. Average daily feed intake (ADFI), average daily gain (ADG) and survival rate of broilers after 42 days of no heat stress (negative control, dark grey bar), heat stress (positive control, red bar), heat stress and supplemented with a generic YCW (1kg/t) (light grey bar), and under heat stress and supplemented with Safmannan (250g/t) (orange bar).



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The high economic cost of heat stress in broilers

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Heat stress causes substantial economic losses for broiler producers. In the USA, the average yearly losses associated with heat stress range from $128 to 165 million, and in China heat stress greatly contributes to the $2.7 billion in losses recorded in poultry livestock. Such a detrimental economic impact is driven by the negative physiological effects of heat stress, such as endocrine and immune disorders, decreased growth performance and increased mortality. Heat stress also has adverse consequences on meat quality. Preslaughter heat stress accelerates an onset of rigor mortis, reduces water holding ability, and increases paleness in poultry meat, all of which result in substandard products that are poorly received by consumers.

Heat stress in broiler farms

Heat stress is triggered by a combination of high temperature and relative humidity levels, as both impact the ability of the birds to regulate body temperature through heat loss. Temperature and humidity data is often used to calculate the temperature humidity index (THI), which is a valuable measure to assess when broilers are becoming heat-stressed. Modern, fast-growing poultry genotypes exhibit higher metabolic activity, which increases heat production and makes broilers highly susceptible to heat stress. This feature synergistically interacts with stocking density, as the large numbers of broilers in controlled environments favours high ambient temperatures and humidity levels, especially during summer. Lastly, the high environmental temperatures often recorded in broiler farms increase the susceptibility to heat stress conditions.

Physiological consequences of heat stress

When exposed to elevated heat conditions, broilers use several coping mechanisms. Broilers try to move away from other birds, attempt to be closer to cooler surfaces or air streams, and lift their wings away from their bodies to reduce insulation. However, when such behaviour does not provide enough relief, the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic-adrenal-medullary axis activate prompting a number of physiological adjustments to help release excess body heat, such as:

- Reduction in feed intake and growth rate. Up to 16% less feed is consumed by animals under heat stress. Heat stressed broilers also process less protein. Consequently, animals have higher fat and lower protein contents, resulting in a lower quality product.
- Increased water consumption. High water intake contributes to the loss of electrolytes, such as calcium, potassium, magnesium, sodium, and chloride, due to an increase in renal output. Such electrolyte imbalances lead to fatigue, lethargy, seizures, vomiting, diarrhoea, and bone disorders.
- Panting. Excess heat is lost as evaporated moisture from airways. As the respiratory rate increases, a decrease in blood carbon dioxide levels is triggered, resulting in an elevated blood pH, also known as respiratory alkalosis. This is particularly detrimental to laying hens since high blood pH decreases bicarbonate availability for shell mineralisation, which affects egg production performance and eggshell thickness.
- Reduced blood and nutrient flow. Preferential blood flow to the peripheral tissues results in reduced blood and nutrient flow to the internal organs leading to hypoxia in the intestinal epithelium, which compromises intestinal integrity and causing the so-called 'leaky gut syndrome'.
- Secretion of corticosterone into the bloodstream. This has many effects in broilers, many of which are not beneficial to their performance:
  - Inhibition of protein synthesis.
  - Reduction in the number of circulating antibodies and lymphocytes.
  - Increase the formation of free radicals.
  - Decrease in the secretion of thyroid hormones T3 and T4.

All these physiological adjustments ultimately lead to a reduced zootechnical performance driven by a lower feed intake, increased FCR, and reduced growth.

Addressing heat stress

One obvious solution to prevent heat stress is the artificial control of high temperatures through improved insulation, house design, and ventilation. There are also biological solutions available on the market for addressing heat stress in broilers, such as feed supplementation with a selected yeast fraction developed by Phileo by Lesaffre. Safmannan is a nutritional and health approach that normalises the HPA axis. As a consequence, broilers raised under heat stress conditions and supplemented with this premium yeast-based product are able to counterbalance the increase in body temperature and improve specific growth rate as compared with birds with no supplementation. Ultimately, this selected yeast fraction reverses the negative physiological consequences of heat stress in broilers and potentiates zootechnical performance. It was shown that birds exposed to heat stress have better zootechnical performances and lower corticosterone concentrations when they are receiving the selected yeast fraction. In a trial carried out in Mexico in 2016 in INDEPESA Experimental Farm, birds were challenged with an extremely high variation of temperature: maximum temperature above 41°C/105°F and minimum temperature of 6°C/42.8°F. At 42 days, the feed conversion was reduced by around 70g of feed per kilogram of body weight, when the birds were supplemented with Safmannan. Especially during high heat stress, cumulative mortality rate was reduced by 38% with the Safmannan supplementation. Under heat stress conditions, selected yeast fraction helps to reduce the impact of heat stress by supporting the immune system, controlling inflammation and maintaining gut integrity in order to absorb sufficient nutrients for bird growth. Thus, this selected yeast fraction is an important component of a global heat stress mitigation program.

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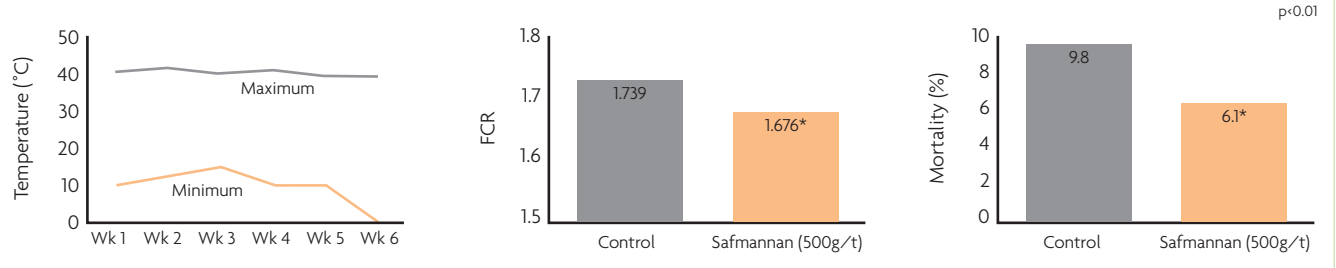
Fig. 1. Left, average minimum and maximum temperature; centre, feed conversion ratio; and right, cumulative mortality at day 42.



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Selected yeast fraction brings consistent heat stress management benefits

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The use of Safmannan to reduce the impact of heat stress on poultry has been studied and trialled extensively over the last decade, testing the effectiveness of the yeast-based supplement across a wide range of production systems and conditions.

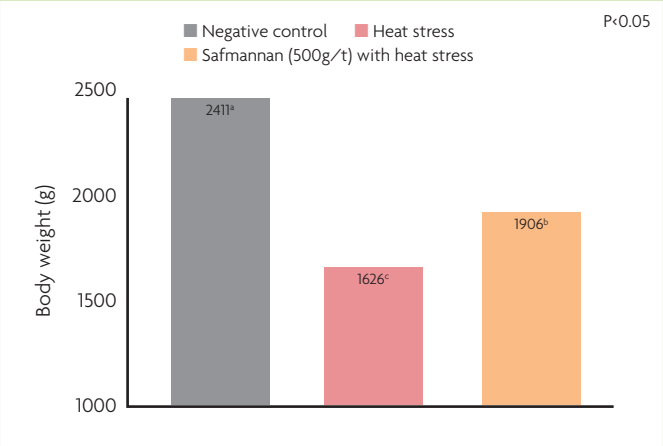
Weight gain benefit

In 2012, Sohail et al. evaluated the effect of Safmannan supplementation on the performance of one-day-old broilers which were subjected to chronic heat stress. Based on three groups (control, heat stress and Safmannan + heat stress), the trial featured broilers kept in floor pens on fresh wood-shavings in environmentally controlled houses. The day one temperature for all three groups was set at 35±2°C, with the heat stress and Safmannan groups staying at the level through to day 42. The control group temperature, meanwhile, decreased by 3°C a week until it reached 26±2°C. All broilers were given a corn-soybean diet, with the Safmannan group receiving an additional 500g/t of Safmannan. Growth performance, measured across the three groups, showed the heat stress birds with 15.4% less body weight gain than the control at day 21 and 32.6% less at day 42. The Safmannan broilers, however, achieved a significant body weight gain over the heat stress group, being 8.1% better on day 21 and 17.2% better on day 42 (Fig. 1). They also achieved the same day 42 FCR as the control birds. Comparing serum corticosterone levels, which are considered an indicator of heat stress, reinforced the study conclusion that Safmannan helps reduce the detrimental effects of chronic heat stress.

Enhanced thyroid hormone levels

Working in Mexico in 2015, Arce et al. examined how different dosages of Safmannan modified the serum thyroid hormone levels of male broilers when kept at 35°C from day 1 to day 42. Split into three groups (control, Safmannan at 250g/t and Safmannan at 500g/t) the trial showed Safmannan delivering better broiler performance, alongside decreased TSH and increased thyroid hormone levels. It was also found that, when faced with only moderate heat stress, the Safmannan dose could be adjusted between 250 and 500g/t, depending on other factors of stress and the life-stage of the birds concerned.

Fig. 1. Body weight of broilers at day 42. Trial carried out by Sohail et al., 2012 during which Ross 708 birds were exposed to severe heat stress (THI at 33 at day 42).



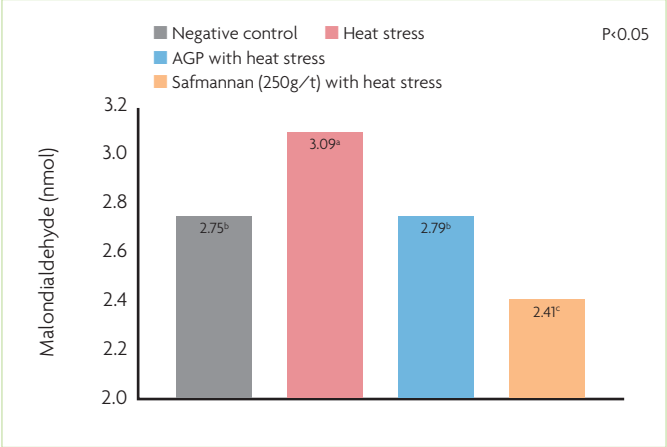


Fig. 2. Lipid peroxidation level of broilers at day 42. Trial carried out in India during which Cobb 400 birds were exposed to severe heat stress (THI at 33 at day42).

Oxidative stress management

Evidence that heat stress can cause a severe oxidative imbalance in poultry, affecting bird health and end product quality, prompted a 42-day trial in India which was designed to measure oxidative stress parameters in the blood. Based on four broiler groups (negative control and three different heat stress conditions), it was found that the group given a Safmannan supplement achieved boosted levels of antioxidant enzymes and glutathione peroxidase. This increased the birds' antioxidant power and reduced their lipid peroxidation (Fig. 2).

Immunity benefits

Core findings from the same India trial, based on birds kept under natural chronic heat stress, with a moderate stocking density (13.2 birds/m^2), clearly demonstrated the beneficial effect of Safmannan on immunity in heat-stressed birds. Results drawn from four groups of birds (negative control, heat stress, AGP and Safmannan) indicated that Safmannan stimulates both cell-mediated and humoral immune responses. This improved the immune function of the birds concerned.

Performance improvement

Birds kept under mild heat stress conditions were featured in a 2016 French trial carried out by Gabarrou et al. Divided into four groups (control and three different doses of Safmannan; 125g/t, 250g/t and 500g/t), the birds were exposed to two different temperature rooms (control and a daytime peak temperature of 28°C). The 28°C room comparisons showed that Safmannan, given at between 250 and 500g/t in the feed, positively influenced broiler performance.

Mortality rate reduction

Turning to Brazil in 2017, UFMG Veterinary School decided to evaluate the effect of Safmannan on broiler performance under severe heat stress conditions. Working with Cobb broilers, split into two groups (control heat stress and heat stress with Safmannan), it was found that birds fed Safmannan at 250g/t had lower FCR ($p<0.05$) and mortality (numerically) than the control group. Similar mortality rate reduction was also identified during a 2016 trial in Mexico. Located at INDEPESA Experimental Farm and run by Arce et al., this trial challenged birds with an extremely high variation of temperatures, from 41°C+ to a minimum of 6°C. Trial results showed cumulative mortality rates being reduced by 38% in birds given Safmannan supplementation.

Safmannan shows better performance than commercial YCW

Finally, a 2017 study carried out in China by the College of Animal Science and Technology, Nanjing Agricultural University, compared Safmannan and a commercial yeast cell wall product (YCW) in terms of their relative impact on zootechnical performance in broilers under severe heat stress. Working with male Arbor Acres broilers, split into four groups (control, heat stress, Safmannan and YCW), the birds were exposed to 32-33°C for the first three days, reducing by 2-3°C per week to a final temperature of 20°C.

Safmannan was added to the broilers' feed at 250g/t, while YCW was fed at its recommended dosage of 1kg/t. Trial results showed both feed intake and daily gain for the Safmannan group being significantly higher than either the control group or the YCW group.

In the same study, birds under severe heat stress also had lower body temperatures in the Safmannan group than either the control or YCW groups, with survival at day 42 being 100% in the Safmannan group, compared with nearly 4% mortality in the YCW group.

The core conclusion, based on all available study and trial evidence, is that Safmannan, fed as a dietary supplement in the face of even the most severe temperature challenge, is capable of positively preventing heat stress in poultry. Data also shows that Safmannan reduces the impact of heat stress more effectively than other yeast cell wall products which, according to Phileo by Lesaffre, makes it a 'must use' item in heat stress prevention programs across the world.

References are available on request
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Fig. 3. Studies have been carried out in different areas in the world to evaluate the effects of Safmannan. Data shows that Safmannan can bring consistent benefits to poultry under heat stress conditions.