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# Influence of blue mussel (*Mytilus edulis*) and starfish (*Asterias rubens*) meals on production performance, egg quality and apparent total tract digestibility of nutrients of laying hens

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ABSTRACT

The aim of the study was to evaluate mussel meal and starfish meals as protein sources for organic layers by studying the effect on production performance, nutrient digestibility and egg quality. A total of 300 Hisex white laying hens (20-week old) were distributed randomly to 6 dietary treatment groups, each with five replicates, including a control diet providing fish meal, 3 diets providing mussel meal (4, 8 and 12 g/100 g) and 2 diets providing starfish meal (4 and 8 g/100 g). Laying rate, egg mass, feed conversion ratio, mortality and live weight of the hens did not differ among treatments. The egg weight was not different from the egg weights of control diets, but the inclusion of 4 g mussel meal resulted in a lower ($P < 0.05$) egg weight than 8 g and 12 g mussel meal per 100 g feed. The egg shell strength was not affected by any of the diets. The egg yolk colour was lower ($P < 0.05$) in lightness (L*) and higher ($P < 0.05$) in redness (a*) for each increase in mussel meal concentration, but was not affected by starfish meal. The albumen dry matter content was not significantly different among diets, whereas the albumen gel fracture stress was lower ($P < 0.05$) in eggs from hens fed 4 g mussel meal/100 g diet compared to the starfish diets. Eggs from hens fed 12 g mussel meal/100 g diet showed a fishy smell in the sensory evaluations. The retention of nitrogen was significantly higher in hens receiving 12 g mussel meal and 8 g starfish meal than in control hens ($P < 0.05$). Increasing the dietary mussel meal concentrations increased the total tract nitrogen corrected apparent metabolisable energy (AMEn) ($P < 0.001$). Diets with 8 g and 12 g mussel meal/100 g diet showed the highest apparent metabolisable energy, whereas the lowest was observed in diets providing 4 and 8 g starfish meals/100 g. The apparent total tract amino acid digestibility was higher ($P < 0.05$) in the diets with 8 and 12 g mussel meal and 4 g starfish meal compared with the control diet. Compared to the control diet, the apparent digestibility of methionine was higher ($P < 0.05$) in hens fed with 8 and 12 g mussel meal, and the apparent digestibility of lysine was higher in hens fed 4, 8 and 12 g mussel meal and 4 g starfish meal/100 g diet. Fat digestibility was higher ($P < 0.05$) in diets with 4, 8 and 12 g mussel meal compared with the control diet. In conclusion, up

*Abbreviations:* AMEn, nitrogen corrected apparent metabolisable energy; DC, digestibility coefficient; DM, dry matter; GLM, general linear model; SEM, standard error mean.

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to 8 g mussel meal and starfish meal per 100 g feed can be used in diets as a high quality protein source for egg production. These meals can replace fish meal; however, an inclusion level higher than 8 g/100 g of mussel or starfish meal may result in a fishy smell of the eggs.


## 1. Introduction

It is prohibited to use crystalline amino acids in diets for organic layers (EC, 2007). Therefore, the requirement of hens for essential amino acids, especially sulphur containing amino acids, has to be covered by the available feed ingredients. Deficient dietary methionine has a negative effect on poultry welfare by increasing the risk of feather pecking and cannibalism in floor rearing systems (Tiller, 2001). Furthermore, methionine deficiency can lead to poor feather quality which results in increased feed intake and reduced egg weight (Elwinger et al., 2008). Since 2005, the transition to use 100% organic feed ingredients in organic poultry production has been discussed intensively within the European Union, and the date for implementing this has been postponed until 1 January 2018 (EC, 2014).

Approved organic high quality protein sources are limited in European countries, since only a few countries grow soya beans which have a good amino acid profile for poultry (Van Krimpen et al., 2013). Most soya beans are imported from overseas countries, not complying with the idea of organic production based on local feedstuffs. Today, it is allowed to use conventional ingredients such as potato protein concentrate and corn gluten meal at levels of maximum 5% in organic poultry diets to ensure that especially the methionine requirement of the birds is covered. With the introduction of 100% organic diets by 1 January 2018, potato protein concentrate and corn gluten meal will most likely be phased out, since an organic production of these ingredients will be limited and very expensive. Fish meal is rich in sulphur amino acids and is today used in organic poultry diets. However, the sustainability of using fish meal in animal feeds may be questioned, and increasing market prices may limit the availability of fish meal in the future. If the organic poultry production is going to use diets based on 100% organically produced ingredients, it is necessary to find new high value protein sources rich in methionine (Elwinger et al., 2008).

Blue mussel (*Mytilus edulis*) cultivation as a marine nutrient mitigating tool has emerged during recent years (Lindahl and Kollberg, 2009; Petersen et al., 2014). Off-bottom cultivation with long-line production of blue mussels can be used to recycle nitrogen and phosphorus surplus from the surrounding land and thereby improve the water environment. Furthermore, the blue mussels contain carotenoids and chlorophyll as they are filter feeders and consume algae (Matsuno, 1989). The xanthophylls, which are oxy-carotenoids, are known to be efficient egg yolk pigmenters (Hammershøj et al., 2010); hence, the inclusion of mussel meal in a layer diet is hypothesised to potentially affect the egg yolk colour.

The common starfish (*Asteria rubens*) is a predator which has been a major problem for mussel fishermen in the fjords for many years. Starfish was considered a good source of protein and amino acids for poultry more than 50 years ago (Levin et al., 1960).

The aim of the study was to evaluate mussel meal and starfish meal in different dietary concentrations as protein sources in organic layer diets taking hen production performance, nutrient digestibility and egg quality into consideration.

## 2. Materials and methods

### 2.1. Hens, housing and experimental design

A total of 300 Hisex white pullets, 17 weeks of age, were allocated at random to 6 diets in 30 floor pens, i.e., 5 replicates per treatment. The 30 floor pens were divided in 5 blocks of 6 pens and each treatment was allocated randomly in each block. The floor pens were located in a poultry house equipped with automatic ventilation and controlled temperature and light. Each replicate pen contained 10 hens, and the floor area (4 $m^2$) was equipped with 4 single nest boxes, 1 feed silo and a tape with nipple drinkers. To prevent visual contact between hens from separate pens, the pens were separated by 2 m high wooden walls from the floor up to 1.6 m and with wire mesh. According to legislation (Danish Ministry of Justice, 1998: No. 210 of 6/4-1998) for organic egg production, the hens were not beak-trimmed. The lighting programme included 12 h of light and 12 h of darkness at 17 weeks of age. The day length was increased gradually to 16 h of light and 8 h of darkness at 19 weeks which continued to the end of the experiment. The experiment started when the hens were 20 weeks old and lasted 12 weeks.

### 2.2. Diets, ingredients and feeding

Mussels from off-bottom cultivation with long-line production were harvested at an age of approx. 9 months from Skive Fjord (Denmark) in March 2013 and were de-shelled by boiling (Vildsund Blue, Nykøbing Mors, Denmark) where after the meat was frozen. Frozen mussel meat was loaded into a drum dryer for defrosting and heated so that the mussel meat reached a temperature over 85 °C for at least 1 h. The dried meat was cooled to room temperature and then ground into meal by using a high speed rotating grain mill with a mesh size of 2.5 mm. Starfish were caught in the same fjord in May 2013,