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Storage and characterization of cotton gin waste for ethanol production

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Abstract

In 2002, about 17.1 million bales of cotton were ginned in the United States and the estimated cotton gin waste was 2.25×10^9 kg. The disposal of cotton gin waste (CGW) is a significant problem in the cotton ginning industry, but CGW could be potentially used as feedstock for bioethanol. Freshly discharged CGW and stored CGW were characterized for storage stability and potential for ethanol production by determining their summative compositions. The bulk densities of the fresh wet and dry CGW were $210.2 \pm 59.9\,\mathrm{kg\,m^{-3}}$ and $183.3 \pm 52.2\,\mathrm{kg\,m^{-3}}$, respectively. After six months of storage the volume of piles A, B, and C decreased by 38.7%, 41.5%, and 33.3%, respectively, relative to the volume of the pile at the start of the storage. The ash content of the CGW was very high ranging from 10% to 21% and the acid-insoluble fraction was high (21–24%). The total carbohydrate content was very low and ranged from 34% to 49%. After three months storage, chemical compositional analysis showed the loss of total carbohydrates was minimal but after six months, the losses were as high as 25%. This loss of carbohydrates suggests that under open storage conditions, the feedstock must be processed within three months to reduce ethanol yield losses.

Keywords: Cotton gin waste; Summative composition; Total carbohydrates; Glucan; Storage

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1. Introduction

Waste management is a significant problem facing the cotton ginning industry. The ginning of one lint bale (227 kg) of spindle harvested seed cotton generates between 37 kg and 147 kg of waste (Thomasson, 1990). In 2002, about 17.1 million bales of cotton were ginned in the United States (Adams et al., 2003) and the estimated cotton gin waste was 2.25×10^9 kg. Cotton gin waste (CGW) consists of sticks, leaves, burs, soil particles, mote, cotton lint, and other plant materials (Schacht and Lepori, 1978). Slight differences in the proportions of the components are usually found between varying mechanical harvest methods (Thomasson, 1990).

The traditional methods of CGW disposal include incineration, landfilling, and incorporation into the soil (Thomasson, 1990). Until the enactment of the Clean Air Act in 1970, incineration was an acceptable and convenient choice. The most recent amendment of the act (July 1997) further restricts particulate matter discharge into the atmosphere, thus eliminating incineration as an option for small cotton gins (Fuller et al., 1997). Furthermore, because of the high ash content of the feedstock, there could be potential slagging problems associated with large-scale incineration.

Landfilling is not a viable option because tipping fees are very high. The current method of choice is the incorporation of the waste into the soil, an option that is unsuitable for the climatic conditions of some states such as Virginia. There is much concern over the presence of weed seeds, insect infestations, diseases, and excess chemicals in the waste that may degrade the receiving land.

The conversion of CGW to value-added products has not been extensively studied. Brink (1981) and Beck and Clements (1982) studied the conversion of CGW to ethanol and concluded that 142.8 L (37.8 gal) ethanol per tonne could be produced from this feedstock. Griffin (1974) and Schacht and LePori (1978) analyzed cotton gin waste to assess its fuel value for combustion. These researchers proposed using the feedstock for the production of char, hydrogen, protein, and pyrolysis gases. Parnell et al. (1991) investigated the gasification of cotton gin waste in a fluidized bed reactor. The gas produced had a low heating value and the projected net revenue from the process was very low. However, activated carbon produced from the gasification of the feedstock was found to be cheaper, but less effective than those produced from conventional carbon sources (Capareda et al., 1989).

Our studies (Agblevor, 2001) on CGW using steam explosion/enzyme hydrolysis and fermentation showed that ethanol yield was dependent on the source of feedstock. The ethanol yields ranged from 113 L/tonne to 190 L/tonne CGW. The differences stemmed from the cotton lint and hull content of the CGW. Where the lint content was high the ethanol yield was subsequently high and vice versa. We observed that at the cotton gins in Southeast Virginia, because of the high cotton lint content of the raw material and the spraying of the CGW with water at the point of discharge, the material was easily degraded by microorganisms. For a year-round production of ethanol from this feedstock, effective storage will be essential. Our literature survey did not reveal any published data on the stability of CGW during storage. Thus, the need to characterize both fresh and stored CGW is warranted. In this paper, we report the influence of storage on the composition and potential ethanol yield from CGW.