Using algae to help the digestive performance of laying hens

Algae are being increasingly explored for their nutritional, structural and biological properties. For 20 years, Olmix has developed marine biotechnology for animal care, specialising in the identification, characterisation and extraction of specific Marine Sulphated Polysaccharides (MSP) from green, red and brown algae.

Among them, a type of MSP with anti-hyperlipidemic properties was identified and is being used in poultry production for its capacity to stimulate digestion, thanks to its action on the bile acid cycle and lipid metabolism.

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Macroalgae, or seaweeds, are eukaryotic and pluricellular organisms. They contain a variable part of carbohydrates (mainly polysaccharides), proteins, minerals, lipids and vitamins.

The specificity of MSP stands in the complexity of their structure (Fig. 1). Indeed, MSP are branched hetero-polysaccharides, meaning that they have 3D structure and are composed of various sugar units (including rare ones like rhamnose).

Moreover, these sugars can be sulphated, conferring them a special reactivity. All these parameters show a phylogenetic similarity with polysaccharides from the animal kingdom (such as heparin), explaining the unique biological activities of MSP. 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 MSP with distinct biological activities can be found in algae.

Biological activities of MSP

The different biological activities of MSP (among others immune-modulating, antioxidant and intestinal mucin production stimulating) have been studied in recent years.

Current scientific publications have shown that some MSP have a direct impact on liver function. These new MSP have anti-hyperlipidemic properties which regulate the cycle of bile acids and the lipid metabolism.

Bile acid and lipid metabolism in the liver and the intestine rely on complex biochemical signalling pathways, being the activation of a specific nuclear receptor, the Farnesoid X Receptor (FXR), the initial point of these metabolic pathways. Present both in hepatocytes and enterocytes, the FXR upregulates and/or downregulates the activity of several enzymes and the expression of several genes in the liver that lead to the synthesis of specific molecules involved in the bile acid metabolism.

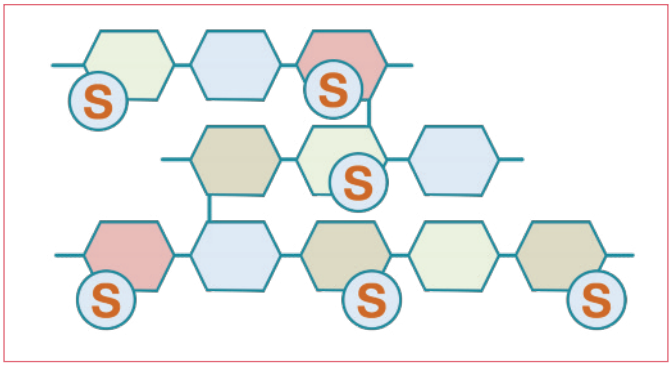

Fig. 1. Marine sulphated polysaccharide (MSP) structure.

Excretion of bile acids

The main effect of FXRs in the liver is to favour the excretion of bile acids from the liver to the bile duct.

The bile acids are further transported to the intestine, where they play a key role in the digestion of fat, by forming micelles with dietary lipids, thus making possible the digestion of fat by lipase.

The absorption of bile acids in the ileum relies on specific transporters, whose synthesis is also downregulated by the FXR to prevent any liver injury caused by an overload of bile acids.

As a consequence, the reabsorption of bile acids in the intestine is limited and the excretion of bile acids in the faeces is enhanced.

From its action in the liver, the FXR also decreases the synthesis of PreVLDL (very low density lipoproteins), a precursor of cholesterol transporters, and increases its passage into the blood in the form of VLDL. In the blood, the transformation of VLDL to LDL (low density lipoproteins) and then HDL (high density lipoproteins) is favoured.

Contrary to LDL, HDL bring back cholesterol from peripheral organs to the liver, and so the cholesterol they transport is more easily detoxified via the bile acids cycle.

The capacity of algal polysaccharides to improve liver metabolism

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Fig. 2. Effect of various green algae MSP: ulvan extracts (UE) on inhibiting pathological changes in the liver, in comparison with negative control and positive control (inositol niacinate). Scoring: mild = 1, moderate = 2, severe = 3. Different alphabets are significantly different ($p<0.05$ by one-way ANOVA). Adapted from Pengzhan et al., 2003.

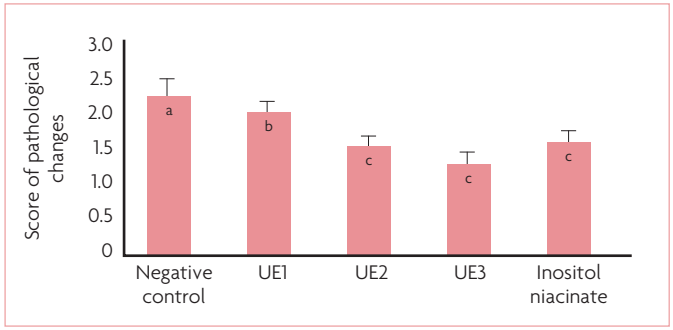
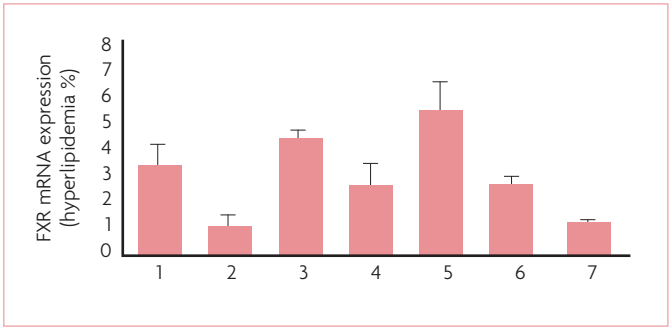


Fig. 3. Effect of different ulvan extracts (UE) on FXR mRNA expression in the livers of male rats. 1: normal control group; 2: hyperlipidemia group; 3: UE1 (250mg/kg); 4: UE2 (125mg/kg); 5: UE2 (250mg/kg); 6: UE2 (500mg/kg); 7: positive control (cholestyramine, 500 mg/kg). Adapted from Qi et al., 2015.



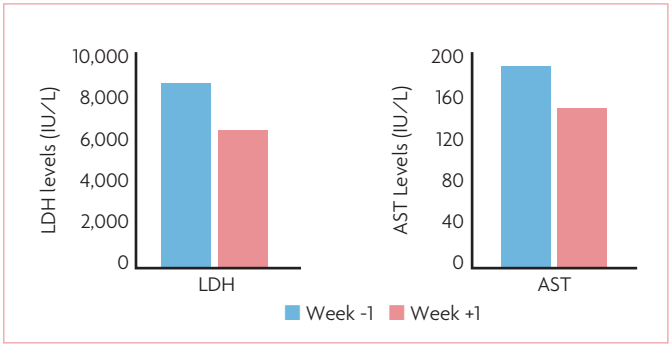


Fig. 4. LDH and AST serum levels before and after DigestSea administration (IU/L).

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was first evidenced by Pengzhan et al. (2003), who highlighted the capacity of ulvans (sulphated polysaccharides from green algae Ulva sp) to lower the level of liver pathologies of rats (Fig. 2), while decreasing their levels of triglycerides (TG), total cholesterol (TC) and LDL-cholesterol and increasing the excretion of bile acids in the faeces.

Anti-hyperlipidemic

Qi et al. (2011, 2012) also highlighted the anti-hyperlipidemic properties of ulvans by monitoring the lipid profile of the animals. While the positive control group (fed a hyperlipidemic diet) had higher TG, TC and LDL than the negative control (fed a normal diet), and a lower HDL level, the supplementation with ulvans highly significantly decreased TG, TC and LDL levels, while increasing HDL levels.

In 2015, Qi et al. further demonstrated that the regulation of lipid metabolism by ulvans could be linked with an up-regulation of the FXR by the algae extract, also pointing out that all ulvans do not have the same capacity to regulate hyperlipidemia (Fig. 3).

Hassan et al. (2011) also demonstrated an improvement of lipid profile (Atherogenic index, measuring a ratio between TG and HDL-cholesterol) in rats supplemented with Ulva lactuca polysaccharides.

The stressed mode of action was rather linked with a better antioxidant capacity in the liver, via the increased activity of hepatic enzymes such as catalase, glutathione peroxidase and superoxide dismutase, which are free radicals scavenging enzymes.

In the end, it seems that ulvans have a great potential to regulate lipid metabolism and bile acids cycle by activating FXR on one hand, which accelerates the bile acids cycle and by activating detoxifying enzymes on the other hand, which eliminate free radicals.

Based on this, Olmix has worked on the extraction of a specific MSP with enhanced anti-hyperlipidemic properties: the MSPANTI-HYPERLIPIDEMIC, which is the backbone of the Olmix feed complement DigestSea.

DigestSea is formulated to stimulate the liver, thanks to the above mentioned mechanism, and also contains plant extracts that support kidney activity and draining.

With its unique composition, DigestSea has a positive effect on the digestion process and can be used effectively in layer production to prevent the occurrence of liver troubles, or a decrease in feed intake and egg production during high metabolic periods.

Tested in France, on 90,000 laying hens of 50 weeks of age, DigestSea showed a positive effect on liver function. Laying hens were administered DigestSea in the drinking water for five days, at the dose of 0.3L/1000L of drinking water.

Blood samples were taken just before the supplementation started and one week after the supplementation finished. Serum aspartate aminotransferase (AST) and lactate dehydrogenase (LDH) levels were measured, as markers of liver status and fatty liver syndrome risk.

Results showed that both enzymes levels were decreased, by 22-26% (Fig. 4), reflecting a lower risk of liver troubles for the laying hens. The continued monthly use of DigestSea (five day periods at 0.3ml/L of drinking water) in this farm after the trial confirmed the capacity of the product to improve digestive performance of the laying hens and to prevent liver troubles, as shown by the globally increased laying performance of the hens and productivity of the farm.

Conclusion

The use of algae specific extracts, namely MSPANTI-HYPERLIPIDEMIC, seems to be an efficient strategy to stimulate digestive performance of laying hens thanks to its action on the enterohepatic cycle of bile acids as well as detoxifying enzymes. ■

References are available from the author on request