The New Protein Economy: Opportunities for Alfalfa in the Alternative Protein Market

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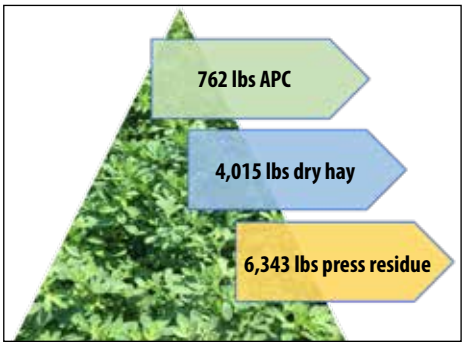
A major challenge facing the world in the 21st century is feeding the growing human population. Not only is the world's population continuing to grow, but the wealth of the population is increasing, and with it the demand for more protein in human diets. Meat has been the main source of protein in developed markets for years, and there is an increasing appetite for traditional protein in developing markets. However, changing consumer behavior and interest in alternative-protein sources have made way for growth in the alternative-proteins market. Plant-based food sales rose 17% in 2018, and the use of alternative protein as a food ingredient is predicted to continue to grow. Consumers are increasingly interested in foods that contribute to a healthy diet and are sustainably produced. What are the opportunities for alfalfa protein in this market? Alfalfa produces more protein per acre than any other crop and provides environmental services highly attractive to 21st century consumers. Research results indicate protein from alfalfa herbage has the characteristics that make it attractive for use in novel animal feeds and the human food market.

Aquaculture is the fastest growing food sector in the world, with production of farmed fish eclipsing that of wild fish harvested. Notably, aquaculture species have the most efficient feed, protein, and energy conversion ratios in animal production systems. To meet the demand for commercial aquaculture, the aquafeeds industry has grown from $99 billion in 2016 to $163 billion in 2021. Traditionally, aquaculture feeds contained high levels of fishmeal derived from wild fish. However, global fishmeal production is declining, and sustainably produced alternative plant-based protein and oil replacements are needed.

Several studies were conducted to develop methods for refining alfalfa herbage into a protein concentrate and associated co-products. The simplest methods consist of dewatering fresh alfalfa foliage using various types of presses. The dewatering results in a press residue that can be used fresh, in haylage, dried and pelleted for feed, or used for biomass-derived energy. The press filtrate, or juice, is processed to extract a protein concentrate by heating, chemical treatments, or filtration methods. Fractionation of fresh alfalfa herbage has the advantage of being a weather-independent harvest method with higher recovery of nutrients from the field than production of dry hay and more intensive utilization of nutrients in food and feed. Recently, large-scale methods for separation of proteins from dried alfalfa leaves were published. They have the benefit of using stored rather than fresh plant material. However, research is needed to develop more efficient methods for extracting proteins and refining the proteins into human foods, novel animal feeds, and to provide feed stocks for other bio-based products from de-proteinized juice and the fiber fraction.

Investigation on the potential of alfalfa protein concentrate (APC) as an aquatic feed ingredient is still very limited. To extend previous studies on the use of APC in aquaculture feeds, ARS scientists at St. Paul, MN, and collaborators at the University of Minnesota carried out research funded by the Minnesota Department of Agriculture. Five methods were evaluated for producing APC: heat, freezing, acid pH, basic pH, and basic pH followed by acid pH. Acid-based precipitation methods resulted in the largest recovery of APC, while heating produced the highest concentration of protein. The percentage of fatty acids and sugars in the concentrate varied significantly by precipitation method. All methods resulted in low amounts of fiber. Next, the amount of APC recovered from a fresh press filtrate was measured from several feedstocks: herbage of a non-lodging biomass-type alfalfa, genetically modified reduced-lignin alfalfa, and conventional alfalfa as well as from leaves of the biomass-type non-lodging fractionated at harvest. Approximately 762 lbs of APC could be produced annually from three harvests of an acre of biomass-type alfalfa (Figure 1), significantly higher than previous reports of APC production from immature hay-type alfalfa. The amounts of APC recovered

Figure 1. Annual production from one acre of non-lodging biomass alfalfa.



from a reduced-lignin alfalfa and a conventional cultivar were similar. These results indicate that a non-lodging biomass-type alfalfa can produce high yields of APC and co-products with fewer harvests than a conventional cultivar, reducing costs and promoting crop productivity.


Fish feed with APC.

Preliminary feeding studies were done over 14 weeks in which APC replaced fishmeal in formulated diets for yellow perch. The fish accepted the APC diet but gained weight at a slightly lower growth rate (-0.07%/day) than fish on the control diet containing fishmeal. More recently, research funded by USDA-NIFA has expanded the studies to investigate use of APC as a feed ingredient for rainbow trout with collaborators at the University of Wisconsin-Milwaukee. Five test diets were formulated to replace fishmeal with different levels of APC (0, 5, 10, 15, and 20%). Inclusion of APC improved many of the feed pellet characteristics. The durability index and water stability of feed pellets was significantly higher with 10-20% APC than the control and the 5% APC diets. The increased density of the feed pellets due to inclusion of APC may facilitate storage or shipping because of increased durability.

Results of the feeding studies look very promising. Palatability by rainbow trout did not change due to the inclusion of APC. The apparent digestibility coefficient (ADC) of dietary protein was similar but the ADC of dry matter and phosphorus (P) was significantly lower in the 20% APC diet. Current studies are investigating the effect of inclusion of phytase, an enzyme to improve P nutrition, to reduce the need for P supplementation and increase retention of P and other minerals. The test diets had no significant impacts on fish morphology or composition of whole fish, although some changes in metabolic pathways were observed at the higher levels of APC. The results of this study provide baseline information for establishing an optimal APC-based feed formulation for rainbow trout. During the summer of 2022, the optimal diet will be tested compared to a conventional trout feed at a commercial trout farm to calculate production efficiency and profitability.