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Treatment of inedible poultry carcasses through composting

tratamento de cortes nobres de frangos de corte impróprios para o consumo humano através da compostagem

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Abstract

A trial was conducted to evaluate the treatment of inedible poultry carcasses through composting. Physical and chemical transformations of biomass were monitored during 180 days of composting. A completely randomized design was used and data were subjected to ANOVA and polynomial regression at 5%. Moisture was not a conditioning factor for efficiency of second stage of composting, highlighting the significance of intermittent revolving of composting material. Poultry litter supplied nitrogen (N) for the microorganisms, hence should not be used as a carbon (C) source for composting of inedible poultry carcasses and must be replaced for materials containing a high C:N ratio. The mixture of inedible poultry carcasses and poultry litter resulted in a low initial C:N ratio, leading to volatilization of N and, as a consequence, increasing C:N ratio during the whole composting process. As a result, additional time was needed for proper stabilization of biomass. The final compost showed a high pH and therefore may be used for correcting acid soils. Composting process increased nutrients concentration in the biomass. The values herein obtained were within limits of environmental legislation of some countries, such as Brazil (Normative Instruction Nº25/2009). In conclusion, composting is an alternative for ecologically correct disposing of inedible poultry cuts and ought to be used for poultry producers and industry, helping achieving its environmental sustainability.

Keywords: animal production, environmental sustainability, poultry production.

Resumo

O objetivo do estudo foi avaliar o tratamento de cortes nobres de frangos de corte impróprios para o consumo humano através do processo de compostagem. O monitoramento das transformações físico-químicas da biomassa foi realizado durante o período de 180 dias de compostagem. O delineamento utilizado foi o inteiramente casualizado. Os dados coletados foram submetidos à análise de variância e regressão a 5% de significância. Os resultados indicaram que a umidade não foi um fator condicionante de eficiência no segundo estágio de compostagem, ressaltando assim a importância dos revolvimentos intermitentes. O substrato cama de aviário serviu de fonte de N aos micro-organismos, não devendo ser utilizado como fonte de C na compostagem de cortes nobres de frangos de corte, sendo necessária a substituição por materiais que apresentem uma alta relação C/N. A mistura de cortes nobres de frangos de corte e cama de aviário acarretou uma baixa relação C/N inicial, favorecendo a volatilização do nitrogênio e, por conseqüência, o aumento da relação C/N no decorrer do processo de compostagem, fazendo-se necessário um tempo maior para a bioestabilização da biomassa. O composto produzido pode ser utilizado como corretivo de solos ácidos por apresentar um pH alcalino. A compostagem proporcionou a concentração dos nutrientes na biomassa, encontrando-se dentro dos valores máximos tolerados pela Instrução Normativa nº25/2009 do Ministério da Agricultura, Pecuária e Abastecimento. O processo de compostagem é uma alternativa para a disposição ecologicamente correta dos cortes nobres de frangos de corte considerados impróprios para o consumo humano, podendo ser utilizado pelo setor avícola e também por granjas, auxiliando no desenvolvimento sustentável desta atividade.

Palavras-chave: produção animal, sustentabilidade ambiental, avicultura.

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I. INTRODUCTION

The population and economic growing as well has leaded to a higher worldwide demand for food. As a consequence, different agricultural systems had to increase its production in order to attend such an increasing demand. Additionally, the world market organization raised the possibility for exporting a great variety of products, increasing even more the agricultural systems, particularly in developing countries.

Therefore, the Brazilian poultry production system presents a vertical integration with processing companies. In this integration, producers receive the birds, feed and technical assistance from the processing companies. As a consequence, companies retain technology, productive processes and commercialization of production. A contractual commercial relationship is established among producers and industry. Such relationship may vary according to the type of integration, rights and duties among both parts involved.

In the Southern Brazil, poultry production takes place in small properties and by familiar hand labor. High density confinements and growing rates characterize intensive poultry production systems. Official data estimate the Brazilian poultry production in about 10,703 million tons per year (ANUALPEC, 2009). According to Lucas Junior and Santos (2003), both poultry management and intensity of production generates a high amount of poultry litter. Additionally, 16 to 20 birds are allotted per square meter and 1.75 kg of wood shavings is available per bird (MIRAGLIOTTA et al., 2002). Therefore, an annual production of 5,15 billion of poultry produces about 9,01 billion of poultry litter (FUKAYAMA, 2008).

Another important aspect to consider is the natural mortality of poultry during a regular production cycle, varying from 3 to 5%, which represents approximately 0.1% daily (LUCAS JUNIOR and SANTOS, 2003). Confinement and high densities increase even more the sanitary risks. According to Santos (2001), in a regular commercial poultry production, where about 15,200 birds are reared in the same building, with 4.42% mortality index, a total of 671.60 kg of dead birds or 14.30 kg of dead birds a day are produced by the end of 47 days.

Dead birds are responsible for a considerable amount of residues generated by the poultry production system (LUCAS JUNIOR and SANTOS, 2003). Wood shaving residues can be reutilized. Dead birds, on the other hand, comprise a high pathogenic residue which is retained in the property and require a proper disposal. Therefore, they represent a potential problem for producers. According to Fiori et al. (2008), the increasing production of residues is way higher than its degradation and is therefore negatively impacting the environment.

However, due to the implementation of more severe environmental laws highlighting the environmental managing, a gradual awareness about the harmful effects of continuous releasing of solid and liquid residues in the environment is taking place. Together, the market is also pressing the companies for presenting a more concrete action in terms of environment preservation. Such actions should include activities that result in less environmental impact. Thus, poultry production sector is encouraging the recycling of residues to increase the performance of productive processes and, as a consequence, to generate lesser residues and lowering the costs for its final deposition. Therefore, one of the goals is to synchronize the release of nutrients according to the vegetable needs. In order to do so, new technologies for helping the biodegradation of those organic residues must be developed.

Different methods for treating and disposal of organic residues were and have been developed around the world (VERGNOUX et al., 2009), with emphasis in composting. Such technology is generally applied to non fluid residues, that is, solid residues coming from different sources, as urban, agro industrial and agricultural sources (AMINE-KHODJA et al., 2006). Vergnoux et al. (2009) affirm that composting is utilized for a wide variety of organic sources showing similar characteristics and processes for all residues.

Composting of poultry carcasses must be developed in two stages. The first one consists in transform, in a safe way, a material hard to deal with at the beginning into another one that can be manipulated in a posterior process of composting. According to Pereira Neto and Stentiford (1992), this process presents a higher operational flexibility which combines low costs and high efficiency and has been considered environmental friendly for correct disposal of inedible carcasses. However, because it is a microbiological process, its efficiency relies on the action and interaction among microorganisms. According to Valente et al. (2009), the way microorganisms act depends on favorable conditions of temperature, moisture, aeration, type of organic compost, relation carbon/nitrogen (C:N ratio), particle and pile size. The efficiency of composting is based on the interdependency and interrelationship among those factors (PEIXOTO, 1988). Martín-Gil et al. (2008) affirm that different populations of mesophiles and thermophiles microorganisms are responsible for substrates biodegradation and both determine the rate composting process occurs.

This trial aimed to evaluate the treatment of inedible poultry carcasses through composting.

2. MATERIALS AND METHODS

The trial was carried out between January and July 2007 at the Laboratory of Teaching and Animal Experimentation (LEEZO) of Federal University of Pelotas (UFPel), Capão do Leão, Brazil.

The first stage of composting took place in an impermeable composting cell (2.20 m wide, 1.70 m long and 1.20 m height) with a 2.5 m height hoof. Its frontal part had wooden boards, instead of a door, allowing it to be filled layer by layer with organic residues until 1.00 m height (Figure 1). Composting was conducted for a total of 120 days.

Figure 1. Composting cell
Fonte: Acervo dos autores (2007)

Composting cell was loaded with inedible poultry cuts (chest, wings, legs, drumstick and back). The birds had been fed experimental diets containing two types of corn (with and without fungi) as well as aflatoxins, making them inedible. Poultry litter was composed of pine three (*Pinus spp*) shavings from two lots of poultry (35 days each) with an average particle size of 2.20 mm.

The second stage last for 60 days and was carried out inside an impermeable building. A pile (1.60 m wide, 3.00 m long and 1.00 m height) was built with the material from the first stage.

In the first stage, the experiment was assembled according to Paiva (2004). The first layer was 0.15 m height. This layer was built using a scale and a metric tape. Poultry litter mass for the first layer was 109 kg. The other layers were 0.10 m height and weight 72 kg each. The proportion among organic residues were 3:1 (3 kg poultry litter: 1 kg of inedible poultry cuts), according to Costa et al. (2006). Using the same methodology, water was added at 30% of each layer weight. Inedible poultry cuts were added on the top of first layer and then covered with 0.10 m height poultry litter. Then, another layer of poultry inedible cuts was built and covered with another 0.10 m height poultry litter, and so on, until the composting material reached 1.00 m height. Five numbered wooden stakes were added at 0.20 m from each other for collecting and measurement purposes. In each of the five collect points a 1.00 m height PVC tube was introduced.

In order to calculate the amount of water to be added during the second stage of composting, all biomass was removed and weighed at the end of 120 days of composting. The methodology for adding water was the same one utilized during the first stage of composting. A total of 285 L was added when layers were revolved, at each 18 days.

Biomass temperature was collected inside each PVC tube twice a day (9:00 a.m. and 4:00 p.m.) with a digital thermo hygrometer (Incoterm, 0.1ºC). Average daily temperature was obtained at Pelotas Agro Meteorological Station, located at 31º52'00" South and 52º21'24" West, and altitude of 13.24 m.

During the whole experimental period biomass physic and chemical analysis was carried out. The first sampling and analysis was performed when initial substrates were combined, at day one. The others were performed at days 30, 60, 90, 120, 150 and 180 of composting. Analyses of pH, moisture, total organic matter (OM), total organic carbon (C) and total nitrogen (N) were performed at the Laboratory of Animal Nutrition of UFPel. For pH analysis 10g of sample was transferred to a Becker cup and diluted with 100mL of distilled water. Total OM was obtained by the equation: OM = 100 - % ash, according to Kiehl (1985). Total organic carbon was obtained through Bemmelen´s factor: C = OM x 1.8^{-1}, according to Kiehl (1985). Total nitrogen was determined through digestion of sample in sulfuric acid and then distillation in Kjedahl, according to Silva and Queiroz (2004). The C:N ratio was obtained by the equation: C:N = % C x % N^{-1}, according to Tedesco et al. (1995).

Additionally, total P, total Mg and total K were analyzed at the Laboratory of Soil Chemistry of UFPel, according to Tedesco et al. (1995). Phosphorus content was obtained through mineral solution reading in UV visible spectrophotometer. Potassium content was obtained through mineral solution reading in flame spectrophotometer. And Ca and Mg content were determined through mineral solution reading in atomic absorption spectrophotometer.

A completely randomized design was used. Data were subjected to General Linear Models of Statistical Analysis System version 9.1 (SAS Institute Inc. 2002-2003) and polynomial regression at 5%.

3. RESULTS AND DISCUSSION

No specific trend was observed for biomass temperature during the whole experimental period (Figure 2). Hence, no equations were obtained. However, at the beginning of composting (T0) the initial temperature reached 39.2ºC, indicating the presence of mesophile microorganisms. Rashad et al. (2010) studied composting of rice hulls and agro industrial residues and also found an increase of the mesophile bacterial population for all the treatments at the beginning of composting. After the initial period (T0), a transition phase of composting became clear, characterized by the death of mesophile microorganisms along with the multiplication and installation of a thermophilic microbial population.

Such findings were strengthened due to the increasing temperature observed during the next 30 days of composting as a result of warm generated during oxidation of organic matter. This oxidation occurred because microbial metabolism is exothermic and remains inside the biomass (TANG et al., 2004), increasing the temperature from 25ºC to 40-45ºC for 2 to 3 days (KIEHL, 1985). When temperature reaches more than 45ºC the mesophilic microbiological activity is suppressed by the growing of a thermophilic microbial community (TIQUIA, 2005).

However, starting at 60 days biomass temperature decreased (47.3ºC) up to 120 days, when the average temperature reached 30.9ºC. Therefore, a second transition phase was shown with the death of thermophilic microorganisms and the growing of a new mesophilic microbial population. This fact can be explained for the continuous decreasing of moisture observed for the composting mass (Figure 3A) and reduction of water activity, both of which affect growth, metabolic activity, resistance and survivability of microorganisms. Additionally, compression of substrates within composting cell along with a higher specific surface of inedible poultry carcasses probably lead to the appearance of a second transition phase, which is composed of molecules of easier degradation than wood shavings, generally utilized on the floor of poultry farms. This finding is in agreement with Kiehl (1985) who affirms that the intensity of microbiological activity is directly related to the lower particle sizes of composting material, speeding up the decomposition process. According to Kirk and Farrel (1987), lignin, part of wood shavings, is very resistant to microorganisms attack and is the last material to be decomposed. Tuomela et al. (2000) state that fungi are the most efficient microorganisms for mineralization of lignin. Such microorganisms grow up in lower water activity than bacteria (JAY, 2005) and are present during compost maturation stage which occurs during second mesophilic phase where lower temperatures are present.

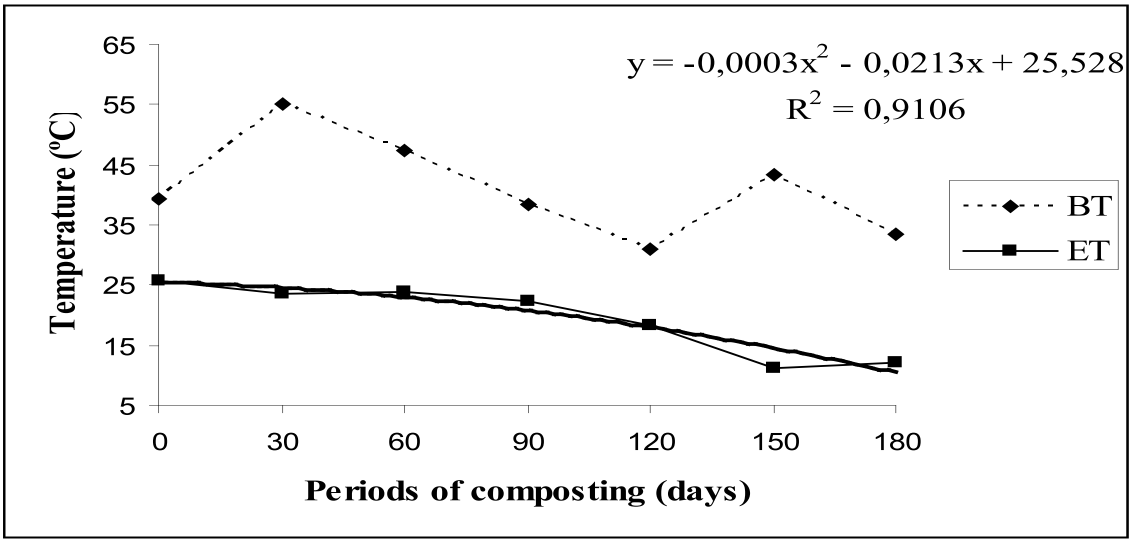

Figure 2. Biomass temperature (BT) and environmental temperature (ET) during composting of inedible poultry cuts and poultry litter (Capão do Leão, RS, 2007).

Moreover, the presence of a mesophilic microbial population was observed during the second phase of composting, not only at 150 days (43.2ºC) but also at 180 days (33.5ºC). Initially (120 days), revolving made the composting mass cool down and, lately, leaded to a temperature increase due to a higher oxygen penetration inside the biomass. This finding agrees with Pereira Neto (2007) who affirms that frequent revolving during the second stage of composting promotes a more effective and uniform aeration, favoring the temperature increase. However, the results disagreed with Kader et al. (2007), who studied composting of bovine manure in piles with or without revolving. According to these authors, during the first and second day of composting, the revolving pile presented higher temperatures than the static ones. Nonetheless, at the third day of composting the maximum temperature in the center of the piles was similar for both treatments, 75ºC and 78ºC, respectively.

Environmental temperature during composting becomes another important piece of information. At 150 days of composting the average environmental temperature was the lowest for the period (11.2ºC) and the biomass temperature increased from 30.9ºC to 43.2ºC as a result of oxygen incorporation into the biomass during revolving. Therefore, biomass temperature was not affected by environmental temperature, and no specific trend was observed. Average environmental temperature decreased during composting and showed a quadratic response. This result is in disagreement with Peixoto (1988) who affirms that composting in piles is affected by the environmental temperature. However, the result agrees with Kiehl (1985) who affirms that even during cold weather in winter biomass remains warm and releases water steam and temperature proportional to the pile dimensions. The result also agrees with Joshua et al. (1998). According to the authors, the external part of the pile works as a protection mass, retaining temperature. The extension of it depends on the thermic properties of composting material (KLAMER; BAATH, 1998).

Moisture is indispensable for metabolic and physiologic activity of microorganisms. However, in this study the addition of water did not affect the pile temperature and the lowest values were found at day zero, 150 and 180 (6.96%, 6.35% and 7.70%, respectively) (Figure 3A). The results are in agreement with Valente et al. (2009) who affirm that the optimal moisture for microbial activity vary according to both the type of composting material and the cellulosic substrate. Additionally, Jay (2005) highlights that water needs of microorganisms must be described in terms of water activity of medium and also that changes in temperature or nutrient amounts may lead to microbial growing in lower water activities.

No specific trend was observed for both total organic matter (Figure 3B) and total organic carbon (Figure 3C). Therefore, no regression equations were adjusted. Dai Prá (2006) analyzed physic and chemical characteristics of swine residues added to different cellulosic materials (wood shavings, wood sawdust and poultry litter) subjected to 150 days of composting. The author found a result similar to the obtained herein. However, more reduced levels were observed for both variables during 90 days of composting. This result highlights the mineralization of organic matter as a response to biomass carbon degradation by microorganisms trying to obtain energy for growing and development (TANG et al., 2004). Loureiro et al. (2007) evaluated composting of home residues with and without adding of bovine manure. The authors found a reduction of total C during 27 days of composting. Additionally, Costa et al. (2006) studied composting of poultry carcasses and poultry litter during 180 days. The authors found a reduction of total C not only during the first but also during the second stage. However, an increase of both total organic matter (90.6%) and total organic carbon (51%) was observed at 120 days of composting. This is probably a result of reduction of microorganisms' activity, because temperature of composting mass reduced during the same period.

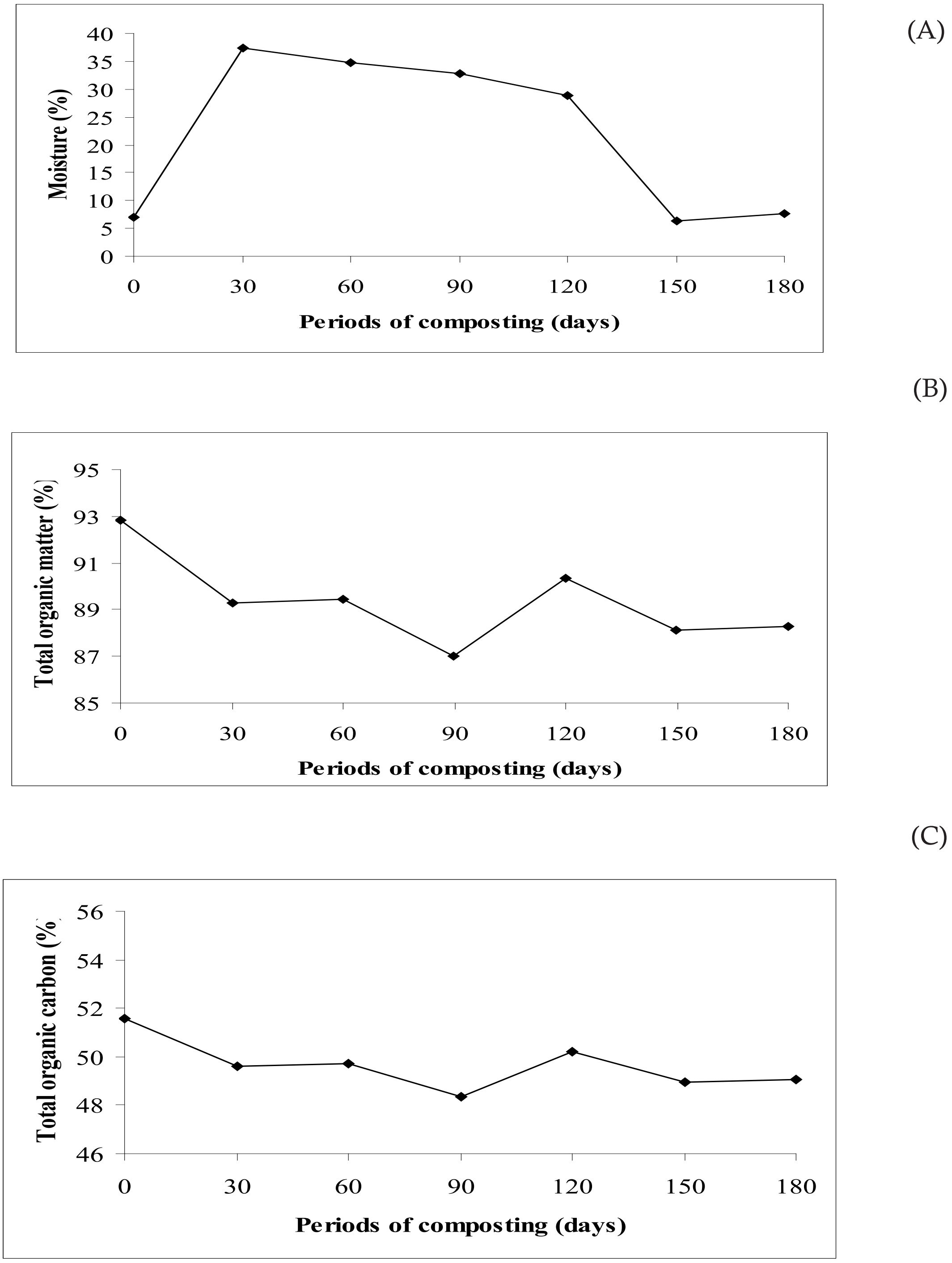

Figure 3. Moisture (A), total organic matter (B) and total organic carbon (C) of a mixture of inedible poultry cuts and poultry litter (Capão do Leão, RS, 2007).

Biomass pH (Figure 4A) showed alkalinity (pH= 7.7-9.7) during the whole experimental period as a result of organic matter biodegradation. During respiration microorganisms release C in the form of CO_2 which reacts with bases and forms H_2CO_3, increasing pH (VALENTE et al., 2009).

A reduction of total N (Figure 4B) was observed during the first 60 days of composting and also at 150 and 180 days of composting, probably as a result of a low C:N ratio (Figure 4C) of composting material. This result along with alkaline pH (Figure 4A) and biomass temperature fluctuations (Figure 2) favored N volatilization. The result agrees with Kelleher et al. (2002) who affirm that low C:N ratio of poultry residues contribute to losses of ammonia. Additionally, Beck-Friis et al. (2001) affirm that ammonia emission starts when temperature is higher or lower than 45ºC and when pH is around 9.0. Biomass pH is responsible for keeping the balance among ammonium, NH_4, and ammonia, NH_3.

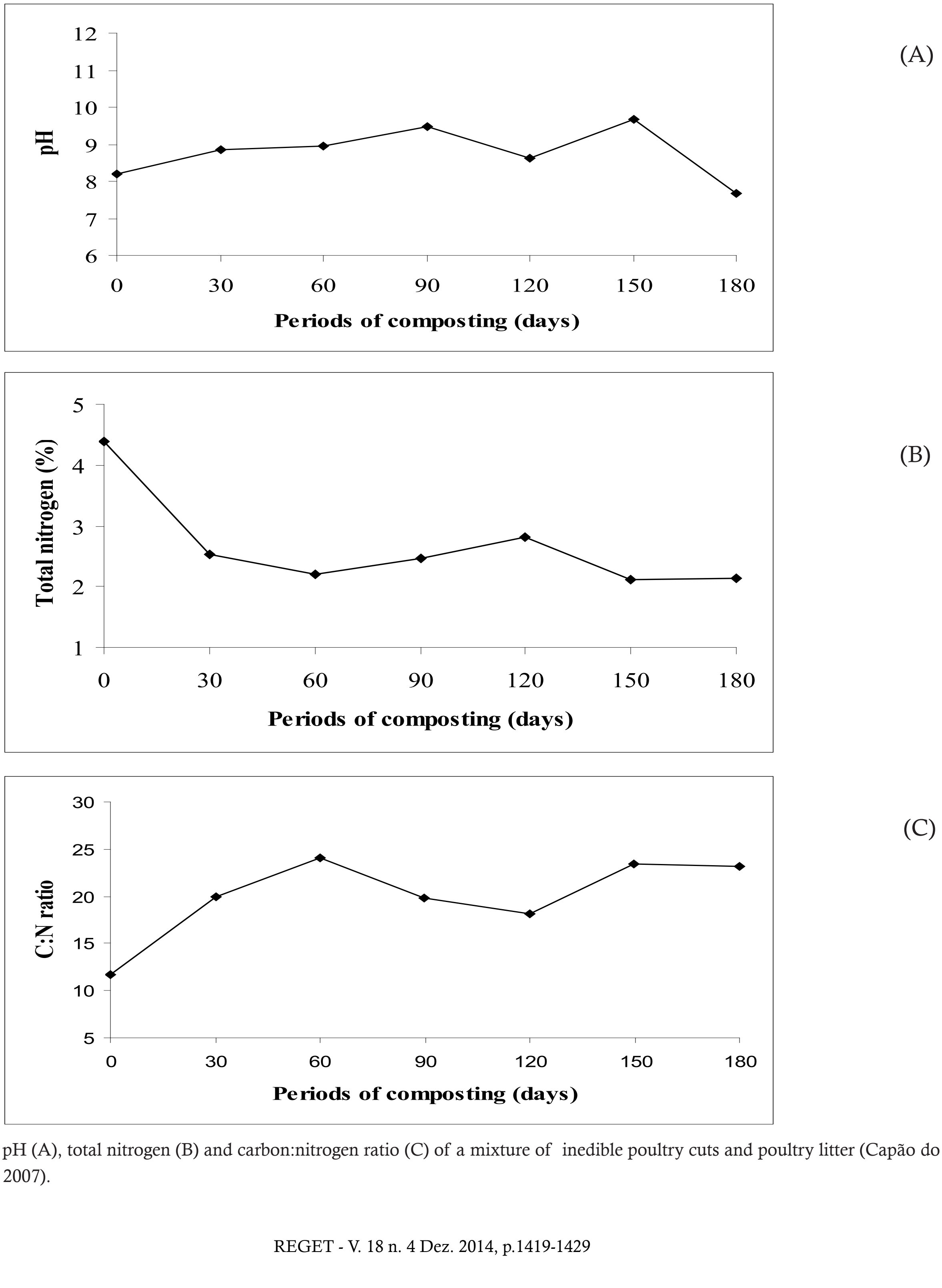

Figure 4. pH (A), total nitrogen (B) and carbon:nitrogen ratio (C) of a mixture of inedible poultry cuts and poultry litter (Capão do Leão, RS, 2007).

Poultry litter was composed of wood shavings. Even though wood shavings in general present a high C:N ratio, the presence of poultry residues from two 35 days lots leaded to a low C:N ratio in the composting substrate. However, Figure 4C shows that C:N ratio increased during composting process. A possible explanation is that wood shavings are hard to decompose. According to Valente et al. (2009), when part of available C is of difficult degradation, such as cellulose, lignin and hemicellulose, the bioavailable C which will be used as energy source by the microorganisms is lower than the total C.

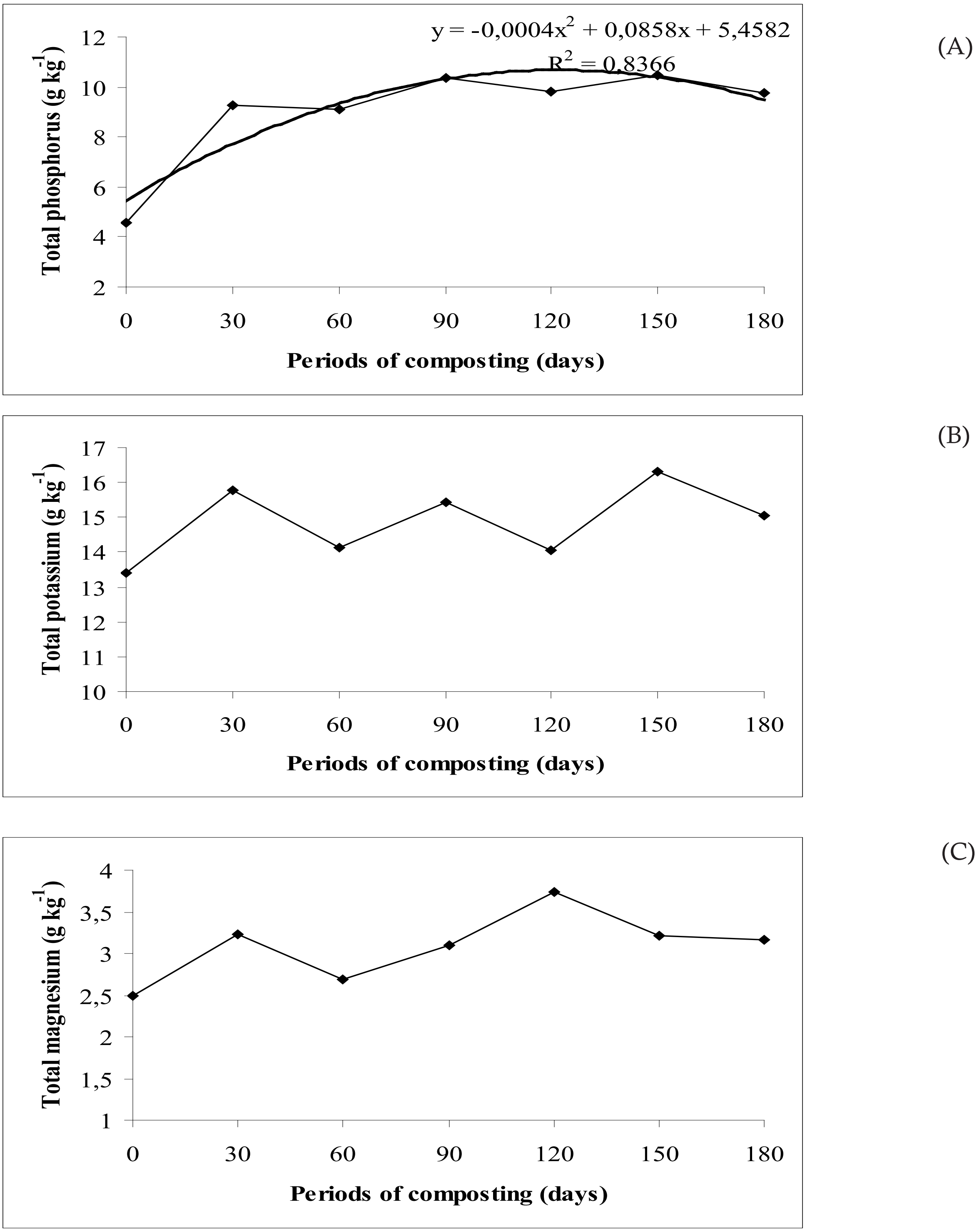

Figure 5. Total phosphorus (A), total potassium (B) and total magnesium (C) of a mixture of poultry cuts and poultry litter (Capão do Leão, RS, 2007).

The quality of C that will be digested also influences the speed and quantity of C transformed in CO_2 during composting Costa (2005). The results herein obtained agree with Dai Prá (2006) who evaluated the transformation of swine liquid residues in solid residues through addition of different cellulosic materials. The researcher found that C:N ratio of poultry residues increased from 5:1 to 15:1 during composting process.

Total P tended to increase during the whole composting period (Figure 5A). Similar results were obtained by Rashad et al. (2010) studying composting of rice straw and agro industrial residues. They also found an increase of total P in all treatments and suggested that soluble P was immobilized by microbial cells. Similarly, Elango et al. (2009) evaluating composting of urban solid residues found a gradual increase of total P and pH, which was alkaline at the end of composting process. The result suggests that the alkaline pH of composting mass probably influenced microorganisms' metabolism and agrees with Kiehl (1985), who affirms that a higher availability of inorganic P is obtained in alkaline pH.

In terms of total K, no specific trend was observed during the composting process (Figure 5B). However, in comparison to the initial concentration (13.4 g kg^{-1}), an increase was observed at the end of composting. This is probably explained by the initial total organic matter (92.8%) and agrees with Veras and Povinelli (2004) who affirm that residues containing a higher content of organic matter present a higher concentration of K because the mineral are electrostatically adsorbed to organic matter.

Total magnesium increased during 180 days of composting (Figure 5C). Costa et al. (2005) studying composting of poultry carcasses also found increasing levels of total Mg as a result of increased bioavailability due to the microbial action on the substrate.

CONCLUSIONS

Composting is an alternative for ecologically correct disposing of inedible poultry carcasses and might be used by poultry farms and industry.

Moisture is not conditioning of efficiency of second stage of composting. However, intermittent revolving of composting material is very important.

As a substrate, poultry litter is a source of nitrogen for the micro organisms and should not be used as a source of carbon for composting of inedible poultry cuts. It needs to be replaced by substrates showing a higher C:N ratio.

The mixture of inedible poultry cuts and poultry litter leads to a low initial C:N ratio which results in volatilization of nitrogen and a higher C:N ratio during composting process and additional time for biomass stabilization.

Composting presents an alkaline pH and might be used for correcting acid soils.

Composting concentrates nutrients in the biomass and the results are close to the tolerate values according to the environmental legislation of some countries, such as Brazil (Normative Instruction Nº 25/2009).

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