ONLINE ISSN 2069-7430
ISSN-L 1841-4737
PRO LIGNO
www.proligno.ro
Vol. 13 N° 4 2017
pp. 579-585

RESEARCH ON BRIQUETTES OBTAINED FROM SHREDDED TOBACCO CIGARETTES, AS A LIGNO-CELLULOSE FUEL

Aurel LUNGULEASA
Transilvania University of Brasov, Faculty of Wood Engineering
Str. Universitatii nr. 1, 500068 Brasov, Romania
E-mail: lunga@unitbv.ro

Cosmin SPIRCHEZ
Transilvania University of Brasov, Faculty of Wood Engineering
Str. Universitatii nr. 1, 500068 Brasov, Romania
E-mail: cosminspirchez@unitbv.ro

Adriana FOTIN
Lecturer dr.eng.- Transilvania University of Brasov, Faculty of Wood Engineering
Str. Universității nr. 1, 500068 Brasov, Romania
E-mail: adrianafotin@unitbv.ro

Abstract:
The paper presents some considerations about briquettes derived from waste shredded tobacco cigarettes, used as a ligno-celluloses fuel. A synthesis of main advantages and disadvantages of tobacco plants is presented. Physical and calorific values of these types of briquettes are presented according to their different methodologies. If density and calorific value fall into the European standardized restrictions, ash content exceeds these restrictions due to the torrefaction process of tobacco manufacturing and the fact that tobacco actually is an agricultural plant (cereal and other agricultural plants usually have an higher ash content). Finally it is concluded that the briquettes obtained from shredded tobacco can be used moderately as fuel for stoves and furnaces.

***Key words**: tobacco; briquette; ash content; calorific value.*

INTRODUCTION

Tobacco cigarette consumption has increased worldwide in recent years, despite negative advertising imposed by the European community and other international organizations. In particular the illegal sale of cigarettes has increased, mainly due to soaring prices caused by the imposition of customs duty and tax. As a result there are increasing quantities of cigarettes seized by authorities that must be destroyed. Destruction of these cigarettes is necessary because there is no company stamp and thus no legal liability imposed. As a result all consumers can have their lives threatened. Usually the seized cigarettes must be destroyed by shredding, following disposal in landfill by companies who are specialized in this field. These companies can recycle the remnants of tobacco, filters and paper resulting from shredding and can, for example, produce briquettes to be used in combustion. To be able to use them in good condition in heating boilers and stoves, cigarette briquettes made from chopped material had to be analysed for physical, mechanical and calorific value. Also, before knowing the characteristics of briquettes it is necessary to know the components of cigarettes, especially tobacco leaves, with form the majority by over 80% by mass.

Tobacco has the botanical name *Nicotiana species* L, Solanaceae family. Worldwide there are about 70 species of tobacco, from which *Nicotiana tabacum* is the most common, followed by the stronger one *Nicotiana rustica*, both of which originate from the USA. Tobacco can grow on the same land for over 15 years, without apparent fatigue of the soil (TTG 2017). Due to its sensitivity to cold, seeds are first germinated on a warm seedbed (with fresh manure), then planted in the field. Before planting, seedlings are prepared by reducing total exposure and contact with the outside air both during the day and the night. Planting is done in cooler periods of the day, morning and evening in April and May (for conditions of Romania and other countries of South-eastern Europe). Weed control is realized with herbicide and/or by performing manual or mechanized weeding. Before harvesting, the cutting of the flowers is recommended, to avoid the leaves growing too vigorously (Fig. 1).

ONLINE ISSN 2069-7430
ISSN-L 1841-4737
PRO LIGNO
www.proligno.ro
Vol. 13 N° 4 2017
pp. 579-585

Fig. 1.
Plant of tobacco and its inflorescence.

Leaf tobacco harvesting is done manually in several episodes, by peeling off the 5-6 leaves from the central stem. After harvesting, the leaves are kept for 2 hours in a pile for a slight wilting, so that leaves do not break during subsequent manipulations. Leaf tobacco drying is done in several stages, the first stage being their yellowing, which is obtained under conditions of constant temperature and humidity, in order to reduce the moisture content of the leaves from 80% to 40%. Drying can be made natural or artificial, in a shaded area and without air flows. Tobacco is placed in bundles of 10-15 sheets of leaves (Fig. 2). Current production is 1000-2000kg/ha. In the production process of cigarettes the torrefaction operation of leaves is used, employing a thermal process at high temperatures above 200^0C, in order to intensify the flavour of the tobacco.

Fig. 2.
Leaves of tobacco in time of naturally drying.

Tobacco dried leaves are smoked as cigarettes, cigars and in pipes. Using cigarettes generally has both advantages and disadvantages. The main disadvantage is considered that smokers have a risk factor for many diseases that are potentially life-threatening, such as those affecting the heart, liver and lungs, especially the onset of cancers. The World Health Organization sets forth that smoking is the biggest cause of premature death in the world (Stefani 2010). Fig. 3 shows the top of 5 global manufacturers of tobacco. It notes that big countries are in the top position, like China, India, Brazil and the USA. Tobacco **c**igarette consumption is however different when referring to the number of inhabitants of the country of reference, the first places being taken by the Czech Republic and South Korea, followed by Germany, Switzerland and Turkey (as at 2011).

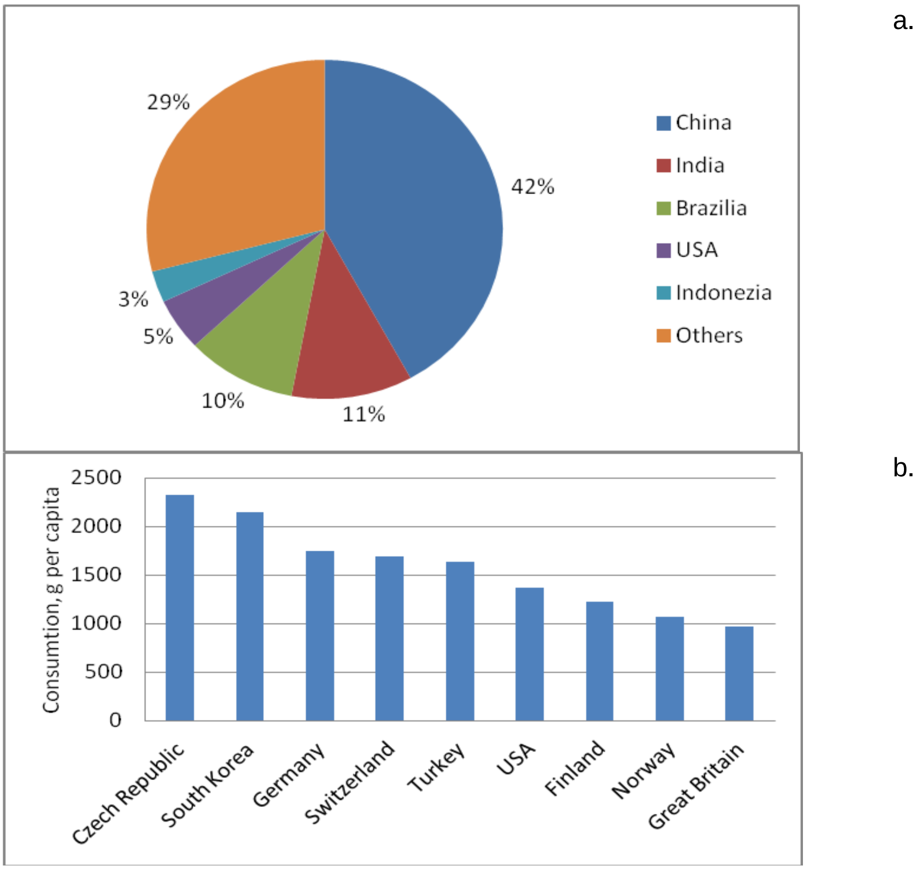

Fig. 3.
Top 5 big world-wide producers of tobacco on 2012 (a) and annual consumption per capita (b) (adaptation from Wiki 2017).

Tobacco has long been used as a medicinal plant in South and North America, being consumed in many forms such as chewing, smoking, snuff, eating, drinking, and body anointments and in the form of eye drops (Stefani 2010). Tobacco popularity is due to the fact that small amounts of tobacco produces a mild stimulating effect on the functions of the user, while large quantities can produce hallucinations and even deep trances. Tobacco was also a guide to health and healing, had mystical connections and was part of ancient cultures and civilizations. Some American tribes have used tobacco to cure ailments such as ear pain, snake bites, cuts and burns, respiratory disease, fever, seizures, nerve disorders, urinary and skin diseases. In Europe, tobacco was introduced after its discovery in America by Christopher Columbus in 1492, by Jean Nicot in 1585, the French ambassador in Portugal, after whom the name nicotine was adopted (Vlaescu 2011). At first the tobacco was used as a decorative element (due to special and beautiful blossom), then for its medicinal properties. The main compound of tobacco is nicotine which is an alkaloid that has a relaxing effect and stimulates the person consuming it by increasing levels of dopamine and serotonin. Nicotine is an anti-inflammatory and has been scientifically proved that it can treat Alzheimer's and Parkinson's disease or may cause their delay (TTG 2017). When ancient tribes make peace, they smoke the peace pipe.

Over time briquettes were made from ligno-cellulosic stems of tobacco (Xinfeng et al. 2015, Peševski et al. 2010) due to their properties but never from destroyed cigarettes because there was insufficient quantity.

OBJECTIVE

The main objective of the present research is to investigate the possibility of using briquettes made of tobacco cigarettes, in order to use them as ligno-cellulose fuel in stoves and furnaces.

MATERIALS AND METHOD

Some briquettes were made from shredded remains of tobacco cigarettes, experimentally on a hydraulically driven machine. These briquettes were graded related to EN ISO 17225-2: 2014. The density of cigarette briquettes was determined as the ratio between the mass and volume of briquettes in each piece. Taking into account that the briquettes form is cylindrical, it follows that their density is determined by the following relationship:

$$\rho = \frac{4 \cdot m}{\pi \cdot d^2 \cdot l} \left[\frac{kg}{m^3}\right] \quad (1)$$

where: m is mass of briquettes, in g; d-diameter of briquettes, in mm; l-length of briquettes, in mm.

Prior to determining the length, the briquettes were partitioned to 5mm length and the ends were polished in order to measure length with high precision, by using a calliper with an accuracy of 0.01mm. A minimum of 10 samples were taken from five different long briquettes.

From the each briquette sub-samples were taken by cutting pieces of 0.6-0.8g in order to determine calorific values, using a XRY-1C bomb calorimeter, (made in China.) The calorific value is expressed as the amount of heat released from burning of mass unit. The relationship for determining the calorific value is as follows:

$$CV = k\frac{(t_f - t_i) - q}{m} \quad [MJ/kg] \quad (2)$$

where: there are**:** k- calorific characteristics of installation, determined by calibration with benzoic acid; t_f - final temperature, in ^{0}C; t_i - initial temperature, in ^{0}C; m -mass of briquette sample, in g; q– heat obtained during the combustion of the nickel-chromium alloy and cotton wire.

The calorific characteristic of the installation is determined by calibration, using benzoic acid encapsulated every of 0.5 or 1g, having a known calorific value (usually 26.463MJ/kg). In fact in relation 2 it is known to have a calorific value CV of acid, the heat given off by wire of nickel –chromium alloy and cotton noted with q, and mass of nitric acid m. During the calibration test the two temperatures t_f and t_i, are determined the only unknown value that the device will determine being its characteristic k. This characteristic will be used for the next set of about 20-50 tests, but for a period not exceeding 30 days.

For the determination of ash content, the material is prepared by chopping and sorting shredded material with a 1×1mm sieve. The test material taken is that fraction that passes through the sieve. Some portions that are dried to constant mass in a laboratory oven are taken from the sorted material. For all tests a crucible made of an alloy resistant steel is used, which is prepared for testing by weighing and repeated drying up to 4-5 times until constant weight is achieved. It was weighed with 3 decimal place precision. All material pieces were retained within the crucible so as to not lose material after burning. Also, to protect the laboratory oven that works at 800^{0}C, all smoke is eliminated by primary burning over a gas flame. The test is considered terminated when sparks are no longer seen in the ash and that is a light grey, but certainly for not less than 20 minutes. Usually, ash content is determined as the ratio between the amount of ash (m_a) and the initial mass sample of the resulting ash (m_{s0}), i.e.:

$$A_c = \frac{m_a}{m_{s0}} \cdot 100\ [\%] \quad (3)$$

Relationship (3) is valid only for a moisture content of 0% for both sample (powdered raw material and the resulting ash). If working with certain initial moisture of initial dust, especially when there are more tests, it is necessary to make changes in the relationship (3). It takes into account the overall relationship of absolute moisture content MC, determined by the ratio of water content mass and mass of oven-dry material:

$$MC = \frac{m_m - m_0}{m_0} \cdot 100\ [\%]$$

ONLINE ISSN 2069-7430
ISSN-L 1841-4737
PRO LIGNO
www.proligno.ro
Vol. 13 N° 4 2017
pp. 579-585

The necessary calculations to extract m_0 are made:

$$MC \cdot m_0 = 100 \cdot m_m - 100 \cdot m_0$$
$$MC \cdot m_0 + 100 \cdot m_0 = 100 \cdot m_m$$
$$m_0(MC + 100) = 100 \cdot m_m$$

From the above last relation, the m_0 value is extracted:

$$m_0 = m_m \cdot \frac{100}{100 + MC}$$

By introducing this value in the above general relationship of ash content (3), obtain the next relation can be obtained:

$$A_c = \frac{m_a \cdot (MC + 100)}{m_m} \, [\%] \qquad (4)$$

where: m_a-mass of ash, in g; MC-moisture content, in %; m_m-mass of moist sample, in g.

Knowing the mass of the crucible m_c, the ash content of the tobacco briquettes could be determined by the following relationship:

$$A_c = \frac{m_s - m_c}{m_a - m_c} \cdot 100 \qquad [\%] \qquad (5)$$

where:

m_{si} - the mass of the initial dried sample with the crucible, in g;
m_c - the mass of the empty crucible, in g;
m_{sf} - the mass of the final dried ash with the crucible, in g.

The ash content must be determined for at least 10 valid samples. Any sample or tests that were susceptible to errors had to be eliminated.

RESULTS AND DISCUSSION

Since the briquettes made from cigarettes contain paper, filter (cellulose acetate) and graded tobacco, all determinations were performed separately for each component and for the briquettes containing all three main components in the mixture. The main element is tobacco, the other two components having only a weight percentage of 15-20%. Moisture content of all samples taken from briquettes stored in polyethylene film was determined referring to EN ISO/IEC 322, by drying and weighing method. The value of moisture content was around 10%. In making relevant comparisons the calorific and ash content values were extracted for some combustible products, which are presented in Table 1.

Table 1

Comparative values of calorific value and ash content

Combustible material	Calorific value		Ash content
	MJ/kg	Kcal/kg	
Fire wood, beech and hornbeam	18.400	4397	0,2-1.2%
Vegetable straws	16.000	3824	3-8-12 %
Pellets and briquettes	18.900	4517	0,3-0,8%
Superior fossil coals	29.400	7026	2-3%
Petrol	46.200	11042	0.8-1.3%
Methane gas	35.170	8405	------

Briquettes density was determined based on the European standard EN ISO/IEC 323: 2005 and the averaged value of 914kg/m^3 was obtained, above the reference standard ÖNORM M7135 product of 860kg/m^3. Density of filters and paper briquettes was lower, just under 900kg/m^3.

The calorific value of the components and the mixture is shown in Table 1. It is observed that the calorific value of paper and filters is slightly higher, but the lowest calorific value of purely tobacco is due to the elimination of exothermic volatiles during the torrefaction process of tobacco. Overall the calorific value limit imposed is within the standard product over 17.5MJ/kg.

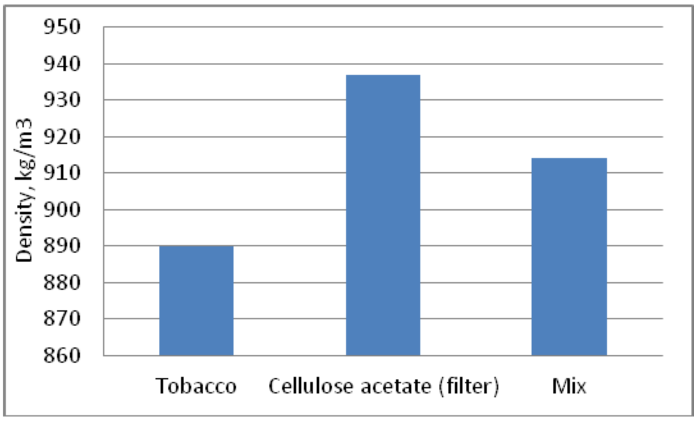

Fig. 4.
Density of briquettes.

Ash content of briquettes was very high in pure tobacco, small for a mixture of paper and filter and large for the mixture of the three components. In general, ash content exceeded the upper limit prescribed by the product standard, up to 6%. This is due to two main causes. Firstly, tobacco is a plant that has a higher ash content that wood. Secondly, in the manufacturing process, the torrefaction operation of tobacco occurs, which significantly increases its ash content, by removing volatiles.

Table 2

Calorific value and ash content of tobacco briquettes

Features		**Mixture**	**Filters and paper**	**Pure tobacco**
Calorific value, MJ/kg	super	17.652	17.654	13.051
	infer	17.210	17.213	12.632
Ash content, %		15.0	6.0	19.2

Because these briquettes have high ash content and this adversely affects their calorific value it is necessary to analyse the influences using the following relationships:

$$CV_{Mc} = CV_0(1 - Mc - 0.1 \cdot A_c) \quad [MJ/kg] \qquad (6)$$

Where we have: CV_{Mc}- calorific briquettes at certain moisture content, in MJ/kg; CV_0- the calorific value of the dried material, in MJ/kg; Mc-moisture content, in decimal units; A_c-ash content, in decimal units.

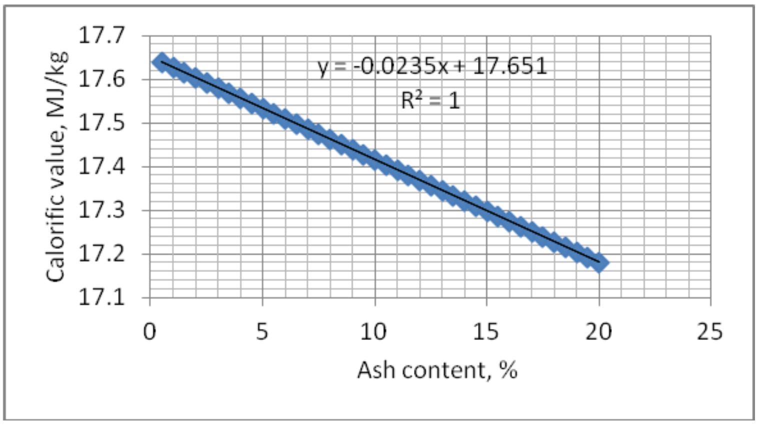

Fig. 5.
Influence of ash content on calorific value of tobacco briquettes.

High ash content exists in all lignocelluloses plants, but also in tree bark. Given the calorific values obtained from testing of mixture samples (17.652MJ/kg), an average moisture content of briquettes 10% and using the relation (4), a mathematical model can be made using Excel program, that shows the influence of ash content on calorific mix briquettes, as shown in Fig. 5. It can be seen that there is a linear influence of ash on the calorific content, from a calorific value of 17.65 to 17.18MJ/kg, i.e. a decrease by 2.6% of calorific value due to the 20% ash content. This is explained by the fact that the minerals have a great amount inside of lignocelluloses plants. Large quantity of ash and minerals reduces lignin content (chemical compound that is responsible for calorific value increasing). Similar considerations were found by other authors on some cereal plants (Xinfeng et al. 2015, Peševski et al. 2010) or wood-bark sawdust (Sotannde et al. 2010, Hytonen and Nurmi 2014).

CONCLUSIONS

Briquettes made from the remains of disintegrated tobacco cigarettes can be used as fuel due to their combustible properties even if these are modest. If the low price of these briquettes compensates for their low calorific performance, then briquetting of cigarette waste is a step forward compared to sending them to landfill, when they will be decomposed by nature. It is recommended to use these briquettes with caution because of noxious gaseous emissions produced by burning and to use tobacco mixed with sawdust (for increasing calorific power, compactness and reduced ash content), the latter procedure remaining the only way to boost the performance of such briquettes (and constitutes new direction of research).

REFERENCES

EN ISO 17225-2: 2014-05-01 (2014) Solid bio-fuels – Fuel specifications and classes – Part 2: Graded wood pellets, European Committee of Standardization. Brussels, Belgium.

Hytonen J, Nurmi J (2014) Heating value and ash content of intensively managed stands, Wood Research 60(1):71-82.

ÖNORM M7135 (2000) Pellets and briquettes – Requirements and test conditions, Austrian Standards Institute, Vienna, Austria.

Peševski M, Iliev B, Živković D, Jakimovska Popovska V, Srbinoska M, Filiposki B (2010) Possibilities for utilisation of tobacco stems for production of energetic briquettes, Journal of Agricultural Sciences, 55(1), 45-54. DOI: 10.2298/JAS1001045P.

Sotannde OA, Oluyege AO, Abah GB (2010) Physical and combustion properties of briquettes from sawdust of *Azadirachta indica*. Journal of Forestry Research (2010) 21(1):63-67; DOI 10.1007/s11676-010-0010-6.

Stefani C (2010) Estimarea prevalenţei consumului de tutun în unităţile sanitare din Ministerul Apărării Naţionale - Elaborarea unui program de prevenire şi abandon a fumatului în mediul militar, Doctoral thesis, University of Medicine and Pharmacology, Craiova.

TTG (2017) Technology of tobacco growth. www.svgenebank.ro/tehnologia%20culturii%20tutunului.pdf. Accessed January 2017.

Vlaescu G (2011) Istoria tutunului si a fumatului (history of tabacco and smoking); https://georgevlaescu.wordpress.com/2011/12/11/istoria-tutunului-si-a-fumatului/. Accessed January 2017.

Wiki (2017) wikipedia, *Nicotiana tabacum,* https://ro.wikipedia.org/wiki/Nicotiana_tabacum. Accessed January 2017.

Xinfeng W, Guizhuan X, Bailiang Z, Youzhou J, Haifeng L, Baoming L (2015) Application of tobacco stems briquetting in tobacco flue-curing in rural area of China; International Journal of Agricultural and Biological Engineering, 8(6). http://www.ijabe.org