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Bioenergy Valuation of Poultry Litter by Applying an Enzyme Product for Environmental Purposes: A New Applied Technology †

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Abstract: The increase and intensification of food production entail some potential risks to the environment due to emissions of greenhouse gases, acid rain and other pollutants. European policies are focused on environmental protection and particularly on the health and welfare of animals intended for human consumption. The transposition of the Directive of water protection (91/676/EEC) and the increase botulism cases in countries such as Ireland have necessitated the search for alternative solutions for the management of poultry manure, which has traditionally been used as a fertilizer. Research has targeted eco-friendly, techno-economical and time-effective solutions, together with a simplified large-scale operational approach. Given this scenario, this project aims to study the use of Colombian enzyme product, called Bioterre, in European farms. This product is used in that country as a stabilizer and composting accelerator of organic waste for fertilizer production. After experimental testing application the average moisture content of the poultry litter in treated sheds of the different farms, at the end of the cycle, is 27%, versus 47% in the untreated sheds. This product decreases the moisture content in the biomass increasing the Lower Heating Value (LHV). Equipment based on this technology could be used mainly in the food processing industry and their bioenergy sustainable projects.

Keywords: poultry litter; biomass; ammonia

1. Introduction

The poultry sector presents a positive growth trend in many countries, because of the world population increase, which leads to an increase in the volume of waste and emissions generated. This means new management and treatment challenges [1]. Poultry industry waste includes a mixture of excrement (manure), bedding material (wood shavings, straw...), food debris, dead birds, broken eggs, feathers, etc. It is commonly referred as a chicken manure. This chicken litter has a high value in nutrients (nitrogen, phosphorus and potassium), and has been used as an organic fertilizer, using techniques of direct dumping on land [2]. However, excessive application of this material can result in too high enrichment of water nutrients, resulting in eutrophication, spread of pathogens, generation of toxic substances, air pollution and emissions of greenhouse gases [3].

The European Union (EU) has intensified, over the last few years, the legislation on the care of the environment, with regulations on the protection of water and air quality, such as Directive 91/676/EEC, or Directive 2001/81/EC. Eutrophication has been identified as the main cause of diminishing surface water resources. On the other hand, high levels of nitrates in drinking water can cause various diseases in animals and humans [4]. In particular, European laws have also been strengthened with respect to the management of poultry industry waste, which means that this sector and the governments are looking for new energy alternatives to allow the continuity of this industry.

In a deeper analysis about this type of biomass or "bio-product", worldwide, an enzymatic product was found, developed and used in Colombia as an accelerator of composting, in order to produce a fertilizer of greater added value. Given its properties, it was decided to conduct an experimental study in Europe, in order to obtain a biomass with higher calorific value and at the same time improve the environmental conditions of the farms and reduce, therefore, the emissions.

The use of chicken manure as an energy source, besides being an alternative to its use as a fertilizer, is of special interest in the EU given their energy dependence. This would be particularly positive in Ireland, a country that needs to import around 90% of the energy. The case study is developed in Irish farms during the chicken growth cycle.

This new industrial technology is a promising candidate for sustainable green pre-treatment solutions for biomass waste valuation in a large scale as waste industrial bioenergy [5]. Two objectives were sought by applying the product during the growth cycle of chickens, and therefore along residue generation: reducing the moisture of the final residue (poultry litter), and thus increasing the calorific value for use as biomass, and reducing ammonia emissions, improving environmental conditions inside the buildings, in the same ventilation and acclimatization context.

2. Materials and Methods

Biodegradable organic matter, in the presence of aerobic organisms and with oxygen from the environment, decomposes into humus (compost), releasing CO_2, heat and water.

At the end of 2009, research began on the Colombian enzymatic product called Bioterre, used in this country mainly as an accelerator of composting, an aerobic biological process in which organic matter is decomposed by the action of microorganisms quickly. The resulting product, compost, is a fertilizer used in agriculture. The main difference with natural decomposition is that in composting the variables that take part in it are controlled. The limiting factors of the process are those that influence the development of microorganisms, namely: temperature, humidity, aeration, nutrients, pH, C/N ratio and microbiota composition.

The Bioterre is prebiotic, that is, a no digestible food ingredient that stimulates the growth or activity of one or more types of bacteria in the organic matter decomposition process. Since the product has to be sprayed on the largest possible waste surface, an ultra-low volume sprayer was used. For the analysis of the poultry manure at the end of each cycle, we collected, in each case, a sample of the residue from different random points along the housing [4].

The result for each shed is the average of two satisfactory analytics performed for each sample. Moreover, the MS-70 moisture analyzer from A&D was used in our laboratory to carry out this study. The equipment supplies the percentage value in moisture.

For the development of the present study, we carried out the application of the enzymatic product tests in twenty-four Irish farms during the growth cycle of the broilers, in different stages. Each farm had between two and six sheds, so we worked on a total of more than seventy chickens sheds. The product was applied inside farms with three scenarios: 7 day-old chickens, 10 day-old chickens and 15–18 day-old chickens.

3. Results and Discussion

In the first case, the poultry manure moisture at the end of the cycle was lower than those not treated, remaining in all cases below 40%. On average, the moisture in the treated farms was 32%, compared to 47% in the untreated ones. The ammonia measurements were made inside the housings during the chicken growth cycle. The particular way of operating in each farms conditions its state. That is, the human factor is a relevant variable in the development of the activity.

The concentration of gases inside the housings will depend largely on the ventilation cycles, which are the responsibility of the farmer. This, along with the fact that we cannot ensure that the farms were not ventilated before making the measurements, makes the results between farms not comparable, so that the analysis of the results obtained must be individualized for each of the farms under study. The average reduction was 70%. If we remove the highest and the minimum value, the average reduction is 76%. In view of these results, we made the decision to do the test by applying the product during the first third of the cycle, that is, with 10-day-old chickens, to study if a greater reduction could be achieved.

In the second case carried out, the product was applied inside farms with 10-day-old chickens. Again, the moisture content of the poultry manure in treated sheds was lower than in untreated ones, increasing Lower Heating Value (LHV) [6]. In this case, the average was 30% in the treated, compared to 49% in no treated (taking into account only the untreated farms studied in this second test). Ammonia analysis inside the farms. In this case, the average reduction was 74%.

In third case, we only have moisture data of untreated poultry manure. What can be affirmed is that the moisture average of the poultry manure, at the end of the cycle, of the poultry sheds treated at seven days was 27%, compared to 47% of those not treated. Ammonia analysis inside the farms.

During this test, ammonia measurements could not be made in the untreated farms, so it has not been possible to determine the reduction implied by treatment after 7 days. What can be assured is that in the treated sheds the concentration measured in any case exceeded 6 ppm. Figure 1 shows the results of the samples analysed from untreated farms, and those treated at different times in the cycle.

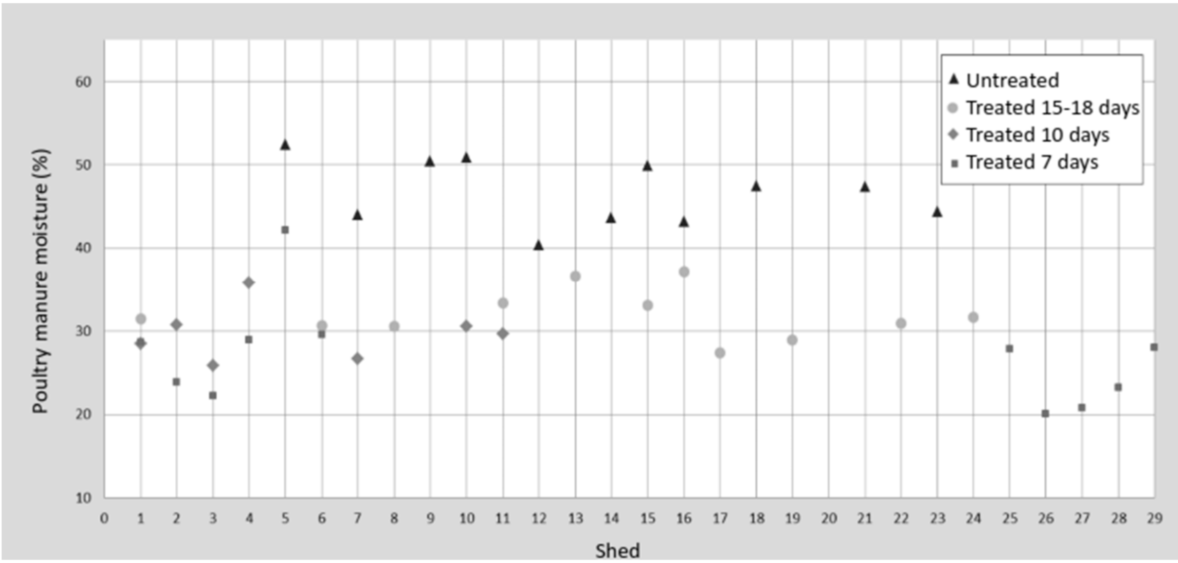

Figure 1. Poultry manure moisture of the all test made.

Bioenergy is expected to play an important role in the low carbon economy [7,8]. In this future context, the profitability index for the construction and operation of a 40 MW biomass power plant in Ireland have been calculated. The fuel considered is 83% chicken manure treated with the enzymatic product Bioterre in the farms, and 17% of biomass from the willow crop [4].

The results are the net present value of the project (NPV) and internal rate of return (IRR) of 202,741,143 € and 30%, respectively. With the conditions analysed, the biomass power plant is a realizable project.

4. Conclusions

The enzymatic product Bioterre can be applied inside the farms, during the growth cycle, without any risk to the broilers or significant modifications in their infrastructure. The study of its use in Irish poultry farms is a first step for commercial use in the EU.

According to the data collected and the samples analysed, an application of the product after 7 days of the cycle would mean a reduction of between 2 and 5% moisture with respect to the application at 10 to 15–18 days, so that it is concluded that the optimal application time would be during the first week of the cycle.

The moisture average of poultry manure, at the end of the cycle, in treated sheds of different farms is 27%, compared to 47% in the untreated ones.

Ammonia emission records at different stages of the production cycle in treated poultry sheds did not exceed 6 ppm, while in untreated sheds that record was always higher, exceeding in some cases 35 ppm.

In the farms where we were able to measure the concentration of ammonia in treated and untreated poultry sheds, the reduction was 70% with the application of the Bioterre.

Author Contributions: G.B.-F. performed the experiments; G.B.-F, J.P.P.-S. and J.X.-B. analyzed the data and wrote the paper.

Conflicts of Interest: The authors declare no conflict of interest.

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