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Viability of some African agricultural by-products as a feedstock for solid biofuel production

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Abstract: As a source of renewable energy, agricultural by-products after pre-processing and cleaning in post-harvest lines can be used as a feedstock for the production of pellets or briquettes. This can be achieved by determining the physicochemical properties of the by-products. Groundnut pods, maize cobs and the husks of rice, millet and sorghum were considered, and their properties were determined, which were then compared with the standard properties of pellets and briquettes to ascertain their viability as a feedstock for the pellet or briquette production. The by-products were transported from Nigeria to the Czech Republic and the research was carried out at the Department of Technological Equipment of Buildings, the Faculty of Engineering, Czech University of Life Sciences Prague. The moisture content, ash content, calorific value, nitrogen content and sulfur content were the properties considered of the by-products. Groundnut pods and maize cobs with a calorific value of 17.48 $MJ \cdot kg^{-1}$ and 16.25 $MJ \cdot kg^{-1}$, an ash content of 3.46% weight and 1.79% weight, a nitrogen content of 1.24% weight and 0.44% weight and a moisture content of 7.92 weight and 7.56% weight, respectively, were discovered to fulfill all the requirements for graded non-woody pellets A. With the exception of rice husks and millet husks, which were discovered to have high ash contents and low calorific values, all the by-products fulfilled the standard requirements for one or more grade of pellet/briquette. They can, therefore, be used as a good feedstock for pellet or briquette production.

Keywords: briquette; groundnut pods; maize cobs; pellet

The effects of global warming can be reduced through the use of renewable energy sources such as biomass (McKendry 2002). Agricultural activities, like grain production, are considered as being one of the main sources of greenhouse gasses (Lenerts et al. 2019). Agricultural by-products are discarded or burned directly on the farm without any processing, this fact leads to the production of greenhouse gasses (Bappah et al. 2019), which can contribute to climate change.

The energy value of a biomass material depends on its physical and chemical properties which include its moisture, ash, organic matter contents and elemental composition (Jenkins 2010; Vassilev et al. 2010; Kraszkiewicz et al. 2015; Akhmedov et al. 2017). Appropriate technologies that can be ef-

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fectively used for biomass feedstock conversion and its environmental impacts depend on the chemical characteristics of the biomass (Vassilev et al. 2010).

The moisture content is a very important characteristic of the biomass feedstock that always needs to be considered due to its influence in the design, control and optimisation of boiler settings. A higher flue-gas content, longer burn-out time and longer residence time in the boiler are negative aspects associated with a high moisture content with regards to the feedstock (Černý et al. 2016). Usually, the fresh biomass contains about 30–50% moisture (Vassilev et al. 2010). It is, therefore, regarded as one of the most important biomass characteristics, which is considered when determining the energy conversion technology that can be used. A certain amount of moisture is contained in the biomass irrespective of its source or form, which must be reduced to achieve the desired combustion (Jenkins et al. 1998). The moisture content of the raw material should not be too dry or too wet, it must be between 8 and 12% weight (wt.) before passing it into a pellet press, depending on the kind of biomass used (Wang et al. 2012). Though a biomass with a low moisture content is more appropriate for thermal conversion technologies, fermentation and anaerobic digestion are the most appropriate conversion technologies for a biomass with high moisture content (Vassilev et al. 2010).

The ash content is the mass of the inorganic matter remaining after a fuel's combustion under specified conditions (Obernberger et al. 2006; Szemmelveisz et al. 2009; Kraszkiewicz et al. 2015), which can suffer considerable variation in its content and composition between the feedstocks, ranging from below 0.5% wt. in dry state (d.s.) in wood pellets to 5–10% wt. in d.s. in agricultural residue, straw and miscanthus. The ash-forming elements and the ash melting point also vary considerably between different biomasses. Silicon, calcium, magnesium, sodium and potassium are the major ash-forming elements, the concentrations of which are of great importance for the combustion characteristics. The temperature at which the ash starts to flow and eventually melt (melting point) leading to slag formation on the grate and in the bed increases with the magnesium and calcium content and decreases with the potassium and sodium content (Nunes 2016; Caraschi et al. 2019). Handling ash is not cost effective, as it has to be included in the biomass conversion cost with a high ash content, thereby raising the price of biofuels (Bradna et al. 2016). Agricultural biomasses are considered to have a higher ash content than wood biomasses, which has a negative impact on both the combustion process and heating value (Bradna and Malaťák 2016).

The calorific value of the biomass is the measure of heat released after combusting the biomass in a controlled environment. The heat released is proportional to the calorific value of the substance (Obernberger and Thek 2004; Hnilička et al. 2015). The calorific value depends on the moisture content of the biomass feedstock, which increases with a decreasing moisture content (Piętka et al. 2019). The type of feedstock used and the combustion efficiency of the appliance determines the amount of heat that will be produced by combusting the feedstock (Demirbas 2004).

The elemental composition is the content of the carbon, hydrogen, oxygen, nitrogen, sulfur and chlorine in the biomass feedstock. Harmful emissions are produced by nitrogen and sulfur during combustion (Kraszkiewicz et al. 2015) and high nitrogen oxide (NO_X) emissions are attributed to the high nitrogen content of the biomass (Díaz-Ramírez et al. 2014; Malaťák et al. 2020a). Due to their negative impact on environment, chlorine, nitrogen and sulfur are considered to be undesirable components of fuel combustion, with chlorine and sulfur being corrosive on the technological equipment used for the energy conversion (Winter et al. 1999).

Palletisation is the production of solid materials of uniform shapes and sizes from powdery or coarse material of partly dissimilar particle size (Obernberger and Thek 2004). This involves compressing the milled particles in a flat or vertical mounted die, which binds the pellets by the cohesion of the inner surface, by fibrous parts of particles and primarily by adhesion caused by lignin (Gendek et al. 2018).

Briquetting is one of the oldest techniques which has been used in Europe since the 19^{th} century to make fuel from low-grade peat and brown coals, even though its use for the conversion of agricultural residue is comparatively recent (Gürdil et al. 2009; Gendek et al. 2018). The basic use of a briquette can be to substitute wood and coal, thereby conserving the natural wealth (Chen et al. 2009). The aim of the article is to prove the possibility of using the by-products and waste after the post-harvest pre-cleaning and sorting of special types of crops from different parts of Bauchi state in Nigeria as a source for production of pellets or briquettes with standard EU properties.

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MATERIAL AND METHODS

Materials. Representative samples of five different agricultural by-products (rice husks, millet husks, groundnut pods, maize cobs and sorghum husks) were collected from different parts of Bauchi state in Nigeria and transported to the Czech University of Life Sciences Prague, where the laboratory tests were carried out.

Methods. The moisture content of the as received by-products were determined using a UF30 laboratory oven (Memmert, Germany) at a temperature of 105 °C and calculated using Equation (1) in accordance with the provision of the ISO 18134-3:2015 standard (Hnilička et al. 2015).

$$w = \left(\frac{m_0 - m_1}{m_0} \right) \times 100 \qquad (1)$$

where: w – moisture content; m_0 – mass of the samples before drying; m_1 – mass of the samples after drying.

A SM100 cutting mill (Retsch, Germany) was used in milling the samples to a 1 mm screen fraction. The moisture and ash content of the samples were determined according to the ISO 18122:2015 standard (International Organization for Standardization 2015), using a TGA701 automated oven (LECO, USA). A AC600 calorimeter (LECO, USA) was used in determining the higher heating values in accordance with the provision of the ISO 1928:2020 standard (International Organization for Standardization 2020) and the lower heating values were calculated using Equation (2) (Pňakovič and Dzurenda 2015).

$$LHV = \left[HHV - 212w_{Hd} - 0.8\left(w_{Od} + w_{Hd}\right)\right] \times \times \left(1 - 0.01M_T\right) - 24.43M_T \qquad (2)$$

where: LHV – lower heating value (MJ·kg^{-1}); HHV – higher heating value (MJ·kg^{-1}); w_{Od} – oxygen content in a dry state (% wt.); w_{Hd} – hydrogen content in a dry state (% wt.); M_T – target moisture (0% for a dry state).

The composition of the carbon, hydrogen, oxygen and sulfur in the biomass samples were determined by an ultimate analysis using a CHN628/628S instrument (LECO, USA) (Ivanova et al. 2018; Malaťák et al. 2020b).

Standards. ISO standards ISO 17225-2:2021, ISO 17225-6:2021, ISO 17225-3:2021, ISO 17225-7:2021 (International Organization for Standardization 2021a–d) were used in comparing the properties of the biomass tested with the standard properties of different grades of pellet and briquette in order to ascertain their viability.

RESULTS AND DISCUSSION

The properties of the tested by-products were compared with the international standard limits for graded wood pellets, graded wood briquettes, graded non-woody pellets and graded non-woody briquettes, as presented in Table 1 and Table 2, respectively.

All the tested by-products have a low moisture content of less than 8% wt. in original sample. Maize cobs have the lowest ash content of 1.79% wt. in d.s., followed by groundnut pods and sorghum husks with 3.46% wt. d.s. and 9.08% wt. in d.s., respectively. The net calorific value of the groundnut pods and maize cobs were discovered to be 17.48 MJ·kg^{-1} in original sample and 16.25 MJ·kg^{-1} in original sample, respectively, which are the highest among the tested by-products. Compared to the dendromass, where the average combustion temperature of the cone samples is reached at a value of 20.54 MJ·kg^{-1} (Malaťák et al. 2020a) and the herbal biomass, where the combustion temperature is around 18 MJ·kg^{-1} (Vassilev et al. 2010), the values set in the article are at a low level. The nitrogen content, as an element that helps in the production of oxides of nitrogen, was discovered (2016) to be the lowest in the sorghum husks and maize cobs (0.44% wt.) and highest in the rice husks (0.92% wt.). The sulfur content for all the by-products was discovered to be less than 0.05% wt., which is considered to be negligible (Juszczak 2016).

The moisture content, as one of the most important characteristics of biomass that need to be considered when using it as biofuel (Szemmelveisz et al. 2009), was found to be low for all the investigated by-products, which is approximately 7% wt. and satisfied the requirements of all the pellet and briquette categories.

Millet husks were discovered to have a higher ash content (32.16% wt.) which can be attributed to contamination with sand or dust particles during the threshing and sample collection (Pňakovič and Dzurenda 2015; Bappah et al. 2019). The ash content of the rice husks was also found to be 23.58% wt. in d.s., which makes them unfavourable for any pellet or briquette category. Maize cobs were able to satisfy the requirement for both

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Table 1. Comparison of the properties of the tested graded wood and non-woody pellets with standard values

Property	Unit	Graded wood pellets[1]			Graded non-woody pellets[2]	
		A1	A2	B	A	B
Moisture	% wt. o.s.	≤ 10[f]	≤ 10[f]	≤ 10[f]	≤ 12[f]	≤ 15[f]
Ash	% wt. d.s.	≤ 0.7	≤ 1.2	≤ 2.0[d]	≤ 6[cd]	≤ 10[bcd]
Net calorific value	MJ·kg^{-1} o.s.	≥ 16.5[c]	≥ 16.5[c]	≥ 16.5[c]	≥ 14.5[cd]	≥ 14.5[cd]
Nitrogen	% wt. d.s.	≤ 0.3	≤ 0.5[bd]	≤ 1.0[abde]	≤ 1.5[f]	≤ 2.0[f]
Sulfur	% wt. d.s.	≤ 0.04[f]	≤ 0.05[f]	≤ 0.05[f]	≤ 0.20[f]	≤ 0.30[f]

o.s. – original sample; d.s. – dry state; [a]rice husks fulfilled the requirement; [b]sorghum husks fulfilled the requirement; [c]groundnut pods fulfilled the requirement; [d]maize cobs fulfilled the requirement; [e]millet husks fulfilled the requirement; [f]all the by-products fulfilled the requirement; [1]ISO 17225-2:2021 (International Organization for Standardization 2021a); [2]ISO 17225-6:2021 (International Organization for Standardization 2021b)

Table 2. Comparison of the properties of the tested graded wood and non-woody briquettes with standard values

Property	Unit	Graded wood briquettes[3]			Graded non-woody briquettes[4]	
		A1	A2	B	A	B
Moisture	% wt. o.s.	≤ 12[f]	≤ 15[f]	≤ 15[f]	≤ 12[f]	≤ 15[f]
Ash	% wt. d.s.	≤ 1.0	≤ 1.5	≤ 3.0[d]	≤ 6[cd]	≤ 10[bcd]
Net calorific value	MJ·kg^{-1} o.s.	≥ 15.5[bcd]	≥ 15.3[bcd]	≥ 14.9[bcd]	≥ 14.5[cd]	≥ 14.5[cd]
Nitrogen	% wt. d.s.	≤ 0.3	≤ 0.5[bd]	≤ 1.0[abde]	≤ 1.5[f]	≤ 2.0[f]
Sulfur	% wt. d.s.	≤ 0.04[f]	≤ 0.04[f]	≤ 0.05[f]	≤ 0.20[f]	≤ 0.30[f]

o.s. – original sample; d.s. – dry state; [a]rice husks fulfilled the requirement; [b]sorghum husks fulfilled the requirement; [c]groundnut pods fulfilled the requirement; [d]maize cobs fulfilled the requirement; [e]millet husks fulfilled the requirement; [f]all the by-products fulfilled the requirement; [3]ISO 17225-3:2021 (International Organization for Standardization 2021c); [4]ISO 17225-7:2021 (International Organization for Standardization (2021d)

Table 3. Comparison of the properties of the tested by-products from Nigeria agriculture

Property	Unit	Rice husks[5]	Sorghum husks[5]	Groundnut pods[5]	Maize cobs[5]	Millet husks[5]
Moisture	% wt. o.s.	6.63	7.26	7.92	7.56	5.37
Ash	% wt. d.s.	23.58	9.08	3.46	1.79	32.16
Net calorific value	MJ·kg^{-1} o.s.	13.32	14.66	17.48	16.25	11.68
Nitrogen	% wt. d.s.	0.92	0.44	1.24	0.44	0.89
Sulfur	% wt. d.s.	<0.05	<0.05	<0.05	<0.05	<0.05

o.s. – original sample; d.s. – dry state; [5]Bappah et al. (2019)

graded woody pellets and briquettes as well as graded non-woody pellets and briquettes, while the groundnut pods and sorghum husks only satisfied the requirement of the non-woody pellets and briquettes (Table 3).

The calorific value, which increases with a decreasing ash content (Bappah et al. 2019), was discovered to be 17.48 MJ·kg^{-1} in original sample for the groundnut pods and satisfied the requirement for graded woody pellets A1. It can, therefore, be considered as an excellent feedstock for pellet production judging by its net calorific value and can be used for all the pellet and briquette categories.

All the tested by-products were discovered to have a nitrogen content of less than 1.5% wt. in d.s., which is suitable for all graded non-woody pellet and briquette categories. They can, therefore, be considered as free from emitting any associated nitrogen oxides when combusted (Pňakovič and Dzurenda 2015; Malaťák et al. 2017; Bappah et al. 2019), which are

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harmful to human health. With the exception of the groundnut pods, all the tested by-products satisfied the nitrogen requirement for graded wood pellets and briquettes, with the sorghum husks and maize cobs being the best.

Judging by the sulfur content, which is considered to be undesirable for fuel combustion due to its corrosive nature on the technological equipment that is used for energy conversion (Johansson et al. 2004; Malaťák et al. 2018), all the by-products have a lower sulfur content than the required maximum for the production of pellets or briquettes.

Due to its availability and the cost required for disposal in most Africa countries, the viability of rice husks as a feedstock for biofuel production may be improved by mixing it with groundnut pods or maize cobs in order to increase the energy value and reduce the ash content.

CONCLUSION

The properties of some selected agricultural by-products were investigated and compared with the standard characteristics of different grades of pellets and briquettes, in order to ascertain their viability as a feedstock for a solid biofuel production. All the considered by-products were non-woody biomasses.

Groundnut pods and maize cobs, as by-products with a high energy value and a low ash content, can be used as a good feedstock for the production of graded non-woody pellets and graded non-woody briquette.

Though maize cobs satisfied all the characteristics considered to be used as a feedstock for the production of graded wood pellets or briquettes, groundnuts cannot be used due to the slightly high ash content.

Considering its availability and emissions or cost which is attached to its disposal, rice husks can be improved by mixing it with maize cobs and or groundnut pods. This may increase its energy value and reduce the ash content so it can be used as a feedstock for solid fuel production. The process can also save the environment from any associated emissions during open burning or disposal.

REFERENCES

Akhmedov S., Ivanova T., Krepl V., Muntean A. (2017): Research on solid biofuels from cotton waste biomass – Alternative for Tajikistan's energy sector development. Agronomy Research, 15: 1846–1855.

Bappah M., Bradna J., Velebil J., Malatak J. (2019): The potential of energy recovery from by-products of small agricultural farms in Nigeria. Agronomy Research, 17: 2180–2186.

Bradna J., Malaťák J. (2016): Flue gases thermal emission concentration during waste biomass combustion in small combustion device with manual fuel supply. Research in Agricultural Engineering, 62: 1–7.

Bradna J., Malaťák J., Hájek D. (2016): The properties of wheat straw combustion and use of fly ash as a soil amendment. Agronomy Research, 14: 1257–1265.

Caraschi J.C., Goveia D., Dezajacomo G., Prates G.A. (2019): Evaluation of biomass properties for the production of solid biofuels. Floresta e Ambiente, 26: e20180433.

Chen L., Xing L., Han L. (2009): Renewable energy from agro-residues in China: Solid biofuels and biomass briquetting technology. Renewable and Sustainable Energy Reviews, 13: 2689–2695.

Černý D., Malaťák J., Bradna J. (2016): Influence of biofuel moisture content on combustion and emission characteristics of stove. Agronomy Research, 14: 725–732.

Demirbas A. (2004): Combustion characteristics of different biomass fuels. Progress in Energy and Combustion Science, 30: 219–230.

Díaz-Ramírez M., Sebastián F., Royo J., Rezeau A. (2014): Influencing factors on NO_X emission level during grate conversion of three pelletized energy crops. Applied Energy, 115: 360–373.

Gendek A., Aniszewska M., Malaťák J., Velebil J. (2018): Evaluation of selected physical and mechanical properties of briquettes produced from cones of three coniferous tree species. Biomass and Bioenergy, 117: 173–179.

Gürdil G.A.K., Selvi K.C., Malaták J., Pinar Y. (2009): Biomass utilization for thermal energy. Agricultural Mechanization in Asia, Africa Latin & America, 40: 80–85.

Hnilička F., Hniličková H., Hejnák V. (2015): Use of combustion methods for calorimetry in the applied physiology of plants. Journal of Thermal Analysis and Calorimetry, 120: 411–417.

Hnilička F., Hniličková H., Kudrna J., Kraus K., Kukla J., Kuklová M. (2020): Combustion calorimetry and its application in the assessment of ecosystems. Journal of Thermal Analysis and Calorimetry, 142: 771–781.

International Organization for Standardization (2015): ISO 18122:2015. Solid biofuels — Determination of ash content. Geneva, Switzerland.

International Organization for Standardization (2020): ISO 1928:2020. Coal and coke — Determination of gross calorific value. Geneva, Switzerland.

International Organization for Standardization (2021a): ISO 17225-2. Fuel specifications and classes – Part 2: Graded wood pellets. Geneva, Switzerland.

https://doi.org/10.17221/74/2021-RAE

International Organization for Standardization (2021b): ISO 17225-6. Solid biofuels – Fuel specifications and classes – Part 6: Graded non-woody pellets. Geneva, Switzerland.

International Organization for Standardization (2021c): ISO 17225-3. Solid biofuels — Fuel specifications and classes Part 3: Graded wood briquettes. Geneva, Switzerland.

International Organization for Standardization (2021d): ISO 17225-7. Solid biofuels – Fuel specifications and classes Part 7: Graded non-woody briquettes. Geneva, Switzerland.

Ivanova T., Mendoza Hernández A.H., Bradna J., Cusimamani E.F., Montoya J.C.G., Espinel D.A.A. (2018): Assessment of Guava (*Psidium guajava* L.) wood biomass for briquettes' production. Forests, 9: 613.

Jenkins B.M., Baxter L.L., Miles T.R. Jr., Miles T.R. (1998): Combustion properties of biomass. Fuel Processing Technology, 54: 17–46.

Jenkins D. (2010): Wood Pellet Heating Systems: The Earthscan Expert Handbook on Planning, Design and Installation. London, Routledge.

Johansson L.S., Leckner B., Gustavsson L., Cooper D., Tullin C., Potter A. (2004): Emission characteristics of modern and old-type residential boilers fired with wood logs and wood pellets. Atmospheric Environment, 38: 4183–4195.

Juszczak M. (2016): Comparison of CO and NOx concentrations from a 20 kW boiler for periodic and constant wood pellet supply. Environment Protection Engineering, 42: 95–107.

Kraszkiewicz A., Kachel-Jakubowska M., Niedziółka I. (2015): Analysis of selected physical and chemical properties of plant biomass of agricultural origin in terms of its energy use. Bulgarian Journal of Agricultural Science, 21: 1295–1299.

Lenerts A., Popluga D., Naglis-Liepa K. (2019): Benchmarking the GHG emissions intensities of crop and livestock–derived agricultural commodities produced in Latvia. Agronomy Research, 17: 1942–1952.

Malat'ák J., Velebil J., Bradna J. (2018): Specialty types of waste paper as an energetic commodity. Agronomy Research, 16: 534–542.

Malaťák J., Bradna J., Velebil J. (2017): The dependence of COx and NOx emission concentrations on the excess air coefficient during combustion of selected agricultural briquetted by-products. Agronomy Research, 15: 1084–1093.

Malaťák J., Velebil J., Bradna J., Gendek A., Tamelová B. (2020a): Evaluation of CO and NOx emissions in real-life operating conditions of herbaceous biomass briquettes combustion. Acta Technologica Agriculturae, 23: 53–59.

Malaťák J., Gendek A., Aniszewska M., Velebil J. (2020b): Emissions from combustion of renewable solid biofuels from coniferous tree cones. Fuel, 276: 118001.

McKendry P. (2002): Energy production from biomass (Part 1): Overview of biomass. Bioresource Technology, 83: 37–46.

Nunes L.J.R., Matias J.C.O., Catalão J.P.S. (2016): Biomass combustion systems: A review on the physical and chemical properties of the ashes. Renewable and Sustainable Energy Reviews, 53: 235–242.

Obernberger I., Brunner T., Bärnthaler G. (2006): Chemical properties of solid biofuels-significance and impact. Biomass and Bioenergy, 30: 973–982.

Obernberger I., Thek G. (2004): Physical characterisation and chemical composition of densified biomass fuels with regard to their combustion behaviour. Biomass and Bioenergy, 27: 653–669.

Piętka J., Gendek A., Malaťák J., Velebil J., Moskalik T. (2019): Effects of selected white-rot fungi on the calorific value of beech wood (*Fagus sylvatica* L.). Biomass and Bioenergy, 127: 105290.

Pňakovič Ľ., Dzurenda L. (2015): Combustion characteristics of fallen fall leaves from ornamental trees in city and forest parks. BioResources, 10: 5563–5572.

Szemmelveisz K., Szucs I., Palotás Á.B., Winkler L., Eddings E.G. (2009): Examination of the combustion conditions of herbaceous biomass. Fuel Processing Technology, 90: 839–847.

Vassilev S.V., Baxter D., Andersen L.K., Vassileva C.G. (2010): An overview of the chemical composition of biomass. Fuel, 89: 913–33.

Wang L., Hustad J.E., Skreiberg Ø., Skjevrak G., Grønli M. (2012): A critical review on additives to reduce ash related operation problems in biomass combustion applications. Energy Procedia, 20: 20–29.

Winter F., Wartha C., Hofbauer H. (1999): NO and N_2O formation during the combustion of wood, straw, malt waste and peat. Bioresource Technology, 70: 39–49.

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