Study on the Difference of Transformation of Livestock and Poultry Feces by Black Soldier Fly

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Abstract. In this experiment, livestock and Poultry feces (chicken manure and pig manure) were mixed in different proportions, and cow dung and co-substrates (rice bran) were added in chicken manure and pig manure in different proportions, so as to analyze and study the transformation of livestock and poultry feces by black soldier fly larvae (BSFL) under different treatments. The results showed that the conversion rate of chicken manure by BSFL was higher than that of pig manure, and the highest conversion rate of pure chicken manure was 15.31%. Adding cow dung to chicken manure and pig manure resulted in a significant decrease in the conversion rate of BSFL, and the addition of cow dung was not conducive to the conversion of mixed feces by BSFL. The transformation effect of BSFL on chicken manure, pig manure and cow manure is: chicken manure > pig manure > cow dung. The addition of rice bran can promote the transformation of chicken manure and pig manure by BSFL. When the proportion of adding is 15%, the conversion rate of BSFL is the highest, which is 19.74% and 19.25%, respectively.

Keywords: Black soldier fly; Livestock and Poultry feces; Co-substrates; Conversion rate.

1. Introduction
With the development of intensive farming, a large amount of livestock droppings are produced. If not handled properly, pollution sources will be formed and placed great pressure on the local environment [1-2]. The traditional livestock and poultry manure treatment method is mainly composting, which has the disadvantages of occupying land, long processing time, low utilization rate[3-4], and low price of organic manure by simple composted. Most breeding enterprises cannot afford the cost of collection and transportation, so they are not highly motivated to deal with livestock and poultry manure. In response to the 2017 issued by the general office of the state council of China "Opinions on accelerating the recycling and utilization of waste from livestock and poultry breeding"[5], We choose the saprophytic insect, BSFL which can take livestock and poultry manure and domestic waste, can reduce the odor of feces while processing animal manure, and produce high-value animal protein feed[6-7] and insect feces organic fertilizer, which can not only eliminate environmental pollution, but provide animal protein source feed and high-quality organic fertilizer to the market, thereby realizing the resource utilization of agricultural waste.
The research on the conversion of BSFL is mainly focused on the kitchen waste\cite{8}, while the effects of mixing different animal manure and adding co-substrates on the conversion of BSFL have not been reported. In this experiment, the effects of mixed feces with different proportions and added different proportions of co-substrates (rice bran) into chicken and pig feces on the transformation effect of BSFL were studied, in order to provide theoretical basis for the biological treatment of livestock and poultry feces.

2. Materials and Methods

2.1. Experimental Materials
2-day-old BSFL; fresh chicken manure; fresh pig manure; fresh cow dung; rice bran;

2.2. Experimental Setup and Methods

2.2.1. Influence of mixing chicken manure and pig manure in different proportions on the transformation of BSFL. The experiment was conducted in the laboratory of Tianjin Agricultural College in China in April 2018. 20g of 2-day-old BSFL were placed in a breeding box (length 33cm, width 25cm, height 9cm). 500g mixtures of the chicken manure and pig manure were introduced into the box. The mixtures were set to the following six treatments according to the ratio of pig manure to chicken manure (Table 1), and the experiment was conducts in triplicate. In the process of conversion and treatment of livestock and poultry feces by BSFL, 500g of mixed livestock and poultry feces of different proportions was added to the feeding box on the first day, but not added on the second day. For the next five days, adding 100g of mixtures to the feeding box at 9:00 am each day. During the process of transforming livestock and poultry manure, keep the humidity in the growth environment of BSFL to 75%. On the eighth day, screen and weigh the BSFL and insect feces and record relevant data.

| Treatment | T0  | T1  | T2  | T3  | T4  | T5  |
|-----------|-----|-----|-----|-----|-----|-----|
| pig manure: chicken manure | 0:100% | 10:90% | 20:80% | 30:70% | 40:60% | 50:50% |

2.2.2. Influence of different proportions of cow dung mixed with chicken manure and pig manure on the transformation of BSFL. 20g of the 2-day-old BSFL were placed in the feeding box, and then 500g of mixed manure consisting of different proportions of cow manure, chicken manure and pig manure was added to the feeding box. According to the ratio of cow manure to chicken manure and pig manure, the following five treatments were set up (table 2). Each treatment was repeated three times. The breeding process of BSFL for treating livestock and poultry manure is the same as above.

| Treatment | T0  | T1  | T2  | T3  | T4  |
|-----------|-----|-----|-----|-----|-----|
| cow dung: chicken manure | 0:100% | 5:95% | 10:90% | 15:85% | 20:80% |
| cow dung: pig manure | 0:100% | 5:95% | 10:90% | 15:85% | 20:80% |
2.2.3. Effects of adding rice bran on the conversion of BSFL to livestock and poultry manure. 20g of the 2-day-old BSFL was introduced into a breeding box, then added 500g of raw materials composed of a mixture of rice bran and chicken manure and pig manure to the breeding box (Table 3), and each treatment is repeated three times. The breeding process of BSFL for treating livestock and poultry manure is the same as above.

Table 3. Ratio of rice bran to livestock and poultry manure.

| Treatment                  | T0         | T1         | T2         | T3         |
|----------------------------|------------|------------|------------|------------|
| rice bran: chicken manure  | 0:100%     | 5%:95%     | 10%:90%    | 15%:85%    |
| rice bran: pig manure      | 0:100%     | 5%:95%     | 10%:90%    | 15%:85%    |

2.3. Statistical analyses

The data obtained in the experiment were disposed of Excel. The significant difference analysis was completed by DPS data processing system. The calculation formula for the conversion rate of BSFL into different livestock and poultry manure is:

\[ a = \frac{(m_2 - m_1)}{m} \times 100\% \quad (1) \]

Notes: \(a\) is the conversion rate of BSFL to different livestock and poultry manure (%); \(m_1\) is the mass of BSFL before breeding (g); \(m_2\) is the mass of BSFL after breeding (g); \(m\) is rearing total mass of raw materials (g).

3. Results and analysis

3.1. Effect of mixing chicken manure and pig manure in different proportions on the transformation of BSFL.

When 10% of pig manure is added in the chicken manure treatment compared with pure chicken manure treatment, the conversion rate of BSFL was not significantly difference (Figure 1). With the increase of proportion of pig manure, the conversion rate is less than the pure chicken manure treatment and attained significant level. This shows that BSFL transformation effect of chicken manure is better than that of pig manure. In this experiment, BSFL had the highest conversion rate in the treatment of pure chicken manure, which was 15.31%. When the proportion of adding pig manure to chicken manure was 50%, the BSFL had the lowest conversion rate to mixtures, which was 7.36%, and the conversion rate decreased by 7.95% compared with the pure chicken manure.

Figure 1. Effects of mixing chicken manure and pig manure in different proportions on the conversion rate of BSFL.
3.2. Effect of different proportions of cow dung mixed with chicken manure and pig manure on the transformation of BSFL.
Compared with the treatment of pure chicken manure and pig manure, the conversion rate of BSFL decreased significantly when adding cow dung to chicken manure and pig manure, and the conversion rate became lower and lower as cow dung increased (figure 2). It indicated that the addition of cow dung to chicken manure and pig manure is not conducive to the conversion of BSFL to feces. The conversion rate of BSFL to chicken manure group was significantly higher than that of pig manure group, indicating that BSFL had better conversion effect on chicken manure than pig manure. When the proportion of cow dung in chicken manure and pig manure was 20%, the conversion rate of BSFL was the lowest. Compared with the treatment of pure chicken manure and pig manure, the conversion rate of BSFL was reduced by 5.42% and 4.75%, respectively.

![Figure 2. Effects of different proportions of cow dung mixed with chicken manure and pig manure on the transformation of BSFL.](image)

3.3. Effects of the addition of co-substrates (rice bran) on the transformation of chicken manure and pig manure by BSFL.
The effect of adding rice bran on the transformation of chicken manure and pig manure by BSFL promote the transformation of chicken manure and pig manure by BSFL (figure 3). When the proportion of rice bran added to chicken manure and pig manure was 5%, the transformation of BSFL was not significantly different from that of pure chicken manure and pig manure. The proportion of adding rice bran in chicken manure and pig manure was 10% and 15%, which significantly promoted the transformation of chicken manure and pig manure by BSFL, and showed great difference compared with the treatment of pure manure group. In this experiment, when the proportion of rice bran in chicken manure and pig manure was 15%, the conversion rate of BSFL to chicken manure and pig manure was the highest (19.74% and 19.25%, respectively), which increased by 3.37% and 4.99% respectively compared with that of pure manure treatment.
4. Discussion

The intestinal tract of BSFL is rich in enzymes, antibacterial peptides, and unique intestinal flora, which enables BSFL to efficiently treat livestock and poultry manure and transform it into its own nutrition [9]. In this experiment, the conversion effect of BSFL on chicken manure was higher than that of pig manure. With the increase of the proportion of adding pig manure to chicken dung, the conversion rate of BSFL decreased. This is due to the short digestive tract of chickens, which are based on concentrates, and only 1/3 of the ingested feed is digested and utilized, so rich nutrients remain in chicken manure. Aifen Li [10] and other studies have shown that Crude protein 25.03% -31.74%, crude fat 2.34% -5.13%, crude fiber 11.32% -15.73%, crude ash 22.14% -35.63%, rich in Cu, Zn, Mn, Mg, Na, K, Fe, and other mineral elements and B vitamins [11-12]. The feed is also not fully digested and absorbed by pigs, and about 30% -40% of the nutrients remain in the manure. Studies have shown that the efficiency of BSFL's conversion of manure is strongly related to the content of organic matter in the manure [13]. The nutritional content of chicken manure is higher than that of pig manure, and the pig manure is thin, sticky, and poorly ventilated. Therefore, the conversion effect of BSFL on chicken manure is better than pig manure.

With the expansion of the proportion of cow dung in chicken manure and pig manure, the conversion rate of BSFL to mixed manure gradually decreased. This may be due to the fact that cow feed mostly on grasses, and there are many crude fibers and ash in cow dung, and the nutrient content is low. Although some crude fibers in cow dung can reduce the viscosity of chicken manure and pig manure to a certain extent, which is conducive to the growth of BSFL, the addition of cow dung also reduces the available nutrients of BSFL. The BSFL growth is affected. So the addition of cow dung is not conducive to the transformation of chicken manure and pig manure by BSFL, and the conversion of chicken manure and pig manure by BSFL is better than that of cow dung.

Rice bran is a milled product during the milling process of rice. It is rich in protein and fat, and can be used as a substance for the growth and development of BSFL. Adding it to chicken manure and pig manure can reduce the viscosity of manure and increasing the ventilation of livestock and poultry manure. This is beneficial to the growth and transformation of BSFL, so adding rice bran to chicken manure and pig manure can promote the conversion of BSFL to chicken manure and pig manure. Under the conditions of this test, when 15% rice bran was added, the conversion rate of BSFL to chicken manure and pig manure was the largest.

5. Conclusion

The conversion rate of BSFL to chicken manure is higher than that of pig manure, and the conversion rate of BSFL in mixed manure decreases as the proportion of pig manure added to chicken manure
increases; the addition of cow dung is not conducive to the conversion of chicken manure and pig manure with BSFL. The effect of BSFL on the conversion of chicken manure and pig manure is better than that of cow dung. The addition of rice bran also promotes the conversion of chicken manure and pig manure with BSFL. When the addition ratio is 15%, the transformation effect of BSFL was the best.

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