NEW PERSPECTIVE OF NUTRIENT DIGESTIBILITY AND RETENTION IN DIETS CONTAINING DEFATTED MICROALGAE

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INTRODUCTION

The world population has already reached 7.4 billion and the number is still growing. Total food production has increased every year to meet the massive demand for this rapidly increasing global population. In 2015, the U.S. poultry industry raised 9 billion broiler chickens and served more than 40 billion pounds of chicken products on ready-to-cook basis (Broiler Chicken Council, 2016). Total poultry production has increased from 1,500 million pounds of meat in 1950 to 40,000 million pounds in 2016. Approximately 17 million and 13.6 million metric tons of corn and soybean meal, respectively, are used as animal feed annually. This use directly competes against the need of corn and soybean as a staple for human consumption. Thus, it is necessary to find alternative sources of feed for maintaining sustainable animal production.

Recently, microalgae have gained a great deal of interest for their potential as the third generation of feedstock for biofuel production and the high contents of protein and other nutrients in the defatted biomass as a new source of animal feed. Previous research in our laboratory has shown that broiler chicks, laying hens, and weanling pigs are able to utilize 7.5% to 10% defatted microalgae in their diets without decreases in growth or egg production performance (Ekmay et al., 2014, 2015; Gatrell et al., 2014; Leng et al., 2014; Kim et al., 2016). However, the exact nutrient digestibility or retention of these diets containing the defatted microalgae remains unclear.

NUTRITIONAL APPLICATION OF MICROALGAE AND DEFATTED MICROALGAE

Microalgae are aquatic photoautotrophic single cellular organisms that have the potential to convert carbon dioxide to biofuels, foods, and feeds [Chisti, 2007; Brune et al., 2009]. The biofuel industry has recently developed oil extraction techniques from microalgae that are more efficient than from the biomass of conventional crops [Chisti, 2007]. In addition to high levels of protein and amino acids, the defatted microalgal biomass contains beneficial components including n-3 fatty acids and bioactive compounds [Spolaore et al., 2006]. Both microalgae and their defatted biomass are used as a viable feed protein source for aquatic as well as terrestrial animals [Becker, 2007; Kiron et al., 2012]. In an early study (Combs, 1952), dried Chlorella was used in the broiler diet to replace 10% soybean meal that resulted in improved body weight gain and feed efficiency. Thereafter, a variety of microalgae including *Chlorella sp*., *Spriulina sp*., *Coelastrum* and *Scenedsmus* have been used as animal feed ingredients. During the past seven years, our laboratory has evaluated nutrient composition and feeding values of three types of defatted microalgae including *Staurospira sp*., *Desmodesmus sp*., and

Nannochloropsis Oceanica in the diets for weanling pigs, broiler chicks, and laying hens [Austic, 2013; Ekmay, 2014; Leng et al., 2014]. The defatted microalgae was effective in enriching n-3 fatty acids in the liver and muscle (breast and thigh) of broiler chicks (Gatrell et al., 2015) and eggs (Kim et al., 2016).

NUTRIENT DIGESTIBLITY AND RETENTION OF MICROALGAE

Few studies in the past have determined nutrient digestibility and retention of microalgae. The digestibility of crude protein in *Chlorella*, *Spriulina* and *Coelastrum* were reported to be 89.3, 89.2, and 88.6% respectively, when being used as the sole source of protein (10% of the diet) in rats [Saleh et al., 1985]. Meanwhile, the digestibility of crude protein in *Sprirulina maxima* was found to be between 75.5 to 76.7% at 15% level in the rat diet [Clement et al., 1967]. Although these digestibility values derived from feeding microalgae as the sole source of dietary protein were encouraging, their nutritional relevance was problematic. This was because feeding microalgae over 20% caused adverse growth performance in chicks [Combs, 1952], let alone feeding them with microalgae as the only protein source [Grau and Klein, 1957]. Likewise, adverse performance was also observed from feeding chicks with high levels of Diatom microalgae due to relative deficiency in methionine and cysteine [Austic et al., 2013]. Therefore, the nutrient digestibility or retention of microalgae may be estimated by feeding testing animals graded doses of the biomass and then developing a linear regression equation between the dietary concentration of the biomass and the respective diet digestibility [Kies et al., 2006]. Nutrient digestibility and retention can be determined by direct method (total collection of excreta) or indirect method (using indigestible marker such as chromic oxide). However, indirect determination of mineral digestibility using chromic oxide might not be always reliable because chromic oxide recovery rate varies with different conditions. Direct method provides more accurate estimates, but requires more efforts.

DEFATTED MICROALGAE ON NUTRIENT DIGESTIBILITY AND RETENTION

We determined impacts of supplemental 10% defatted microalgae (*Nannochloropsis oceanica*, 45% crude protein and 3.8% ether extract) from biofuel production in a corn-soybean meal basal diet (BD) on nutrient digestibility and retention in broiler chicks. Day-old hatchling Cornish Giant cockerels were divided into two groups (5 cages/group, 4-5 chicks/cage) and fed the BD or the microalgae diet for 6 week. Starting week 3, chicks were fed diets containing 0.2% chromic oxide as an indigestible marker. Total excreta of individual cages was collected daily for consecutive 5 and 3 d during weeks 5 and 6, respectively. At the end of week 6, chicks were euthanized to collect ileal digesta from 1 chick/cage. Apparent nutrient retention was calculated based on total excreta collection and chromic oxide as an indigestible marker. The latter was also used to estimate apparent ileal digestibility of nutrients. Chicks fed the two diets had similar average daily feed intake and gain/feed ratio. Feeding the microalgae diet enhanced ($P < 0.05$) and decreased ($P < 0.05$) apparent retention and digestibility of dry matter by 3.3 and by 1.8%, respectively. Feeding the microalgae diet elevated (1.6 to 3.8%, $P < 0.05$) apparent retention of ether extract determined by the indirect method, but not by the direct method. Supplemental defatted microalgae did not affect apparent retention of crude protein determined by both methods at either time-point except for a 17.8% decrease ($P < 0.01$) by the 5-day total collection. Feeding the microalgae diet decreased ($P < 0.05$) apparent ileal digestibility of 8 essential amino acids, and 6 non-essential amino acids, ranging from 32% for isoleucine to 7% for glutamic acid. Feeding that diet also decreased ($P < 0.05$) apparent retention of 6 essential amino acids and 5 non-essential amino acids, ranging from 16% for threonine to 0.6% for leucine. In conclusion, supplementing 10% of defatted microalgae in the corn-soybean meal diet did not show consistent effect on apparent retention or ileal digestibility of dry matter, ether extract, or crude protein determined by the two methods at the two time-points, but the diet decreased apparent retention or ileal digestibility of a number of amino acids.

SUMMARY

Defatted microalgae from the biofuel production have the potential to spare corn and soybean meal as conventional ingredients for feeding food-producing animals. This will help improve fuel, food, and environmental sustainability. For the efficient nutritional application, accurate and systematic determination of nutrient digestibility and retention in the defatted microalgal biomass and diets containing the biomass warrants future research.

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