CAN FEEDING DEFATTED MICROALGAE PRODUCE HEALTHIER ANIMAL FOODS?

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INTRODUCTION

The increasing demand of good quality animal products and limited supply of traditional feed lead to exploration of alternative and sustainable food and feed resources. Microalgae are microscopic or single cell algae, usually found in freshwater and marine systems (Thurman, 1997). Recently, they have gained popularity as a feedstock for biofuel production (Chisti, 2007). After oil extraction, the defatted microalgal biomass still contains good amounts of polyunsaturated fatty acids (PUFA), protein, carbohydrates, minerals, and vitamins (Brune et al., 2009; Shields and Lupatsch, 2012). PUFA, particularly n-3 fatty acids, in defatted biomass may bolster its appeal as a source for developing n-3 fatty acids-enriched animal products (Lum et al., 2013). Likewise, the desirable profile of protein, mineral and vitamin makes microalgae a potential replacement for soybean or corn meal in animal feed (Austic et al., 2013). In this paper, potential utilization of defatted microalgae in producing health-value improved animal foods will be discussed.

ENRICHMENT OF N-3 FATTY ACIDS IN CHICKEN EGGS AND MEAT

Dietary n-3 fatty acids can impact the n-3 fatty acid pattern in animal products. For example, the eicosapentanoic acid (EPA) and docosahexanoic acid (DHA) concentrations in the yolk are highly dependent on dietary EPA and DHA concentrations (R^2 = 0.89) (Koppenol et al., 2014). EPA supplied from diet can be converted into DHA (Huang et al., 1990; Lemahieu et al., 2015). Concentration of tissue EPA is usually below 1% and reaches saturation in eggs at about 22 mg/egg (Coorey et al., 2015). Dietary α-linolenic acid (ALA) can contribute to ALA in tissues and can also be converted to EPA and DHA through desaturation and elongation. In humans, the conversion rate from ALA to EPA and DHA is less than 5% (Gerster, 1998; Brenna, 2002). However, chicks have shown a relatively higher conversion efficiency due to high activity of elongases 2 and 5 (Gregory and Geier, 2013). In this case, dietary supplementation of ALA has potential of enriching EPA and DHA in poultry products.

As a rich source of n-3 fatty acids, particularly EPA and(or) DHA, microalgae has been added to diets of dairy cattle, pigs and layers to enhance DHA contents in their products (Sardi et al., 2006; Stamey et al., 2012; Trentacoste, 2013; Park et al., 2015) The defatted microalgae (*Nannochloropsis oceanica*) used in our lab contained a high concentration of EPA (16.4%), but a low amount of ALA (0.12%). In a broiler chick study, we observed an increase of n-3 fatty acids in the liver, breast, and thigh with increasing doses of microalgae supplemented to the diet. Similar effects were observed in laying hens. When hens were fed with 0-23% defatted *N. oceanica*, the level of n-3 fatty acids and n-3 to n-6 ratios were increased in their liver, breast, thigh, and eggs with the acclimation of microalgae supplementation. In eggs, for example, 23% microalgae supplementation resulted in an approximately 3-fold increase in DHA over the control. EPA concentration was also significantly increased by the microalgae feeding while its level was undetectable in control eggs. In another study, 3 or 5% flaxseed oil (FO) was supplemented alone or together with full-fat *Staurosira sp.*, defatted *N. oceanica,* and *Desmodesmus sp*. Surprisingly, FO alone efficiently increased ALA, EPA and DHA levels in eggs. Addition of full-fat *Staurosira sp.* did not have an obvious enhancement in egg n-3 fatty acids, but prevented 5% FO-induced negative effects on weight gain. While defatted *N. oceanica* (16.4% EPA) or defatted *Desmodesmus sp.* (22.1% ALA) was expected to induce more desirable changes in egg PUFA than full-fat *Staurosira sp.* (no ALA, only 2.3% PUFA), it turned out that together with 3% FO, all algae-supplemented groups accumulated similar amounts of ALA, EPA and DHA. Diet with 3% FO might provide sufficient ALA to saturate the tissue capacity of synthesizing EPA and DHA and thereby limiting any observable benefits of defatted *N. oceanica* and *Desmodesmus sp*. In a later study, we tried to reduce the FO to 1.5%. At the low level of FO, addition of 5% defatted *N. oceanica* exerted some positive effects on EPA and DHA in the liver, plasma, and eggs.

PROTEIN, MINERALS, VITAMINS, AND SO ON

There has been increased interest in microalgae as a viable protein source in animal feeds, particularly the defatted biomass from the biofuels industry (Lum et al., 2013). Microalgae can be high in essential amino acids comparable to soybean meal (Becker, 2007; Tibbetts et al., 2014). Previous work in our lab has shown that pigs and chicks were able to tolerate a moderate incorporation of microalgae into their diets as a protein source without any detrimental effects on their growth performance or egg production (Ekmay et al., 2014; Gatrell et al., 2014; Ekmay et al., 2015).

In addition to protein, microalgae are a promising source for minerals and vitamins. Our group have demonstrated the incorporation of defatted microalgal biomass into diets to be an adequate source of iron in weanling pigs (Kim and Lei, 2014). Volkman et al. summarized literature on microalgal strains that showed microalgae to be a bountiful source of ascorbic acid, β-carotene, niacin, α-tocopherol, and many other vitamins (Volkman et al., 2006). Apart from meeting nutritional requirements, the antioxidant activity of some of the vitamins such as β-carotene and α-tocopherol are potentially able to assist in the stabilization of eggs enriched with n-3 fatty acids (Sies and Stahl, 1995), similar to the role of vitamin E and organic Selenium (Ren and Perez, 2013).

SUMMARY

Defatted microalgal biomass supplementation can be an excellent source of protein, vitamins, minerals, and PUFA for animal nutrition (Spolaore and Joannis-Cassan, 2006). More importantly, the inclusion of the biomass in animal diets has potential to produce health value-added animal products such as EPA/DHA-enriched eggs and meat. Future research will be required to find out the optimal species and doses of the biofuel-producing microalgae that can be used to improve nutritional quality, health value, and economic efficiency of animal products.

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