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Alkaline and Enzymatic Treatments for the Extraction of High Purity Natural Rubber from *Taraxacum kok-saghyz* (TK)

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ABSTRACT

Taraxacum kok-saghyz (TK), a rubber-producing dandelion, is currently being investigated as an alternative source of NR. Organic solvent extraction can be used to recover and purify natural rubber from TK roots but it is complex, expensive, and environmentally problematic. Current water-based processing methods do not result in rubber that meets industry standards for purity. In this study, various water-based methods to extract NR from TK roots were compared in order to identify those that result in the recovery of NR at high yield and purity. Various combinations of mechanical, alkaline, and enzymatic treatments were applied to hot water extracted TK roots. All methods recovered more than 50% of the rubber in the roots, but the amount of contaminants varied substantially. Rubber contaminants in enzyme hydrolyzed TK roots were 1.87% w/w dry weight, while alkaline pretreated and enzyme hydrolyzed TK rubber had contaminant levels as low as 0.48% w/w dry weight. Alkaline treatment of extracted rubber also diminished the levels of contaminants of TK rubber. However, further analysis is needed to determine the effect of alkaline treatments on TK NR quality. These results indicate that coupling alkaline pretreatment and enzymatic digestion may result in natural rubber that meets industry standards without using organic solvents.

INTRODUCTION

Natural rubber is an essential, naturally occurring, raw material used throughout the world and is vital to the modern economy. The US imports 100% of the natural rubber it uses, which represents 8% of global production worth US$2 billion (1). To date, 92% of NR consumed is produced in Southeast Asia from a single plant species; the para rubber tree, *Hevea brasiliensis* (1). The supply of NR is insecure, due to burgeoning demand, price instability, labor shortage, and disease (2). *Taraxacum kok-saghyz* (TK), a rubber-producing dandelion, is currently being developed as an alternative source for NR production. Processes for TK NR recovery and purification date back to the 1940's, when TK was studied for the first time as an alternative source of NR by the US (3). TK NR extraction consisted of water extraction of dried roots followed by pebble milling in aqueous media and NR recovery by flotation (3). However, the pebble milling step entrains root material in the rubber at concentrations as high as 10-15% w/w dry NR, limiting its use (3). Organic solvent extraction can be used to recover and purify natural rubber from TK roots that meets industry standards, but it is complex, expensive, and environmentally problematic. More recently, several patents have been issued describing water-based methods for the extraction of NR from non-Hevea rubber plants, among them TK. Nevertheless, it is not clear if these methods generate rubber that meets industry specifications. The goal of this research was to investigate and optimize methods to improve the purity of TK NR sufficiently to meet rubber industry standards required for commercial applications, without compromising yield and polymer quality.

MATERIALS AND METHODS

TK planted in spring and harvested in fall, 2016, at OARDC were used for this research. Harvested roots were washed, dried at 50°C, thoroughly mixed and then stored at 4°C until use. The rubber concentration was 70 mg rubber/g dry root as determined by accelerated solvent extraction (2). A variety of treatment combinations were tested as summarized in Fig.1. The dry TK roots (800 g) were extracted 6 times with a 1:10 volume of 98˚C water. Pebble milling was conducted in 315 g wet water extracted roots following established methods (3). Alkaline treatment involved 387 g of wet water extracted roots, 180 mg NaOH/ g dry water extracted roots at 160˚C for 20 min. For enzymatic treatment, roots were 315 g wet water extracted roots. Enzymatic hydrolysis was conducted using Cellic Ctec 2 cellulase and Novozyme pectinase NS-81215 in 0.1 M sodium citrate buffer pH 6.0, 50°C, at 200 rpm for 48 h. Centrifugation was conducted in 500 mL centrifuge bottles at 10000 rpm, 10°C for 15 min. Alkaline treatments was conducted with a solution of 2% NaOH at 120°C for 20 min. Filtration was done using a sieve N.20. Rubber yield was determined gravimetrically and rubber purity was determined according to ASTM D1278-91a.

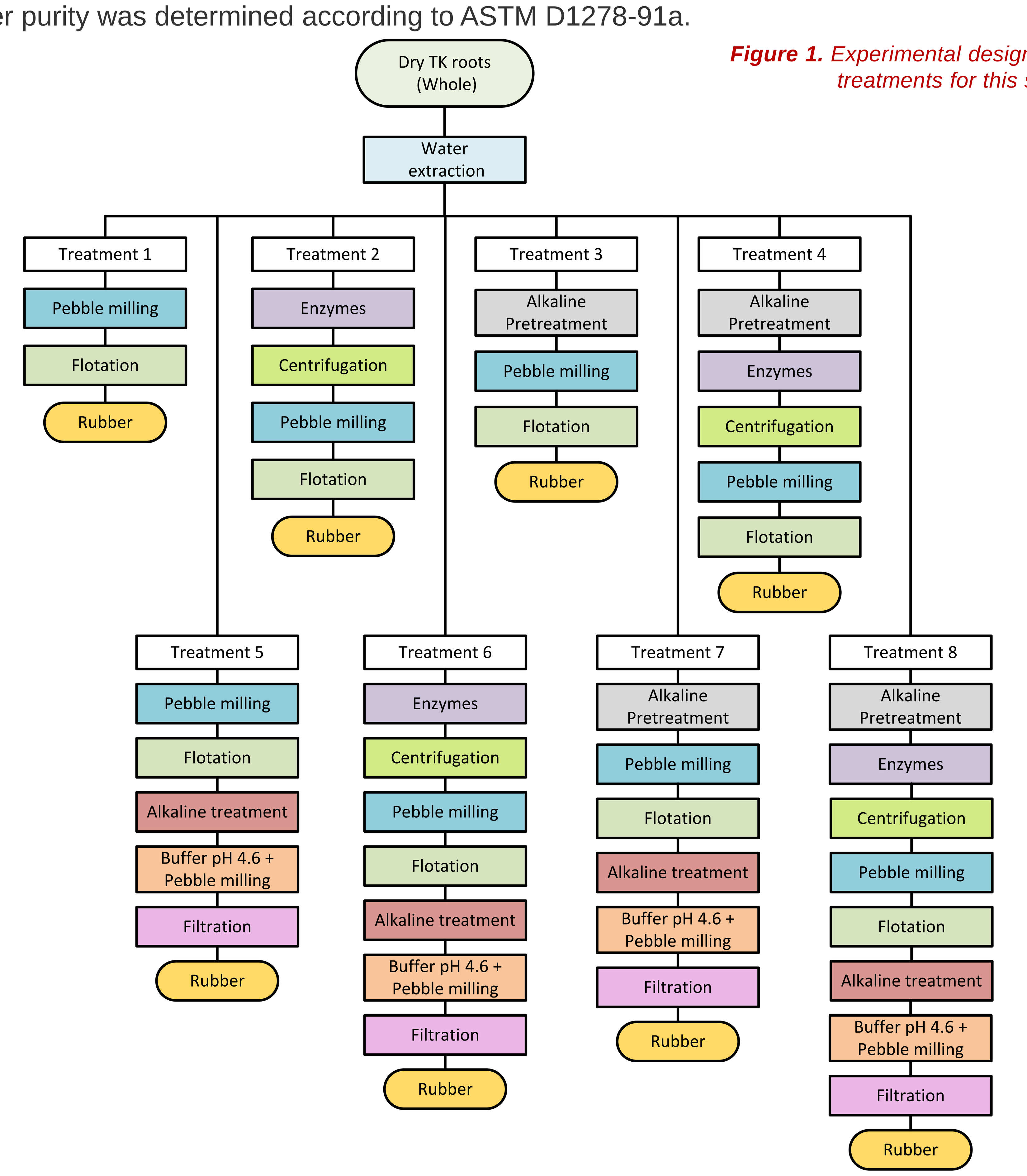

Figure 1. *Experimental design and treatments for this study*

RESULTS

Rubber yield and rubber purity for TK NR after applying different treatments (Fig. 2) indicated that the best results were obtained with treatment 4 (Table 1). The best yields however were less than 70%. Purity in the best cases reached 99.5% which nearly meets ASTM standards for commercial grades of NR.

Treatments	Yield %	Purity %
1	44.17	91.00
2	59.59	98.13
3	53.13	NA
4	67.49	99.52
5	35.42	94.39
6	57.02	99.15
7	51.10	NA
8	66.19	99.49

Table 1. *Yield and purity of rubber produced from TK roots using treatments 1 to 8 (Fig. 1).*

DISCUSSION

Application of alkaline pretreatment or enzymatic digestion of whole TK roots by themselves improved rubber yield and purity as compared to previous methods developed during the 1940s (treatment 1, [3]). The use of both alkaline pretreatment and enzymatic hydrolysis further increased rubber yield and purity. Rubber purity of 99.5% are the best results reported and represent a big step forward in the development of water-based processes for the recovery of pure rubber from TK roots at high yield. The use of alkaline treatments on extracted TK NR also improved rubber purity while diminished rubber yield. This is because degradation of rubber contaminants reduced rubber yield, since yield was calculated based on recovered rubber (pure NR plus contaminants). Effects of alkaline pretreatments on rubber from TK need to be further evaluated, since when applied alone, they seemed to reduce TK rubber quality (data not shown). This was evident in treatments [3] and [7] in which rubber could not be dissolved in solvents used for the determination of rubber purity. In future work, rubber molecular weight and mechanical properties will be used to asses the effects of the treatments on rubber quality.

CONCLUSIONS

Alkaline pretreatment, enzymatic digestion, and combinations of these treatments markedly improved rubber yield and purity as compared to mechanical methods. The best treatments resulted in rubber with purities nearly meeting ASTM standards. Further optimization to improve yield and purity to meet ASTM specification is needed to determine a suitable method for commercial TK NR production. In future studies the effects of treatments on rubber quality will be determined.

REFERENCES

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