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NOTE DE RECHERCHE

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UTILIZATION OF LOW QUALITY SUGAR MAPLE TREES FOR WOOD FUEL PELLETS PRODUCTION

Analyses of chemical composition and pelletizing characteristics of wood particles from vigorous and non-vigorous sugar maple trees were conducted. Tree vigor classes were determined based on the MSCR classification system proposed by Boulet[1]. Results indicated that, compared to the most vigorous trees, wood particles from the least vigorous trees had several advantages for the production of fuel pellets. Their higher extractives and lignin content demonstrated the suitability of this material for pelletization since the higher contents could raise the calorific value of the fuel, contribute to the self-bonding of wood particles and facilitate the pelletization process. No significant difference in the higher heating value of wood among tree vigor classes and between unextracted and extracted wood samples was observed. Finally, less friction in the pelletizer and higher pellet strength were observed during the study.

INTRODUCTION

Past harvesting practices used in the temperate hardwood forests of the province of Québec, Canada, led to most of the valuable tree stems of both sugar maple and yellow birch being cut for the production of hardwood lumber. This resulted in a depletion of valuable stems and/or vigorous trees and, ultimately, in degraded hardwood forests currently containing a large proportion of non-vigorous tree stems with very little or no commercial value. From a forest management standpoint, the presence of these low vigor trees with low quality stems has a negative effect on forest health and value and harvesting priority is now given to low vigor trees.

An economically efficient practice for improving the vigor of degraded hardwood forests requires markets for low quality unused trees. The increasing demand for renewable energy in recent years has raised interest in the use of low quality trees as raw material for the production of fuel pellets. The objective of this study was to evaluate the suitability of low quality sugar maple stems for fuel pellet production.

I. MATERIALS AND METHODS

•Nine sugar maple trees of various vigor classes in a hardwood stand located in Mont-Laurier, Québec, Canada were sampled and felled. Three, with green foliage and no external wounds, were classified as healthy trees (class R - reserve stock tree), three, with signs of wounds, poor foliage and the presence of sapstain fungi, were classified as weakened or defective trees (class S – surviving stock tree), and the rest, showing signs of loose and/or fallen bark and the presence of wood rotting fungi, were classified as dying trees (class M - moribund tree).

•Three logs were extracted from each tree. The first log, of about 60 cm in length, was extracted from a distance of approximately 70 cm from the root collar and used for chemical analyses. The other two were 1.2 m long, one extracted from a height of 1.3 m and the other from one-third of the trunk length down from the crown base, were used for pellet production.

•A full split-plot factorial design with four independent variables was used to study the influence of temperature, moisture content, compressive force, and particle size on friction and properties of pellets made from wood particles. Pellets were individually produced in a single pelletizer (Figure 1) under controlled conditions as indicated in Table 1.

Table 1. Experimental ranges and levels of variables.

Parameter	Code	Level		
		0	1	2
Temperature (°C)	X1	75	100	125
Moisture content (%)	X2	8.1	11.2	17.2
Compressive force (N)	X3	1500	2000	2500
Particle size (mm)	X4	< 0.25	0.25-0.5	0.5-1.0

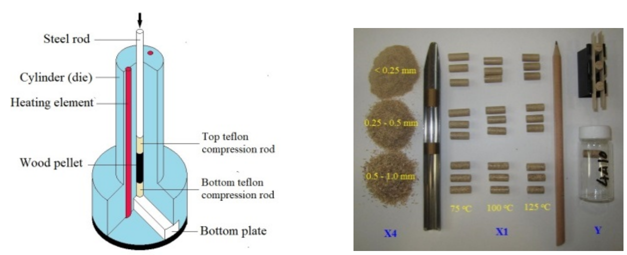

Figure 1. Schematic diagram of the single pelletizer (left), and pellets produced from wood particles of various size at three preset temperatures (right).

II. RESULTS AND DISCUSSION

•The chemical composition of wood samples is presented in Table 2. The mean ash content varied from 0.38% in healthy trees to 0.73% in weakened trees and 0.97% in moribund trees. The amounts of extractives and lignin are two important parameters positively affecting the heating value of wood. In the current study, the mean extractive content was 5.4%, 4.8%, and 7.3% for wood samples from trees of classes R, S, and M respectively. The amount of total lignin varied significantly from 25.0% in healthy trees to 26.4% in weakened trees, and 26.8% in moribund trees. Lignin content increases due to its resistance to degradation by pathogens has been reported in the literature.

Table 2. Chemical composition of analyzed wood samples by tree vigor classes. Standard deviations are in parentheses.

Tree vigor class	Ash (%)	Extractives† (%)	Lignin‡ (%)
Healthy tree (class R)	0.38^{c} (0.03)	5.44^{b} (0.20)	25.06^{b} (0.35)
Weakened tree (class S)	0.73^{b} (0.07)	4.88^{c} (0.31)	26.40^{ab} (0.52)
Moribund tree (class M)	0.97^{a} (0.05)	7.32^{a} (0.03)	26.83^{a} (0.75)

† Total extractives; ‡ total lignin. Means with the different letters within the same column are significantly different (*p < 0.05*).

•The calorific value of wood samples is presented in Table 3. In general, the higher heating values of wood did not change measurably among tree vigor classes and between extracted and unextracted samples. The greater amounts of extractives and lignin in wood of the less vigorous trees had a positive role in maintaining calorific values, in spite of the negative effect of ash on wood calorific value.

Table 3. Mean of higher heating value (HHV) by tree vigor classes. Standard deviations are in parentheses.

Tree vigor class	HHV of sugar maple (MJ/kg)	
	Non-extracted wood	Extracted wood
Healthy tree (class R)	19.59^{abc} (0.08)	19.57^{abc} (0.07)
Weakened tree (class S)	19.68^{ab} (0.10)	19.64^{abc} (0.07)
Moribund tree (class M)	19.62^{abc} (0.12)	19.56^{abc} (0.05)

Means with the same letter do not differ significantly (*p < 0.05*).

•The ANOVA results show that linear terms of all main effects were significant at the $P < 0.001$ level for all dependent variables. The interactions were also all significant at the $P < 0.02$ or less. Friction was observed to be higher for pellets pressed from particles of healthy trees than for those from particles of less vigorous trees (Figure 2). Overall average friction values of 19.6 N/mm and 17.9 N/mm were measured for pellets pressed from particles of the most and the least vigorous trees, respectively. The higher extractive content in particles of less vigorous trees could have contributed to the reduction in friction. Compression strength was observed to be higher for pellets pressed from particles of less vigorous trees than those pressed from particles of healthy trees (Figure 3). The overall average compressive strength values of 43.0 N/mm and 46.6 N/mm were measured for pellets pressed from particles of the most and the least vigorous trees, respectively. The higher lignin content and hot water-soluble extractives in wood particles from the less vigorous trees could contribute to pellet compression strength. In addition, lower hardness due to fungal attack of some of the particles from the less vigorous trees could also contribute to the compression strength of pellets produced under the combined effects of the pelletizing conditions (temperature, moisture content, compressive force, and particle size) as shown in Table 1

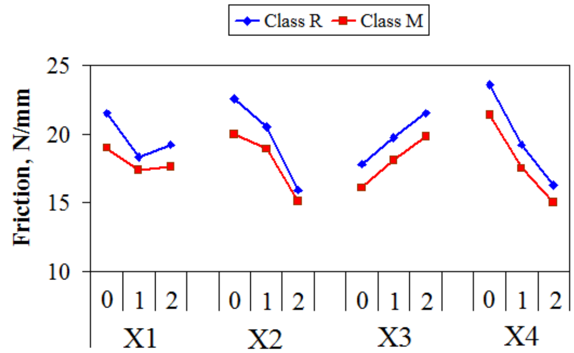

Figure 2. Main effects plot of friction for pellets pressed from particles of healthy trees (class R) and moribund trees (class M).

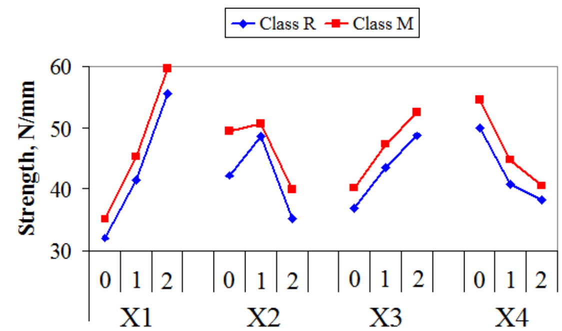

Figure 3. Main effects plot of compression strength for pellets pressed from particles of healthy trees (class R) and moribund trees (class M).

III. Conclusions

•Tree vigor in sugar maple had a significant effect on wood chemical composition, including the amounts of ash, extractives, and lignin.

•No significant differences in the higher heating value of wood among tree vigor classes and between extracted and non-extracted wood samples were found.

•Compared to particles from healthy trees, the use of particles from less vigorous trees reduces friction and increases the compression strength of the pellets produced.

•Wood particles from low quality trees are more favorable than those from healthy trees for pellet manufacturing.

[1]Réf: BOULET, B. 2007. Défauts et indices de la carie des arbres: guide d'interprétation. 2e édition. Ministère des Ressources naturelles et de la Faune, Québec, Canada.

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