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The Energy Potential of Brewer's Spent Grain for Breweries in Nigeria

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Abstract: In order to counter the increasing environmental degradation in Nigeria caused by increasing energy demands and indiscriminate dumping of industrial wastes, this study has been undertaken to determine possibilities of using energy-friendly waste, brewer's spent grain as an alternative fuel especially in the brewery industry. The fuel properties of brewer's spent grain have been compared with those of brown coal in terms of emission of polluting gases and energy content. The carbon and sulphur contents and the average calorific value of this waste were found to be 48.36%, 0.32% and 4664.11 kcal kg^{-1}, respectively, indicating that brown coal may be complemented by brewers spent grain with a consequent reduction in the emissions of greenhouse gas.

Key words: Energy, brewer's grain, waste, biomass, environment

INTRODUCTION

In the past, traditional sources of energy such as fuel-wood, charcoal, crop residue or animal dung were the only sources of energy used for all types of application. It is only during the last 250 years that fossil fuel such as coal; oil and gas have emerged as major sources of energy in most developed countries (RWEDP, 1993; Bryden *et al*., 2003).

However, the production of energy from biomass has regained its importance in recent years due to its environmental-friendly nature (Hall *et al*., 1992; Jain, 2006). Biomass currently provides about 14% of the world's total energy, predominantly in the developing countries. In these countries, over 2 billion people depend on biomass as their primary source of energy; 70% of the population live in rural areas and biomass accounts for 43% of total energy used (Pimentel *et al*., 1998; IEA, 2000).

Nigeria has the largest lignite deposit in Africa and this has been a good source of energy for her industries. However, any energy source should be evaluated with consideration of its environmental impacts. The utilization of biomass for energy production should fulfill 2 important criteria for sustainable energy development, namely, utilization of domestic resources and minimization of environmental damage (Ture *et al*., 1997; Ojolo and Bamgboye, 2005). Chief among these criteria should be placing less burden on the forests, reduction of dumping of wastes leading to soil and air pollution and emission of CO_2, SO_2 and NO_X in the atmosphere.

There are over 20 breweries in Nigeria producing different brands of beer and malted drinks. These breweries use barley, wheat, sorghum and maize as brewer's grain and in turn generate large quantities of waste in the form of spent grains, hops and the residue from malting and milling operations. These wastes have been a subject matter of interest to environmentalists and the public in general. From its method of indiscriminate disposal in every brewery town in Nigeria, to the effervescences and odor released from the waste, there have been concerns on the effects it has on the ecosystem. Hence, proper waste management is required to curb the adverse effects from them. These wastes are biomass, which contain enormous amount of energy. Hence, the potential exists for in-plant conversion of these wastes into energy for generation of steam and hot water in boilers (Sargent and Steffe, 1986). Also economic conditions continue to indicate that the already high energy costs paid by brewers to run their plant process systems are continuing on an upward spiral. According to USEIA (2007), Nigeria has the tenth largest natural gas reserves in the world estimated at 51.5 billion m^3. Most of

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these gases are flared during crude oil production and a large chunk of what remains is exported for the hard currency. In recent times, natural gas prices are almost five times what they were a decade ago and show no signs of leveling off (Richards, 2003) while crude oil prices have gone up as well.

In view of these increasing costs, the possibility that a company could be able to burn its own process-generated waste to produce process steam and hot water can be very attractive if the concept used is technically and economically viable and the payout period is reasonable. Also this biomass waste can provide a relatively constant source of energy which will not only lower fuel costs but will also relieve the cost for disposal.

Therefore, this study has been undertaken to determine the energy potential of brewer's spent grain with a view to utilizing them in-plant as source of energy and reducing its disposal problem with the attendant environmental degradation.

MATERIALS AND METHODS

The brewer's spent grain used in this study was obtained from the Nigerian Breweries Plc., Ibadan, Nigeria. The spent grain is a mixture of waste from barley and sorghum and barley and maize.

Analyses of the brewer's spent grain have been carried out in International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria using sulphur-analysis equipment, Gallenkamp Ballistic Calorimeter and an ash furnace. The ultimate analysis was carried out in accordance with the Official Methods of the Association of Official Analytical Chemists (AOAC, 2003).

In addition to the use of calorimeter for the determination of the calorific value, the Dulong formula as modified by Channiwala in 1992 (Gaur and Reed, 1998), was used to calculate the high heating value (HHV) and the results compared. The Channiwala formula is expressed by:

$$\text{HHV (kJ g}^{-1}) = 0.3491C + 1.1783H - 0.1034O - 0.0211Ash + 0.1005S - 0.0151N \quad (1)$$

RESULTS AND DISCUSSION

The results of these measurements and calculations are summarized in Table 1 and 2.

From Table 1 and 2, the sulphur and ash contents of the brewers spent grain were found to be lower than those of most known sources of lignite in Nigeria (LEC, 2005). The measured calorific value of brewers spent grain produced from barley and sorghum was 4664.11 kcal kg^{-1} while the calculated value was 4796.65 kcal kg^{-1} which is comparable to a value of 5073 kcal kg^{-1} for a lignite source. As shown in Table 2, there was only a marginal difference in the measured and calculated values of calorific values of spent grain generated from barley and maize with 4322.83 and 3981.55 kcal kg^{-1} for the measured and calculated values, respectively.

Table 3 shows a comparison of CO_2 and SO_2 per unit energy for brewers spent grain from barley-sorghum and lignite. CO_2 emission per unit energy were about 0.439×10^{-3} kg kcal^{-1} and 0.5 kg kcal^{-1} for brewers spent grain from barley-sorghum and lignite, respectively, when using a carbon content for brewers spent grain of 48.36 and 64.50% lignite (dry basis). Using a typical sulphur content of 0.32 and 3.6% for brewers spent grain and lignite, respectively; SO_2 emissions per unit energy are calculated to be 1.74×10^{-9} kg kcal^{-1} and 19.99×10^{-9} kg kcal^{-1} for the brewers spent grain (barley-sorghum) and lignite, respectively.

In Table 4 a comparison of CO_2 and SO_2 per unit energy for brewers spent grain from barley-maize shows that CO_2 emission per unit energy was about 0.457×10^{-3} kg kcal^{-1} when using a carbon content of 49.10%. Using sulphur content of 0.36% for the same brewers spent grain; a SO2 emission per unit energy was calculated to be 1.97×10^{-9} kg kcal^{-1}.

Table 1: Average fuel characteristics of brewer's spent grain (Barley-Sorghum)

Ultimate analysis (wt % dry basis)						HHV (kcal kg^{-1})	
C (%)	H (%)	N (%)	S (%)	O (%)	Ash (%)	Measured	Calculated
48.36	6.02	4.11	0.32	36.73	4.46	4664.11	4796.65

Table 2: Average fuel characteristics of brewer's spent grain (Barley-Maize)

Ultimate analysis (wt % dry basis)						HHV (kcal kg^{-1})	
C (%)	H (%)	N (%)	S (%)	O (%)	Ash (%)	Measured	Calculated
49.10	6.24	4.69	0.36	39.61	6.00	4322.83	3981.55

Table 3: Average CO_2 and SO_2 emissions per unit energy for brewers spent grain (Barley-Sorghum)

CO_2 (kg kcal^{-1})	SO_2 (kg kcal^{-1})
0.439×10^{-3}	1.74×10^{-9}

Table 4: Average CO_2 and SO_2 emissions per unit energy for brewers spent grain (Barley- Maize)

CO_2 (kg kcal^{-1})	SO_2 (kg kcal^{-1})
0.457×10^{-3}	1.97×10^{-9}

CONCLUSION

Based on the value of the calorific value of brewers spent grain which is comparable to some source of lignite, the breweries in Nigeria have a good source of biomass available in substantial quantity and should consider processing the material for recovery due to its inherent energy value. In the face of ever escalating fuel costs, this method could lower costs or, perhaps eliminate them. Since increase in fuel costs will lead to the cost for hauling and disposal of waste being significant, then the economic advantages of waste fuel-firing become even more pronounced. Also, converting the wastes will reduce the adverse environmental effect which they have on the ecosystem.

And because the coal-fired boilers were existing units, the decision and method to fire the biomass in the same manner as coal taking into consideration the excellent heat content of the processed waste, its combustion characteristics, which are similar to that of coal, will be a matter of good techno-economic analysis.

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