TEXAS A&M AGRILIFE RESEARCH | EXTENSION

Wood-to-Feed

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Introduction

Wood-to-feed program is an innovative initiative, unifying research and extension, from the preliminary studies to the technology adoption, passing through technology development and legal approvals, to use Juniper tree as animal feed.

After 10+ years of basic and applied research with positive results, in the end of last year Juniper was approved by FDA as feed ingredient.

Now, Wood-to-Feed Program focus on the technology adoption by producers and feed companies.

The problem of Juniper encroachment

Juniper trees have taken over a considerable land area in the southwestern US. The plants are very difficult to control; therefore, the land prices have dropped. In addition, biodiversity and pasture carrying capacity are reduced.

Advantages of Wood-to-Feed

Wood-to-Feed Program converts a problem into a solution. From one side, harvesting Juniper trees will control the endemic plant in the rangelands, increasing carrying capacity and land productivity. From another side, the ground tree consists in an affordable and greatly available feedstuff to be included in animal diets, in both extensive and intensive systems, helping producers to mitigate periods with low forage production and reduce costs.

Scientific evidences

We initially evaluated effects of replacing CSH with air-dried redberry juniper leaves in Rambouillet lamb feedlot diets (Whitney and Muir 2010). In this trial, a maximum of 30% juniper leaves was included in a mixed diet that fed for 28 days; lambs were transitioned onto a mixed diet containing 15% juniper. No negative effects on animal health were reported but replacing 50% of the CSH with redberry juniper leaves increased lamb growth performance. We concluded, "that redberry juniper leaves can effectively be used as a roughage source and can replace all of the CSH in lamb feedlot rations, but may reduce intake and consecutively growth at greater inclusion levels"

The same lambs from Whitney and Muir (2010) were evaluated for wool, carcass, meat fatty acids, and sensory panel traits (Whitney et al., 2011). We concluded: "that air-dried juniper leaves can effectively replace cottonseed hulls in lamb feedlot rations. However, increasing concentration of juniper increased saturated fatty acids, which have been negatively associated with human health and greater off-flavor."

Results from Whitney and Muir (2010) led to a trial in which mixed diets containing ground juniper leaves and small stems were fed to lambs (Whitney et al., 2014). Whitney et al. (2014) evaluated effects of using redberry juniper in wether lamb diets. Lambs were individually fed DDGS-based diets where 0% (0JUN), 33% (33JUN), 66% (66JUN), or 100% (100JUN) of the oat hay was replaced by juniper. Results indicated that replacing all of the ground oat hay with ground juniper in lamb growing and finishing diets is not detrimental to animal performance or health." The same lambs from Whitney et al. (2014) were evaluated for carcass characteristics, adipose tissue fatty acid composition, and sensory panel traits (Whitney and Smith, 2015). We concluded, "…Replacing all of the oat hay with juniper resulted in similar carcass characteristics and greater sensory characteristics of lamb chops. According to industry standards, all lambs had acceptable carcass characteristics; however, taking all carcass, fatty acid, and sensory characteristics into consideration, lambs fed diets with a combination of oat hay and ground juniper (33JUN and 66JUN) seemed to have produced the most acceptable carcasses and lamb chops. Results also suggested that ground redberry juniper is as valuable as ground oat hay in lamb feedlot diets with potential for greater value if

premiums are received for greater HCW and LM area and enhanced sensory characteristics. It is apparent that DDGS and ground juniper should be given greater consideration as dietary ingredients in lamb feedlot diets."

Between 2010 and 2014, we modified and developed a new assay to evaluate how various feeds and plant secondary compounds affect internal parasite function in the rumen (Whitney et al., 2011). We then began to evaluate the effects of *Juniperus* spp. on reducing internal parasite (*Haemonchus contortus*) larvae viability (Armstrong et al., 2013) and fecal egg shedding. The conclusion of Armstrong et al. (2013): "Dried and fresh juniper material reduced larval motility, but only dried juniper increased IVM efficacy. The reduction in IVM efficacy due to larvae initially being incubated in OIL was exactly opposite of what was expected and is currently unexplainable. Further in vivo research is warranted to determine if feeding dried juniper in mixed feeds to sheep and goats can reduce in vivo *H. contortus* motility, fecal egg shedding and increase IVM efficacy. Numerous benefits such as re-instating non-effective synthetic anthelmintics by increasing their efficacy would be realized if feeding sheep and goats dry juniper can weaken larvae in the host prior to drenching.

We took this knowledge, applied it to a field setting, and published, "The use of redberry juniper (*Juniperus pinchotii*) to reduce *Haemonchus contortus* fecal egg counts and increase ivermectin efficacy" (Whitney et al., 2013). Conclusion: "Compared to lambs fed a control diet, results indicated that feeding lambs mixed diets containing 30% redberry juniper leaves and stems can at times, reduce fecal egg counts without any IVM treatment. Results also indicated that feeding lambs a juniper-based diet before treating with IVM, increased IVM efficacy by 65% as compared to lambs fed a control diet. However, this reduction is not enough to suggest that this practice provides effective anthelmintic control. At times, feeding the juniper-based diet negatively affected growth rate but this is mainly attributed to nutritional differences between the diets. Feeding juniper-based diets throughout the year, increasing %age of juniper and CP in the diet, using fresh vs. dried juniper, or replacing juniper with ingredients that contain greater concentrations of secondary compounds, has potential to increase IVM efficacy enough to justify its use in flocks with IVM-resistant trichostrongyles. Other classes of anthelmintics with different modes of action, need to be evaluated and exact mechanisms

involved in increasing IVM efficacy by feeding bioactive compounds need to be further investigated. Being able to reinstate ineffective synthetic anthelmintics would be extremely beneficial to small ruminant parasite management."

In 2017, we published Whitney et al., 2017; "Substituting ground woody plants for cottonseed hulls in lamb feedlot diets: Growth performance, blood serum chemistry, and rumen fluid parameters." We concluded, "Results suggested that even though lamb DMI was reduced during Period 1 when growing diets contained 30% *J. pinchotii*, *J. monosperma*, *J. virginiana*, and *P. glandulosa*, rumen fluid parameters were not negatively affected and all lambs fed woody-based diets remained healthy throughout the trial. Due to the physical characteristics of the woody-based diets, lamb growth performance would probably increase if a small amount of ground hay was included. Ground woody products are unique in that they are not subject to seasonal feed pricing and availability, require no inputs by man to establish and grow, and are the only feed ingredients that can increase rangeland forage production after harvest. Therefore, the development of a commercialized industry to supply ground woody products for livestock production is warranted."

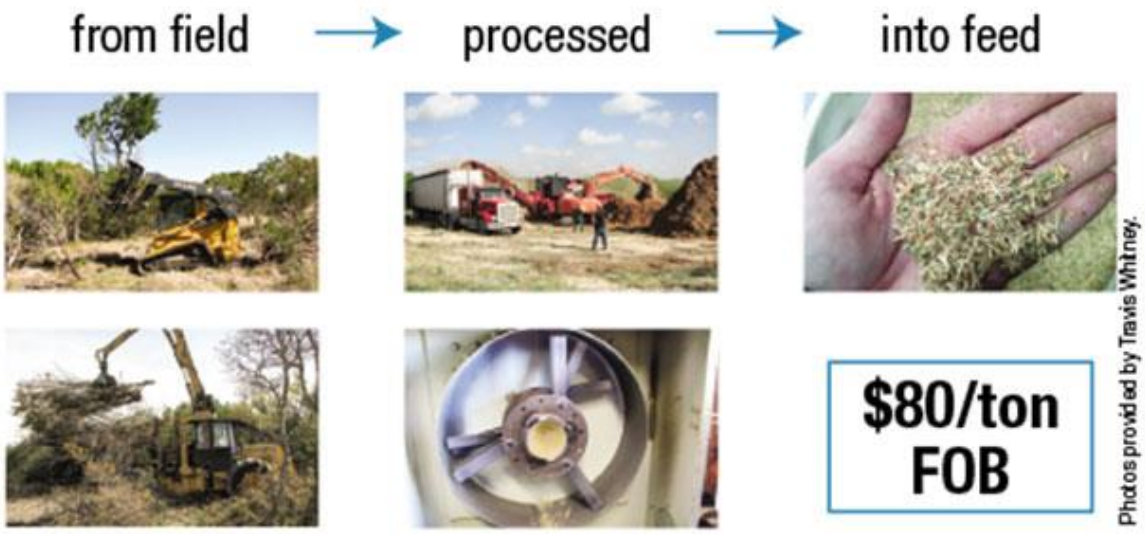
The same lambs from Whitney et al. (2017) were evaluated for carcass characteristics, adipose tissue fatty acid composition, and sensory panel traits. We concluded, "Minimizing input costs associated with feeding livestock is important, and furthermore, utilizing raw materials that might otherwise be thought of as pastoral waste has the potential to provide an opportunity for finishing ruminants. The research reported here indicated that lambs can be finished on a diet with 30% of the diet as ground juniper or mesquite as a source of roughage without negatively affecting carcass traits, fatty acid composition, or sensory traits."

We also completed a beef cattle feedlot trial, "Substituting hammermilled *Juniperus* spp. for chopped alfalfa hay in steer feedlot diets." Conclusions of this trial: "Although the differences in nutritive value between alfalfa and juniper resulted in a reduction in DMI, and thus growth rate of steers as juniper increasingly replaced alfalfa in steer diets, such replacement was shown to be feasible. Observations from this experiment coupled with appropriate valuation of production in a given scenario will allow prediction of the

ingredient pricing offset (relative to alfalfa) required to achieve economic viability. Because the price of juniper would be viewed as a cost reduction to land reclamation or rehabilitation, its price would likely be stable; this would enhance its viability as a substitute ingredient during times when the price of other roughage ingredients increases due to competition or scarcity, as often occurs during drought."

Harvesting Juniper

FIGURE 1 Harvesting juniper trees for livestock feed



Source: Wood to Feed Program. Texas A&M AgriLife Research.

We are working with some companies that have been already removing brush from properties commercially. The companies and several other outfits who grind brush and make mulch and chips have shown interest in the Wood-to-Feed Program. Economic estimates show that trees can be harvested, chipped, hammermilled and sold profitably at $130 per dry ton. This is comparable to cottonseed hulls and much cheaper than hay.

The market potential, considering the number of cattle, sheep and goats on feed in Texas and estimated the amount of roughage they would consume, days on feed, and there

forth, if even just 25 % of the traditional roughage sources currently fed was to be replaced with ground juniper, more than 433,000 tons of ground juniper or mesquite would be needed each year, as a rough estimate. This is a huge potential. If there is value in the product, commercial tree harvesters could remove – for free – about 4.2 million trees per year. The positive effects on natural resources, improving range and pastures, water tables, etc. would be huge. Another option, on a smaller scale, might be for individual companies to hand harvest juniper trees. The rancher could back a trailer up to the site so the material could be blown right into the trailer.

If livestock producers had access to those chips, all they need to do is hammermill and mix it to create an economical feed source.

Nutrition characteristics

The leaves are about 65% digested, which is very close to alfalfa.

The leaves are between 6% and 7.5% protein.

The neutral detergent fiber in mature redberry juniper trees (the whole ground-up tree) is about 66% and acid detergent fiber about 56%.

The fiber content is lower compared to cottonseed hulls, often used as a roughage source. Cottonseed hulls are 21 % to 28 % digested with 5 % to 6.5 % crude protein, 80 % neutral detergent fiber and 70 % acid detergent fiber. Neutral detergent fiber is an indicator of intake. Acid detergent fiber is correlated to digestibility.

When we replaced all the cottonseed hulls with juniper leaves the lambs performed similarly, but they actually did better when we only replaced half the cottonseed hulls – because digestibility of the juniper leaves is so high that they didn't make a very good roughage source.

The leaves made a pretty good energy source. We fed it at 30 % of the diet for the first 28 days of our study and at 10 % until the end (replacing all the cottonseed hulls). Those lambs performed very well, comparable to the controls.

As they got farther into the study, the labor costs of getting the leaves off the trees more than offset the advantages. It's like getting the needles from a dry Christmas tree. Then we started lopping off the limbs and grinding them up with the leaves, to make a good roughage source. We used the smaller limbs that were less than 2 inches in diameter. We chipped that material, blowing it into a peanut-drying trailer and let it dry about four hours. In that length of time it goes from about 60- % dry matter to about 92- % dry matter. We put that dried material into a hammermill to reduce it to small particles, putting it through a 4.75 millimeter screen (nearly 3/16 inch) to make a feed product.

The limbs are chopped from the green tree rather than having to dry them.

In one of the studies using this product they fed lambs again in a feedlot situation and gradually replaced the oat hay in the mixed diet. We compared four treatments, replacing none of the oat hay, 33 % of the oat hay, 66 % of the oat hay or all the oat hay with ground juniper. When we replaced all the oat hay with ground juniper, those lambs' growth performance and efficiency were the same as the lambs on 100 % oat hay.

When we replaced either 33 % or 66 % of the oat hay, the lambs actually did better than the ones on just oat hay. I think the additional fiber in the juniper may help the rumen environment, altering rumen bacteria and increasing digestibility efficiency. All of these diets included 40 % dried distillers grains, which contain a lot of highly digestible fiber. The lignin in the juniper wood may be complementing this.

The applicability of the technology is to harvest the whole trees and not just the limbs.

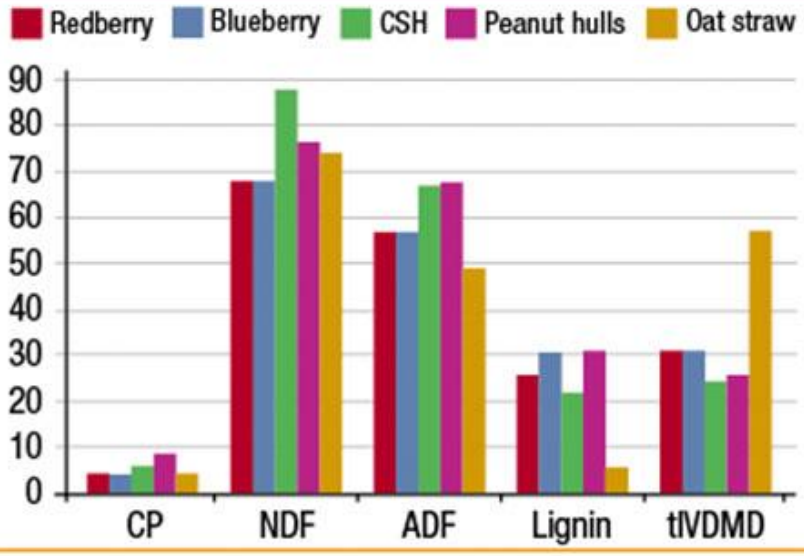
In this way, we are trying to expand this work to other juniper species to make it applicable in more regions. We've done a research project comparing red berry juniper to blue berry juniper, one-seed juniper (prevalent in New Mexico) and eastern red cedar (prevalent from central Texas to all eastern states). Eastern red cedar is a huge problem, taking over many pastures. It contains different terpene profiles and grows more looks like a pine tree than the other juniperus species.

The eastern red cedar may have higher lignin and be less digestible because it is bigger. However, it was 29% digestible. Looking at cottonseed hulls there are a few reports showing up to 30% digested, but in the batches we used, we found them about 20% to

23% digested. So, when grinding up the whole tree juniper tree and finding that it's more digestible than cottonseed hulls, this is incredible.

Crude protein in mature trees was 3.5 % to 3.6%. When they looked at smaller trees, less than 6 feet tall, their feed quality increased to almost 4.7% crude protein. Fiber went down significantly, and digestibility jumped up. Immature red berry trees were 50% digestible, blue berry about 44%, the one-seed about 50 % and the eastern red cedar 33%.

FIGURE 2 Juniper versus other roughages – nutritional value and digestibility



Source: Wood to Feed Program. Texas A&M AgriLife Research.

Final remarks

When juniper chips are valued at $20 to $30 per ton, this allows a landowner to recover the entire cost of juniper removal; approximately $300 to $500 per acre. Sounds great, but it gets better.

Ground juniper has unique characteristics not shared by any other feed ingredient in existence: (1) it requires no inputs by man to grow, e.g., land cultivation, planting, irrigated water, fertilizer, pesticides or herbicides; (2) when harvested, it can concurrently enhance

natural resources and land value, increase forage production and water availability, and reduce the risk of wildfires; and (3) it is available year-round, thus not subjected to seasonal pricing characteristics or availability.

Furthermore, ground juniper contains volatile oils (aka, terpenes, terpenoids) and condensed tannins (CT) at concentrations, which have been shown to positively affect animal growth performance, health and end product quality. These compounds may bring many advantages to the livestock production systems, such as:

- reduce urinary nitrogen excretion, fecal odors (associated with ammonia, skatole and indole) and fecal fly larvae development, all of which would be beneficial to feedyards;
- increase bypass protein, which could reduce crude protein intake requirements;
- reduce acidosis and bloat due to unique buoyancy and rate of hydration characteristics of the ground juniper fiber;
- alter rumen microbial populations, acting in a similar manner as ionophores;
- complement feedlot or pasture feed intake management systems;
- enhance colostrum quality and milk fatty acid composition; and
- maintain bodyweight and body condition during drought or winter conditions when used up to 50 percent of the mixed diet.

Now, we are amplifying our program not only to J*. monosperma, and J. virginiana*), but also to ground *Prosopis glandulosa* (mesquite), another very problematic plant in our rangelands that can have the same successful fate.