TECNO-LÓGICA
Revista do depto. de Química e Física, do depto. de Engenharia, Arquitetura e Ciências Agrárias e do Mestrado em Tecnologia Ambiental
http://online.unisc.br/seer/index.php/tecnologica

PHYSICAL AND CHEMICAL CHARACTERIZATION OF EARTHWORMS AND HUMUS OBTAINED BY VERTICAL VERMICOMPOSTING

Lucélia Hoehne[1], Rosecler Ribeiro[1], Wagner Manica Carlesso[1], Eduardo Miranda Ethur[1] e Simone Stülp[1]*
[1]Centro Universitário do Vale do Taquari - Univates. Rua Avelino Tallini, 171, sala 406 prédio 8. Lajeado, RS.

**E-mail: luceliah@univates.br*

Recebido em 18/02/2013
Aceito em 18/06/2013

Abstract

Earthworms culture are usually made horizontally and it is necessary a lot of area. In order to minimize the size of earthworms culture and the possibility to be applied in residences, this paper proposed evaluate conditions for vertical vermicomposting. For this, were purchased vertical boxes and organic matter. The earthworms of species *Eisenia andrei*, california red earthworms, were used. There were evaluated the adaptation of earthworms and physical and chemical characterization of the humus. Results showed that there was a good adaptation of earthworms in this configuration, minimizing the space required, and it is one technique for environmentally friendly recycling of organic waste, creating a bio-product wich can used as fertilizers.

Keywords: Earthworms culture. Vertical form. Bio-product

1 Introduction

The earthworms culture is as environmentally friendly as there are conversion of residues in food and subsequent treatment of this waste (vermicomposting), rich in organic matter, being transformed into humus [1, 2].

One of the advantages presented by vermicomposting is the production of humus (vermicompost), because it has interesting properties bioenergy, for the recovery of land [3], as well as the favorable changes [4] in microbiological terms, provided by this treatment, plus the ability to use earthworm and its bio-products in food systems as a source of digestible energy in the form of meal earthworms for example [5].

The Vale do Taquari is a great food producer region, and consequently there is the generation of waste, rich in organic matter, which often lacks a proper destination. Thus, the vermicomposting constitutes one possibility to target these wastes could generate subsequent products of commercial interest.

One important issue when talking about earthworms culture is the area necessary for the creation of earthworms as standards for commercial building construction sites, generally since this process is generally built in horizontal form [1]. In this work we use the measures about 20 x 1.20 x 0.50 m over common [6]. Considering the region's CODEVAT being comprised of farms that have area around 13 hectares [7, 8] it is necessary to develop farming systems that minimize the area used to be one of the vertical possibilities of creation. Therefore, this study aimed to evaluate the suitability of earthworms, as well as the generation of humus from a vertical earthworm culture, with a view to optimizing the area necessary for the realization of vermicomposting, becoming thus an innovation in process to implement a method of producing significantly improved [9,10].

1.1 Vertical Vermicomposting versus Composting conventional

Composting is the process of biodecomposition organic matter oxygen dependent. This treatment is a biological process and involve complex ecology by various groups of microorganisms in succession that transform the decaying substrate and that affect and are affected by physical and biochemical factors involved in the process. It differs from simple organic matter decomposition that occurs in nature, as it is a method used predominantly by action of microorganisms [11].

Subsequent composting, may join vermicompost, which is a process of enrichment of the organic compound, known as earthworm humus. These earthworms ingest organic materials in the decomposition process and excrete humified organic matter. To achieve a phase humic composting process, the total decomposition of organic matter (end of the carbon cycle) undergoes a slow and delicate process that depends on intrinsic combination of materials, moisture, temperature and microorganism. It can take months or even years. Thus, with the use of earthworms in vermicomposting process can accelerate the degradation of the compounds. These annelids hasten and streamline the carbon cycle, substantially reducing the travel time between photosynthesis and humus [12].

The main processes involved in the action of earthworms on organic matter and biological mechanics are represented by revolving the compound and grinding of organic particles that pass through the digestive tract of the animals, respectively. The contribution of biochemical effect is present when the decomposition of organic matter by microorganisms existing in the gut of earthworms, generating more waste rich in nutrients assimilable by plants. This new thinking promoted the possibility of using a wide variety of products from earthworms culture between such products are humified organic matter and slurry which are used in agricultura [12].

The *Eisenia andrei* can measure 6 to 8 cm in length and adapts to different types of organic wastes. These earthworms are well suited to the cooler area of the base compound and therefore proliferate rapidly [13]. The earthworms begin to attack by base, reaching the top of the stack as it moves decomposing matter and as tolerate the temperature is around 13 °C to 22 °C higher ideal. Thus, vermicomposting can be used for various types of waste, provided it is within the bounds of acceptability of earthworms as temperature, pH, moisture, toxicity and other factors that do not harm your development [14].

1.2 Vertical vermicomposting

The vertical vermicomposting involves the construction of verticals buildings, divided into stacks of boxes. The vertical systems are relatively simple and can be made of plastic sealed boxes containing holes between for the earthworms to move from one box to another in search of food. Further, at the bottom there is a device for the release of liquid waste generated by vermicompost [15]. This residue can also be used as fertilizer liquid. The vermicomposting system offers greater vertical control system, such as temperature, humidity and pH appropriate, offering a bioproduct as humus minimizing the area required for creating eartworms [16].

Therefore, this study evaluated the building type earthworms *Eisenia andrei* and the generation of humus using vermicomposting vertical, becoming thus in a process innovation with implementation of a production [10].

2 Materials and methods

2.1 Acquiring and preparing the boxes for earthworm culture

To develop the study, boxes were purchased in the special stores containing 200 g of the California Red earthworms (*Eisenia andrei*). The system had three closed plastic boxes (each with 0.70 x 0.50 x 0.40 m) with holes in the lids (Figure 1) so that the earthworms could move from one box to another in the same earthworm culture.

The systems were installed in the laboratory of Animal Experimentation I, belonging to the Museum of Natural Sciences Univates without the incidence of rain and sun, with a daily control of temperature and humidity.

Organic matter added in boxes for feeding the earthworms culture was added in the top box and center as: vegetables, fruit peel, coffee grounds, paper and filter paper. Thus, the earthworms could move from one compartment to another when there was lack of food or when the environment was not suitable for the development of these.

Also, one can change the position of boxes to remove the formed humus or adding more organic residues. The lower compartment had a tap to collect the leachate generated by the process.

Figure 1- Vertical earthworm culture.

2.2 Earthworm adaptation and growth

The younger earthworms were inoculated in the top of the box in the system with organic matter. After the inoculation the earthworms performed the process of vermicomposting of the material for 90 days. The growth of earthworms was assessed by measurement of size and weight every two weeks, for three months with n = 20, considering that this is the time to reach the stage of adults earthworms [17]. The onset of this study was made from the reproductive phase earthworms purchased commercially.

2.3 Characterization of humus generated

The physicochemical characterization of humus generated was done through analysis of pH, moisture, total ash, total organic carbon dissolved (TOCd) and total dissolved nitrogen (TDN).

All analyzes were performed in triplicate and performed statistical analysis using the program Graph Pad, Inc. (Instat 2.1). The average results were compared using the Student's test (t), at 95% confidence. A comparison of three or more means was done by analysis of variance (ANOVA) for a confidence interval of 95%, with Tukey-Kramer post test.

For the analyzes of pH, were determined using a pHmeter (Digimed, model DM 20) according Souza [18].

For moisture analysis, it was necessary to use an oven (model BioPar S33A) where humus was dried at 105 °C for 8 hours [19].

For the determination of ashes, one flask was used (Marconi, model MA38512) set at 550 °C until constant weight according to the literature [19].

For the determination of total nitrogen dissolved (TND) and total organic carbon dissolved (TOCd) in the soil, it was necessary to use nitrogen detector (Shimadzu, Total Nitrogen Measuring unit, TNM-1) and organic carbon, chemiluminescence and combustion and infrared detection, respectively (Shimadzu TOC-CPH). The conditions were made according to the manufacturer [20].

3 Results and discussion

3.1 Composting and vermicomposting vertical

To check the decomposition of organic matter, when the addition of organic waste in earthworms culture was evaluated daily the inside temperature, while Figure 2 shows the temperature values monitored during 60 days of vertical composting process.

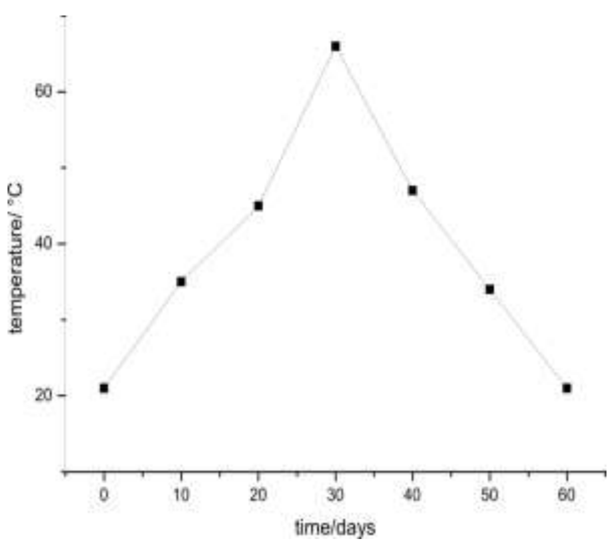

Figure 2 - Earthworms culture temperature for 60 days vertical composting process.

As can be seen in Figure 2, the composting process has occurred for 60 days. There was a temperature rise until the first 30 days, beginning where the step mesophilic where exactly the earthworms start to act on the organic matter already pre-decomposed by other microorganisms. These temperature value were consistent with the work of others authors [21- 22], where the peak temperature is around 60 °C for horizontal earthworm culture.

The performance of vermicomposting occurred after 30 days with significant development of earthworms and relative increase in its population. Since when the temperature of the compost was around 60 °C, was observed to migrate to these areas of the pile surface until the proper environment for them to stay the vermicomposting process. Is a decreasing volume of composted starting towards the end, around 15% after vermicomposting, this was probably due to the biotransformation of organic matter due to the action of detritivorous earthworms [23].

3.2 Adaptation and development of earthworms

In thirty days after the inoculation of earthworms in the vertical system, was observed the good adaptation of the annelids to the environment and appearance of manure in the lower compartment of earthworms culture showed the occurrence of biotransformation of organic matter, as literature [15].

The adaptation of earthworms was assessed by their size and weight. It should be noted that it was expected to occur in the reproduction of this animals in the earthworms culture vertical to start checking their weight and length. Table 1 shows the mean (x) and standard deviations (sd) of the size and mass of earthworms for 90 days.

As can seen from the results of Table 1 that an increase of weight and length of earthworms in size and mass to 90 days. As other studies in the literature, the results of mass of earthworms during that time were in agreement with the mass of earthworms grown in earthworms culture horizontal, not being significantly different results ($P < 0.05$) [21, 24]. Thus, it can verify good adaptation of earthworms in this vertical system.

However, the values achieved in the experiment should be observed carefully, since the type and quality of food can have a strong influence on the mass of earthworms [25].

.

Table 1- Size and weight of earthworms for 90 days. n = 20. The values are in x ± sd.

	1 day	30 days	60 days	70 days	80 days	90 days
Size (mm)	9 ± 1	24 ± 2	50 ± 3	60 ± 1	64 ± 2	72 ± 3
Weight (mg)	0.0128 ±0.0008	0.235 ±0.003	0.288 ±0.003	0.353 ±0.004	0.412 ±0.002	0.456 ±0.004

After evaluating the adaptation of earthworms in culture vertical, we evaluated the physicochemical characteristics of humus generated by vertical vermicomposting to compare with the humus generated in other papers obtained by vermicomposting horizontal [25-27]

The humus samples were collected biweekly and humidity values are shown in Table 2.

Table 2 - Variation of moisture (% in weight) throughout the process of vermicomposting. The values are represented in x ± sd.

Collection day	1	15	30	45	60	75	90
Moisture	35 ± 0.5	40 ± 0.3	39 ± 0.3	41±0.4	40 ±0.3	39 ±3	40± 0.3

Analyzing the results in Table 2, we found that there was an increase in moisture content compared to the beginning of the process. These results are consistent with other studies made with horizontal vermicomposting using different organic materials to feed earthworms culture [27, 28].

For the analysis of pH, the earthworm samples were collected and analyzed fortnightly. Figure 3 shows the results.

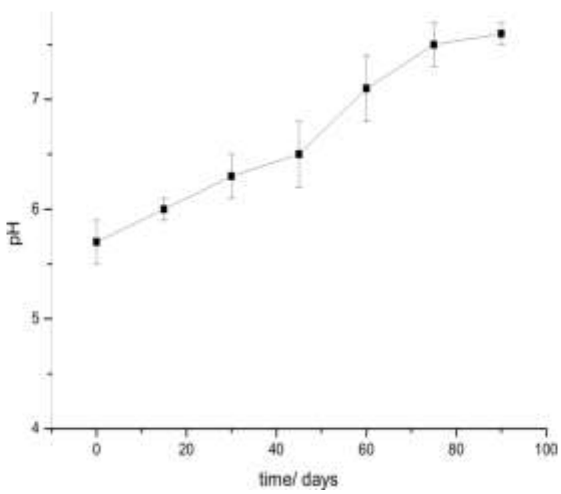

Figure 3 - Variation of pH during 90 days of vermicomposting

According to the data of Figure 3, an increase in the pH of compost, due to the biotransformation of organic matter in humus and according to the literature, five studies showed that the esophagus leaving small pockets of the earthworms, the earthworms glands that secrete carbonate calcium, controlling the content of that element in the body of the animal. The CO_2 produced by respiration is eliminated with excess calcium absorbed soil, forming $CaCO_3$, which is released to the exterior along with undigested particles in the form of excrement. Thus, the constant additions of calcium carbonate contribute to increasing the pH explaining the increases observed in this experiment verified that the four composting causes rise in pH. This statement is in agreement with the results obtained in this study using vertical vermicomposting.

For the analysis Total Dissolved Organic Carbon (TOCd) Figure 4 shows the results of humus during vermicomposting vertical.

According to the values shown in Figure 4, there was a decrease in TOCd during vermicomposting due to the decomposition of organic waste, and part of the carbon is biotransformed into CO_2, and the assimilation of the earthworms C, changing into a material more mineralized, namely humus.

The levels of dissolved total nitrogen (TNd) in the humus during vermicomposting vertical were also analyzed. The results showed that there was an increase in the nitrogen content during vermicomposting vertical. In the first day there was 0.019% of TN and in the final of the 90 days of the tests, the TN level was 0.026%. These results are consistent with other studies that analyzed the content of nitrogen during horizontal vermicomposting. This was due to nitrogen fixation in the form of minerals depending on biotranformation vermicompost organic waste through vermicomposting [25, 27-30].

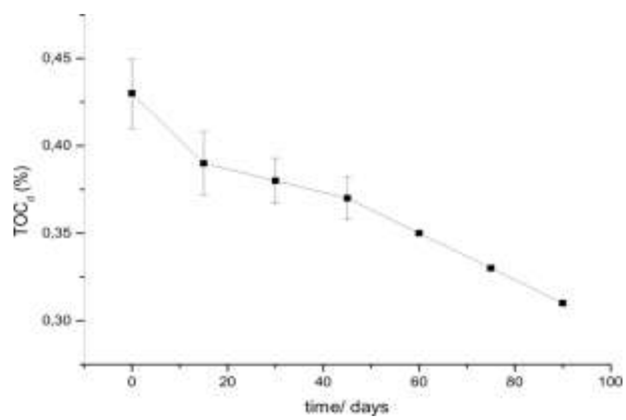

Figure 4 - COTD values (%) dissolved in the soil for 90 days vermicomposting vertical.

The phosphorus analyzes were also carried out for 90 days vermicompost and the results were statistically equal, while at the beginning of the process the content of phosphorus was 0.5 ± 1.64 and after three months was 1.60 ± 0.3 in mass%.

The C/N ratio is the parameter traditionally considered to determine the degree of compost maturity and set its agronomic quality. Figure 5 shows the results analyzed for the full 90 days of decomposition process of organic matter.

According to the results of Figure 5, there was a decrease in C/N ratio due to the loss of carbon as CO_2 and increasing N as a function of mineralization of sludge [31]. On the first day the C/N ratio was 22 and the end of 90 days was 12, indicating the maturity of compost. This was consistent with studies described in the literature using horizontal vermicomposting [29, 30].

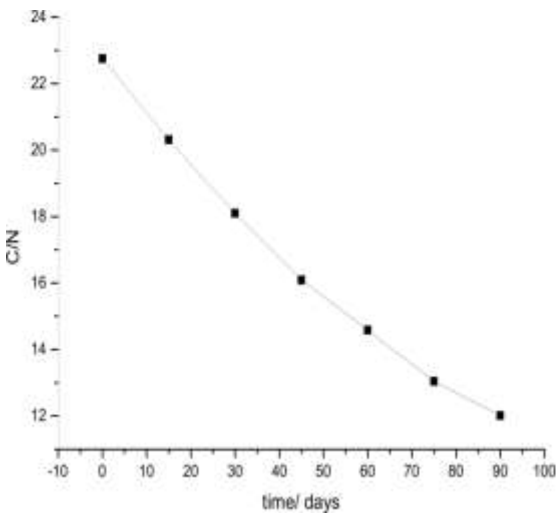

Figure 5 - C / N ratio of humus during vermicomposting vertical.

Also, applying an exponential model fit to the results of C/N obtained, it can be seen that R^2 is equal to 0.99948, consistent with results described in the literature [32], which relate degradation of organic matter and nitrogen with mathematical models. These results confirm the hypothesis put forward by other studies that relate the kinetic behavior of mineralization and their C/N ratio, with the formation of more recalcitrant organic matter and therefore more stable, as the process occurs biodecomposition [33].

4 Conclusion

Preliminary tests showed that it was possible biotransformation organic waste into compost through vertical vermicomposting. There was a good adaptation of earthworms this configuration earthworms culture. It was seen that the earthworms could migrate from one box to another when the environment was unsuitable for them. And the manure produced can be collected in the lower compartment of the vertical earthworm culture. This type of vermicomposting can be applied in homes or apartments, to reuse their own organic waste generated by the residents of the home and require little physical space, a technique being environmentally friendly. Moreover, the physics and chemicals properties of humus generated were consistent with the results of humus generated by horizontal vermicomposting. Thus, it was possible to demonstrate in this paper a byproduct of vermicomposting vertical containing nutrients favorable to be used as bio-fertilizers and organic soil conditioner.

Acknowledgements

Our thanks to Univates, CNPq, Fapergs and Promin for the support.

CARACTERIZAÇÃO FÍSICA E QUÍMICA DE MINHOCAS E DE HÚMUS OBTIDOS POR VERMICOMPOSTAGEM VERTICAL

RESUMO: Minhocários são normalmente feitos horizontalmente sendo necessária uma área grande. A fim de minimizar o tamanho da cultura de minhocas e a possibilidade de ser aplicado em residências, este trabalho propõe avaliar as condições de vermicompostagem vertical. Para isso, foram adquiridas caixas verticais e matéria orgânica. Foram usadas minhocas da espécie *Eisenia andrei*, minhocas vermelhas da califórmia. Foi avaliada a adaptação das minhocas e caracterização físico-química do húmus gerado. Os resultados mostraram que houve uma boa adaptação das minhocas nesta configuração, minimizando o espaço utilizado, e é uma técnica de reciclagem ecológica de resíduos orgânicos, a criação de um bioproduto o qual pode ser usado como adubo.

Palavras-chave: Minhocário. Forma vertical. Bioproduto

References

[1] Aquino, A. M.; Oliveira, A. M. G.; Loureiro, D. C.; Integrando Compostagem e Vermicompostagem na Reciclagem de resíduos Orgânico Domésticos. Circular técnica. Embrapa. Rj, junho, **2005**.

[2]Theunissen, J.; Ndakidemi P. A.; Laubscher, C.P.; International Journal of the Physical Sciences, vol. 5 (13), pp. 1964-1973, 18 October, **2010**.

[3] Fernandes, J. D. ; Monteiro A. F.; Santos, S. A. ; Vasconcellos, A. Rev. Bras. de Agroecologia, vol. 4, n. 2, p. 2388-2391, **2009**.

[4] Tiago, P. V.; Melz, E. M.; Schiedeck, G.; Rev. Ciên. Agron. vol. 39, n. 02, p. 187-192, **2008.**

[5]Istiqomah, L.; Sofyan, A.; Damayanti E.; Julendra H.; J.Indonesian Trop.Anim.Agric. 34 (4), **2009.**

[6] Fiori, A. A.; Boletim Técnico 242: Minhocultura. SP. 3 ed. Cati, , 66p. **2004**.

[7]Schultz, G.; Barden; J. E. Berra, L.; Wiebusch, F. C.; Gorgen, J.; In: Agricultura orgânica na região do Vale do Taquari/RS: análise da estrutura de coordenação e gerenciamento da cadeia produtiva de hortaliças orgânicas, In: Sociedade Brasileira de Economia, Administração e Sociologia Rural. Porto Alegre, 26 a 30 de julho de **2009**, p. 121.

[8] Souza, O. T.; Alavim, A. M.; Hoppe, L.; Martins, L. M..; Pasquetti, G.; Meio ambiente e desenvolvimento na região metropolitana de Porto Alegre: notas introdutórias baseadas no espaço rural metropolitano, In: Sociedade Brasileira de Economia, Administração e Sociologia Rural, Porto Alegre, 26 a 30 de julho de **2009**, p. 1-20.

[9] Selden, P.; Duponte, M.; Sipes, B.; Dinges, K.; Home Garden, 45, **2005.**

[10] Manual de oslo. Diretrizes para coleta e interpretação de dados sobre inovação. 3 ed. OECD, **2005**.

[11] Mason, I. G.; Milke, M. W. Christchurch Vol.25, Issue 5, Pages 481–500, **2005**

[12] Garg, V. K.; Yaday, A. Bioresource Technology, vol. 102, n. 10, p. 5891-5895, **2011**.

[13] Domingez, J.; Velando, A.; Ferreiro, A.; Pedobiologia, vol.49, p.81-87, **2005**

[14] Marcondes, A. C.; Lammoglia, D. A.; Biologia: ciência da vida. São Paulo: Atual, **1995**.

[15] Kiehl, E. J.; Fertilizantes orgânicos. São Paulo: Agronomia, Ceres, **1985**.

[16] Carlesso, W. M.; Ribeiro, R.; Hoehne, L.; Rev. Destaques Acadêmicos, vol. 3, n 4, 105-110, **2011**.

[17]Dominguez J.; Briones, M. J. I.; Mato, S.; Pedobiologia 41, 566-576, **1997**.

[18] Souza, J. M. L.; Negreiros, J. R. S.; Alvares, V. S.; Leite, F. M. N.; Souza, M. L.; Reis, F. S.; Felisberto, F. A. V.; Ciênc. Tecn. Alim. vol. 28, n. 4, p. 1-6, **2008**.

[19] Instituto Adolfo Lutz: Métodos físico-químicos para análise de alimentos: 4 ed. São Paulo,4 ed. **2005.**

[20] Manual do Oslo. Diretrizes para coleta e interpretação de dados sobre inovação, 3. ed., OECD, **2008**.

[21] Alameida, P. C.; Minhocultura. 3 ed. Sebrae/MT, 106 p. **1999**.

[22] Correa, R. S.; Fonseca, Y. M. F.; Correa, A. S.; Rev. Bras. Engenharia Agrícola e Ambiental. vol.11, n.4, p.420–426, **2007**.

[23] Eastman, B. R.; In BioCycle, Page 62, 391–395, **1999**.

[24]Schiavon, G. A . Schiedeck, G.; Araujo, J. M. G.; Schwengber, J. E. Rev. Bras. Agroecologia, vol.2 No. 2, **2007.**

[25] Garg, P.; Gupta, A. Satya, S.; Bioresource Technology, 97, 391–395.

2006.

[26] Bidone, F. R. A.; Resíduos Sólidos Provenientes de Coletas Especiais: Eliminação e Valorização. ABES, 218 p. Rio de Janeiro, **2001.**

[27] Dores-silva, P. R.; Landgraf, M. D.; Rezende, M. O.O.; Quim. Nov. vol. 34, n° 6, 956-961, **2011**.

[28] Suthar, S; Applied ecology and environmental research 5(2): 79-92. **2007**.

[29]Ndegwa, P.M.; Thompson, S.A.; Technology**,** 75, **2000.**

[30] Atiyeh, R. M; Lee, S.; Edwards, C. A.; Aracon, N. Q.; Metzger, J. D. Bioresource Technology, 84, 7-14, **2002.**

[31]Alidadi, H.; Parvaresh,A.R. Shalumanso M. R.; Pourmoghadas H.; Iran. **J**. Environ. Health. Sci. Eng, Vol. 2, n 4, pp. 251-254 2, **2005**.

[32] Freire, J. L. ; Dubeux, J. J. C. B ; Lira, M. A.; Ferreira, R.L.C.; Santos, M.V. F.; Freitas, E. V. Revista Brasileira de Zootecnia vol.39, n.8, p.1659-1665, **2010**.

[33] Martines, A. M.; Andrade, C. A.; Cardoso, E. J. B. N. Pesq. Agro. Bras. vol.41, n.7, p.1149-1155, **2006**.