

PROGRESS REPORT

Project Title: Increasing NE Wheat Productivity by Expanding Proso Millet Market

Reporting Period: July 1, 2009 to June 30, 2010

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We are delighted to report that the project was completed successfully. Our findings revealed interesting and important information on the potential of using proso millet on fuel ethanol production. According to our knowledge, this is the first study that investigated proso millet as a raw material for fuel ethanol. The findings of this project will not only allow us to conduct further research in this area, but also will contribute to Nebraska economy by improving ethanol production efficiency using this underutilized crop.

Materials and Method

We used two different proso millet varieties: 'Huntsman' (non-waxy type) and 'Plateau' (waxy type) and one corn hybrid (D104097 from O'Malley Grain Co.). Yeast fermentation was conducted using 30g grain mixture in 100 ml solvent in a 250 ml conical flask. Six different grain mixtures with different proportions of corn and proso millet corn were used in fermentation. Ethanol yield was measured after 48 hrs of fermentation.

Results and Discussion

There is significant difference in **grain composition** (Table 1) between corn and proso millet as well as between waxy and non-waxy types of proso millet. Proso millet has significantly lesser starch than corn. Whereas, proso millet has higher protein, fat, fiber and ash than corn. There is also some difference in starch content between two types of proso millet. These differences in grain composition might have influenced ethanol fermentation results as discussed below.

Table 1. Chemical composition of corn and proso millet.

Grain	Moisture %, db	Starch %, db	Crude Protein %, db	Crude Fat %, db	Crude Fiber %, db	Ash %, db
Corn	13.12	75.8	8.2	3.4	2.1	1.29
Plateau (waxy)	9.73	62.8	12.2	4.9	6.9	4.04
Huntsman (non-waxy)	10.97	66.7	12.5	3.95	6	3.11

Fermentation efficiency for ethanol production was higher using 100% proso or mixture of corn and proso compared to 100% corn (Table 2). It seems that the highest efficiency was obtained when 100% proso millet was used as raw material but this did not correlate with corresponding ethanol yield. **Ethanol yield** was higher when 10-25% proso millet was mixed with corn compared to 100% corn, 100% proso or other grain mixtures. Fermentation efficiency between 'Plateau' (waxy proso) and 'Huntsman' (non-waxy proso) was different but corresponding ethanol yield was not different. We did not find any consistent difference in fermentation efficiency or ethanol yield whether waxy or non-waxy proso was used in the grain mixture. Starch content is a major factor for ethanol fermentation. In general, ethanol yield increases as

starch content increases. Starch quality is also factor. Waxy starch is easy to digest compared with amylose starch. However, we did not see any effect in our preliminary data. We don't know why mixing proso millet with corn yielded higher ethanol compared to either 100% corn or 100% proso millet. It may be protein quantity or quality present in proso millet. Further experiments will be necessary to understand the differences. Fermentation experiment in a large capacity bioreactor will be necessary to scale up the fermentation, and obtain more "industry relevant" information.

Table 2. Fermentation efficiency and ethanol yield using corn, corn & proso mixture and proso were in ethanol fermentation.

Sample	Fermentation Efficiency (%)		Ethanol Yield (ml/lb grain)	
	Plateau	Huntsman	Plateau	Huntsman
100% corn	67	67	142.87	142.87
90% corn + 10% proso	72.8	73.1	153.15	154.40
75% corn + 25% proso	75.8	73	156.12	151.90
50% corn + 50% proso	75	68.9	148.83	139.71
25% corn + 75% proso	78.1	77.1	149.21	152.38
100% proso	80.5	76.5	147.77	147.10

Key findings

- Proso millet could be fermented to produce fuel ethanol using identical procedures those used for conventional corn fermentation.
- Ethanol production efficiency could be improved significantly by using proso millet, along with corn in the same fermentation mixture.
- Our findings suggest that starch-to-ethanol conversion efficiency of proso millet is significantly higher than that of corn, despite the fact that proso millet contains less starch than corn.
- Further research on proso millet grain structure, starch characteristics, and protein composition would provide answers to critical questions on the observed high ethanol yields from proso millet-corn blends.

Conclusion

The preliminary data is promising and exciting. However, we need to further research in the areas of (1) Detail characterization of proso millet grain, (2) optimization of fermentation using current proso millet varieties, (3) utilization of proso-based DDGS for cattle feeding, and (4) genetic improvement of proso millet to improve ethanol yield.

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