MACERATION: WHAT IS ITS POTENTIAL FOR CALIFORNIA GROWERS?

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ABSTRACT

Maceration, or severe conditioning, of alfalfa has several potential benefits for California alfalfa growers. Research has indicated that macerated alfalfa dries much faster than alfalfa cut using conventional equipment. In fact, it could be cut and baled the same day. The reduced drying time could help avoid rain damage, minimize yield losses associated with traffic damage, and allow for more timely irrigation after cutting. An additional cutting may be feasible in some areas. These factors may increase yield by approximately 10 percent. Additionally, maceration was found to significantly improve digestibility of alfalfa cut at two different levels of maturity. The increase in digestibility could allow growers to produce superior quality hay if they continue with their current harvest schedule. Or, growers could produce the same quality hay but improve yield and stand life by lengthening the cutting interval.

Key Words: alfalfa, harvesting, forage quality, feeding value, conditioning, drying time

INTRODUCTION

Maceration, or intensive conditioning, of forage crops is a revolutionary concept in hay harvesting technology. It may completely reform the hay-making process. To date, nearly all the forage maceration research has been conducted in the Midwest. There are numerous clear-cut advantages to this harvesting technique for growers in that part of the country. However, the potential advantages of maceration in western alfalfa hay-production systems are not as well defined.

Benefits attributed to forage maceration include: accelerated field curing, reduced harvest losses, and increased forage digestibility. How these benefits may impact alfalfa hay production in California is the topic of this paper. Preliminary results of a forage digestibility study with macerated California alfalfa are also presented.

ACCELERATED FIELD CURING

The most obvious advantage of maceration is a reduction in alfalfa drying time compared with alfalfa harvested with a conventional swather. The maceration process splits and shreds stems and abrades the waxy cuticle coating on plants. As a result, there is a significant increase in the surface area of the plant exposed to the environment and a large reduction in curing time. Under favorable conditions, the drying time required to produce hay has been reduced to as little as 5 hours. The hay is exposed to the elements for a much shorter time period and the probability of rain damage is reduced accordingly.

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However, for much of California, avoidance of rain damage is not a major concern for most of the year. Rain damage is most likely in early spring. But, unfortunately, maceration has less of an impact on drying rate when curing conditions are poor (i.e., cool weather with high humidity). Even though maceration can help growers escape rain damage this is not a major advantage in the Central Valley and Low Desert alfalfa production regions where mid-season rain is unlikely.

There are several other less evident advantages to rapid curing that will clearly benefit alfalfa growers throughout California. Four to eight days are typically required to dry alfalfa to a moisture content suitable for baling. The semi-dormant and non-dormant alfalfa varieties produced in much of California have considerable regrowth by the time the alfalfa is baled and removed from the field. Wheels from harvest equipment run over and pinch young regrowth shoots, injuring them and forcing them to regrow. This effect is significant; wheel traffic covers up to 70% of land area of an alfalfa field. Much of the wheel traffic is from the rake, baler, bale wagon, and the tractors used to pull these implements. It has been estimated that mechanical damage to regrowth shoots reduces yield up to 15 to 20 percent. Most of the yield decrease attributed to wheel traffic would be eliminated if alfalfa could be removed from the field the same day it is cut.

All alfalfa growers have observed the weakened and yellow appearance of alfalfa regrowth where windrows have laid. The effect of windrow curing time on alfalfa yield was quantified in a 4-year study in Nevada (Jensen and Gilbert, 1984). Alfalfa yield was compared in areas where windrows were and were not present. Yield loss under the windrow averaged 5, 7, and 18 percent for 2, 4, and 8-day curing times respectively. The ability to cut and bale in the same day would greatly reduce yield losses under windrows.

Table 1. The effect of delayed irrigation on alfalfa yield.

Days between cutting and irrigation	Yield (%)
1	100
2	89
3	86
4	86
6	70

(Source: H.J. Finkel, 1983, Irrigation of alfalfa. In: Handbook of Irrigation Technology, Vol. II. CRC Press.)

Alfalfa is most sensitive to moisture stress when young shoots begin growth following cutting. This is the time when growers are least able to deliver water. Growers cease irrigating prior to cutting to allow the soil to dry sufficiently to permit entry with harvest equipment and for improved field curing. Under conventional harvesting conditions, there is typically a 6- to 20-day period without irrigation. The soil may become excessively dry by the time the field is irrigated. The effects of delayed irrigation following cutting can be dramatic (Table 1). The degree of yield loss associated with delayed irrigation after cutting obviously varies depending on soil type, rooting depth of the alfalfa and other factors, but these data definitely indicate yield loss can be severe under some circumstances. Faster field curing of macerated alfalfa would enable growers to irrigate sooner after cutting, possibly avoiding the moisture stress that often occurs.

REDUCED HARVEST LOSSES

Macerated alfalfa is shredded into small fragments that can be easily lost. . To prevent harvest losses, rollers are used to press the macerated forage into a thin cohesive 'mat'. Harvest losses with conventional hay-making equipment are typically in the range of 6 to 19 percent. The macerator mat harvester could keep harvest losses well below this level.

POTENTIAL YIELD INCREASES WITH MACERATION

It is difficult to estimate the exact yield increase that could be anticipated with the maceration system. However, we feel a yield increase is likely as a result of the factors mentioned above: more timely irrigation, a reduction in harvest losses, and decreased windrow and traffic damage. The combination of reduced curing time and more timely irrigation after cutting may even result in an extra cutting in some areas.

A direct comparison of maceration and conventional systems has not been done in California. However, a comparison of baling and bagging was done in California that may give an indication of the potential yield increases with maceration. Greenchopping and harvesting alfalfa for silage are similar to maceration in that the alfalfa is removed from the field the same day it is cut, usually within a few hours. Even though both baled and bagged treatments were irrigated the same in this study, there was still was a 12 percent yield increase in bagged alfalfa over baled alfalfa treatments due to decreased leaf shatter and a reduction in traffic damage to regrowth. Therefore, we feel a yield increase of 10 percent is a reasonable prediction for a maceration harvest system compared with a conventional haymaking.

IMPROVED DIGESTIBILITY

Several studies conducted in the Midwest have shown a 10 percent or greater increase in the digestibility of severely-conditioned alfalfa. A trial was recently initiated at UC Davis to determine the effect of severe conditioning on the digestibility of California-grown alfalfa. Plots of alfalfa at two maturity levels, 31- and 45-days, was harvested July 31 with a plot-type sickle bar mower. Alfalfa of each maturity level was then macerated using a portable maceration unit. The degree of conditioning with the portable machine was greater than that which would occur with a field-scale macerator. The intent of this trial was to determine the effect of maceration on digestibility, not to quantify the actual improvement that could be achieved with a field-scale unit.

Macerated and non-macerated alfalfa samples of the 31- and 45-day alfalfa were analyzed for Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF), and Crude Protein (CP). In addition, we measured dry matter disappearance using a fistulated dairy cow (*in situ* technique). As expected, the 45-day hay was higher in fiber (ADF and NDF) and lower in CP than the 31-day alfalfa (Table 2). The maceration process lowered the apparent fiber concentration of both the 31- and 45-day alfalfa. However, the true ADF and NDF content of the control and macerated treatments should actually be similar. Maceration does not add or remove fiber; it just

changes physical structure of the plant. A reduction in measured fiber has been observed in other studies. A possible explanation for the reduction in measured fiber concentration may be related to greater digestion in the detergent fiber analyses caused by shredding action of the macerator. Another possible explanation was that there may have been some initial enzyme activity in the maceration treatment in the hours before the samples were dried. There was no difference in CP between the macerated and control alfalfa (Table 2).

Table 2. The effect of maceration on the forage quality of alfalfa cut at 31 and 45 days (data from UC Davis, 1997).

Treatment	ADF	NDF	CP	TDN
31 Day Control	32.3	38.3	20.2	52.3
31 Day Macerated	29.1	35.6	20.3	54.4
45 Day Control	34.6	41.7	18.0	50.8
45 Day Macerated	30.8	38.2	19.2	53.3

Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF), Crude Protein (CP) expressed on 100% DM basis. Total Digestible Nutrients (TDN) expressed on 90% DM basis calculated using the CA equation.

Dry-matter disappearance was the same for the 31- and 45-day alfalfa (Figure 1). However, there were dramatic differences between control treatments (whole unconditioned plants) and macerated forage. At zero time (samples were rinsed in rumen fluid to remove any immediately soluble components), about 80% of the plant DM was insoluble in the control treatments and 65% insoluble in the macerated treatments. This indicates that a much greater quantity of the sugars, starches, free amino acids and minerals which are contained within plant cells may be immediately available to the animal with the macerated alfalfa compared with the non-macerated.

This initial difference between control and macerated forage continued throughout the digestive process. Even at 48 hours, there were differences in the dry matter disappearance between the macerated and non-macerated treatments (more of the forage had digested in 48 hours in the macerated treatments). Digestion in the rumen is influenced by surface area. The shredding and rupturing of cells occurring with maceration greatly increases the surface area of the forage, and may explain the increased digestibility of the macerated forage.

As mentioned above, the degree of conditioning with the portable macerator was greater than that which would occur with a field unit. Therefore, the improvement in digestibility presented here should be viewed as the upper limit to what can be achieved through maceration rather than the expected improvement. Still, these results indicate that maceration should improve the digestibility of California alfalfa, as it has in studies conducted in the Midwest. We feel that a 10 percent improvement in the digestibility of alfalfa is a reasonable expectation.

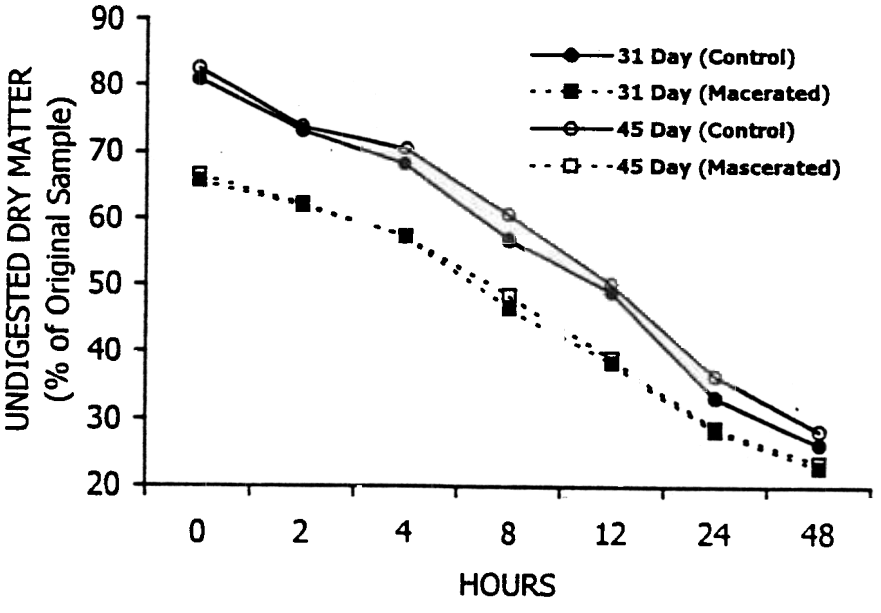

Figure 1. Effect of maceration on *In Situ* Dry Matter Disappearance (DDMD) of alfalfa harvested at 31 days and 45 days in Davis, CA. Each point represents 6 reps in 2 runs (12 observations).

POTENTIAL IMPACT

What impact will maceration have on alfalfa hay producers and the alfalfa market in California, if the above benefits can be confirmed? For most of the year, especially midsummer, it is difficult for alfalfa growers to produce alfalfa hay that meets the quality standards imposed for "dairy quality" alfalfa. In the springtime, growers can produce excellent quality hay, but there is risk of rain damage. During the summer in all parts of the state, growers find it difficult to produce high quality (low fiber) hay. This is mostly due to high temperatures causing very rapid alfalfa growth rates. In the desert regions of California, many growers completely give up on the dairy market during summer cuttings due to their inability to produce low fiber, high TDN hay. We estimate the proportion of California's production for which growers have difficulty meeting dairy standards to be 80%.

At the same time, the demand for high-quality forages continues to expand and California is an alfalfa-deficit state. The "high quality" proportion of the California market in particular is almost never satisfied. In both high and low price years, there is heavy demand for premium and extra premium hay (ADF <29%). Hence, if maceration can be widely shown to have a significant impact on feeding value, macerated alfalfa would find a place in California's expanding dairy industry.

The traditional approach to meeting dairy standards is through manipulation of cutting schedules. Growers often shorten cutting intervals (even as short as 21 days) to meet demands from their customers for high-quality alfalfa. However, these short cutting schedules usually decrease seasonal yield and cause poor stand persistence, often decreasing profitability.

With maceration, two scenarios are possible. First, alfalfa producers may choose to harvest using the same cutting frequency they are currently using (most growers' schedules are close to 28 days). Our data and other research data indicate that with maceration, growers might be able to meet dairy-quality standards even in mid summer, while maintaining or increasing current yield levels at the same harvest frequency.

Secondly, alfalfa growers may elect to lengthen harvest intervals, thereby increasing yields. At UC Davis, lengthening harvest intervals by one week resulted in a 0.6 to 2.2 ton/acre increase in annual yield. Thus, a seven-day delay in harvest schedule might result in over a ton/acre increase in yield. If maceration significantly improves feeding value of this mature hay, growers could potentially produce the same quality hay they produce now, but with greater annual yield.

DISADVANTAGES

Disadvantages of a maceration harvesting system are not yet fully clear, since production-scale machines have not been tested in California. Intensive conditioners would have greater power requirements than traditional harvesters. Since macerated forages have significantly different physical characteristics, baling and handling methods may have to be altered to handle the cured forage. Bales may not have the same integrity as traditionally-harvested hay, and may be more difficult to handle and transport. Although it would be easier to avoid rain damage, if rain does occur, losses would be greater with macerated than with conventionally harvested alfalfa. Forage testing procedures and ration balancing may have to be revised to try to evaluate the feeding potential of macerated forage. Lastly, even if the feeding value of macerated forage can be firmly established, the marketability must be tested.

CONCLUSIONS

If the practical and economic limitations to the development of macerator harvesters can be overcome, maceration could have a profound, even revolutionary impact upon California alfalfa production. Research data to date indicate that reduced drying time, as well as potential irrigation and other practical advantages, could increase yields over 10% in California, compared with conventional harvesting methods. Maceration of alfalfa would also result in hay that is higher in feeding value. The maceration process reduces drying time significantly, and may shorten the harvest process to as little as one-day (from cutting through baling). Although equipment manufacturers have indicated an interest in the development of macerators, it will be years until these machines are widely available. Further efforts to develop and explore maceration as a harvesting technique would be worthwhile.

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