*environmental sciences proceedings*

MDPI

*Proceeding Paper*

# Possibilities for Using Waste Hemp Straw for Solid Biofuel Production †

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† Presented at Innovations-Sustainability-Modernity-Openness Conference (ISMO'21), Bialystok, Poland, 14 May 2021.

**Abstract:** Hemp biomass is useful in many branches of the economy. Hemp cultivation to obtain seeds has been gaining importance recently. In this process, shredded straw is a waste biomass which can be used for energy purposes. The possibilities for using waste hemp straw for solid biofuel production are described in this extended abstract, using the example of the Henola variety. The analyzed biomass was characterized by a high content of cellulose (over 40%) and hemicellulose (almost 30%), as well as a high calorific value (18,300 kJ·kg$^{-1}$) and heat of combustion (17,100 kJ·kg$^{-1}$).

**Keywords:** bioenergy; *Cannabis sativa*; circular economy; pellets; briquettes



**Citation:** Frankowski, J.; Sieracka, D. Possibilities for Using Waste Hemp Straw for Solid Biofuel Production. *Environ. Sci. Proc.* **2021**, *4*, 9018. https://doi.org/10.3390/environsciproc2021009018

Academic Editors: Dorota Anna Krawczyk, Iwona Skoczko and Antonio Rodero Serrano

Published: 25 October 2021



## 1. Introduction

Hemp (*Cannabis sativa* L.) was one of the first species used by humans for economic purposes. It has been cultivated for centuries in many regions of the world in order to obtain fiber for textiles and seeds, which are used in various branches of the economy [1]. Seeds are a source of protein and oil, rich in multi-saturated fatty acids [2,3]. Their inflorescences have been used in medicine due to the cannabinoids contained in them in high amounts [4]. Owing to its unique properties, hemp biomass is also useful for biocomposite production [5]. In addition, it can be used for energy purposes; shafts, which are waste produced when obtaining fiber, can be successfully used for the production of solid biofuels, such as pellets or briquettes [6]. Given the circular economy, this is a particularly reasonable way to use the waste biomass remaining after panicle deseeding. This biomass is not suitable for textile purposes or as a fertilizer due to difficulties in plowing. With the growing demand for hemp seed use for food and seed purposes, the volume of this type of waste biomass is increasing every year [7,8]. The aim of this study was to determine the possibilities of using waste hemp straw of Henola, one of the most popular Polish hemp varieties, for solid biofuel production.

## 2. Materials and Methods

Typical varieties of hemp give low yields of seeds (approx. 8–12 dt/ha), which are mainly used as seed for further reproduction or for the production of nutritious edible oil. Due to consumers' growing interest in products from *Cannabis* L., other than for fiber, work on the creative breeding of new varieties has been intensified in recent years. Henola, one variety of hemp registered in 2017, is characterized by an approximately one month-shorter vegetation period, two times-shorter length of plants, significantly larger inflorescences and a much higher seed yield compared to typical hemp fiber cultivars. The average yield of straw from Henola seed plantation is approx. 18 Mg·ha$^{-1}$ of dry mass [7,8]. Nowadays,

this variety has been successfully cultivated in Europe and North and South America, as well as in Australia.

Analyses of the chemical composition of the hemp biomass from the growing season 2020 were performed at the Faculty of Wood Technology PULS, according to the PN-92/P-50092 standard for plant material. The following parameters were determined:

- moisture content using the oven-dry (gravimetric) method,
- content of cellulose according to Seifert using a mixture of acetylacetone and dioxane,
- content of lignin according to Tappi using concentrated sulfuric acid,
- content of holocellulose using sodium chlorite,
- pentosanes using the trihydroxybenzene method,
- contents of minerals determined according to the DIN 51731 standards.

Experimental materials were ground in a Pulverisette 15 laboratory mill, with the analytical fraction of 0.4–0.1 mm being separated on sieves.

The determination of the heat of combustion was carried out in accordance with PN-81/G-04513 in the ZKL-4 calorimeter, which is designed to measure the heat of combustion of solid fuels. In the hemp straw sample, the content of carbon, hydrogen and nitrogen was also determined using procedures compliant with the requirements of the following standards: PN-EN 15104: 2011 and PN-EN 15289: 2011 [8–10].

## 3. Results

The obtained results of hemp biomass of the Henola variety were shown in Table 1, as the mean value of three analyzed samples.

**Table 1.** The results of hemp biomass chemical composition analyses (% of dry mass).

| Analyzed Characteristics | Content (% of DM) |
|---|---|
| cellulose | 41.23 |
| lignin | 14.12 |
| hemicellulose | 29.76 |
| pentosans | 19.42 |
| substances soluble in cold water | 16.24 |
| substances soluble in hot water | 19.13 |
| substances soluble in 1% NaOH | 43.05 |
| ash | 6.58 |
| nitrogen | $0.52 \pm 0.07$ |
| hydrogen | $5.66 \pm 0.02$ |
| humidity | 8.5 |
| heat of combustion | 18,300 $kJ \cdot kg^{-1}$ |
| calorific value | 17,100 $kJ \cdot kg^{-1}$ |

The biomass of the Henola variety is characterized by a high content of cellulose (over 40%) and hemicellulose (almost 30%). Moreover, analyzing the obtained results, it can be concluded that its calorific value is only slightly lower than that of other wastes commonly regarded as a valuable substrate for the production of solid biofuels; it is higher than the heat of combustion of kenaf biomass (15,800 $kJ \cdot kg^{-1}$), Virginia mallow (17,200 $kJ \cdot kg^{-1}$) and rapeseed (17,600 $kJ \cdot kg^{-1}$). Nevertheless, the obtained value of this parameter is lower than in the case of wheat straw (18,700 $kJ \cdot kg^{-1}$) or hemp panicles (19,800 $kJ \cdot kg^{-1}$) [11]. Henola's calorific value is also higher compared to floriculture waste such as tulips and chrysanthemums. Nevertheless, the obtained result is lower than the calorific value of roses and sunflowers [12].

## 4. Conclusions

The results of the carried-out analyses indicated that the hemp biomass of the Henola variety is a good substrate for the production of solid biofuels. In addition, the development of a comprehensive technology for cultivation, harvesting and use of biomass in industry

based on the issues of agricultural engineering will allow the determination of not only the energy potential, but also the general economic potential of the Henola variety, as well as the best methods for implementing the obtained results into practice in accordance with the principles of the circular economy.

**Author Contributions:** Conceptualization, J.F., D.S.; methodology, J.F.; software, J.F.; validation, J.F., D.S.; formal analysis, J.F., D.S.; investigation, J.F., D.S.; resources, J.F., D.S.; data curation, J.F., D.S.; writing—original draft preparation, J.F., D.S.; writing—review and editing, J.F., D.S.; visualization, J.F.; supervision, project administration and funding acquisition, J.F. All authors have read and agreed to the published version of the manuscript.

**Acknowledgments:** This extended abstract was prepared as a result of the realization of the project entitled: "Improving the technology of hemp biomass pelletization" as part of the project "Incubator of Innovation 4.0" under the Intelligent Development Operational Program 2014–2020 financed by the Polish Ministry of Science and Higher Education (contract number: 3/11/2020/IWNiRZ).

**Conflicts of Interest:** The authors declare no conflict of interest.

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