The relationship between bulk density and energy input, in biomass pellet production

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Introduction The search for alternatives to fossil fuels has stimulated interest in lignocellulosic pellets for home heating. Currently all pellets used in Ireland are produced from wood sawdust. Sawdust has many advantages for pellet production, but its supply is limited by the scale of wood processing. If Irish pellet production is to keep pace with demand, other feed-stocks will have to be found. The most likely options are wood residues, willow, miscanthus, rape straw and cereal straws. Significant quantities of these materials are readily available with rape and some cereal straws being thought of currently as a waste product. The objective of this research is to determine the pellet production rate for the various raw materials by analysis of material flows through the pellet mill; and to determine the relationships between bulk density, material flows and the energy input in the production process.

Material and methods Biomass pellets were produced using a Farm Feed Systems biomass pellet mill (Cinderford, Gloucestershire, England) located at Oak Park Research Centre. The raw materials were firstly tested for moisture content and then chopped using a Teagle Tomahawk straw chopper (Teagle Machinery Ltd., Truro, Cornwall, England)) with a 24 mm sieve. The pelleting process involves movement through a 5 kW hammer mill with 4 mm screen, addition of oil and water and then forcing of the material through a 6 mm die to form cylindrical pellets. The pellet mill has a rated capacity of 150 kg/h for wood pellet production from sawdust.

Each biomass was processed in this way until settings of material throughput and oil and water addition, which produced stable pellets, were found. The mill was run for 30 minutes to allow the system to reach steady state and then run for one hour at these steady state conditions. The raw material throughput was determined by weighing the amount of pellets produced in a measured time to give a kg/hr throughput rate. An Elster A1100 kWhr meter (Elster Metering Ltd., USA) was used to determine the amount of energy required by the pelleting system to create this quantity of pellets and then converted to a kW per kg of pellet produced figure. This was repeated five times for each biomass. Wood pellets were produced for comparison purposes. Raw material and pellets were tested for bulk density using CEN Standard TS 15 103. The GenStat Analysis of Variance Multiple Comparisons tool (Bonferroni Test) was used to test for statistical differences between biomass pellets.

Results and Discussion While stable pellets could be consistently produced for miscanthus, willow, wood and rape straw, pellet production from wheat and barley straw proved more difficult and less consistent. It was also noticed that the rated throughput of 150kg/h could not be achieved, as a maximum of 80 kg/h was seen for wood. A summary of the test results is shown in Table 1. As can be seen, the throughput rate for wheat and barley straw was significantly different to that of all the other products. This was due mainly to the very low bulk density of the raw material (<20kg/m^3) after milling as compared to 180 kg/m ^{3} for miscanthus and 210 kg/m^3 for willow. The low bulk density led to flow difficulties and blockages throughout the pelleting system.

The throughput rate is proportional to the bulk density (R^2 = 0.895).The energy input is inversely proportional to the throughput rate (R^2 = 0.85). i.e. the more quickly the material can flow through the system, due to a low bulk density, the less energy is used in pellet production. This shows that the bulk density of the biomass has a greater influence on the energy used in pelleting, than the actual type of biomass to be pelleted.

Table 1 Summary of data on different biomass materials

	Throughput rate (kg/hr)	Energy input (kW/kg)	Bulk Density (kg/m^3)
Wood	80	0.2	225
Willow	60	0.26	210
Miscanthus	55	0.28	180
Rape Straw	40	0.31	50
Barley Straw	10	0.4	18
Wheat Straw	15	0.35	20

Conclusion These results demonstrate that while it is possible to make pellets from almost any biomass, the energy efficiency in so doing varies greatly from one raw material to the next. The pelleting energy input: output ratio for barley straw is almost twice that of willow or miscanthus. However a full life cycle analysis taking into account crop production, transport, drying etc. is required to make any conclusions on the overall energy efficiency of each biomass.

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