Case Study

Production of organic fertilizers from expired food and vegetable and fruit waste using a multi-step method: case study: Oslo, Norway

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ABSTRACT

The prerequisite for this multi-step method was to separate food waste and scraps into different groups: A) vegetables and fruits, as cellulose carbohydrates containing fructose sugar; B) expired protein foods such as fish, meat, sausage, and eggs; and C) bread and coffee waste. Then they were processed in the following steps:
Step 1: After the packaging materials were separated, the pure materials were crushed in a mixer.Step 2: Organic residue soaking: The crushed pure materials were exposed to a temperature of 70°C in the first tank to destroy pathogenic bacteria such as salmonella. Then they were mixed with mesophilic and thermophilic bacteria using a circulation axis to be pasteurized. Step 3: The author designed the second tank, in which the temperature dropped by 20°C. This temperature is optimal for cellulase activity. As a result, cellulase activity in this tank desalinated organic fertilizer at this stage. The resulting material emerged from the reactor as a brown powder. Step 4: The resulting material was left outside the reactor for three weeks to mature in the tank. Step 5: After three weeks, organic fertilizers with different functions were produced. The first type of organic fertilizer, which is regarded as a germination miracle, was created by combining reactor powder with coffee waste at a 1:15 ratio and then adding ten mg of glucagon per liter to this mixture. The second type of organic fertilizer was made by mixing reactor powder with coffee residue and nettles at a 2:15 ratio and then adding 15 mg/l of cortisol. This hormone stimulates superoxide dismutase and improves growth index and seedling length.

Keywords: Mesophilic bacteria, Thermophilic bacteria; Reactor, Glucagon; Cortisol, Organic fertilizer

Introduction

A large amount of food goes to waste every day due to expired or spoiled waste in homes and stores as well as food waste sent to garbage in restaurants. According to official reports, the value of food waste in Norway is equal to NOK 8 billion, and a total of 300,000 loaves of bread are wasted in this country. However, food waste and scraps are sent to biogas plants to be converted into energy.

Norway has a very high relative commercial advantage in fertilizer production, in addition to salmon, which has a very high relative advantage in Europe and is regarded as a global market brand. Therefore, the authors selected Norway as a case for this study. It is noteworthy that this formulation was used to produce these two types of fertilizers for the first time in Oslo, Norway, after obtaining a production license from the Mattilsynet of Norway. Moreover, Food waste and scraps from restaurants and hotels were not used to produce organic fertilizer because the high quantity of salt and spices in such foods reduces the quality of fertilizers, and the long-term use of such fertilizers destroys the soil texture.

Garbage and waste are used to produce biogas in Norway. Biogas is a natural and renewable source of energy that positively affects both the environment and industries. This gas is produced by the decomposition of organic materials, such as animal manure, food waste, and sewage. The anaerobic digestion of fertilizers and waste produces biogas. It should be noted that biogas is flammable because methane accounts for about 50-70% of biogas. Methane, hydrogen, carbon monoxide, and oxygen are combined to produce fuel because air contains 21% oxygen. The energy released in biogas is used as fuel. As the most cost-effective renewable fuel, biogas is used in many countries for cooking, cooling and heating, electricity, methanol and steam production, waste management, and mechanical power generation.

Biogas has many advantages over other fuels, some of which are as follows:

- Energy production (including heat, light, electricity)
- Reduction of discarded waste
- Reduction of pathogens (flies, worm eggs)
- Conversion of organic waste into high-quality fertilizers
- Protection of vegetation, soil, and water
- Improvement of livestock and agriculture productivity

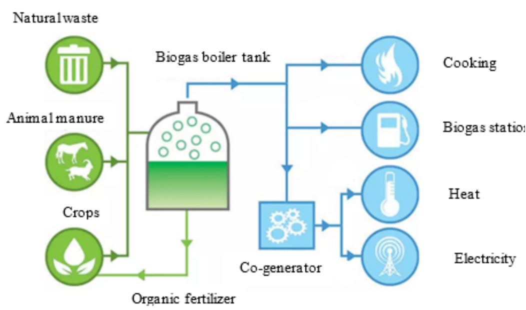

Figure2. Use of food waste in biogas production

Biogas-based fertilizers are organic with the same standards as compost and cannot compete with chemical fertilizers. Therefore, farmers still tend to use chemical fertilizers.

Table 1: Characteristics of biogas-based organic fertilizer

	Nitrogen (mg/liter)	Potassium (mg/liter)	Phosphorus (mg/liter)	pH	EC	Organic matter (%)
Biogas-based organic fertilizer	5	74	1	2.5	53.29	19.8

Materials and Methods

Expired food and unusable vegetables and fruits were collected from the contracted stores, a large amount of wasted bread was collected from bakeries, and coffee waste was collected from coffee shops every week. After the packaging materials were separated in a factory, the waste materials were classified into three groups: 1- fruit and vegetable waste, 2- meat waste (fish, chicken, etc.), and 3- bread and coffee waste (Figure 1).

Figure 1. Fruit waste is collected and separated

Every day, 400 kg of these three categories of materials were introduced to the reactor, including 260 kg of vegetables and fruits, 100 kg of meat waste, and 40 kg of bread and coffee waste. Bananas, oranges, apples, pineapples, and mangoes were among the most abundant fruits, and lettuce, cabbage, tomatoes, cucumbers, and beets were more abundant than others among vegetables. [1] This ratio should be observed to produce an organic fertilizer that contains adequate amino acids and high levels of nitrogen, phosphorus, and potassium. However, this ratio was changed slightly depending on the factory input. About 20% of the materials that were fed into the reactor every day were converted into coffee powder as the output. The materials were exposed to mesophilic and neutrophilic bacteria at 70°C in the first tank. The material from the previous day was directed to the front tank when fresh material arrived the following day. Cellulase was added to the material in the second tank where the temperature was set to 50°C. The required amount of cellulase was calculated using Equation 1 [2].

$$1\text{-} \quad U = \frac{[(A_E - A_B) \times K \oplus C]}{M \times t}$$

Where, U, K, C, M, and t denote enzyme activity, calibration graph slope, calibration intercept, molecular weight of glucose, and duration of reaction (minute), respectively.

The resulting brown powder was investigated through spectrometry in a laboratory. [3] It should be noted that spectrometry was performed on various ratios of materials added to the reactor to achieve the best input combination (Figure 2). Accordingly, the 400 kg input materials consisted of 200-250 kg of fruits and vegetables, 100-150 kg of meat and protein products, and 40-60 kg of bread scraps. The spectrometry results showed that the resulting product was free of elements and heavy metals. Table 2 shows the elements and features of this powder.

Figure 2. Fertilizer decomposition machine

Table 2. Characteristics of organic fertilizer multi-step method

Feature	Dry matter (%)	Nitrogen (% of dry matter)	Phosphorus (% of dry matter)	Potassium (% of dry matter)	pH
Quantity	94	9.1	8.1	8.6	5.6

The C/N ratio in the pulp was equal to 21, which typically resulted in the release of N during decomposition. These figures can change based on the ratio of input materials. [4,5]

This powder has great agricultural potential when used directly. The NPK element content is similar to that of chemical fertilizer [7]. This powder can be fed to biogas plants for fuel, and the ash from the plants can be used as fertilizer. This fertilizer cannot compete with chemical fertilizers; therefore, there is a need for further studies on this powder and its various mixing ratios to produce various types of fertilizers that can compete with chemical ones. [6]

This powder can be used for producing the following types of fertilizer:

1- Germination powder (D1): Mix this powder with coffee waste and 10 mg of glucagon at a 1:15 ratio.
2- Growth promotion fertilizer (D2): Mix coffee waste with nettle, kelp powder, and 15 mg of cortisol at a 2:15 ratio.
3- Compost Plus (D3): Mix coffee waste with mature compost at a 2:14 ratio. This fertilizer increases the effectiveness of compost on plant nutrition.

Table 3 presents the spectrometry results for multi-step method.

Table 3. Research findings

	Analyse	Result Enhet	LOQ	MU	Metode
a)	dry matter	84.6%	0.1		SFS-EN 13040:2008
a)	Total nitrogen	7.1 kg/ton	0.1	1.4	SFS-EN 13342:2000, SFS-EN 13654-1:2002
a)	Ammonium-N	0.122 kg/ton	0.1		
b)	Fosfor(p)	1.2 kg/ton		0.30	SFS-EN 13650:2002
c)	potassium (k)	8.2 kg/ton		2.0	SFS-EN 13650:2002
d)	Sulfur	<0.85 kg/ton			SFS-EN 13650:2002
e)	pH	4.1			SFS-EN 13650:2002
f)	Na	0.50 kg/ton			SFS-EN 13650:2002
g)	Mg	2.7 kg/ton			SFS-EN 13650:2002
h)	Ca	5.6 kg /ton			SFS-EN 13650:2002
i)	B(Bor)	<20 mg /kg			SFS-EN 13650:2002
j)	Mn	430mg/kg			SFS-EN 13650:2002
k)	Fe	11000mg/kg			SFS-EN 13650:2002
l)	Cu	21mg/kg		4.1	SFS-EN 13650:2002
m)	Zn	130mg/kg		25	SFS-EN 13650:2002
n)	pb	7.6 mg/kg		2.3	SFS-EN 13650:2002
o)	cd	0.25mg/kg		0.087	SFS-EN 13650:2002
p)	cr	38mg/kg		7.7	SFS-EN 13650:2002
q)	Ni	17mg/kg		5.2	SFS-EN 13650:2002
r)	Hg	<0.07 mg/kg			SFS-EN 13650:2002
s)	Ar	<5.1mg/kg			SFS-EN 13650:2002

Results and Discussion

The effects of the three types of fertilizer produced in this study on cherry tomatoes were examined to evaluate their effectiveness and determine their optimal combination. A fertilizer with an appropriate percentage of NPK is the most effective option for tomatoes. Micronutrients like calcium and magnesium are also necessary for the tomato plant to grow well and produce high-quality fruit. In addition, tomatoes require plenty of nitrogen during their early stages of growth to produce leaves. Since egg, meat, and chicken waste along with small bones were used to produce fertilizer, the produced fertilizer contains sufficient amounts of calcium. Therefore, the use of these fertilizers improved both the yield and taste of cherry tomatoes.

For D1:

After applying this fertilizer, the mean number of leaves and fruits was 15 and 17, respectively, as opposed to the control with 4 leaves and 7 fruits (Figure 3).

For D2:

After applying this fertilizer, the height of the plant increased to about 32 cm (the plant's height in the control pot was 26 cm). In addition, the mean number of leaves and fruits was 7 and 11, respectively, which was comparable to the control, with 4 leaves and 7 fruits.

For D3:

After applying this fertilizer, the height of the plant increased to about 32 cm (the plant's height in the control pot was 26 cm). Moreover, the mean number of leaves and fruits was 7 and 9, respectively, which was comparable to the control, with 4 leaves and 7 fruits.

Figure 3. Tomato samples treated with organic fertilizer

The lycopene pigment was enhanced by the high potassium content of the organic fertilizers, which helped the tomatoes take better and more favorable color, shape, and taste. The magnesium content of the organic fertilizers also increased leaf thickness, chlorophyll content, greenness, and photosynthesis of cherry tomatoes.

A comparison between the effectiveness of the organic fertilizers produced in this study and chemical fertilizer (10-10-10) NPK showed that the organic fertilizers were more effective than the chemical fertilizer, as the number of leaves increased from 4 to 11. In addition, the organic fertilizers were more effective than the chemical fertilizers in the number of fruits, color, and taste of cherry tomatoes. Therefore, it can be concluded that the use of organic fertilizers allows people to enjoy organic and healthy fruits without worrying about the negative impacts of chemical fertilizers on the environment.

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Conflict of interest: Since this project uses human hormones, it does not pose any threat to human health.

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