FutureFoods

Collaborate to Succeed | Cydweithio i Lwyddo

ALGAE

Natalie Rouse

20th January 2020

Algae in agriculture

Following from the series of articles from Dr. Molly Price-Jones, investigating seaweed as a component of a healthy diet and its applications in the food industry. This third article investigates the role of seaweed and algae in agricultural use as a potential alternative to conventional livestock feed.

Algae use in Agriculture

This is an exciting area of development where algae and its array of nutritional compounds can be potentially utilised as an environmentally sustainable valuable feed source. The use of algae can reduce the need of importing soya for animal feed from across the globe, reducing environmental damage, deforestation and food miles (Taelman et al 2015).

Algae and seaweed are cultivated worldwide for the food industry, health markets and within agriculture. Algae can produce clean and carbon-neutral food sources, whilst able to be grown on large- and small-scale production sites including hostile environments, disused land space and with minimal demand on fresh water supplies (Abdel-Raouf et al 2012). Furthermore, algae are diverse microorganisms that capture energy from sunlight via photosynthesis, similarly to land plants but unlike land plants proliferate by 100% every 24 hours should the conditions be optimal making production fast and efficient (Khan et al 2018).

Algae can play an important role in agriculture as water cleaning system, as fertiliser and as a feed stock. Particularly seaweeds, that when are used as fertilisers create much lesser eutrophication and chemical runoff that that of traditional fertilisers; by reducing eutrophication water quality can be improved and its ecosystem left to thrive (Boyd 2020).

Microalgae can result in added value functional foods

Microalgae have the potential to produce high-value products and there is a great interest and research within this area to meet the increasing demands of a growing population whilst becoming more environmentally sustainable. Most biomolecules within algae are not produced by animals but are considered essential nutrients for both animal and human health.
Spirulina specifically, has been viewed as the algae species of preference as a human food/supplement and livestock feed (Wuang et al 2016). This is due to its impressive nutrient profile containing; B vitamins, minerals, proteins, essential fatty acids and anti-oxidants such as beta-carotene, vitamin E. Algae species such as chlorella, nori and spirulina were speculated to be a potential source of plant derived B12 for human use, but this has subsequently been dismissed (Kumar et al 2010). The small amount of B12 thought to be contained in the algae has been found to not be that of B12 analogues and not the 'real thing'. This is a disappointing view from a human perspective as B12 analogues inhibit the uptake of B12 as they bind to the receptors. However, as ruminates produce B12 from the microflora within their rumen they do not require B12 from their diet. Therefore, the absence of such is not a hindering factor. Ruminants do need cobalt to ensure B12 can be made in the rumen and this is abundant in algae (Allen 2010)
The utilisation of specific nutrients from algae and seaweed can be capitalised on. Here, iodine, a commonly deficient essential nutrient in the human diet is abundant in seaweeds and algae. The transfer of iodine is observed when feeding dairy cattle seaweed, that increases the content of iodine in milk (Lopez et al 2016).

Feeding dairy cows' lipid-encapsulated algae supplements may increase omega-3 fatty acid content in milk fat without adversely affecting milk fat yield. However, algae is not advised as an exclusive feed stock, but use as an additive/supplement has shown to be effective (Yaakob et al 2014). Algae supplementation making up approx. 10 g kg-1 of dry matter intake proved to be effective in modifying the milk fatty acid composition toward increasing conjugated linolenic acid (CLA) and Docosahexaenoic (DHA) concentrations (Angulo et al 2012). As the health enhancing fatty acids increased the overall fat content was decreased, this change of profile can be viewed as a great functional food with great added value for health markets.

Compared to other microorganisms, algae varieties can be cultivated in highly salted waters and alkaline conditions which give an advantage to function as a livestock feed as the salt is seen as being highly palatable. An Australian study using sheep demonstrated that the use of algae specifically Spirulina 'Arthrospira platensis' as a feed stock enhanced the growth, live weight, growth and body conformation significantly compared to those not fed the algae (Ali et al 2014).

Seaweed and methane
Great excitement has been associated with brown and red seaweed in the reduction of methane produced by ruminants, specifically bovine species when supplemented in feed (Machado et al 2014). Feeding seaweed to cows could significantly

reduce the amount of greenhouse gas emissions, thus in turn reducing the negative environmental pressures associated with livestock farming. The seaweed varieties researched to date have shown to reduce methane output from 60 to 99% (Molina-Alcaide et al 2017). The seaweed accessed from the UK shoreline can potentially providing a locally grown alternative that is high in protein improve livestock sustainability and environmentally viable

Poultry feed

There are more chickens in the world than any other bird with an estimated 50 billion chickens reared annually as a source of food, for both their meat and eggs (Miele 2019). Nutritional studies have demonstrated that algae contain proteins that are of higher quality compared to vegetable proteins (Kovač et al 2013).
The role of algae (specifically Porphyridium sp.) as a feed supplement showed positive changes in the overall metabolism of the chicken, resulting in a positive change to the nutrient profile of the meat and eggs produced (Bou et al 2009). It was found that the total cholesterol content in the egg yolk was reduced by approx. 10% and changes to the colour of egg yolk became darker indicating the increased production of carotenoids (Park et al 2015).
In poultry, algae ratios making up to 5-10% of daily feed have been speculated to be used safely as partial replacement for conventional proteins, but prolonged feeding of algae at higher concentration may cause adverse effects. This is due to the major component of the microalgae being polysaccharides whose cell wall-bound proteins are hard to digest (Bleakley and Hayes 2017). This was also the case in monogastric studies (Madeira et al 2017). Therefore, at present ruminants are expected to gain the greatest benefit from microalgae and its nutrient profile.

Fish foods

Demands on fish stocks have risen due to global demands for protein and the associated health attributes of marine food sources but as a consequence environmental concerns of over fishing and depleting fish stocks have escalated (Stafford 2019). Microalgae represent the primary food source for cultivated marine animals at specific lifestages of development in the life cycle. Therefore, algae biomass is expected to be in high demand for fish-feed stocks and aquaculture in the future and provide ample revenues for the algae industry (Hinz et al 2019).
A challenge in fish farming (along with all areas of livestock farming) is to generate value added products containing high levels of the health benefiting nutrients. Within fish farming the consumer demand for omega-3 fatty acid enriched food continues to grow as the benefits and research into omega 3 increases to produced positive associated to human health (Tocher et al 2019). Omega-3 oils have a high market value in both the human nutrition. The omega-3 market was valued at 2.2bn in 2018 and expected to increase by 14.9 % during the forecast period until 2025 as a human and animal food source (Allied Market Research 2020)
Algae meal is a rich source of high-quality protein, vitamins, micronutrients and carotenoids, which can be used directly in aquatics and fish feeds and transferred onto am enhanced nutrient-rich end product (Kandathil Radhakrishnan et al 2020). Research into tilapia fed on algae reported significantly better growth weight and protein efficiency ratios, this is encouraging when it is estimated that 85% of global fish stocks are overexploited, depleted or endangered, while demand for fish protein is exploding (Hilborn and Hilborn 2019)

Summary

Microalgae maybe the most under exploited resource to achieve and produce a sustainable feed crop. Microalgae has emerged as a potential alternative to traditional land-based plant crops. Algae is a rich source of high-quality protein, vitamins, micronutrients, carotenoids and long-chain PUFAs, especially of omega 3. The main concern is that the nutrient value within algae and seaweed species is variable depending on seasonality, habitat and external conditions.

The effects of the different microalgae and seaweed species and its function has been largely under researched and not known however due to algae being the fastest-growing organisms in nature, there are a number of projects investigating production techniques and the use of algae portions in animal feed. Research has been dominated by setting up artificial ponds and bio systems in the USA. After harvesting, algae can be dried and powdered to produce meal. Average values of powdered algae are approx. 45-50% protein, 45-55% oils/lipids with a high concentration of essential amino acids and essential fatty acids.

The production of algae as animal and aquatic feed support the needed shift of animal feeds from soya to home-grown sustainable systems. The nutrient profile of algae is highly valuable.

References

Abdel-Raouf, N., Al-Homaidan, A.A. and Ibraheem, I.B.M., 2012. Agricultural importance of algae. *African Journal of Biotechnology*, *11*(54), pp.11648-11658.

Ali, E., Zainal, A., Mohamad, M. and Takriff, M.S., 2014. An overview: biomolecules from microalgae for animal feed and aquaculture. *Journal of Biological Research-Thessaloniki*, *21*(1), p.6.

Allen, J.D., 2010. Cobalt in ruminants diets. *Feed Compounder*, *30*(9), pp.18-19.

AlliedMarket Research 2020 Omega 3 market projections [online] https://www.alliedmarketresearch.com/omega-3-market. Accessed 13th January 2020

Angulo, J., Hiller, B., Olivera, M., Mahecha, L., Dannenberger, D., Nuernberg, G., Losand, B. and Nuernberg, K., 2012. Dietary fatty acid intervention of lactating cows simultaneously affects lipid profiles of meat and milk. *Journal of the Science of Food and Agriculture*, *92*(15), pp.2968-2974.

Bou, R., Codony, R., Tres, A., Decker, E.A. and Guardiola, F., 2009. Dietary strategies to improve nutritional value, oxidative stability, and sensory properties of poultry products. *Critical reviews in food science and nutrition*, *49*(9), pp.800-822.

Boyd, C.E., 2020. Eutrophication. In *Water Quality* (pp. 311-322). Springer, Cham.

Hilborn, R. and Hilborn, U., 2019. *Ocean Recovery: A sustainable future for global fisheries?*. Oxford University Press.

Hinz, H., Reñones, O., Gouraguine, A., Johnson, A.F. and Moranta, J., 2019. Fish nursery value of algae habitats in temperate coastal reefs. *PeerJ*, *7*, p.e6797.

Kandathil Radhakrishnan, D., AkbarAli, I., Schmidt, B.V., John, E.M., Sivanpillai, S. and Thazhakot Vasunambesan, S., 2020. Improvement of nutritional quality of live feed for aquaculture: An overview. *Aquaculture Research*, *51*(1), pp.1-17.

Khan, M.I., Shin, J.H. and Kim, J.D., 2018. The promising future of microalgae: current status, challenges, and optimization of a sustainable and renewable industry for biofuels, feed, and other products. *Microbial cell factories*, *17*(1), p.36.

Kovač, D.J., Simeunović, J.B., Babić, O.B., Mišan, A.Č. and Milovanović, I.L., 2013. Algae in food and feed. *Food and Feed research*, *40*(1), pp.21-32.

Kumar, S.S., Chouhan, R.S. and Thakur, M.S., 2010. Trends in analysis of vitamin B12. *Analytical biochemistry*, *398*(2), pp.139-149.

Lopez, C.C., Serio, A., Rossi, C., Mazzarrino, G., Marchetti, S., Castellani, F., Grotta, L., Fiorentino, F.P., Paparella, A. and Martino, G., 2016. Effect of diet supplementation with Ascophyllum nodosum on cow milk composition and microbiota. *Journal of dairy science*, *99*(8), pp.6285-6297.

Machado, L., Magnusson, M., Paul, N.A., de Nys, R. and Tomkins, N., 2014. Effects of marine and freshwater macroalgae on in vitro total gas and methane production. *PLoS One*, *9*(1), p.e85289.

Madeira, M.S., Cardoso, C., Lopes, P.A., Coelho, D., Afonso, C., Bandarra, N.M. and Prates, J.A., 2017. Microalgae as feed ingredients for livestock production and meat quality: A review. *Livestock Science*, *205*, pp.111-121.

Miele, M., 2019. The taste of happiness: Free-range chicken. *Environment and Planning A*, *43*(9), pp.2076-2090.

Molina-Alcaide, E., Carro, M.D., Roleda, M.Y., Weisbjerg, M.R., Lind, V. and Novoa-Garrido, M., 2017. In vitro ruminal fermentation and methane production of different seaweed species. *Animal Feed Science and Technology*, *228*, pp.1-12.

Park, J.H., Upadhaya, S.D. and Kim, I.H., 2015. Effect of dietary marine microalgae (Schizochytrium) powder on egg production, blood lipid profiles, egg quality, and fatty acid composition of egg yolk in layers. *Asian-Australasian journal of animal sciences*, *28*(3), p.391.

Stafford, R., 2019. Sustainability: A flawed concept for fisheries management?. *Elementa: Science of the Anthropocene*, *7*(1).

Taelman, S.E., De Meester, S., Van Dijk, W., da Silva, V. and Dewulf, J., 2015. Environmental sustainability analysis of a protein-rich livestock feed ingredient in The Netherlands: Microalgae production versus soybean import. *Resources, Conservation and Recycling*, *101*, pp.61-72.

Tocher, D., Betancor, M., Sprague, M., Olsen, R. and Napier, J., 2019. Omega-3 Long-Chain Polyunsaturated Fatty Acids, EPA and DHA: Bridging the Gap between Supply and Demand. *Nutrients*, *11*(1), p.89.

Wuang, S.C., Khin, M.C., Chua, P.Q.D. and Luo, Y.D., 2016. Use of Spirulina biomass produced from treatment of aquaculture wastewater as agricultural fertilizers. *Algal research*, *15*, pp.59-64.

Yaakob, Z., Ali, E., Zainal, A., Mohamad, M. and Takriff, M.S., 2014. An overview: biomolecules from microalgae for animal feed and aquaculture. *Journal of Biological Research-Thessaloniki*, *21*(1), p.6.