The characteristics of organic fertilizer made of cow feces using the Indigenous Micro-Organisms (IMO) from raw manures

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Abstract. Raw manures are very potential if it can be processed into Indigenous Micro-Organisms (IMO) and organic fertilizers. It has sustainable availability in large number, yet if it is not processed into the useful matter, it causes water and air pollution. IMO is a kind of biological products which can be used as decomposers in the production of organic fertilizers, yet it is almost unknown to the public. The IMO of raw manures is cheaper, easier to produce and more economical than IMO of commercial products such as EM4 or others. The making of the IMO used the experimental method called Complete Randomized Design (CRD) in which 5 treatments were given by using raw manures from the different animal such as cow, goat, rabbit, quail, and chicken with 4 replications for each. The result IMO was further examined for the moisture content, pH value, total plate count, lactic acid bacteria count, fungal count, and N. Then the IMO was applied in the production of organic fertilizer from cow feces with 21 days fermentation time, then it is further examined for the value of moisture content, pH, N, P, K, and C/N ratio. If the results of variance analysis (ANOVA) showed a significant effect then it is proceeded by Duncan’s test. Based on the research results, it is obtained that IMO of quail feces produce organic fertilizer with the highest N, P, K content.

Keywords - fermentation, cow feces, raw manures, IMO, organic fertilizer

1. Introduction

Raw manures is the farm waste which often becomes a problem because it is usually left piled up and ignored so it causes contamination in the water and air, and affecting global warming. The number of livestock feces is very abundant while it is potential enough to be utilized as organic fertilizer in sustaining an organic farm which products have greater export opportunities. According to Statistics Centre (BPS, 2016), the population of dairy cows in West Sumatera province was 320,044 heads. A cow is able to produce 23.6 kg/day solid feces, whereas every farmer usually has 6 - 7 cows. Therefore, each farmer produces large enough cow feces for about 141.6 kg/day or 4,248 kg/month. Unfortunately, our farmers are using inorganic fertilizers such as urea which is relatively more expensive.

Raw manures, if left out naturally can be utilized as organic fertilizer but this natural process takes longer time. Manures were made by putting it in a black plastic bag that is loosely folded and it was composted for 16 weeks under room temperature in summer [1]. Making organic fertilizer can be accelerated for 2 - 3 weeks by adding activators or decomposers [2]. Decomposers available in the market such as EM4 and other brands require extra cost to get, whereas natural decomposer is cheap and easy to cultivate from the cattle’s feces. Some livestock feces are potential decomposers or also known as IMO (Indigenous Micro-Organisms) such as the feces of cow, goat, rabbit, quail, and...
chicken. Raw manures contain nutrients such as nitrogen, phosphorus, potassium, and water which have different compositions. Rabbit feces contain higher nitrogen and phosphorus, whereas the goat feces contain higher potassium, and the cow feces contain more water.

Feces naturally contain foods that microbes can use for their lives. Naturally, in the stool there is Nitrosococcus sp, Pseudomonas striata, Nitrosomonas sp, Mycorrhiza, Pseudomonas fluorescens, Streptomyces, Trichoderma sp. The types of bacteria that have been identified in the IMO include Rhizobium sp, Azospirillum sp, Azotobacter sp, Pseudomonas sp, Bacillus sp, and phosphate solvent bacteria. The results of pre-research IMO contain lactic acid bacteria, bacteria, and mold. Composting of cow feces using IMO of manures for 21 days produces organic fertilizer with increased N content. The use of organic fertilizers in plants will give a higher nutritional effect than inorganic [3].

1.1. The purpose of the research

The purpose of this research is to produce cheap, easy and quality from the raw manures, and utilizing it to produce organic fertilizers that meet the standards. It is expected that this research result can be applied by farmers, so it can increase their income by replacing expensive chemical fertilizers and improve the soil structure.

2. Materials and methods

2.1. The material of the research

This study used the feces of farm animals such as cows, goats, rabbits, chickens, and quails which have been produced within the maximum time of 24 hours which were collected from the Universitas Andalas, Animal Farm Unit. Other important ingredients are coconut water and sugar which are gathered from the local market in Padang, Indonesia. The types of equipment used in the experiment and analysis were; analytical scales, stainless steel spoon, electric oven, desiccator, porcelain cup, mortar and pestle, cup clasp, funnel, distillation flask, distiller, glass cup, 30 mesh sieve, AAS, including the tools used for IMO fermentation and black plastic bag for the fertilizer fermentation process.

2.2. Methods

IMO were made by using an experimental method called Complete Randomized Design (CRD) of 5x4 treatments scheme on the feces of cows, goats, rabbits, quails, and chickens. The generated IMO was further examined for the value of moisture content, pH, total plate count, total lactic acid bacteria count, and total mold count. The IMO was then applied in the making of organic fertilizer made of cow feces with 21 days fermentation time. The result was then further examined to check the value of N, P, K, C/N ratio and its water content. If the results from the Analysis of Variance (ANOVA) shows significant impact then it will be proceeded into Duncan's test.

2.3. IMO processing [4]

IMO making procedure were 1) the raw manures were weighed as much as 100 g/sample, 2) then the raw manures were put into a water bucket, 3) then mix in sugar as much as 50 g/sample, 4) it was stirred it has no more grains, 4) coconut water was pour into a bucket as much as 500 ml/sample, 5) after it was stirred thoroughly, put it into a large Aqua bottle which are connected through a small pipe to a smaller Aqua bottle filled by mineral water, so it is not exposed into air and kept in anaerobic condition for 14 days and kept away from the sunlight, 6) after 14 days, IMO was produced from manures. It was then analyzed the pH value, moisture content, total plate count, lactic acid bacteria count, fungal count and N.

2.4. Processing organic fertilizer [4]

The procedure of making organic fertilizer that was: 1) cow feces were dried under the sun for 2 days, 2) once it was dry enough, it was filtered with a size of 30 mesh. Then the IMO was weighted and distributed into 20 units of the black plastic bag which weigh 500 g each and placed on black
plastic, 3) the generated IMO was diluted with water, in a ratio of 1:10, and then it was homogenized, 4) the IMO was sprayed onto cow feces and stirred until it was evenly distributed. It was then fermented for 21 days and stirred every 3 days, 5) the produced organic fertilizer was further examined to check it was the resulting organic fertilizer was tested moisture content, pH, the levels of N, P, K, and C/N ratio.

3. Result and discussion

3.1. IMO

Based on the results of research on IMO production from different raw manures, the results were shown in Table 1.

| Treatments | pH Value | Moisture Content (%) | TPC (x10^4 CFU/ml) | TLAB Count (x10^8 CFU/ml) | TFC (x10^11 CFU/ml) | Total N (%) |
|------------|----------|----------------------|---------------------|----------------------------|---------------------|-------------|
| A          | 3.83±0.03d | 91.46±0.07c          | 49.75±3.69a         | 48.18±10.70b               | 38.16±5.96b        | 0.14±0.04b  |
| B          | 3.88±0.13ed | 88.51±0.41d          | 55.25±10.21a        | 81.63±4.85a                | 48.75±5.74a        | 0.16±0.02b  |
| C          | 4.28±0.04a | 91.27±0.44c          | 35.93±7.36b         | 28.74±4.75d                | 27.93±4.14c        | 0.08±0.03c  |
| D          | 3.92±0.01bc | 92.21±1.61b          | 28.66±10.10c        | 36.48±5.17c                | 29.41±4.17c        | 0.25±0.03a  |
| E          | 3.96±0.05b | 95.20±0.14a          | 39.46±6.67b         | 42.00±8.00b                | 28.96±4.71c        | 0.13±0.05b  |

Note: The mean with different lowercase letters shows a significantly different effect (P <0.05).

Table 1 shows the treatments on several types of manures which were used in the IMO production towards the pH value, moisture content, TPC, total LAB count, total mold count and N. The results from the analysis of variance showed that different treatments on the feces significantly affected the pH value, moisture content, TPC, total LAB count, total fungal count and total N of the generated IMO.

Based on Duncan’s further test at treatment B which used goat feces the highest of real and significant differences from other treatments on the number of total LAB count, total fungal count and TPC (not significantly different from treatment A). Treatment B also shows the lowest pH value and moisture content so that the generated IMO was thicker and more distinctive. The treatment D, on the quail feces, shows the highest total N and the lowest TPC so that the available total N allows microbial food reserves during the process of making organic fertilizer.

The IMO is a liquid containing the microorganisms (bacteria) which are useful for plants and help to fertilize the soil such as Rhizobium sp, Azospirillum sp, Azotobacter sp, Pseudomonas sp, Bacillus sp and phosphate solvent bacteria which were produced from the local materials. The IMO solution is potential as the agent to transform organic matter, thus the IMO can be used as a good decomposer [5].

3.1.1. pH value

During the fermentation process in generating the IMO, there was a decrease in feces’ pH due to the microorganisms activities in it. Measurement of feces’ pH before fermentation was ranged from 7.75 ± 0.13 (cow feces) to 9.73 ± 0.04 (rabbit feces), while the IMO pH was ranged from 3.83 ± 0.03 (IMO of cow feces) to 4.28 ± 0.04 (IMO of rabbit feces) which indicate the decrease of pH value. The decrease of pH value of the feces from neutral-base into acid with the ration between 3.92-5.45 points in the IMO. It was down by almost half, which indicated that microorganisms have been working well under the anaerobic conditions with the pH 3 to 4 [6].

The low pH of cow feces IMO is in line with the pH of cow feces which is also the lowest among other treatments. The low pH of cow feces IMO was caused during fermentation due to the activity of microorganisms which release CO2 and turn into H2CO3 which is easily broken down into H+ + HCO3 ions. The presence of H+ ions will cause acidity or decrease of the pH. Besides the decrease of pH is also caused by lactic acid bacteria which produce lactic acid (acidic) [6]. The pH value of the
generated cow feces IMO was lower than the IMO of banana humps 4.2 [7] and was higher than the pH of papaya IMO, which was researched that is 3.68 and the pH value of rabbit feces IMO is lower than the pH of cabbage IMO which is 4.52 [8], and golden snail IMO 6.55[7], tofu MOL 5.00-5.75 [9].

3.1.2. Moisture content

The moisture content of the generated IMO was very high with the value of 88.51±0.41 (IMO of goat feces) up to 95.20±0.14% (IMO of chicken feces). The high moisture content of generated IMO was due to the high ratio of feces and water (1: 5) and the moisture content of each stool is also high. The high moisture content in chicken feces IMO is caused by the high moisture content of chicken feces as the result of a mix of the feces and urine which is difficult to be separated because they are produced from the same place called cloaca [10]. It is different from the ruminant animals such as cows and goats of which the feces and urine are produced from the different place.

The low moisture content of goat feces IMO is caused by the low moisture content of the goat feces in comparison to the cow feces. The moisture content of goat feces is 60%, while the moisture content of cow feces is 85% [11].

3.1.3. Total Plate Count (TPC)

Based on Table 1 the TPC of the generated IMO from raw manures were ranging between 28.66±10.10x10⁴ (IMO of quail feces) to 55.25±10.21x10⁴ CFU/ml (IMO of goat feces). The TPC of generated IMO were lower than the IMO generated from coconut fiber which value was ranging between 8.97x10⁷ SPK/ml [12] and 29.80 x10⁸ SPK/ml IMO on the tofu pulp [9].

The process of making the IMO is carried out under anaerobic conditions so that the number of aerobic bacteria is much lower than the total LAB and fungi which growth is not expected because they are pathogenic. The growth of aerobic bacteria desperately needs oxygen in order to develop properly, but fermentation is done by closing the container tightly and flowing the air through the hose into a water-filled bottle.

3.1.4. Total Lactic Acid Bacteria (LAB) count

The highest total LAB count was found in treatment B, which value was reached 81.63±4.85x10⁸ CFU/ml and the lowest was in treatment C with the value 28.74±4.75x10⁸ CFU/ml, but it is lower than BAL in honey is 10.43x10⁵-31.30x10⁵ CFU/ml [13].

The high total LAB count generated IMO from goat feces in treatment B was happened because the goats were fed from legume plants which are rich in N and through digestion of ruminants (four stomachs) and the feces were solid with lower moisture content in comparison to other treatments. Thus, the total concentration of the nutrients was also higher which produces optimal growth of the LAB and fungi. Goat feces contain a C/N ratio of 32.65 and an N content of 1.45% [14] which is needed by microbes to grow.

The low total LAB count of rabbit feces IMO in treatment C is influenced by the pH value of the feces were used as an IMO source. The highest pH of rabbit feces used by other feces is 9.76. The analysis results of total LAB count were not found in organic fertilizer with the addition of rabbit IMO, while in fertilizer with addition goats feces IMO were found so that the total colonies on IMO were also high. Indigenous bacteria in cow feces are Lactobacillus sp, Actinomycetes sp [15] while the type of bacteria in poultry feces is the Streptococcus or Lactobacillus genus [16].

In addition, the rabbits’ digestion which is simple or monogastric [17], consume vegetables and concentrates to produce low nutrients for LAB growth results in low N content of IMO as a microbial food source so that bacteria in the phase of death and has stopped producing acid lactate. Lactic acid bacteria will produce lactic acid so that there is a decrease in pH [18], but the pH on rabbit IMO is the highest compared to other treatments.
3.1.5. Total Fungal Count

Total fungal count of IMO was highest in treatment B (48.75±5.74x10^{11} CFU/ml) and the lowest was in treatment C (27.93±4.14x10^{11} CFU/ml). The total fungal count of generated IMO from this study were higher than the generated IMO from rumen contents with soybean medium at the 4th day of breeding stage is 39x10^9 CFU/ml [19], the IMO tofu 5.08x10^5 SPK/ml [9] and [12] the IMO generated from coconut fiber with a total mold count 11.07x10^4 SPK/ml. This condition is influenced by the nutrient content of the fungus which is more available within the feces than the coconut fiber which contains only carbohydrates in the form of cellulose, hemicellulose, and lignin which are difficult to be remodeled by microorganisms.

Total fungal count of goat feces IMO in treatment B and the total fungal of rabbits feces IMO were lower. It is in line with the total LAB colonies which were influenced by microbial growth phase, moisture content, and availability of nutrients for growth. The mold in its growth requires lower moisture content than bacteria. Indigenous mold in cow feces is Aspergillus sp. [15]. In line with the moisture content, the treatment of goat feces IMO has the lowest moisture content. This is caused by the digestive system of the goat which absorbs water in the rumen so that the feces is denser.

3.1.6. Total N

Total N of feces IMO were ranged from 0.08±0.03 to 0.25±0.03% (rabbit and quail). The total N of manures IMO is higher than that of tofu pulp which is 0.06% [9] and is lower than research papaya IMO is 0.45% [8] and coconut fiber IMO is 0.53% [12]. This is influenced by the development of microbes which need N for their lives. Rabbits IMO with the lowest total N cause microbes to be lacking in nutrients for their life so that the microbial content in the IMO is the lowest, while in other feces IMO, total N have been widely used by microbes to grow but it is still available in sufficient quantities so that the microbial population is higher and much higher than coconut fiber IMO.

Quail feces IMO have the highest total N of other treatments. This is due to the type of ration from quail are corn and soybean meal which is high in total N [20]. Different feces in the fermentation process will occur the mineralized process of N by microbes which affect the N content of IMO produced.

3.2. Organic fertilizer

Table 2. pH value, moisture content, N, P, K content and C/N ratio of organic fertilizer.

| Treatments | pH     | Moisture Content (%) | Total N (%) | P Content (%) | K Content (%) | C/N Ratio |
|------------|--------|----------------------|-------------|---------------|---------------|-----------|
| A          | 7.66±0.42\(^a^\) | 68.58±0.77\(^a^\) | 1.4140±0.13\(^c^\) | 1.6682±0.05\(^b^\) | .8493±0.04\(^b^\) | 24.31±1.73\(^c^\) |
| B          | 7.44±0.25\(^bc^\) | 68.78±1.32\(^a^\) | 1.1192±0.15\(^d^\) | 1.8042±0.04\(^a^\) | 0.8823±0.19\(^b^\) | 25.68±4.56\(^a^\) |
| C          | 7.32±0.20\(^c^\) | 67.42±0.89\(^b^\) | 1.5954±0.10\(^b^\) | 1.7936±0.14\(^a^\) | 0.8708±0.16\(^b^\) | 20.43±0.97\(^b^\) |
| D          | 6.80±0.11\(^d^\) | 66.68±0.24\(^c^\) | 1.6502±0.12\(^ab^\) | 1.8264±0.04\(^a^\) | 1.2618±0.25\(^a^\) | 17.62±1.88\(^c^\) |
| E          | 7.52±0.08\(^ab^\) | 68.30±1.24\(^ab^\) | 1.7894±0.34\(^a^\) | 1.6278±0.02\(^b^\) | 0.7189±0.05\(^c^\) | 19.30±3.77\(^bc^\) |

Note : The mean with different lowercase letters shows a significantly different effect (P <0.05).

Treatments of different IMO from raw manures in the production of organic fertilizer from cow feces to pH value, moisture content, N, P, K content and C/N ratio generated data as in Table 2. Results of variance analysis (ANOVA) showed that IMO treatments at different raw manures give significant effect (P<0.05) on pH, moisture content, N, P, K, and C/N ratio. Treatment D which used the quail feces IMO produced the highest P, K content and the lowest pH and C/N ratio. Based on Duncan's test treatment D was significantly different from other treatments for pH, moisture, K content and was not significantly different from C treatment to N content, with B, C treatments to P values, with treatment E to C/N ratio.
3.2.1. pH value
The organic fertilizers made by using livestock feces IMO produces pH with a range of 6.80±0.11 to 7.66±7.66 at the treatment using the quail and cow feces IMO. The pH range of the produced organic fertilizer is close to the neutral range. This is influenced by the overhaul of animal feces into organic fertilizer by IMO. The IMO generated of organic household waste has a pH 8.4 [21]. The pH within several types of organic fertilizers are shown as follow; compost 7.7, bokashi 8.0, vermicompost 8.2, from. manure 7.9, liquid humus 8.0 [22].
The pH of organic fertilizers that use quail feces IMO is closer to neutral than the other treatments that will help accelerate changes by the assistance of the enzymes to become organic fertilizers. The enzyme works optimally at neutral pH while the optimum pH of the enzyme depends on the origin of the enzyme [23].

3.2.2. Moisture Content
The moisture content of organic fertilizers was ranging between 66.68±0.24 to 68.78±1.32%. The moisture content of organic fertilizer was lowest in quail feces IMO and highest in goat feces IMO. The moisture content of organic fertilizer which was produced is still below SNI. According to the SNI, the moisture content of organic fertilizer is 50%. The moisture content of organic fertilizer was higher compared to SNI is caused by the high moisture content of cow feces used for making the organic fertilizer. In line with the ratio of C/N organic fertilizers that use goat feces IMO have the highest C/N ratio. The higher the C/N ratio, the more crumb the fertilizer and the lower the moisture content, the more optimal the work from microbes to break down cow feces into fertilizer. In line with the research on making the rabbit feces Bokashi using EM4, the lower the moisture content, the lower the C/N fertilizer ratio produced [24].

3.2.3. Total N
The total N of organic fertilizer were ranging between 1.1129±0.15% to 1.7894±0.34%. The highest N content is found in the chicken feces IMO and not significantly different from the treatment of quail feces IMO. Total N in dry animal feces which will be used as fertilizer is 0.85%. After being kept for 21 days in anaerobic conditions without the addition of IMO, the total N turns into 0.89% which means that there was an increase in total N. But, it is higher with IMO addition 0.26 - 0.94% of feces which have not been fermented. The total N of organic fertilizer research results has met the standards of SNI 19-7030-2004, which is 0.40%.
The lower total N in the exclusion of organic fertilizers which use goat feces IMO in line with the results of the composting research using several types of feces with the lowest total N of feces of goats < camel < cow < poultry < buffalo [1].
The high total N organic fertilizer from chicken feces IMO results are almost the same as the solid organic fertilizer from biogas sludge which has been improved in quality by adding blood flour which is 1.7894±0.34% [21], and organic fertilizer using Promi bio-activator is 1.76% by 10 days fermentation [11].
The high total N organic fertilizer from chicken feces IMO results are almost the same as solid organic fertilizer from biogas sludge which has been improved in quality by adding blood flour which is 1.7894±0.34% [25] and organic fertilizer using Promi bio-activator is 1.76% by fermentation for 10 days [14].

There was no real difference between the organic fertilizer made of chicken feces IMO and that of the quail feces IMO due to the characteristics of quail feces which has more intense odor compared to other feces because of its high protein content. Besides that, fertilizer made of quail feces is classified as heat fertilizer which is rapidly decomposed so that absorption by plants is faster. Quail manure contains N 1.56%, P 0.02%, K 1.55%, S 1.24% and C/N 11.58, besides quail manure can improve the efficiency of S uptake [26].
3.2.4. $P$ content

The $P$ levels of organic fertilizer were produced ranged from 1.6278±0.02% (chicken feces IMO) to 1.2618±0.25% (quail IMO) as shown in Table 2. The $P$ level of cow feces that will be used as fertilizer 2.08%, after 21 days without the addition of IMO decreases to 1.87%, but with the addition of IMO more down to 0.45-0.82% of the initial content. However, this $P$ content meets SNI 19-7030-2004 which is 0.10%.

The low $P$ content was caused by a decrease in $P$ content in the fermentation process which consumed by microbes. In line with the results of the study [27] the $P$ level of chicken feces was 2.55% and after fermentation for 4-6 weeks the $P$ content becomes 1.93%.

3.2.5. $K$ content

The $K$ content of organic fertilizer research results is ranging from 0.7189±0.05 to 1.2618±0.25% using chicken and quail feces IMO. The $K$ value of cow feces that will be fermented is 0.91% and is changed to 1.12% after 21 days without the addition of IMO. In general, there is an increase in $K$ values in the fermented feces without IMO except in the one using quail feces IMO. In line with the results of the study on making rabbit feces bokashi, there was a decrease in $K$ values with longer fermentation due to the treatment (reversal) that occurred during the fermentation process [24].

During the fermentation process of making organic fertilizers using cow feces, there was a reshuffle with the help of cow feces IMO. The $K$ content of research results is much higher than the results of research on solid organic fertilizer from sludge biogas of cow feces which has been improved with the addition of husk ash which is 0.3416% [25].

3.2.6. C/N ratio

Organic fertilizers with the use of feces IMO in their remodeling process resulted in a C/N ratio ranging from 17.62±1.88-25.68±4.56 namely the lowest quail feces IMO and highest goat's feces IMO. The C/N ratio of organic fertilizer produced has met SNI 19-7030-2004, which is a maximum of 20. This is influenced by the physical properties of different feces. The high C/N ratio of organic fertilizer that used cow feces IMO because it is slow to break down. Goat and cow fertilizers with more solid experience slower decomposition [28].

Quail feces IMO was used with the highest N content causes fermented cow feces to decompose quickly so that the lowest C/N ratio in treatment D. In line with research the total N chicken feces is higher than cow and goats feces cause chicken feces to get faster [28].

4. Conclusions

Raw manures were used in making IMO and on the best result was shown in the treatment using the goat feces IMO with pH 3.88±0.13, moisture content 88.51±0.41%, total plate count 55.25±10.21x10^4 CFU/ml, total BAL count 81.63±4.85x10^8 CFU/ml, total fungal count 48.75±5.74x10^11 CFU/ml and total N 0.16±0.02%. After being was applied in the production of organic fertilizer made of cow feces, it produced the best organic fertilizer by using quail feces IMO with pH 6.80±0.11, moisture content 66.68±0.24%, total N 1.6502±0.12%, P 1.8264±0.04%, K 1.2618±0.25%, and C/N ratio 17.62±1.88.

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