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Solid Fuel Production from Animal Manure

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Three of the biggest problems that the world will face in the future are energy, food and water security. The need for alternative energy sources is increasing due to the fact that the world's energy resources are depleted and especially the damage of fossil fuels to ecology. Today, studies on alternative energy sources are carried out intensively. One of the alternative energy sources is biomass solid fuels obtained from plant or animal manure. In this study, biomass in block form will be obtained by using binders from chicken and sheep manure. Finally, the obtained biomass will be analyzed in the solid fuel analysis laboratory, and the results will be compared and written statistically.

Keywords: Biomass; manure; energy; sulfur; coal.

1. INTRODUCTION

Energy is the ability to do work and is associated with all our activities. Energy, which is required in all aspects of life, is critical to a country's progress. Countries must use energy efficiently in order to compete on a global scale and secure long-term development. In physics, energy is defined as the ability to perform work. It can be potential, kinetic, thermal, electrical, chemical, radioactive, or in other forms. To meet rising demand, innovations in new energy technologies must reach market maturity [1-3]. The fact that it is still far intensifies countries' concerns about

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energy security on a daily basis. Population increase, industrialization, and urbanization are worldwide processes that are expanding commerce as a result of globalization opportunities, as is the demand for natural resources and energy. The easy availability of energy aids a country's industrialization development [4-7]. It is unquestionable that some driving force must enable growth factors such as land, labor, investment, organization, technology, and knowledge in each economic sector and process of economic activity to result in Economic growth. Energy consumption increases in parallel with economic growth and development [8-10]. In this way, energy need should be met sufficiently and economically [11-13,14]. Most of the energy we use today comes from primary and secondary energy forms. Primary energy sources are sources which can be found naturally such as fossil fuels - coal, oil, and natural gas, biomass, radioactive minerals etc., which have not been subject to any sort of man-made conversion process [15-18,14]. When primary energy is converted to a different form like electricity, gasoline etc., they are secondary forms of energy, also known as energy carriers and they need to be made using these primary energy sources.

1.1 Importance of Energy

Easy availability of energy helps in the process of industrializations in a country. It is certain that some driving force must enable growth factors, such as land, labor, capital, organization, technology and knowledge in each economic sector and in each process of economic activity, to result in the growth of the domestic product. That's just energy. Namely, the process of production (and economic growth as the final resultant) involves the transformation of matter from one form to another, ie the transformation of inputs, ie, raw material in the final product, and this transformation requires energy (Cleveland et al., 1996). Energy enables the continuity and longterm nature of the entire economic activity not only as a supplement to standard production inputs, but without it the economy would not be possible at all. According to Alam (2006), every business consists of energy flows that are directed towards the production of goods and services. Such a focus on energy creates many new assumptions. Namely, putting energy into the focus of economic activity identifies the use of energy as an important source of economic growth and the inevitable driving force of all economic activities (Stern and Cleveland, 2004). In other words, the economy should be seen as an energy system consisting of energy flows and conversions that culminate precisely in the production of goods and services, and energy as a key source of economic growth, industrialization and urbanization (Imran, 2010, p. 206). Production of energy leads to the efficient utilization of natural resources. For example, solar energy, wind energy and hydro-electricity power can be generated by using sun light, wind and water resources respectively. Scope of employment opportunities can be possible with the process of industrialization that is possible with easy availability of energy/ power sources. Easy availability of energy is required for the expansion of infrastructural development in a country. Income of a country can be raised with the expansion of the power sector. It also helps to achieve economic self-sufficiency.

1.2 Energy Resources

1.2.1 Traditional energy resources (fossil fuels)

When the energy production figures in the world are examined, fossil fuels have the largest share with 60%. is seen. When energy is obtained from fossil fuels as a result of combustion, combustion products (CO_2, SO_2 etc. gases) are dispersed in the atmosphere as flue gas. Flue gases also fly ash and hydrocarbons they contain. Toxic metals such as nickel, cadmium, lead and arsenic are also released into the atmosphere as a result of burning fossil fuels. are other substances discarded. CO_2 plays an active role in the greenhouse effect. Increasing CO_2 amount, It causes the earth's temperature to increase, which leads to the deterioration of climate balances. SO_2 and NOx (nitrous oxide) combined with water vapor in the atmosphere mainly cause acid rain. and this causes the ecological balance of the world to deteriorate. All fossil fuel residues winter It causes air pollution that affects many cities in the months of the year. Fossil fuels their effects are not limited to these. For example, coal mining both brings health risks to employees and Another problem is encountered in fossil fuel transportation. Oil-carrying tankers It is known that the accidents it caused hundreds of thousands of tons of oil to spill into the sea.

Oil: 45% of the world's energy needs are provided by oil. The total energy consumed in Turkey Petroleum has an extremely important place among its resources with a ratio of 44%.

Coal: Finding more in the world compared to other fossil fuels, wide support and diversification, its use is preferred due to its economy in power generation.

Nuclear Energy: A combustion in Nuclear Power plants as in other conventional power plants does not react. In the first or second cycle from the power plants and especially the reactor building, no Uncontrolled removal of radioactive elements through process steam from leaks or leaks that may occur. The buildings in question are constantly kept under low pressure to prevent dispersal into the environment. In other words, the air in these buildings is sucked, since the internal pressure will be lower than the outside pressure, an inward flow of air occurs. The sucked air is continuously measured and filtered. and then released into the environment through the chimney in a controlled manner. Likewise, in liquid waste similar It is collected by methods and released to the environment in a controlled manner. Meeting 17% of the world's electricity production nuclear reactors are shown as an alternative to rapidly running out oil. In 40-50 years The waste to be produced is approximately 200 m3. Radioactive wastes from nuclear energy Since they are stored in a controlled manner, they do not pose any danger to the environment. Also nuclear waste storage technology is evolving. The use of nuclear power means it reduces CO_2 emissions. It will also play an active role in preventing SO_2 and NOX emissions.

1.2.2 Renewable energy

Renewable energy uses energy sources that are continually replenished by nature— the sun, the wind, water, the Earth’s heat, and plants. Renewable energy technologies turn these fuels into usable forms of energy—most often electricity, but also heat, chemicals, or mechanical power. Renewable energy is plentiful, and the technologies are improving all the time. There are many ways to use renewable energy. Most of us already use renewable energy in our daily lives.

1.2.3 Hydropower

Hydropower is our most mature and largest source of renewable power, producing about 10 percent of the nation’s electricity. Existing hydropower capacity is about 77,000 megawatts (MW). Hydropower plants convert the energy in flowing water into electricity. The most common form of hydropower uses a dam on a river to retain a large reservoir of water. Water is released through turbines to generate power. “Run of the river” systems, however, divert water from the river and direct it through a pipeline to a turbine. Hydropower plants produce no air emissions but can affect water quality and wildlife habitats. Therefore, hydropower plants are now being designed and operated to minimize impacts on the river. Some of them are diverting a portion of the flow around their dams to mimic the natural flow of the river. But while this improves the wildlife’s river habitat, it also reduces the power plant’s output. In addition, fish ladders and other approaches, such as improved turbines, are being used to assist fish with migration and lower the number of fish killed.

1.2.4 Bioenergy

Bioenergy is the energy derived from biomass (organic matter), such as plants. If you’ve ever burned wood in a fireplace or campfire, you’ve used bioenergy. But we don’t get all of our biomass resources directly from trees or other plants. Many industries, such as those involved in construction or the processing of agricultural products, can create large quantities of unused or residual biomass, which can serve as a bioenergy source.

1.2.5 Biopower

After hydropower, biomass is this country’s second-leading resource of renewable energy, accounting for more than 7,000 MW of installed capacity. Some utilities and power generating companies with coal power plants have found that replacing some coal with biomass is a lowcost option to reduce undesirable emissions. As much as 15 percent of the coal may be replaced with biomass. Biomass has less sulfur than coal. Therefore, less sulfur dioxide, which contributes to acid rain, is released into the air. Additionally, using biomass in these boilers reduces nitrous oxide emissions. A process called gasification—the conversion of biomass into gas, which is burned in a gas turbine—is another way to generate electricity. The decay of biomass in landfills also produces gas, mostly methane, which can be burned in a boiler to produce steam for electricity generation or industrial processes. Biomass can also be heated in the absence of oxygen to chemically convert it into a type of fuel oil, called pyrolysis oil. Pyrolysis oil can be used for power generation and as a feedstock for fuels and chemical production. Biofuels Biomass can be converted directly into liquid fuels, called biofuels. Because biofuels are easy to transport and possess high energy density, they are favored to fuel vehicles and sometimes stationary power generation. The most common biofuel is ethanol, an alcohol made from the fermentation of biomass high in carbohydrates. The current largest source of ethanol is corn. Some cities use ethanol as a gasoline additive to help meet air quality standards for ozone. Flexfuel vehicles are also now on the market, which can use a mixture of gasoline and ethanol, such as E85—a mixture of 85 percent ethanol and 15 percent gasoline. Another biofuel is biodiesel, which can be made from vegetable and animal fats. Biodiesel can be used to fuel a vehicle or as a fuel additive to reduce emissions. Corn ethanol and biodiesel provide about 0.4 percent of the total liquid fuels market. To increase our available supply of biofuels, researchers are testing crop residues— such as cornstalks and leaves—wood chips, food waste, grass, and even trash as potential biofuel sources. Biobased Products Biomass—corn, wheat, soybeans, wood, and residues—can also be used to produce chemicals and materials that we normally obtain from petroleum. Industry has already begun to use cornstarch to produce commodity plastics, such as shrink wrap, plastic eating utensils, and even car bumpers. Commercial development is underway to make thermoset plastics, like electrical switch plate covers, from wood residues.

1.3 Wind Energy

For hundreds of years, people have used windmills to harness the wind's energy. Today's wind turbines, which operate differently from windmills, are a much more efficient technology. Wind turbine technology may look simple: the wind spins turbine blades around a central hub; the hub is connected to a shaft, which powers a generator to make electricity. However, turbines are highly sophisticated power systems that capture the wind's energy by means of new blade designs or airfoils. Modern, mechanical drive systems, combined with advanced generators, convert that energy into electricity. Wind turbines that provide electricity to the utility grid range in size from 50 kW to 1 or 2 MW. Large, utility-scale projects can have hundreds of turbines spread over many acres of land. Small turbines, below 50 kW, are used to charge batteries, electrify homes, pump water for farms and ranches, and power remote telecommunications equipment. Wind turbines can also be placed in the shallow water near a coastline if open land is limited, such as in Europe, and/or to take advantage of strong, offshore winds. Wind energy has been the fastest growing source of energy in the world since 1990, increasing at an average rate of over 25 percent per year. It's a trend driven largely by dramatic improvements in wind technology. Currently, wind energy capacity amounts to about 2500 MW in the United States. Good wind areas, which cover 6 percent of the contiguous U.S. land area, could supply more than one and a half times the 1993 electricity consumption of the entire country.

1.4 Solar Energy

Solar technologies tap directly into the infinite power of the sun and use that energy to produce heat, light, and power. Passive Solar Lighting and Heating People have used the sun to heat and light their homes for centuries. Ancient Native Americans built their dwellings directly into south-facing cliff walls because they knew the sun travels low across the southern sky in the Northern Hemisphere during the winter. They also knew the massive rock of the cliff would absorb heat in winter and protect against wind and snow. At the same time, the cliffdwelling design blocked sunlight during the summer, when the sun is higher in the sky, keeping their dwellings cool. The modern version of this sun-welcoming design is called passive solar because no pumps, fans, or other mechanical devices are used. Its most basic features include large, south-facing windows that fill the home with natural sunlight, and dark tile or brick floors that store the sun's heat and release it back into the home at night. In the summer, when the sun is higher in the sky, window overhangs block direct sunlight, which keeps the house cool. Tile and brick floors also remain cool during the summer. Passive solar design combined with energy efficiency will go even further. Energy-efficient features such as energy saving windows and appliances, along with good insulation and weather stripping, can make a huge difference in energy and cost savings. Solar Water Heating Solar energy can be used to heat water for your home or your swimming pool. Most solar water-heating systems consist of a solar collector and a water storage tank. Solar water-heating systems use collectors, generally mounted on a southfacing roof, to heat either water or a heat-transfer fluid, such as a nontoxic antifreeze. The heated water is then stored in a water tank similar to one used in a conventional gas or electric waterheating system.

1.5 Energy Use in Agriculture

1.5.1Solar energy

The foundation of all agricultural production rests on the unique capability of plants to convert solar energy into stored chemical energy. The success of agricultural production is measured by the amount of solar energy that is captured and converted into food per unit land area as a result of manipulating, plant, land, water, and other resources. Agricultural success can be enhanced by finding ways to augment solar energy using human, animal, and fossil energy power.

1.5.2 Slash and burn agriculture

One of the major factors that caused humans to move from hunting and gathering to slash-andburn agricultural production was the continual expansion of the human population. The increased number of people to feed required a higher and more dependable yield than was possible with hunter-gatherer systems. Today, a shortage of cropland, and venerable land, is a major constraint to using this technology. The only fossil energy input used in slash-and-burn agriculture is in the production of the ax and hoe. However, these tools could be produced using charcoal, making the system totally dependent on solar energy. About 1,144 hours of manpower is required to produce about 1,944 kg/ha of maize in this system (Lewis, 1951; Pimentel and Heichel, 1991).

1.5.3 Draft animal agricultural system

If some of the 1,144 hours of human labor in the slash-and-burn system are replaced with about 200 hours of ox power per hectare, then the human labor input can be reduced to 380 hours/ha. Even with the help of animal power, though, this human labor input of 201,000 kcal still remains a large input in this system. 6.4 Draft animal agroforestry system This agroforestry system is similar to the draft-animal system in terms of labor, ox power, machinery, and seeds. By using the agroforestry system, however, 0.5 ha is planted to maize and the other 0.5 ha to the leguminous tree, Leucaena (Torres, 1983; Kidd and Pimentel, 1992). The contour planting design includes 2 rows of maize alternated with 2 rows of trees. The maize in this system is planted at twice the plant density used in the draft-animal system and a similar yield of 1,944 kg/ha is assumed (Pimentel and Pimentel, 1996). 6.5 The status of world fossil energy resources Although about 50% of all the solar energy captured by photosynthesis worldwide is used by humans, it is still not enough to meet all the energy requirements to provide food, fiber, forest products, and support diverse human activities (Pimentel and Pimentel, 1996). To make up for this shortfall, about 365 quads (1 quad = 1015 BTU or 383 x 1018 Joules) of total energy, including fossil (oil, gas, and coal = 345 quads) and solar energy (biomass, hydroelectric, wind power, and numerous other technologies = 20 quads) are utilized throughout the world each year (International Energy Annual, 1995). Industry, transportation, home heating, and food production account for most of the fossil energy consumed in the United States (DOE, 1991; DOE, 1995a). The per capita use of fossil energy in the United States is about 8,740 liters of oil equivalents per year, more than 12- times the per capita use in China. In China, most fossil energy is used by industry, though a substantial amount, approximately 25%, is used for agriculture and the food system (Wen and Pimentel, 1992, 1998). Developed nations annually consume about 70% of the world's fossil energy, while the developing nations -- which have about 75% of the world population -- use only 30% (International Energy Annual, 1995). The United States, with only 4% of the world's population, consumes about 22% of the world's fossil energy output (Pimentel and Pimentel, 1996). Fossil energy use in the various U.S. economic sectors has increased from 20- to 1,000-fold in the past 3 to 4 decades, attesting to America's heavy reliance on this finite energy resource to support its affluent lifestyle (Pimentel and Hall, 1989; Pimentel and Pimentel, 1996). Current fossil energy expenditure is directly related to many factors, including rapid population growth, urbanization, and high per capita consumption rates. Indeed, energy use has been growing even faster than world population growth. From 1970 to 1995, energy use was increasing at a rate of 2.5% per year (doubling every 30 years) whereas the world population only grew at 1.7% (doubling about 40 years) (PRB, 1996; International Energy Annual, 1995). From 1995 to 2015, energy use is projected to increase at a rate of 2.2% (doubling every 32 years) compared with a population growth rate of 1.5% (doubling every 47 years) (PRB, 1996; International Energy Annual, 1995). Fossil fuel energy has enabled a nation's economy to feed an increasing number of humans and improve the general quality of life for people in many ways, including reducing numerous diseases in humans (Pimentel and Pimentel, 1996). But continued heavy reliance on fossil fuels for food production systems will adversely affect the sustainability of food production. Already, fertilizer production on the whole has declined by more than 23% since 1985, especially in the developing countries, due to fossil fuel shortages and high prices (IFDC, 1998). The world supply of oil is projected to last approximately 50 years at current production rates (BP, 1994; Ivanhoe, 1995; Campbell, 1997; Duncan, 1997; Youngquist, 1997; Duncan and Youngquist, 1998). Worldwide, the natural gas supply is adequate for about 50 years and coal for about 100 years (BP, 1994; Bartlett and Ristinen, 1995; Youngquist, 1997). These projections, however, are based on current consumption rates and current population numbers. If the world population continued to grow at a rate of 1.5% and If all people in the world were to enjoy a standard of living and energy consumption rate similar to that of the average American, then the world's fossil fuel reserves would last only about 15 years (Campbell, 1997; Youngquist, 1997). Youngquist (1997) reports that current oil and gas exploration drilling data has not borne out some of the earlier optimistic estimates of the amount of these resources that have yet to be found in the United States. Both the production rate and proved reserves have continued to decline. Reliable analyses suggest that at present (1998) the United States has consumed about three-quarters of the recoverable oil that was ever in the ground, and that we are currently consuming the last 25% of our oil resources (Bartlett, 1998). Projections suggest that U.S. domestic oil and natural gas production will be substantially less in 20 years than it is today. Even now oil is not sufficient to meet domestic needs, and oil supplies are imported in increasing yearly amounts (DOE, 1991;BP, 1994; Youngquist, 1997). Importing 60% of its oil puts the United States' economy at risk due to fluctuating oil prices and difficult political situations, like those that occurred in the 1973 oil crisis and the 1991 Gulf War (U.S. Congressional Record,1997). All of the chemical and nuclear energy that society uses ultimately adds heat to the Earth's environment. The Second Law of Thermodynamics limits the efficiency of heat engines to about 35%

2. LITERATURE OVERVIEW

According to [18] the paper's research focused on evaluating the theoretical and technological energy potential of chicken dung in certain Polish districts. On the basis of acquired data on yearly chicken manure generation as well as its physicochemical qualities, the performed analysis resulted in calculating the value of this potential. The theoretical potential in terms of its usage as a source of chemical energy of the fuel for directly producing heat and power on chicken-rearing sites is encouraging. Converting chicken waste feedstock into a usable source of energy offers a lot of potential for increasing poultry production's environmental sustainability. In Poland, the volume of chicken dung is expected to be 4.49 million tons, with the cage system accounting for 40.7 percent and the litter system accounting for 57.9%. Chicken dung from free-range chicken's accounts for just 1.4 percent of total poultry output and might be overlooked in terms of energy potential. The bulk of chicken manure is produced in Poland's Wielkopolskie and Mazowieckie regions, which account for 44% of the country's total production. In the examination of poultry systems, the amount of chicken dung does not exactly convert into the potential in terms of various physicochemical qualities of manure. The entire annual volume of theoretical energy potential is 40.38 PJ. It should be noted that the theoretical energy potential of chicken manure ignores the loss of energy conversion in facilities used for manure conditioning (drying) as well as energy losses during the generation of useable energy (e.g., heat). In Poland, a relevant examination of the technical energy potential of chicken dung was carried out for four alternative energy conversion routes. The actual technological potential was far lower than the projected potential. Its annual value fluctuated from 9.01 PJ to 27.3 PJ. The anaerobic digesting method resulted in the greatest energy loss, whereas fluidized bed combustion resulted in the most efficient scenario. Furthermore, based on the analysis performed in the provided study, it should be concluded that the selection of an acceptable pathway for energy conversion of manure usage should be tailored to its availability and physicochemical features.

In Turkey, until 2015, energy production accounted for 85.2 percent of greenhouse gas CO_2 emissions, with agricultural activities accounting for 54.3 percent of CH4 emissions, 25 percent from waste, and 20.5 percent from energy production, and agricultural activities accounting for 75.9 percent of N_2O emissions. When all of this is considered, Turkey has an energy potential of 156 million tons per year and 1.3 million tons of petroleum (oil) equivalent (TOE) energy potential per year. According to the findings of a field research done in the province of Balikesir, the pilot facility can handle just 110 thousand tons of fertilizer per year to produce 8 million m3/year of biogas. This biogas has an energy value of 17.1 GWh/year of electricity and 16 GWh/year of thermal energy output. As a result, the release of 13.68 thousand tons of CO_2 per year from petroleum is eliminated. When the country's energy potential is evaluated using the parameters used in the research data, this model shows a structure capable of producing 186 million m3 of biogas per year from 2 million tons of chicken dung per year (Ulusoy, Yahya & Ulukardesler, A. & Arslan, Rıdvan & Tekin, Yücel [19].

According to the results of previous study paper by (Nagy, Gábor & Takács, Alexandra & Kállay, András [20], the maximum biogas quantity and methane content from sheep dung could be obtained by employing a 10% digested cow manure inoculant and a reactor temperature of 34 °C. In this situation, the greatest methane concentration was 58 vol. percent, with a TS gas production of roughly 116 L/kg. In the instance of a sheep livestock with a population of 2000, the achieved gas quantity and methane content should be sufficient to conserve up to 2150 m3 natural gas per year with continuous operation. Such a quantity of gas could be sufficient to power a 100-kW electrical output gas engine for 8000 hours per year.

Another study highlighted and assessed the Bursa province's animal waste biogas potential by (U. Ü. ZİRAAT FAKÜLTESİ DERGİSİ, 2015, Cilt 29, Sayı 2, 47-53), as well as the calorific and electrical energy values that may be derived from this potential. In 2014, the overall volume of animal waste was 2.679.038 ton, corresponding to a theoretical biogas amount of 129.106 dam3 and capable of producing 2.788 TJ and 271 GWhe calorific and electrical energy, respectively. However, owing to a lack of investment, this potential is underutilized. According to this study, manure output grew from 2008 to 2014 and should continue to rise in the near future. Although not all manure could be used for biogas generation, harnessing 1/4th of the biogas potential might be an essential contribution in meeting the rural sector's energy needs.

[21,22] Stated that, Cow manure produces the most methane when compared to chicken and sheep manure. The methane volume percent from cow dung was enhanced from 10% to 68.5 percent after optimization (40°C, pH 4, trace-element supplementation).

Finally, it worth to mention that, concerns about the rapid depletion of energy supplies, as well as the need to mitigate the negative environmental effects of energy generation from fossil-based fuels, have boosted the use of renewable energy carriers such as biogas. Biogas produced from animal waste might be a viable solution for areas whose economies are heavily reliant on livestock. The anaerobic digestion method for biogas production from animal waste might be poised for commercial applications in Burdur through long-term research activities. This research proposes (Burdur Mehmet Akif Ersoy University 2019) identifying the theoretical potential of energy generation by biogas obtained from animal waste in Burdur province, which is located in Turkey's Mediterranean Region. The province's projected biogas potential is 27.1 million m3/year, which amounts to an annual energy output of 135.4 GWh. The central section of the province has the biggest biogas potential among the districts of Burdur. Biogas produced from livestock manure has the potential to be a substantial source of renewable energy generation as well as a solution to the province's animal waste management problem. The study's findings are important for investors considering biogas projects in the province. Burdur's animal waste potential is tremendous, and farmers and investors may gain from waste-to-energy technology if properly managed and supported by government subsidies.

3. MATERIALS AND METHODS

3.1 Materials

The following materials has been used to conduct the procedure:

1- Manure
2- Dextrin
3- Press
4- Sensitive Scale
5- Distilled Water
6- Caliper Compass

Manure: two types of manure were used, sheep and chicken manure. The manure has been exposed to sunlight for five days under the temperature of approximately 35-40 C. After complete drought the sample has been sieved to separate the organic materials from other derbies to make the process of making matrix easier.

Dextrin: are usually a byproduct or intermediate product of other processes; Dextrin was mixed with warm distilled water to make the matrix hard.

Caliper Compass: to measure the depth of sample. For this experiment 2.5 cm was set.

After preparing chicken manure and sheep manure samples, the sieving process was done with a pore size of 2 millimeters. The sieving process is essential to create a powder-like material to make it pure and easy for the press stage. Purification of manure will also help separate any type of debris. The powder can facilitate the Dextrin mixing step to obtain accurate result. In this experiment, five different samples have been prepared with varying percentages of manure.

Sample one

100% of Sheep Manure. 500 gm of sheep manure, 80 gm of Dextrin, and 120 gm of warm water were used. At first, Dextrin was mixed with warm water to make Dextrin soluble. Then the pure sheep manure was added to the mixture, the total weight of the sample at this point reached 700 gm. After that, the mixture was placed into a Press machine to get a symmetrical texture by setting the caliper to 2.5 cm depth. The process was conducted under the temperature of 120 degrees Celsius for 40 minutes; then, it was left for four hours in the press. At the final stage, the sample has been put on a scale for measurement.

Sample two

100% of Chicken Manure. 500 gm of chicken manure, 80 gm of Dextrin, and 120 gm of warm water were used. At first, Dextrin was mixed with warm water to make Dextrin soluble. Then the pure chicken manure was added to the mixture. After that, the mixture was placed into a Press machine to get a symmetrical texture by setting the caliper to 2.5 cm depth. The process was conducted under the temperature of 120 degrees Celsius for 40 minutes; then, it was left for four hours in the press. At the final stage, the sample has been put on a scale for measurement.

Sample three

50% of Sheep Manure, 50% of Chicken manure. 250 gm of sheep manure. 250 gm of chicken manure, 80 gm of Dextrin, and 120 gm of warm water were used. At first, Dextrin was mixed with warm water to make Dextrin soluble. Then the pure sheep and chicken manure were added to the mixture. After that, the mixture was placed into a Press machine to get a symmetrical texture by setting the caliper to 2.5 cm depth. The process was conducted under the temperature of 120 degrees Celsius for 40 minutes; then, it was left for four hours in the press. At the final stage, the sample has been put on a scale for measurement.

Sample four

75% of Sheep Manure, 25% of Chicken manure. 375 gm of sheep manure. 125 gm of chicken manure, 80 gm of Dextrin, and 120 gm of warm water were used. At first, Dextrin was mixed with warm water to make Dextrin soluble. Then the pure sheep and chicken manure were added to the mixture. After that, the mixture was placed into a Press machine to get a symmetrical texture by setting the caliper to 2.5 cm depth. The process was conducted under the temperature of 120 degrees Celsius for 40 minutes; then, it was left for four hours in the press. At the final stage, the sample has been put on a scale for measurement.

Table 1. Sampling distribution

No.	Percentage	Sample weight (g)	Dextrin (g)	water	Total (g)	Matrix WT (g)	Temperatur (C)	Duration (min)
1	100% sheep	500 g	80	120	700	576	120	40
2	100% chicken	500 g	80	120	700	670	120	40
3	50% chicken 50% sheep	250 g chicken 250g sheep	80	120	700	635	120	40
4	75% chicken 25% sheep	375 g chicken 125g sheep	80	120	700	698	120	40
5	25% chicken 75% sheep	125 g chicken 375 g sheep	80	120	700	690	120	40

Sample five

25% of Sheep Manure, 75% of Chicken manure. 125 gm of sheep manure. 375 gm of chicken manure, 80 gm of Dextrin, and 120 gm of warm water were used. At first, Dextrin was mixed with warm water to make Dextrin soluble. Then the pure sheep and chicken manure were added to the mixture. After that, the mixture was placed into a Press machine to get a symmetrical texture by setting the Caliper to 2.5 cm depth. The process was conducted under the temperature of 120 degrees Celsius for 40 minutes; then, it was left for four hours in the press. At the final stage, the sample has been put on a scale for measurement.

4. RESULTS AND DISCUSSION

The laboratory analysis shows the following results:

Table 2. Solid fuel analysis report 1

Test type	Original basis	Air dried basis	Dry basis	Testing standard
Total moisture	6,52	-	-	ASTM D 3302
Moisture	-	6,52	-	ASTM D 7582
Ash	34,50	34,50	36,91	ASTM D 7582
Volatile matter	51,34	51,34	54,92	ASTM D 7582
Total sulfur	0,50	0,50	0,53	ASTM D 4239
Grosscalorific value (kcal/kg)	2211	2211	2365	ASTM D 5865
Net calorific value (kcal/kg)	2006	2006	2184	ASTM D 5865

Note:Moisture analysis, nitrogen gas environment, ash analysis, by moisture volatile matter-ash sequencing. Until it comes to fixed weight, the oven heating speed is 38C/min in the volatile matter analysis

Table 3. Solid fuel analysis report 2

Test type	Original basis	Air dried basis	Dry basis	Testing standard
Total moisture	9,78	-	-	ASTM D 3302
Moisture	-	9,78	-	ASTM D 7582
Ash	11,17	11,17	12,38	ASTM D 7582
Volatile matter	66,76	66,76	74,00	ASTM D 7582
Total sulfur	0,81	0,81	0,90	ASTM D 4239
Grosscalorific value (kcal/kg)	3529	3529	3911	ASTM D 5865
Net calorific value (kcal/kg)	3236	3236	3646	ASTM D 5865

***Note**:Moisture analysis, nitrogen gas environment, ash analysis, by moisture volatile matter-ash sequencing. Until it comes to fixed weight, the oven heating speed is 38C/min in the volatile matter analysis*

Table 4. Solid fuel analysis report 3

Test type	Original basis	Air dried basis	Dry basis	Testing standard
Total moisture	7,77	-	-	ASTM D 3302
Moisture	-	7,77	-	ASTM D 7582
Ash	21,26	21,26	23,05	ASTM D 7582
Volatile matter	60,47	60,47	65,56	ASTM D 7582
Total sulfur	0,72	0,72	0,78	ASTM D 4239
Grosscalorific value (kcal/kg)	2992	2992	3244	ASTM D 5865
Net calorific value (kcal/kg)	2739	2739	3016	ASTM D 5865

Note:Moisture analysis, nitrogen gas environment, ash analysis, by moisture volatile matter-ash sequencing. Until it comes to fixed weight, the oven heating speed is 38C/min in the volatile matter analysis

Table 5. Solid fuel analysis report 4

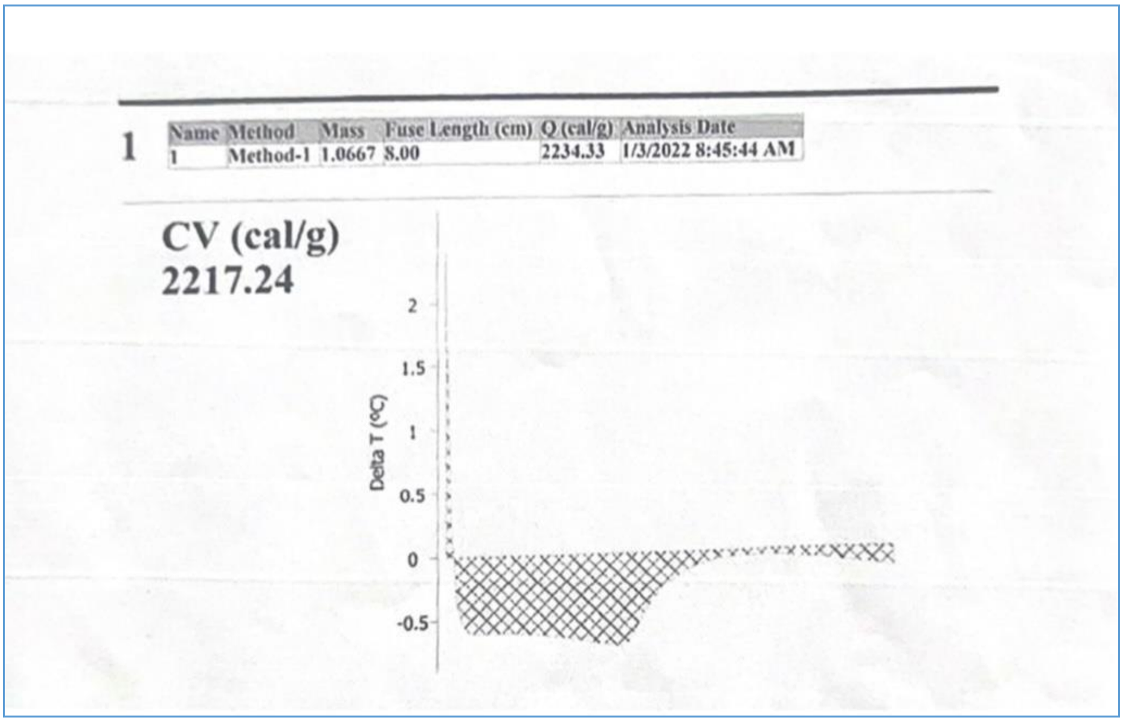
Test type	Original basis	Air dried basis	Dry basis	Testing standard
Total moisture	11,17	-	-	ASTM D 3302
Moisture	-	11,17	-	ASTM D 7582
Ash	15,30	15,30	17,22	ASTM D 7582
Volatile matter	62,87	62,87	70,78	ASTM D 7582
Total sulfur	0,70	0,70	0,79	ASTM D 4239
Grosscalorific value (kcal/kg)	3336	3336	3755	ASTM D 5865
Net calorific value (kcal/kg)	3048	3048	3500	ASTM D 5865

Note:Moisture analysis, nitrogen gas environment, ash analysis, by moisture volatile matter-ash sequencing. Until it comes to fixed weight, the oven heating speed is 38C/min in the volatile matter analysis

Table 6. Solid fuel analysis report 5

Test type	Original basis	Air dried basis	Dry basis	Testing standard
Total moisture	7,44	-	-	ASTM D 3302
Moisture	-	7,44	-	ASTM D 7582
Ash	30,01	30,01	32,42	ASTM D 7582
Volatile matter	55,47	55,47	59,93	ASTM D 7582
Total sulfur	0,48	0,48	0,52	ASTM D 4239
Grosscalorifc value (kcal/kg)	2643	2643	2855	ASTM D 5865
Net calorific value (kcal/kg)	2409	2409	2647	ASTM D 5865

Note:Moisture analysis, nitrogen gas environment, ash analysis, by moisture volatile matter-ash sequencing. Until it comes to fixed weight, the oven heating speed is 38C/min in the volatile matter analysis

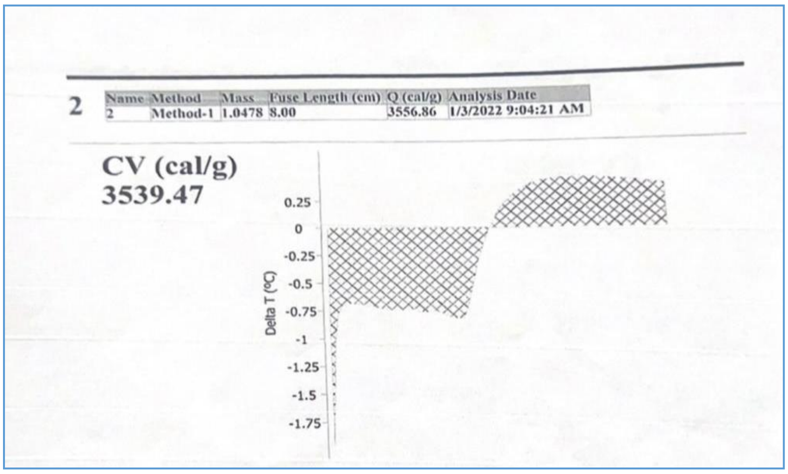


1

Name	Method	Mass	Fuse Length (cm)	Q (cal/g)	Analysis Date
1	Method-1	1.0667	8.00	2234.33	1/3/2022 8:45:44 AM

CV (cal/g)
2217.24

(Fig. 1)

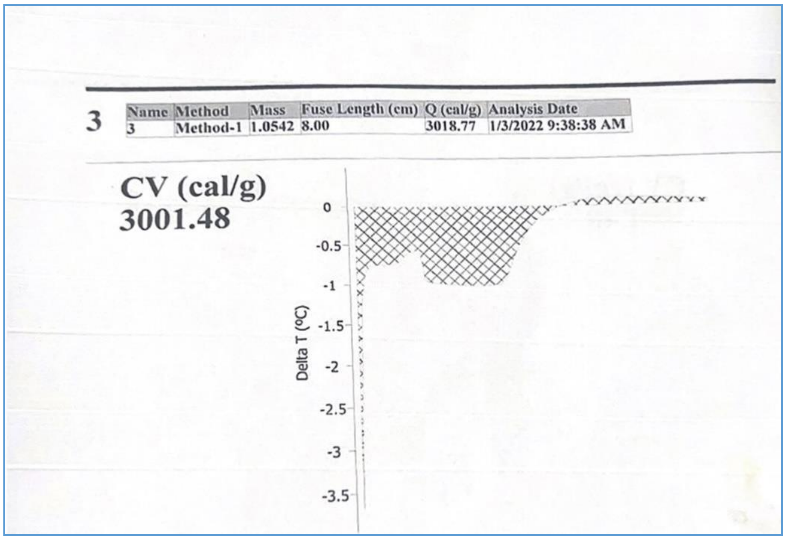


2

Name	Method	Mass	Fuse Length (cm)	Q (cal/g)	Analysis Date
2	Method-1	1.0478	8.00	3556.86	1/3/2022 9:04:21 AM

CV (cal/g)
3539.47

(Fig. 2)

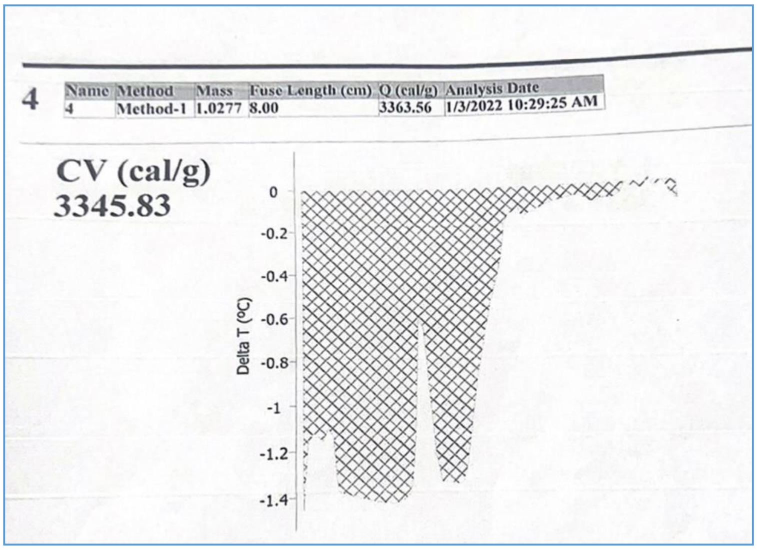


3

Name	Method	Mass	Fuse Length (cm)	Q (cal/g)	Analysis Date
3	Method-1	1.0542	8.00	3018.77	1/3/2022 9:38:38 AM

CV (cal/g)
3001.48

(Fig. 3)



4

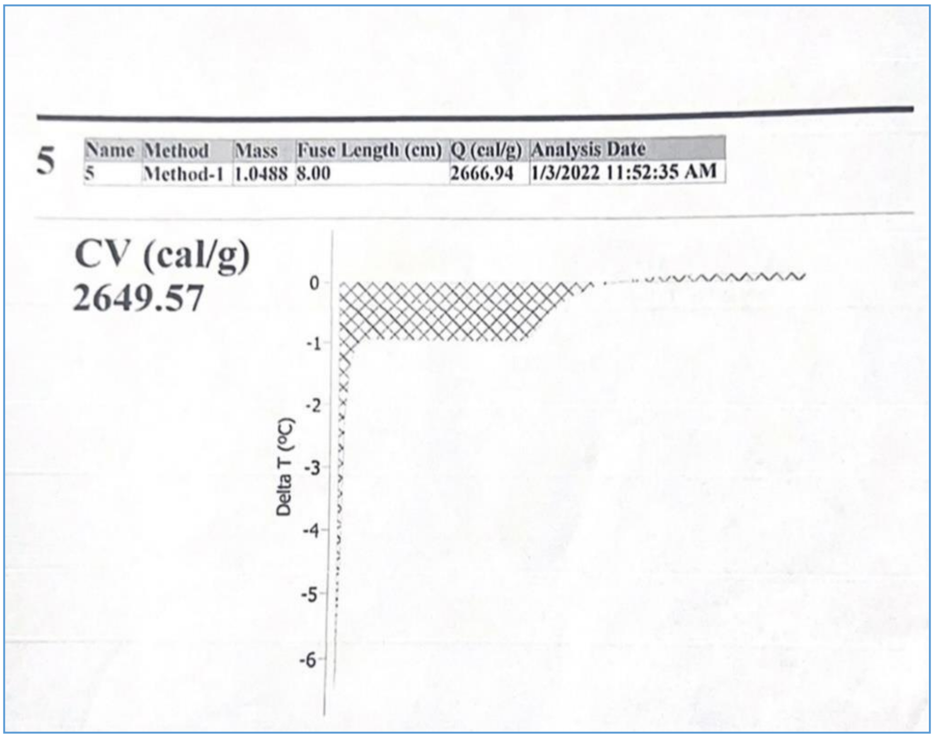
Name	Method	Mass	Fuse Length (cm)	Q (cal/g)	Analysis Date
4	Method-1	1.0277	8.00	3363.56	1/3/2022 10:29:25 AM

CV (cal/g)
3345.83

(Fig. 4)

4.1 Statistical Method

The study performed correlation analysis to determine the relationship between airborne particle measurement levels on a dry and original basis. Regression analysis linked net calorie levels with total moisture, ash%, volatile matter, sulfur and gross calorie levels. The regression analysis examined the significance of R2, Durbin Watson test, Model and coefficient. P values less than 0.05 were considered statistically significant in the study. Analyzes were made with SPSS 25.0 package program.



5

Name	Method	Mass	Fuse Length (cm)	Q (cal/g)	Analysis Date
5	Method-1	1.0488	8.00	2666.94	1/3/2022 11:52:35 AM

CV (cal/g)
2649.57

(Fig. 5)

Table 7. Examining the relationships between the original Base measurements

Measurements		Original Base Total Humidity	Original Base Ash%	Original Base Volatile Matter%	Original Base Total Sulfur%	Original Base Gross Calories	Original Base Net Calories
Original Base Total Humidity	r p	1					
	r p	-0,88	1				
Original Base Ash%		0,04*					
Original Base Volatile Matter%	r p	0,83 0,08	-0,99* 0,01	1			
Original Base Total Sulfur%	r p	0,70 0,19	-0,94* 0,01	0,93* 0,01	1		
Original Base Gross Calories	r p	0,89* 0,04	-0,91* 0,01	0,99* 0,01	0,90* 0,04	1	
		0,86*	-0,99*	0,99*	0,90*	0,99	1
Original Base Net Calories	r p	0,04	0,01	0,01	0,04	0,01	

**Significant correlation at the 0.05 level*

In the study, it was observed that there was a significant negative correlation between Total Moisture and Ash% measurements on the original basis (r=-0.88,p=0.04).

In the study, it was observed that there was no significant relationship between Total Moisture and % volatile matter on the original basis (r=0.83, p=0.08).

In the study, it was observed that there was no significant relationship between Total Moisture and Total Sulfur% on the original basis (r=0.70, p=0.19).

In the study, it was observed that there was a significant positive correlation between Total Moisture and gross calorie measurements on the original basis (r=0.89, p=0.04).

In the study, it was observed that there was a significant positive correlation between Total Moisture and net calorie measurements on the original basis (r=0.86, p=0.04).

In the study, it was observed that there was a significant negative correlation between Ash % and Volatile Matter % measurements on the original basis (r=-0.99, p=0.01).

In the study, it was observed that there was a significant negative correlation between Ash% and Total Sulfur% measurements on the original basis (r=-0.94, p=0.01).

In the study, it was observed that there was a significant negative correlation between Ash % and gross calorie measurements on the original basis (r=-0.91, p=0.01).

In the study, it was observed that there was a significant negative correlation between Ash % and net calorie measurements on the original basis (r=-0.99, p=0.01).

In the study, it was observed that there was a significant positive correlation between Volatile Matter% and Total Sulfur% measurements on the original basis (r=0.93, p=0.01).

In the study, it was observed that there was a significant positive correlation between Volatile Matter% and gross calorie measurements on the original basis (r=0.99, p=0.01).

In the study, it was observed that there was a significant positive correlation between Volatile Matter% and net calorie measurements on the original basis (r=0.99, p=0.01).

In the study, it was observed that there was a significant positive correlation between Total Sulfur% and gross calorie measurements on the original basis (r=0.90, p=0.01).

In the study, it was observed that there was a significant positive correlation between Total Sulfur% and net calorie measurements on the original basis (r=0.90, p=0.01).

In the study, it was observed that there was a significant positive correlation between net calorie and gross calorie measurements on the original basis (r=0.99, p=0.01).

Table 8. Examining the relationships between Dry Base measurements

Measurements		**Dry Base Ash%**	**Dry Base Volatile Matter %**	**Dry Base Total Sulfur %**	**Dry Base Gross Calories**	**Dry Base Net Calories**
Dry Base Ash%	r p	1				
Dry Base Volatile Matter %	r p	-0,99* 0,01	1			
Dry Base Total Sulfur%	r	-0,96*	0,94*	1		
	p	0,01	0,02			
Dry Base Gross Calories	r	-0,98*	0,99*	0,92*	1	
	p	0,01	0,01	0,03		
Dry Base Net Calories	r	-0,98*	0,99*	0,92*	0,99	1
	p	0,01	0,01	0,03	0,01	

**Significant correlation at the 0.05 level*

In the study, it was observed that there was a significant negative correlation between Ash % and Volatile Matter % measurements on dry basis (r=-0.99,p=0.01).

In the study, it was observed that there was a significant negative correlation between Ash% and Total Sulfur% measurements on a dry basis (r=-0.96, p=0.01).

In the study, it was observed that there was a significant negative correlation between Ash % and gross calorie measurements on a dry basis (r=-0.98, p=0.01).

In the study, it was observed that there was a significant negative correlation between Ash % and net calorie measurements on a dry basis (r=-0.98, p=0.01).

In the study, it was observed that there was a significant positive correlation between Volatile Matter% and Total Sulfur% measurements on a dry basis (r=0.94, p=0.02).

In the study, it was observed that there was a significant positive correlation between Volatile Matter% and gross calorie measurements on a dry basis (r=0.99, p=0.01).

In the study, it was observed that there was a significant positive correlation between Volatile Matter% and net calorie measurements on a dry basis (r=0.99, p=0.01).

In the study, it was observed that there was a significant positive correlation between Total Sulfur% and gross calorie measurements on a dry basis (r=0.92, p=0.02).

In the study, it was observed that there was a significant positive correlation between Total Sulfur% and net calorie measurements on a dry basis (r=0.93, p=0.02).

In the study, it was observed that there was a significant positive correlation between net calorie and gross calorie measurements on a dry basis (r=0.99, p=0.01).

Table 9. Variables Affecting Original Base Net Calorie Level

Independent variables				F Model	R^2
The dependent variable	Original Base Gross Calories (β)	Original Base Total Humidity (β)	Original Base Volatile Matter% (β)		
Original Base Net Calories (Y)	1,015 t=510,26 p=0,01	-0,017 t=-8,51, p=0,01	0,06 t=4,59 p=0,01	4653,28 (p=0.01)	0,93

***Applied regression analysis, D.W;1.79*

Table 10. Variables Affecting Dry Base Net Calorie Level

Independent variables				F Model	R^2
The dependent variable	Dry Base Gross Calories (β)	Dry Base Volatile Matter % (β)	Dry Base Total Sulfur % (β)		
Dry Base Net Calories (Y)	1,270 t=510,26 p=0,01	-0,019 t=-9,26 p=0,01	0,09 t=6,23 p=0,01	5623,25 (p=0.01)	0,96

***Applied regression analysis, D.W;1,85*

When the table is examined, it is seen that gross calorie, total moisture and volatile matter % measurements have a significant effect on the net calorie level. The model detected in the study was found to be significant (F=4653.28, p=0.01, p<0.05). It was observed that the percentage of explanation of the model was 93% (R2=0.93) and this rate was quite high. Finally, gross calorie, total moisture and volatile matter % coefficients were also found to be significant (p=0.01,p<0.05). According to the results of the Durbin Watson test performed to examine the presence of autocorrelation in the model, it was observed that there was no autocorrelation in the model (D.W;1.79). As a result, the model was found to be significant.

According to the results, it was seen that the most important variable affecting the net calorie level on the original basis was the gross calorie level, followed by the volatile matter and %total moisture levels. It is stated that the measurements with high gross calorie and volatile substance levels will also have high net calorie levels. It was observed that the net calorie level would be lower in the measurements with a high total humidity level.

When the table is examined, it is seen that gross calorie, sulfur % and volatile matter % measurements have a significant effect on the net calorie level. The model detected in the study was found to be significant (F=5623.25, p=0.01, $p<0.05$). It was observed that the percentage of explanation of the model was 96% ($R2=0.96$) and this rate was quite high. Finally, the coefficients of gross calorie, sulfur % and volatile matter % were also found to be significant (p=0.01, $p<0.05$). According to the results of the Durbin Watson test performed to examine the presence of autocorrelation in the model, it was observed that there was no autocorrelation in the model (D.W;1,85). As a result, the model was found to be significant.

According to the results, it was observed that the most important variable affecting the net calorie level on a dry basis was the gross calorie level, followed by the volatile matter and sulfur % levels. It is stated that the measurements with high gross calorie and sulfur % levels will also have high net calorie levels. It was observed that the net calorie level would be lower in the measurements with high volatile matter level.

5. CONCLUSIONS AND SUGGESTIONS

Following the last consideration of five examples, the energy that exists is analyzed. According to the highest rate of energy discovered, the study provides the following results:

Second sample: 3539.47 CV (Cal/g) Fourth sample: 3345.83 CV (Cal/g) Third sample: 3001.48 CV (Cal/g) Fifth sample: 2649.57 CV (Cal/g) First sample: 2217.24 CV (Cal/g)

The final decision reveals that the second sample, which is made entirely of chicken dung, has the most significant rate of solid fuel energy. Sheep dung, on the other hand, has the lowest energy content.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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