NEW INSIGHTS ON DEFATTED ALGAL BIOMASS AS SINGLE CELL PROTEIN FOR ANIMAL FEED

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The worldwide population has more than doubled since the 1960s, from 3 to over 7 billion. Based on data from the World Bank, the worldwide agricultural land has remained between 35-40%, and arable land has remained below 11% during the same time period. Since land is a limiting resource, the ability to feed the population must come from increased efficiencies or alternative methods and technologies. However, the need to feed an ever-growing number of people does not exist in a vacuum. There is also a need to feed the agricultural animals that are integral to the global food chain. With an ever-increasing population also comes the need for fuel: a need met to date by fossil fuels. Any changes that occur will inevitably need to balance resources for multiple demands.

Microalgae have long been utilized by humans, although the commercial cultivation of algae has been a more recent development. Currently, several commercially available algal products are available for human use. A 2008 publication reported that over 6000 tons of microalgal biomass was generated per year for human nutrition (Gouveia et al., 2008). The long recorded interest in utilizing microalgae has been a result of several characteristics particular to algae. The primary appeal of microalgae is its desirable nutrient profile in concert with their ability to grow in rather undesirable conditions. Microalgae can grow in brackish waters and require only CO2 and sunlight for growth. If the need for arable land disappears, a new frontier for agriculture will emerge. Furthermore, under certain nutritional states, microalgae can synthesis large amounts of lipid. This lipid can then be extracted and converted into biofuels and help relieve the world's reliance on fossil fuels.

MICROALGAE IN ANIMAL NUTRITION

In modern agriculture, diets for food-producing animals are primarily corn and soybean meal (SBM) based with inclusions of non-traditional feedstuffs capped at 10% of the diet. As the primary source of feed protein, SBM is prized for its high protein level (~48%) and balanced amino acid profile. Without supplemental synthetic amino acids, the corn/SBM-based diets are often limited in sulfur amino acids. The importance of a balanced amino acid profile relates to the ideal protein concept. An ideal protein is defined as one whose amino acid profile exactly fulfills the requirements of the animal. Rather than formulating to meet an absolute level of protein or amino acid, diets are formulated to specific ratios to one another.

Current alternatives to soybean meal are few and consist only of a reduction in the amount SBM utilized. The use of ethanol byproducts has already gained in popularity with the use of distiller's dried grains with solubles (DDGS). High variability in nutrient composition and quality in DDGS as well as high fiber content limit its inclusion in diets to 20%, with most commonly used levels around 10%. Furthermore, DDGS (~25% CP) cannot directly replace SBM (~48%) in the diet.

The nutrient profile of microalgae offers a more promising alternative to SBM. Depending on species, crude protein concentrations may reach as high as 70% and the amino acid profile offers adequate levels of many essential amino acids (Ugalde and Castrillo, 2002). Microalgae also typically contain desirable levels of polyunsaturated fatty acids, vitamins, and minerals (Gouevia et al., 2008). However, microalgae present a challenge to protein and amino acid nutrition: single cell protein. Unlike typical protein sources, microalgae are unicellular organisms. As such, about 10-15% of the proteins are in the form of nucleic acids. Previous research on additions of microalgae into diets for swine and poultry also suggested limiting the inclusion rate at 10% of the diets (Becker, 2004). Higher inclusion rates often result in decreased feed intake, growth, or egg production (Blum, 1975, Lipstein et al., 1980, El-Deek et al., 2011, Ginzberg et al., 2000). Our own trials in swine and poultry have shown that inclusion rates lower than 10% effectively replaced SBM but rates higher than 10% decreased feed intake (Lum et al., 2012). In addition, inclusion rates over 10% in laying hens appeared to alter protein metabolism as shown by lower albumen weights and plasma uric acid (Leng et al., 2012). As such, there remains a certain level of uncertainty surrounding single cell proteins. The negative results can be tempered with the addition of exogenous enzymes including xylanase, amylase, protease, and lipase (Al-Harthi et al., 2011). Furthermore, long-term effects of microalgae inclusion have not been investigated.

The goal of our current research is to understand the limitations of microalgae and clearly define the changes in protein digestion and metabolism previously observed. Both *in vitro* and *in vivo* models are currently being utilized to determine structural limitations to digestion, bioactive molecules, physiological changes induced by algae consumption, and finally, possible solutions. New trials with both swine and poultry have been set up with inclusion rates well above the recommended ceiling. Monitoring of plasma uric acid, 3-methylhistidine, glutamine, and total amino acids, as well as ileal total amino acid digestibility enables to illustrate a clear picture of protein metabolism. Results appear to confirm that algae inclusion may alter protein metabolism, but in such a way that it may prove to be beneficial for both the animal and the environment. These results, in concert with improvements in the economics of microalgal harvesting, present a bright future for microalgal biomass as a new protein source.

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