Reinforcing the gut wall integrity of chicks thanks to algae

In poultry production, the first seven days of life (particularly the first 36 hours) are very important to ensure the future performance of the flock. During the first week of age, the small-intestinal weight relative to total body weight increases rapidly from about 2.5% at hatch to about 7% one week after hatch.

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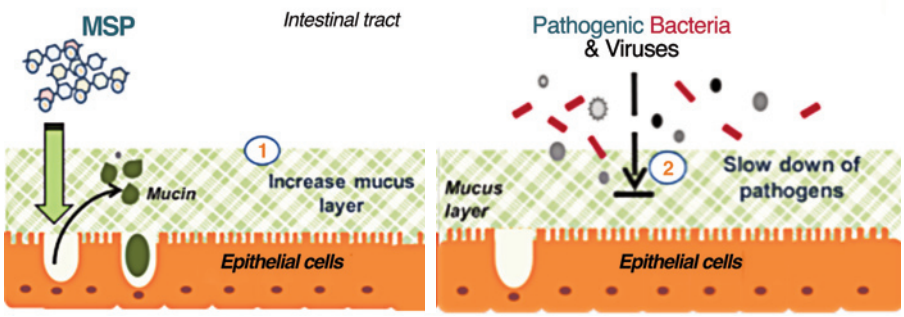

Fig. 2. Action of MSPmucin on the intestinal epithelial barrier function. Left, restorative action and, right, protective action.

The development of the small intestine consistently deteriorates at low feed intake levels and with suboptimal protein nutrition. This may compromise the intestinal barrier function. This often appears in the first hours of life due to a long time in the incubator after hatch, and subsequent long transportation time to the farm.

Hence, the desired development of the intestine and more specifically its barrier function (against aggressions: toxins and pathogens) in chicks after hatch may not be obtained. It may affect early survival rate due to digestive troubles and overall performance.

Importance of mucus layer

The intestinal mucus gel, mainly composed of mucin (glycoproteins), secreted by goblet cells is one of the first lines of defence against external aggressions. Mucus forms a protective layer across a variety of epithelial surfaces. In the gastrointestinal tract, the mucus barrier should permit the uptake of nutrients, while excluding potential hazards.

Consequently, it serves many functions: such as lubrication, maintenance of a hydrated layer over the epithelium and permeable gel layer for the exchange of nutrients.

A lot of studies showed that mucins can reduce the translocation of some microbes. Gut pathogens must pass through this mucous layer before adherence to and invasion of the epithelial cell. Reducing mucin production can allow a rapid translocation of S. typhimurium through other organs as Peyer's patches, spleen and liver.

The biosynthesis and secretion of mucins can be influenced by immediate or delayed access to feed, but also by specific inducing components. Thus, improving the mucosal barrier function, via increased mucus secretion, is a new strategy to keep gut integrity and animals healthier, while potentially decreasing additional antibiotic use.

A source of biological treasures

Macroalgae, or seaweeds, are eukaryotic and pluricellular organisms, divided into three different groups: green, red and brown.

Recent detailed screening of macroalgae functions revealed new ranges of biological activities including anticoagulant, antiviral and antibacterial, anti-tumoral, anti-proliferative and immuno-modulatory activities. Indeed, green, brown and red macroalgae cell walls contain large amounts of sulphated polysaccharides, named respectively ulvans, fucoidans and

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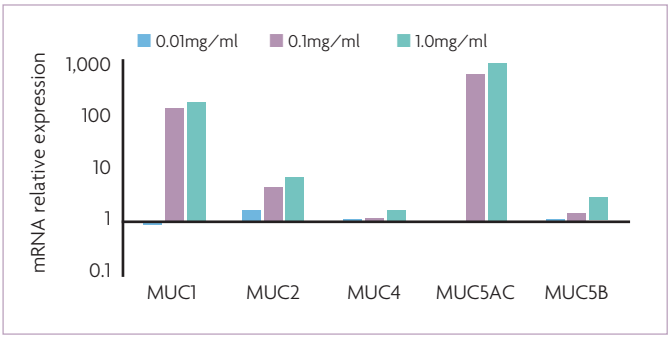
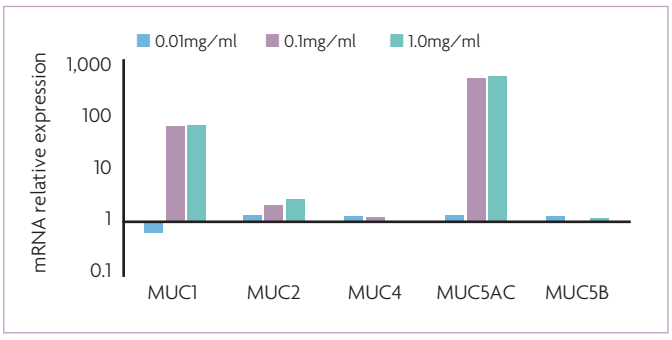
Fig. 1. Mucin gene expression under MSPmucin stimulation in Caco2 cells (left) and HTX29 (right).





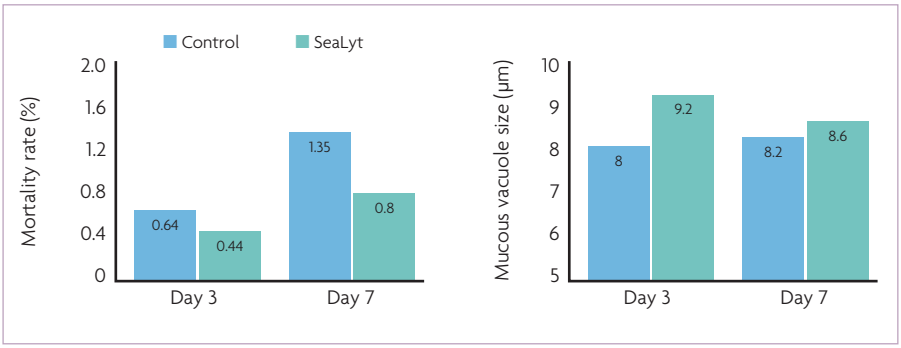


Fig. 3. Left, mortality rate (%) and, right, mucous vacuole size (mm) at day thee and seven.

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carrageenans, ranging from 4% up to 76% of seaweed dry weight.

The high content of these sulphated polysaccharides, their unusual structure, and their biological properties shed a new light on these compounds as promising natural products for medicinal and dietary applications. The specificity of seaweed sulphated polysaccharides stands in the complexity of their structure. Indeed, they are branched polysaccharides, in contrast with linear polysaccharides like cellulose which contain only one type of linkage between sugars.

Also, they are composed of various and some rare sugar units (xylose, rhamnose), unlike homo-polysaccharides like starch, which are exclusively composed of glucose units. Finally, these sugars can be sulphated, conferring them a special reactivity. The whole of these parameters show a phylogenic similarity with polysaccharides from the animal kingdom such as heparin, known for its numerous biological properties, thus explaining their unique activities.

Their reactivity, hence their biological properties, varies a lot according to the type of sugars and linkage they contain, their level of sulphation and also their molecular weight. Therefore, several ones with distinct biological activities can be found in algae. Their specific extraction is key to ensuring a targeted effect on animals.

As specialist of the macroalgae biorefinery, Olmix has isolated a specific sulphated polysaccharide (MSP_{MUCIN}) with mucin secretion promoting properties.

The intestinal mucus layer

In 2000, Barcelo et al showed that an algae extract from Ulva sp. could stimulate the excretion of mucin proteins from colonic goblet cells, making it interesting for use against various intestinal diseases.

In a recent study, conducted in partnership with IBD (Intestinal Biotech Development, in France), Olmix could also demonstrate that MSP_{MUCIN} could reinforce the intestinal barrier by modulating the expression of mucin at the mRNA level.

For this in vitro study, two colonic epithelial cell lines were used, the enterocyte-like Caco2 cells and the mucus-secreting HT-29 MTX cells. The MSP_{MUCIN} was tested in triplicate by addition in these cell cultures for one hour or four hours, at three concentrations (0.01, 0.1 and 1.0mg/ml), in standard conditions.

The gene expression of several mucins (MUC1, MUC2, MUC4, MUC5AB and MUC5AC) was evaluated by mRNA quantification by qRT-PCR.

MSP_{MUCIN} proved its capacity to induce the expression of both membrane-bound mucins (MUC1) involved in cell-cell and cell-matrix interactions, as well as cell-signalling; and gel-forming mucins (MUC5AC and MUC2), which are particularly involved in host-protection and control of pathogen dissemination, in both standard and inflammatory conditions (Results at 4H- Fig 1). In consequence, the MSP_{MUCIN} induces mucin secretion, improving protection of the gut wall (Fig. 2) and limiting digestive troubles.

Application to poultry breeding

These scientific findings, explaining the mode of action of MSP_{MUCIN}, are in line with in vivo poultry results obtained with a commercial product (SeaLyt) mainly composed of MSP_{MUCIN}.

One of the trials was performed on 28,000 day old chicks (Ross 308) distributed in two identical separated rooms within the same building.

The control group received the standard prophylaxis of the farm (vitamin A, D3 and E complex during the first seven days of life and the test group received SeaLyt, in the drinking water, during the first 48 hours after the setting-up of the chicks at the farm.

The mortality was recorded daily during the first seven days. Ten broilers in each group were used for intestinal histological evaluation. Three ileal sections per broiler were collected at day three and day seven and goblet cells were identified by staining slides with periodic acid-Schiff (PAS) reagent.

Sections were examined by light microscopy (50×) to determine the number of goblet cells and the size of the mucous vacuoles contained inside the goblet cells.

The use of SeaLyt triggers a decrease in mortality rate during the first week (-40%, $P<0.05$, Fig. 3). In terms of goblet cell numbers, there was no difference between the control and SeaLyt group.

However, the average size of the mucus vacuoles present in the goblet cells was larger within the SeaLyt group (+13%, $P<0.05$), particularly at day three (Figs. 3 & 4).

Conclusion

Poultry integrators and all supporting professions are continually seeking to increase the performance of farms, with a new constraint in the game, that is to limit the use of antibiotics.

Olmix has recently developed new 100% natural solutions based on specific macroalgal sulphated polysaccharides, more particularly with MSP_{MUCIN}, able to promote gut integrity through higher production of mucins, the main components of the intestinal mucous layer.

In the field, the use of SeaLyt in the chicks' drinking water at the start allows rehydration and reduces digestive troubles leading to higher survival rates.

Based on MSP_{MUCIN}, it quickly metabolises energy (sugars) and electrolytes (impact on rehydration) and stimulates feed intake.

SeaLyt also contributes to better litter quality and naturally contributes to the well-being of broilers during brooding. ■

References are available from the author on request

Fig. 4. Ileal villi, crypts and goblet cells (dark points) at day 7 (x50). Left, the control group and, right, the SeaLyt group.