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Effect of Various Farm Manures and Straw Containing Cattle Manure on Worm and Worm Manure Production

İbrahim Halil Çerçi[1], Murat Kalkan[2], Fatma Terlemez

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ABSTRACT

The aim of this study is to determine the effect of different combinations of farm manure and farm manure on earthworm proliferation and earthworm manure production quantity and property. Accordingly, 100% horse manure (H), 100% cattle manure (C), 100% straw cattle manure (SC), 90% horse manure + 10% hen manure (H/H), 90% cattle + 10% hen manure (C/H) and 90% straw cattle manure + 10% hen manure (SC/H) six research groups were designed. The highest level of worm growth in the experimental period was in group H, followed by SC group. The lowest values were found in C/H group and C group. In the amount of worm manure produced, the highest value was found in H/H group and the lowest value was found in SC group. As a result, it was found that 100% H and 100% SC groups made a better contribution to the increase in worm growth.

Key words: Earthworm, Farm manure, Feed, Stubble, Worm feed.

INTRODUCTION

Epigeal earthworms such as *eisenia fetida* (red wigglers) reproduce very well as they consume organic waste (Chaoui, 2019). The habitat of earthworms should be highly absorptive thus expand in volume. Earthworm feeds should contain low level of nitrogen and have high organic manure/nitrogen rate. Likewise, there is a list of most commonly used bedding models (Munroe, 2007) which provides some information on absorptivity/volume expand potential and organic manure nitrogen (Organic manure: N) rates of each material. The list suggests that horse manure have superiority among other types of manure. That is because horse manure is high fiber and has high organic manure:N rate. These features give horse manure relatively better moisture holding capacity thus making it more expandable in volume. For these reason horse manure is considered the best habitat for *E. Fetida*. Humus worms also noted to be a good consumer of agricultural and animal waste. İn this context these crop stubble straws are used as beddings to prevent diseases (Bal, 2011) since they provide a dry bed for cows, and when combined with animal manure they make up the best bedding model and feed for earthworms and facilitate their reproduction. On the other hand, silkworm waste was used as raw material for vermicomposting. (Venugopal *et al.,* 2010). The manure from these reproduced earthworms can be used in plant production (Munroe, 2007; Atiyeh *et al.,* 2000; Venugopal *et al.,* 2010) and the earthworms themselves as hen-feed (Sözcü and İpek, 2016) and fish-feed (Arıman Karabulut *et al.,* 2016). In this context, comparative studies are needed to bring farm fertilizers to the economy. In order to meet this need, horse manure, cattle manure without wheat stalk, cattle manure containing wheat stalk and worm feeds prepared by combining them with 10% poultry manure were investigated. In this research, it is aimed to determine the effect of these farm fertilizers on the reproduction levels of soil worms and fertilizer production levels.

Bingöl University, Faculty of Veterinary Medicine, Department of Animal Nutrition and Nutritional Diseases, Bingöl, Turkey.
[1]Hatay Mustafa Kemal University, Faculty of Veterinary Medicine, Department of Animal Nutrition and Nutritional Diseases, Hatay, Turkey.
[2]Republic of Turkey Ministry of Agriculture and Forestry, Elazığ, Turkey.

Corresponding Author: Fatma Terlemez, Bingöl University, Faculty of Veterinary Medicine, Department of Animal Nutrition and Nutritional Diseases, Bingöl, Turkey. Email: fatirf_terlemez@hotmail.com

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MATERIALS AND METHODS

Research groups and experiment design

The group in which worm bedding and 100% horse manure used as feed is the horse manure group (Group H). The group in which 100% cattle manure not containing wheat straw were used is the cattle manure group (Group C). The group in which 100% cattle manure containing wheat steam is used is the straw cattle manure group (SC Group). The 90% horse manure + 10% hen manure combination is named the horse/hen manure group (H/H group). The 90% non-straw cattle manure + 10% hen manure combination is named the cattle/hen manure group (C/H) group. The 90% straw cattle manure + 10% hen manure combination is the straw cattle/hen manure group (SC/H). These each beddings and feed were pre-fermented. Each group (blocks) was used in experiment repeatedly 5 times. Randomized block design method is employed in the conducting of the experiment.

Placing the bedding and the worms in cultivation compartments

For each six group with each to be tested five times, 30 cultivation compartments were built onto a concrete flat ground. The pre-fermented subject worm feeds were placed as bedding into an area with 0.4 m x 0.4 m size and 20 cm of height. 10.000 worms were placed into this bedding (Munroe, 2007).

Feeding the worms

About 1-2 kg of pre-prepared worm feed placed once in every week in the cultivation compartments. Then the compartment was springer-irritated in a way to keep humidity about 75-80%.

Harvesting the worms

On the 60th day of the experiment, worms were separated from the humus. This process was done through letting the worm compartment dry in order for worms to gather in the moist area. Then the worms in the moist area was sorted out from the manure.

Determination of the number of harvested worms

Separated worms then filled in the 10 ml measurement cups. Two of these 10 ml cups were taken to count the worm amount, then the average number was multiplied by the total cup amount, which gave the total average worm amount for each sub groups.

Calculating the reproduced worm number

Planted worm amount was subtracted from the harvest worm total.

Reproduction rate of worms

Harvest worm amount was divided by the planted worm amount, and the resulting number multiplied by 100, which makes up the reproduction rate.

Calculating the manure weight

Worm manure after separated from worms weighted for each tests. Also the manure's dry substance was determined. With the help of the below given formula, worm manure amount obtained from dry substance in 60 days was calculated. Manure amount obtained from dry substance (kg) = weight of the post-harvest worm manure (kg) x dry material rate within manure after harvesting: 100.

Analyses on worm feed and worm manure
Measuring salinity level

Added 50 ml of water on a 20 gr. of sample from bedding and worm feed. After letting this mixture wait for one night, the mixture's salinity level was identified using a conductivity meter.

Measuring pH

Added 50 ml of water on a 20 gr sample from bedding and manure. After letting this mixture wait for one night, pH level was measured the next day, using a pH meter.

Raw cellulose that is contained in worm feed was measured with Ankom Fiber Analyser, nitrogen was measured with Kjeldahl apparaturus, dry substance was measured in a drying chamber of 105°C, raw ash was measured in ash oven of 600°C and, organic substance was measured using the methods given in AOAC (AOAC, 1990).

Humic acid level was measured in pursuant with the Appendix-19 (analysis methods) of the Regulation on Organic, Mineral and Microbial Manures and the Regulation on Market Surveillance and Inspection of Manures, with the method stipulated by TS 5869 ISO 5073 (Anonymous, 2019a).

Magnesium level was measured with Absorption Spectrophotometer (Perkin-Elmer Instrument model 2380) in accordance with the method stipulated in AOAC (AOAC, 1990). Potassium level was measured with flame photometry (Anonymous, 2019b). The phosphor level measured with spectrophotometry (Anonymous, 2019b).

Statistical analyses

Statistical analysis of the data was performed using the SPSS 22 program and Kruskal Wallis and Bonferroni Mann Whitney-U test. Kruskal-Wallis Analysis of Variance test was performed to determine whether there was a significant difference between Bonferroni Mann-Whitney-U and subgroups. All the results were produced as average±standard deviation and $p<0.05$ was accepted to be the statistically significant value (SPSS, 2013).

RESULTS AND DISCUSSION

The manure with the highest level of dry substance of 100% was the straw cattle manure ($p<0.05$) (Table 1). This was followed by 100% horse and cattle manure. The reason behind this may be the straw which contains high level of dry substance (Çakmak and Çerçi, 1995; Çerçi and Sarı, 1994). Raw ash level was highest in C/H group ($p<0.05$). When the non-hen manure groups are cross-examined, raw ash levels shows a downward slide respectively from the C-group to the SC and to the H-group. Hen manure contribution seemed to increase the raw ash level. This may be caused by the mineral substances which cattle and hen feeds contain (Sarı *et al.,* 2008). Organic substance (Table 1) is naturally high in group with low raw ash level and vice versa. Raw cellulose level is highest in straw cattle manure. Hen manure contribution on the other hand, seemed to decrease cellulose levels in groups which partly compose hen manure, mainly in the 90% cattle + 10% hen manure combination group. The reasons behind these differences in raw cellulose rates can be listed as follows: 1) Using roughages rich in raw cellulose in cattle and horse diets (Sarı *et al.,* 2008). High raw cellulose level in straw cattle manure group may be caused by the straw it contains (Çakmak and Çerçi, 1995; Çerçi and Sarı, 1994). The decrease in low cellulose level seen in hen manure combination groups is because poultry diets contain low cellulose (Sarı *et al.,* 2008). Nitrogen level showed an increase in hen manure containing groups and

Table 1: Nutrition composition, humic acid, salinity (%) and pH values of farm manure worm feeds.

	1. C group	2. C/H group	3. SC group	4. SC/H group	5. H group	6. H/H group	P value
Dry substance	27.24±1.43	29.57±1.59	50.97±1.25^{AB}	51.17±3.80^{AB}	31.86±1.17^{ACD}	28.49±1.81^{CD}	0.000
Raw ash	28.86±1.01	33.82±1.43^{K}	24.96±0.78^{KL}	28.85±0.90^{LM}	21.59±1.64^{KLMN}	28.79±0.81^{LMO}	0.000
Organic substance	71.14±1.01	66.18±1.43^{f}	75.04±0.78^{fg}	71.15±0.90^{gh}	78.41±1.64^{fghý}	71.21±0.81^{ghj}	0.000
Raw cellulose	37.61±1.94	27.44±2.23^{a}	39.56±1.30^{b}	33.28±0.64^{abc}	34.48±0.79^{abc}	29.06±1.87^{acde}	0.000
Nitrogen	2.67±0.17	2.91±0.13	2.46±0.07^{l}	2.53±0.12^{l}	3.30±0.29^{klmn}	3.92±0.20^{klmn}	0.000
Humic acid	30.36±1.28	31.80±1.66	31.78±0.78	35.78±0.56^{TUX}	31.16±1.33^{Y}	34.62±0.48^{TXZ}	0.001
pH	7.92±0.05	8.10±0.08^{P}	8.13±0.05^{P}	8.00±0.10	7.85±0.06^{RS}	8.02±0.06^{Q}	0.001
Salt	2.34±0.07	3.38±0.03^{t}	1.81±0.02^{tu}	2.16±0.03^{tux}	4.91±0.02^{tuxy}	5.16±0.05^{tuxyz}	0.000

Data based on average ± standard deviation. Statistically regarded significant are the groups with different symbols in the same line. (Dry substance: A; those that differs from C group; B; those that differs from C/H group; C; those that differs from SC group; D; those that differs from SC/H group. Raw Ash: K; those that differs from C group; L; those that differs from C/H group; M; those that differs from SC group; N; those that differs from SC/H group; O; those that differs from H group. Organik madde: f; those that differs from C group; g; those that differs from C/H group; h; those that differs from SC group; ı; those that differs from SC/H group; j; those that differs from H group. Raw cellulose: a; those that differs from C group; b; those that differs from C/H group; c; those that differs from SC group; d; those that differs from SC/H group; e; those that differs from H group. Nitrogen: k; those that differs from C group; l; those that differs from C/H group; m; those that differs from SC group; n; those that differs from SC/H group. Humic acid: T; those that differs from C group; U; those that differs from C/H group; X; those that differs from SC group; Y; those that differs from SC/H group; Z; those that differs from H group. pH: P; those that differs from C group; R; those that differs from C/H group; S; those that differs from SC group; Q; those that differs from H group. Salt: t; those that differs from C group; u; those that differs from C/H group; x; those that differs from SC group; y; those that differs from SC/H group; z; those that differs from H group. $p<0.01$.).

Table 2: Magnesium, phosphor and potassium levels of farm manure worm feeds.

Feed Groups	Magnesium mg/kg	Potassium mg/Kg	Phosphor mg/Kg
C group	60.165	301	284.03
C/H group	60.525	395	252.34
SC Group	59.598	239	345.86
SC/H group	59.751	308	344.48
H group	59.688	732.5	282.76
H/H group	60.228	715	317.59

seemed to be the lowest in straw cattle manure group. The reason is that straw contains low nitrogen and that poultry manure contains high level of nitrogen (İnal *et al.,* 1996; Çakmak and Çerçi, 1995; Çerçi and Sarı, 1994).

SC/H group showed the highest level of humic acid in worm feeds. This was followed by H/H group (Table 1). Poultry manure contribution in worm manure in general increased the humic acid level.

PH values of worm feed found to be around 8 (Table 1). The group which had the highest pH value was the SC group. Hen manure contribution seemed to increase pH levels in cattle and horse manure group. In line with this, a previously conducted study (Munroe, 2007) suggests that ideal pH value for worms is between 7.5 and 8.

The tests proved that the H/H group had the highest level of salinity in worm feeds. And the lowest level was the straw cattle manure group. Horse manure seemed to increase the salinity levels. Also, poultry manure increased the salinity level in worm feeds. Its reason may be the added salt in animal diets. The reason why it was low in straw groups may be because the straw being a vegetative feed has low salinity (Sarı *et al.,* 2008). On the other hand, a previous study (Munroe, 2007) reports higher level of salinity in animal waste, compared to this study.

Magnesium levels of worm feeds (Table 2) in all groups were around 60 mg/kg. The highest potassium level was observed in H group. Potassium levels of cattle manure groups was seen to be much lower than that of horse manure group. Cattle manure groups, when combined with hen manure, slightly increased its potassium levels. The reason behind this increase may be that horse feeds consist mostly of weeds rich in potassium and potassium contribution to poultry feeds (Sarı *et al.,* 2008). The group which showed the highest phosphor level was the SC group. This was followed by the SC/H group and the H/H group.

C/H group showed the highest dry substance level in manures obtained from worms fed with different feeds (Table 3). The highest raw ash level in worm manures was observed in SC group. This was followed by SC/H group, C/H and C groups. The highest organic substance level was observed in H group and lowest organic substance level was observed in SC group. SC/H group showed the lowest raw cellulose level in worm manures. Highest raw cellulose level was observed in H group. While SC group had the lowest nitrogen level in worm manure with 1.68%, highest value was observed with 2.52% was the H group. This is possibly because the worms consume the organic substances, mainly raw celluloses, more efficiently. Indeed, as it is reported in a previous study (Chaoui, 2019), epigeal worms such as eisenia fetida (red wigglers) reproduce very fast as they consume organic waste.

Tablo 3: Nutrient composition and humic acid levels (%) of worm manures obtained from various farm manures (%).

	1. C group	2. C/H group	3. SC group	4. SC/H group	5. H Group	6. H/H group	P value
Dry Substance	45.75±0.76	53.09±1.74*	47.26±2.02^{+}	49.17±2.64	44.39±1.71^{+}	42.78±2.31^{+}	0.001
Raw ash	51.56±0.95	53.44±1.65	59.12±0.75^{ab}	57.45±1.23^{ab}	42.97±1.22^{abcd}	46.14±1.67^{abcd}	0.000
Organic substance	48.44±0.95	46.56±1.65	40.88±0.75^{ef}	42.55±1.23^{ef}	57.03±1.22^{efgh}	53.86±1.67^{efgh}	0.000
Raw cellulose	11.79±1.02	11.32±0.48	9.22±0.72^{AB}	8.80±0.44^{AB}	15.46±0.70^{ABCD}	10.43±0.84^{DE}	0.000
Nitrogen	2.34±0.25	2.38±0.21	1.68±0.11^{KL}	2.26±0.12^{M}	2.52±0.11^{M}	2.26±0.25^{M}	0.007
Humic acid	32.98±0.78	31.60±0.35	33.52±0.31^{l}	27.24±1.09^{klm}	32.66±0.43^{ln}	33.20±0.22^{ln}	0.000

Data based on average ± standard deviation. Statistically regarded significant are the groups with different symbols in the same line. (Dry substance: *; those that differs from C group; +; those that differs from C/H group. Raw ash: a; those that differs from C group; b; those that differs from C/H group; c; those that differs from SC group; d; those that differs from SC/H group. Organic substance: e; those that differs from C group; f; those that differs from C/H group; g; those that differs from SC group; h; those that differs from SC/H group. Raw cellulose: A; those that differs from C group; B; those that differs from C/H group; C; those that differs from SC group; D; those that differs from SC/H group; E; those that differs from H group. Nitrogen: K; those that differs from C group; L; those that differs from C/H group; M; those that differs from SC group. Humic acid: k; those that differs from C group; l; those that differs from C/H group; m; those that differs from SC group; n; those that differs from SC/H group $p<0.01$).

Table 4: Magnesium, phosphor and potassium levels of worm manure obtained from various manures as feed.

Feed groups	Magnesium mg/kg	Potasium mg/Kg	Phosphor mg/Kg
C group	60.39	139	66.18
C/H group	60.813	152	38.91
SC group	61.47	206.4	42.67
SC/H group	60.444	224.8	191.41
H group	60.858	256	217.07
H/H group	-	279	122.76

When looking at worm manures in terms of humic acid, the highest level is observed in SC group, which is closely followed by H/H group.

Among the obtained worm manures, the highest level of magnesium was observed in SC group with 61.47 mg/kg. Potassium levels in worm manures show a descending order from H/H (highest), H, SC/H, SC, C/H and C (lowest). In terms of phosphor level, H group is on the lead, which is followed by SC/H group (Table 4). In terms of cellulose and ingredients, H and SC groups of this study shows a resemblance to another study where 50% brewed tea + 50% cattle manure were combined, for both studies had similar mineral substance level results (Yüksek *et al.,* 2019).

A comparison between worm feed and worm manures shows that, while raw ash level in worm manure increased by 86%; organic substance decreased by 33%, raw cellulose by 67%; nitrogen by 25%, potassium by 59% and phosphor decreased by 63% in worm manures, when compared to worm feed (Table 5). This possibly proves that worms can substantially digest the organic substances and minerals included in their diet and use it for their growth and reproduction. Because these materials directly affect the efficacy of vermicomposting (Barik *et al*., 2011). On the other hand, evaluating the raw ash levels which includes insoluble inorganic salt and minerals, may depend on its solubility rate.

In this 60-day period study (Table 6), worm reproduction and production rate was highest in H group, which was followed by SC group. This, again, was respectively followed by H/H and SC/H groups, while lowest rates observed in C/H and C groups. In terms of manure amount produced, highest rate was observed in H/H group while SC group had the lowest rate. Hen manure added to horse and cattle manures increased the worm manure amount, however it decreased worm reproduction rate. In a previous study (Namlı *et al.,* 2014), it is emphasized that the sludge used in incubation test which contains high level of NH4-N and ammonium, may have negatively affected worm activity and population. This emphasis partly explains the findings of this study. Further more, the method of combining straw with cattle manure to use as bedding, raised the worm production rate to the level that of the worms which consume horse manure. In another study where worms consumed the feed obtained from a 50% brewed tea and 50% cattle manure combination, worm amount and weight showed higher values compared to other subgroups of the same study (Yüksek *et al.,* 2019). One other research (Yüksek, 2019) reports that fiber waste such as nutshell and tea fiber, paper and wood flour added in cattle manure showed highest worm reproduction and worm weight results. Additionally other previous researches (Chaoui, 2019; Venter and Reinecke, 1988) suggest that worms complete their growth within 40 to 60 days and can double their biomass in 60 days. However in practice, the same researches reported slightly lower values. Because many factors can be effective in this for example, winter and rainy seasons are better for conversion rate of vermicompost (%) and proliferation rate of earth worm (%) as compare to summer season (Agarwal and Arora 2011). It can be said that outcome of this study showed a correspondence with the outcomes of previous studies; especially the horse manure and straw cattle manure groups.

Table 5: Change (difference) rate of raw ash, organic substance, raw cellulose, nitrogen, potassium and phosphorus levels between worm feeds and worm manures and the rates of this variability.

Nutritients and mineral (on dry substance) %	in worm feeds	in worm manures	Their increase/decrease rate within worm manure	Change rate in manure compared to worm feed, %
Raw ash	27.81	51.78	+23.97	+86.19
Organic substance	72.19	48.22	-23.97	-33.20
Raw cellulose	33.41	11.17	-22.24	-66.57
nitrogen	2.97	2.24	-0.73	-24.58
Magnesium mg/kg	60.00	60.79	+0.79	+1.32
Potassium mg/kg	448.42	184.2	-264.22	-58.92
Phosphor mg/kg	304.51	113.17	-191.34	-62.84

Table 6: Reproduction rate and produced amount of worms fed with various farm manures and manure production (Planted worm amount: 1000).

	1. C group	2. C/H group	3. SC group	4. SC/H group	5. H group	6. H/H group	P value
Harvested worm (amount)	15100.0±291.6	16060.0±315.0^{A}	21070.0±781.5^{AB}	18810.0±159.7^{ABC}	21780.0±605.8^{ABD}	20290.0±454.7^{ABD}	0.000
Produced worm (amount)	5100.0±291.6	6060.0±315.0^{T}	11070.0±781.5^{TU}	8810.0±159.7^{TUX}	11780.0±605.8^{TUY}	10290.0±454.7^{TUY}	0.000
Reproduction %	51.0±2.9	60.6±3.2^{a}	110.7±7.8^{ab}	88.1±1.6^{abc}	117.9±6.2^{abd}	102.9±4.6^{abd}	0.000
Manure production rate (kg)/KM	17.1±0.3	18.7±0.5^{K}	16.3±0.3^{KL}	21.6±0.7^{KLM}	20.1±0.7^{KLM}	23.0±0.3^{KLMN}	0.000

Data based on average ± standard deviation. Statistically regarded significant are the groups with different symbols in the same line. (Harvested worm amount: A; those that differs from C group; B; those that differs from C/H group; C; those that differs from SC group; D; those that differs from SC/H group. Produced worm amount: T; those that differs from C group; U; those that differs from C/H group; X; those that differs from SC group; Y; those that differs from SC/H group. Reproduction %: a; those that differs from C group; b; those that differs from C/H group; c; those that differs from SC group; d; those that differs from SC/H group. Manure producton rate (kg): K; those that differs from C group; L; those that differs from C/H group; M; those that differs from SC group. p<0.01.).

CONCLUSION

As a result, horse manure proved to be a better contributor to worm reproduction. Cattle manure mixed with wheat straw came closer to horse manure in terms of worm reproduction. Added hen manure affected worm reproduction negatively, while it affected manure production positively. Compared to worm feeds, the worm manures showed higher raw ash level, while it showed lower organic substance, raw cellulose, nitrogen, potassium and phosphor levels.

REFERENCES

Agarwal, S., Arora, L. (2011). Vermıculture bıotechnology for waste management ın dıfferent seasons : a case study. J. Dairying, Foods and H.S. 30(3): 209- 214.

Anonymous. (2019a). Tarımda kullanýlan organik, mineral ve mikrobiyal kaynaklı gübrelere Dair Yönetmelik Ek-19 analiz metodları (OGY) GPGDY (Gübrelerin piyasa gözetimi ve denetimi yönetmeliği) TS 5869 ISO 5073.

Anonymous. (2019b). Toprakta makro besin elementi analizleri–1. 524lt0108 2011http://megep.meb.gov.tr/mte_program_modul/moduller_pdf/Toprakta%20Makro%20Besin%20Elementi%20Analizleri%201.pdf.

AOAC. (1990). Association of Official Analytical Chemists. Official Method of Analysis. 15th.ed. Washington, DC. USA.

Arıman Karabulut, H., Kurtoğlu, İ.Z., Yüksek, T., Osmanoğlu, M.İ. (2016). Balık yemlerinde hayvansal protein kaynağı olarak solucan ununun kullanımı. Anadolu Çevre ve Hayvancılık Bilimleri Dergisi. 1(2): 64-69.

Atiyeh, R.M., Subler, S., Edwards, C.A., Bachman, G., Metzger, J.D., Shuster, W. (2000). Effects of vermicomposts and composts on plant growth in horticultural container media and soil. Pedo Biologia. 44: 579-590.

Bal, Y. (2011). Organik süt ineği işletmelerinde mastitis sorununa yaklaşımlar. Veteriner Hekimler Derneği Dergisi. 82(2): 7-14.

Barik, T., Gulati, J.M.L., Garnayak, L.M., Bastia. D.K. (2010). Productıon of vermıcompost from agrıcultural wastes- A revıew. Agricultural Reviews. 31(3): 172-183.

Chaoui, H. (2019). Vermicasting (or vermicomposting): processing organic wastes through earthworms.http://www.omafra.gov.on.ca/english/engineer/facts/10-009.htm.

Çakmak, C. and Çerçi, İ.H. (1995). Ankara keçilerinde farklı kimyasal maddelerle işlenen buğday samanının ruminal fermenta syonuna etkisi. Turkish Journal of Veterinary and Animal Sciences. 20: 55-61.

Çerçi, İ.H. and Sarı, M. (1994). Farklı kimyasal maddelerle muamele edilen buğday samanının *in vitro* sindirilme derecesi. Turkish Journal of Veterinary and Animal Sciences. 18: 27-32.

İnal, A., Sözüdoğru, S., Erden, D. (1996). Tavuk gübresinin içeriği ve gübre değeri. Tarım Bilimleri Dergisi. 2(3): 45-50.

Munroe, G. (2007). Manual of On-farm Vermicomposting and Vermiculture.

Publication of Organic Agriculture Centre of Canada, Nova Scotia.

Namlı, A., Akça, O., Perçimli, C., Beşe, S., Gür, Ş., Arıkan, H., Eser, İ., İzci, E., *et al* (2014). Evsel ve endüstriyel arıtma çamurlarının solucanlar (Eisenia fetida) ile kompostlanması. Toprak Bilimi ve Bitki Besleme Dergisi. 2(2): 46-56.

Sarı, M., Bolat, D., Çerçi, İ.H., Önal A.G., Deniz, S., Azman, M.A., Şahin, K., Güler, T., *et al* (2008). Hayvan Besleme ve Beslenme Hastalıkları, Medipires, Malatya.

Sözcü, A. and İpek, A. (2016). Kanatlı yetiştiriciliğinde serbest dolaşımlı sistemde (free range) besleme teknikleri. Hayvansal Üretim. 57(2): 68-74.

SPSS. (2013). IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.

Venter, J.M. and Reinecke, A.J. (1988). The life-cycle of the compost worm eisenia fetida (oligochaeta). South African Journal of Zoology. 23(3): 161-165.

Venugopal, A., Chandrasekhar, M., Naidu B.V., Raju S. (2010). Vermıcompostıng ın serıculture usıng mıxed culture of earthworms (eudrıllus eugıneae, eısenıa foetıda and perıonyx excavatus) - A revıew. Agricultural Reviews. 31(2): 150-154.

Yüksek, T. (2019). Farklı tip yemle beslemenin kırmızı kaliforniya solucanında solucan sayısı ve ağırlığına etkisi. Journal of Anatolian Environmental and Animal Sciences. 4(1):1-6.

Yüksek, T., Atamov, V., Türüt, K. (2019). Demlenmiş çay atığı ve evsel yemek atıkları ile beslenen kırmızı kaliforniya solucanından elde edilen katı solucan gübresindeki bazı besin elementlerinin belirlenmesi. Journal of Anatolian Environmental and Animal Sciences. 4(2): 263-271.