NEW MARKETS FOR ALFALFA

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ABSTRACT

A potential new market that could increase alfalfa production. There is a growing demand for protein due to increased population and affluent countries demanding protein rich foods. Most plant-based proteins on the market are storage proteins extracted from seeds. However, the most abundant type of plant-based protein resides in plant leaves and stems as the functional protein RuBisCo. Current methods of protein extraction include either pulping or juicing the material to release the proteins and then either coagulation, acidification, fermentation, or ultrafiltration to concentrate the soluble proteins. Recovered protein yields in alfalfa range from 15 to 43% of the original amount of protein found in the plant. These yields are higher than other leafy plants making alfalfa a prime candidate for cultivation. During processing there are additional markets for the biproducts produced. There are challenges to alfalfa protein; the plant contains high levels of endogenous proteases which could impact the protein recovery rates. Additionally, technology along the processing system needs to be improved.

KEY WORDS

Protein, harvest management, challenges

RATIONAL

Alfalfa is the 4th most common agricultural crop in the US (USDA- NASS 2022). However, alfalfa is undervalued when the plant is only considered for its dietary fiber uses. This crop is one of the pillars that other high value markets like dairy and meat production. The dietary fiber consumed by cattle from alfalfa meets ruminants' unique requirements (National Academies of Science and Medicine, 2016). Alfalfa is also becoming recognized for its contribution to ecosystem services in the crop rotation. In general, the plant has deep root systems that stabilize soil structure, trap carbon within the soil for extended periods of time (Fernandez et al., 2019), and prevent nitrogen leaching (Issah et al., 2020).

Even with these benefits the acreage of alfalfa harvested is decreasing at a rate of approximately 413,000 acres per year since 2005 (USDA-NASS, 2023). In contrast the numbers of acres planted has remained stable over that time period (USDA-NASS, 2023). One of the reasons for the decrease in acres harvested is that there are less cattle in the US. Cattle numbers have been decreasing since the 1970's (USDA-NASS, 2023). Small ruminants, goats and sheep, have increased in the US, but the rate of increase cannot offset the loss of tonnage required for cattle feed. Therefore, new markets need to be found to increase the demand for alfalfa.

With the increased population in the United States meat production has also increased. The increase is being driven by the broiler market and to a lesser extent hogs (USDA-NASS, 2023). These animals are monogastric and cannot metabolize alfalfa in its current form. Another

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In: Proceedings, 2023 Western Alfalfa and Forage Symposium, Reno, NV, Dec. 12-14 UC Cooperative Extension, Plant Sciences Department, University of California, Davis, CA 95616. (See http://alfalfa.ucdavis.edu for this and other alfalfa conference Proceedings.)

growing market is plant-based proteins. The global market is projected to increase by 14% by 2028 (Forecast, 2023). This market utilizes storage proteins found in seeds for human consumption. However, alfalfa leaves contain high levels of protein that could be utilized in this market.

OPPORTUNITIES

Alfalfa has the highest protein yields than other leafy plants ranging from 20 – 43% making it a prime candidate for protein cultivation. The functionality characteristics of alfalfa protein is like egg whites with no adverse flavors (Knuckles & Kohler, 1982). The amino acid profile of alfalfa is similar to soy and meets the FOA requirements for a complete protein. Also, alfalfa protein extract meets at least 10% of the human daily needs for Vitamin K, Calcium, Iron, Selenium, Copper and Manganese. This percentage would allow alfalfa protein concentrate to be utilized as food additive for those compounds resulting in "clean" labels under current packaging laws.

Alfalfa protein market does have its challenges. University and federal scientists are studying all aspects of the processing chain to move alfalfa protein into the mainstream market. The first challenge is with the plant itself. Alfalfa contains high levels of endogenous proteases which could impact protein recovery rates. The activation of these proteases begins as soon as the plant is harvested (Scalet et al., 1984) and within 3 days over 90% of the protein has been broken down to its constituent parts (i.e. amino acids) (Heuschele et al, unpublished). This breakdown does not affect the nutritive value for ruminants, but monogastric animals, like humans, require these proteins to be intact for digestion (Eugenio et al., 2022). This problem could be mitigated with new harvesting methods and equipment. Currently fresh alfalfa is juiced and then dried down to for a "green" or "brown" protein powder. The powder still contains compounds from the alfalfa plant. Which is why many countries have pilot, demo, or industrial scale biorefineries that process alfalfa tissue to extract the proteins for utilization in the animal (monogastric) feed industry (Fiorentini & Galoppini, 1981). To move alfalfa into the human food marketplace further refining is required to create a white pure protein powder. The second challenge is to maintain the alfalfa protein structure and size during the creation of the white protein powder. Stability and consistency of the protein needs to be investigated along with the development of end products. However, solubility of the protein might not matter if the food product requires a curd instead of the solubilized form of protein.

My lab is evaluating how harvest management changes protein size and extraction yields of alfalfa leaf protein. We are also investigating potential markets for the waste products created during purification. At each step of protein extraction and purification process, waste products are produced that could be utilized in some other market (Fig.1). The first waste created is fiber mat or cake containing fibrous materials from both leaves and stems after juicing. Within this material about 20- 30% of the total protein is retained (Heuschele et al, unpublished) along with all the dietary fiber. This material could be sold as lower grade animal feed for ruminants. Additional liquid waste is produced during refinement as the juice is concentrated into "green", "brown" and then "white" protein concentrates. Within these waste liquids are chemical compounds that may have economic value. For example, saponins, while detrimental to cattle health, have been found to reduce blood glucose levels and cholesterol levels in humans (Asgary et al., 2008; Salih & Azeez, 2019). During the protein concentration, these water-soluble compounds are also being extracted and would only need to be collected and concentrated.

Also, during the protein extraction process there are opportunities for other waste products to become byproducts that are utilized as feedstocks in fermentation. There are several piolet and industrial size plants in Europe currently utilizing and creating leaf based biproducts for fermentation (Santamaría-Fernández & Lübeck, 2020). These alfalfa feedstocks can be utilized for ethanol production or microbial protein synthesis for meat analogs.

All levels of the leaf protein value chain need to be improved technologically in order to alfalfa protein to enter the mainstream market. There is an opportunity for producers, scientists, and engineers to collaborate and advance alfalfa as a human protein source.

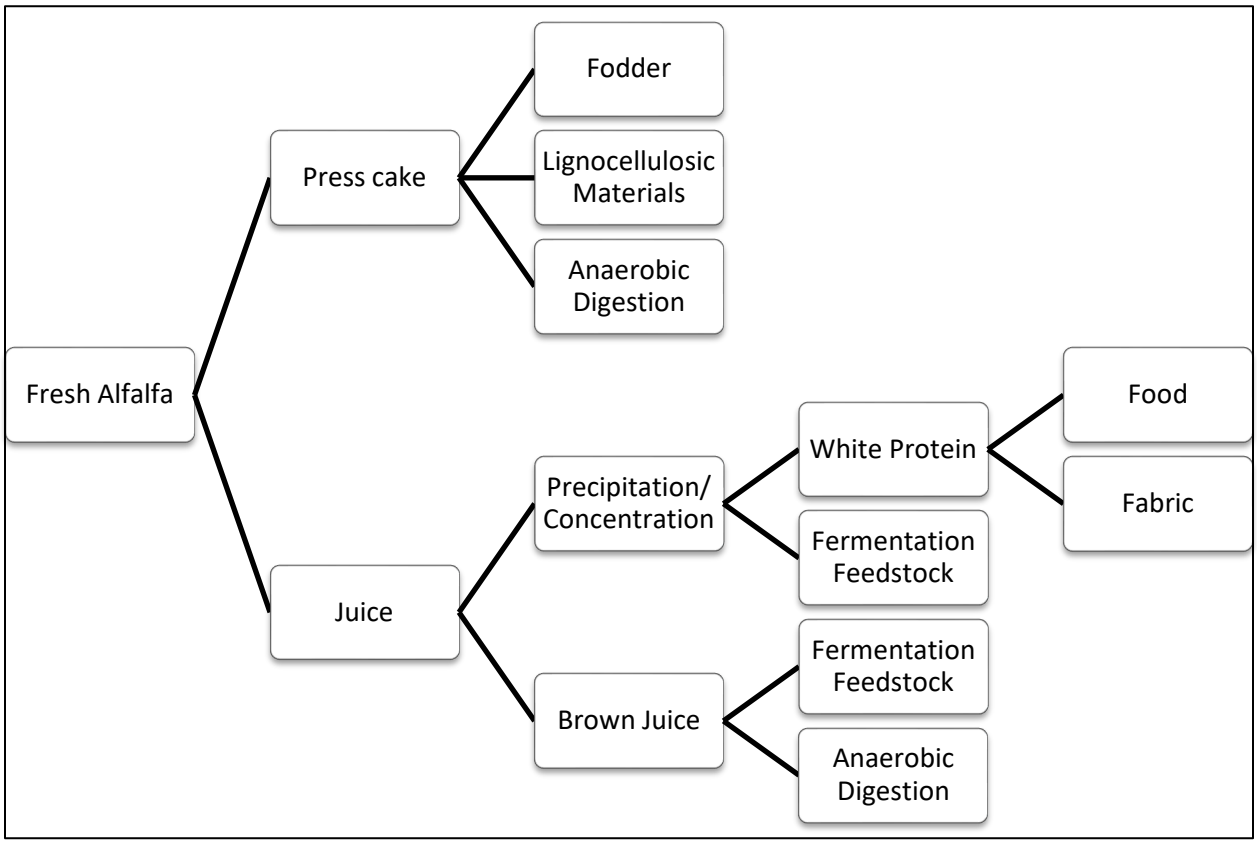

Figure 1. Diagram of potential protein bio refinement and biproducts from alfalfa biomass.

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