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Changes in Quality of Slaughtered Cattle Gastro-intestinal Wastes as Affected by Period of Decomposition and the Effect of Treatments on Decomposers of the Abattoir Wastes

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Abstract: Slaughtered bull rumen and abomasum wastes were exposed to housefly infestation for 11 days and parboiled before drying to examine the effect of decomposition periods on the quality of the wastes and the extent to which the treatments affect the growth of the microbes in the wastes. Analyses of wastes elucidated transformation in quality relative to decomposition periods. Decomposition stimulated maggot growth which significantly (p<0.05) improved the quality of the wastes. Fibre and ash contents were significantly (p<0.05) reduced by the process of decomposition. Drying significantly (p<0.05) arrested microbial growth in wastes. It was suggested that wastes could be used as fertilisers, meal in zoo, fish ponds and protein source for domestic animals scavenging for food after the 6th day of decomposition. Decomposition of the wastes offered an alternative means of breeding maggots used as protein source in animal feed and for medical purpose as it facilitates the healing of wounds.

Key words: Abattoir wastes · Maggots · Microorganisms · Crude protein · Biological activity

INTRODUCTION

Low use of chemical fertilisers, particularly nitrogen, in African agriculture is attributed to their high cost [1], unavailability, poor infrastructure for marketing and their detrimental effects on the environment [2, 3]. In African rural smallholder farming sector, which is largely responsible for the production of vegetables, animal manure is the most primary way of enriching soils for subsistence farming activities [4-6], due to their affordability as they are obtainable at little or no cost from livestock farmers. But in urban small scale vegetable farming in these developing countries, having access to nutrient sources for subsistence farming is one of the factors limiting all year round vegetable production. Despite the affordable cost of animal manure, accessibility to the organic nutrient source becomes only easy where small scale farmers practice mixed farming [7] or in cases where animal farms are situated near resource poor farmers. However, where smallholder farm lands are not in close proximity to animal farms, small scale farmers encounter great barrier in their crop production activities due to inability to have access to these cheap nutrient sources. At times, the collection of manure from animal becomes extremely cumbersome among these peasant farmers, most especially vegetable crop producers farming and dwelling in household close to the urban areas in African communities, as cattle manure, which is predominantly used in vegetable production due to its environmentally friendly nature, is difficult to obtain because ruminant animals are mostly reared under extensive system by herds men in most rural African agrarian grass land. In addition, poultry manure which can also be used is difficult to obtain in most cases, as poultry farms are concentrated far from the cities in developing countries. Despite the problem faced by urban resource poor farmers on the unavailability or inaccessibility of nutrient input sources, several tonnes of wastes from slaughtered cattle remain useless in abattoirs, mainly concentrated in most of the urban largest markets in African communities, where they constitute nuisance to the environment.

The increasing cost of agricultural inputs and the down turn in global economy which tend to indicate that price fixation are directed against the growth and development of agriculture in developing countries has stimulated interest in the utilisation of readily available [8, 9] and cheap input substitutes such as

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wastes and by-products that could be used as alternatives to unaffordable and inaccessible agricultural production inputs [10-12]. It was suggested that the use of wastes could have a significant effect on cost reduction [13] while another opinion saw that using wastes help to solve disposal problems [14].

Abattoir wastes have been classified with some of the non-conventional agricultural resources in tropical countries [15]. These wastes include blood, bone and the wastes from ruminant animals. Although abattoir wastes including the ruminant stomach contents are useful by-products in some of the first world countries, where they are used for the production of methane gas [16] but it is highly unfortunate that this situation is contrary in most developing countries where the method of slaughtering remains rudimentary, as these recyclable wastes are being disposed off in pits and running streams every slaughter day, thereby causing environmental pollution and contaminating the ground water [17, 18] due to improper use and at times they are heaped and burnt in abattoir, resulting in air pollution causing health hazards in our environment [19]. Hence working out modalities as to the use of these wastes to prevent soil contamination, water and air pollution becomes imperative in the environment of developing countries, where slaughtering and animal waste products disposal practices remain unimaginable. Research works conducted on wastes in developing countries suggested that wastes can be recycled or processed for conversion into useful products such as nutrient input for agricultural production including vegetable production, fish farming and even as feed for local chicken or goats reared under extensive system in rural households of these developing nations [20].

The conversion of poultry wastes into high protein feed stuff was reviewed [21] but the main health hazard involved in the use of broiler litter or layer excreta is the effect of pathogenic organisms, heavy metals, pesticides and drug residues [22]. However, in the case of abattoir wastes such as cattle rumen, omasum, reticulum and abomasum contents, the microorganisms involved in the biochemical processes of digestion in the four chambered stomach are potential source of protein, energy and vitamin and this attribute make the ruminant stomach contents have more potentials in its use as source of nutrients. Apart from the usefulness of the microbes in the rumen content, the wastes have been reported to haves high nutritive value [23]. The use of wastes perhaps could assume a significant role in aquaculture for the enhancement of detritus food chain, production of maggot [24]. Therefore, it is envisaged that the decomposition of these wastes could be effective for the growth of housefly maggot, increase the nutrient level as maggot had been reported to contain high protein content [25, 26]. Processing wastes destroys the pathogens, reduce the offensive odour and enhance the storage quality and palatability [27]. Thus an efficient and effective means of processing abattoir wastes becomes imperative. However, studies regarding the assessment of the extent to which decomposition influences the quality of rumen and abomasum contents and the effect of heat application and drying on the waste decomposers have not been documented. This research aligned itself with this development trajectory and in line with this; the objective of this study was to (1) examine the effect of decomposition periods on the quality of the cattle rumen and abomasum wastes and (2) to examine the extent to which boiling and drying will affect the growth of the microbes in the cattle stomach wastes.

Methods: The study was carried out in the Department of Bio-sciences laboratory of the Faculty of Science, Crop and Animal Production laboratories of the Faculty of Agriculture, University of Ilorin. The study employed the model of complete randomised design and all treatments had three replicates.

Materials Used and Their Sources: The materials used in this study include abattoir waste which comprised of rumen and abomasum contents of slaughtered male cattle. These were obtained from central abattoir in the heart of Ilorin city, a slaughter yard and the largest abattoir in Kwara state, situated 42 km north from the University of Ilorin permanent site. The ruminant stomach contents were collected with sacks which contained 100 kg of the rumen and 50 kg of the abomasum contents respectively. The collection was carried out immediately after evisceration of the slaughtered bulls. Following collection, the samples were immediately transported to the Faculty of Agriculture where the materials were put in drums with open top, next to a refuse disposal pit for housefly infestation. Fresh samples containing 300g of rumen and 60g of abomasum contents were weighed using a triple beam balance and kept in a refrigerator adjusted to a temperature of 2 °C in order to arrest the growth of the microbes present in the samples. Subsequently, sampling was carried out at 48 hours interval until the eleventh day and all the samples collected were frozen at a constant temperature of 2°C. Wooden boxes which had open top with an area of 30 cm^2 were constructed from a carpentry workshop for maggot population count. A sieve of 0.4mm was used for maggot collection. Haemocytometer, was used for total cell counts. MacConkey agar was used as the culture media for the growing of viable bacteria cells.

pH Determination: The pH of the samples was estimated in 1:2.5 (rumen or abomasum: water) and KCl solution using glass electrode pH meter [28].

Maggot Population Count: The maggot count commenced from the third day of decomposition to the eleventh day when the decomposing process was terminated and the population count was carried out at 48 hours interval. Prior to counting, collected samples were evenly mixed, weighed (500g for rumen and 60g for abomasum contents) with a triple beam balance and later put in plastic containers with 3 litre volume of water for rumen and 2 litre for abomasum content. The samples were then properly stirred for particles to settle at the bottom of the container while the maggots remained at the surface of the water. Subsequently, maggots collected were introduced into the wooden box for count.

Cell Count: Two methods of cell counts were employed in the study. These were the total cell and viable cell counts. The total cell count involved the counting of both living and dead cells in sample, using haemocytometer while the viable cell count was conducted by growing the microbes initially in culture media before counting exercise commenced.

Total Cell Count: Test tubes containing 9ml sterile water were set up with a test tube rack and 1 g of each of the rumen and abomasum contents was weighed and put into the 9 ml of sterile water in the first test tube. The test tube was thoroughly shaken and 1ml of the suspension was introduced into the second test tube with a sterile pipette. A drop of the dilution was introduced into the haemocytometer using an inoculating loop. The suspension in the last test tube with 10^{-3} dilution was used for the counting exercise as the haemocytometer was placed on the microscope stage while the cells were allowed to settle on the grid for 60 seconds before observation under high power magnification (x100), which was immediately followed by the counting process.

Viable Cell Count: The viable cell count was conducted using the pour plate method [29]. One gram (1 g) of each sample diluted serially in sterile water, 26 g of MacConkey agar weighed into 500 ml distilled water in a conical flask using electronic balance and melted with a hot plate for 45 minutes at a temperature of 120 °C. MacConkey agar is a differential medium used for the isolation of coliforms and intestinal pathogen in specimen. Melted sample was sterilised by autoclaving at a pressure of 1.05 kg cm^{-1} and temperature of 121° C and allowed to cool. Thereafter, the 10^{-3} dilution was plated out in the McConkey agar and Petri-dishes were kept in an incubator for 48 hours at a temperature of 37°C. Consequently, bacteria cells which developed in colonies were counted.

For fungi present in the samples, potato dextrose agar was used for the count. Two hundred gram (200 g) of potato was peeled into a beaker with1 litre of water, boiled for 45 minutes on a hot plate and strained with a sieve afterwards. The filtrate was mixed with melted dextrose agar (15 g l^{-1}), added to the juice and made up to 500 ml with distilled water. Following the addition of 10 g of Dextose, the medium was left for 45 minutes to cool. Chloramphenicol (1 mg ml^{-10}) was then added to the medium after autoclaving at 1.05 kg cm^{-2} to arrest the growth of bacteria in the suspension. Subsequently, the 10^{-3} dilution of each sample was plated out on the potato Dextrose agar, incubated at room temperature and colonies developed after 72 hours were counted.

Bacteria Characterisation: Pure cultures of the isolates were made on MacConkey agar and the bacteria colonies were characterised with respect to colony morphology such as colour; cell morphology including shape and other physiological properties.

Gram Stain Reaction: Gram stain was carried out to identify the bacteria present in the colonies formed. Smear was prepared by putting a drop of water on a glass slide with an inoculating loop and passed through a Bunsen flame. Subsequently, the loop was sterilised with flame before using it to transfer some of the microorganisms from the Petri-dishes into the water on the slide which was later passed through the flame for a period of 9 seconds to dry the smear. Thereafter, crystal violet was added to the smear and washed after 60 seconds. Iodine was added and washed off with water, 60 seconds later, followed by the addition of alcohol. Safranin was then added and washed with water after 30 seconds. Oil immersion was dropped on the spot and the slide was placed on the microscope stage for observation under high power magnification (×100) using 24 hour old organisms.

Catalase Production Test: The test was carried out to detect the presence or absence of catalase enzyme in each isolate. Drop of hydrogen peroxide was added to the smear of 24 hour culture on a slide. A positive catalase was based on the evolution of gas in the form of white froth and formation of bubble while a negative catalase did not form bubble. Oxygen relationship was determined

by observing the location of isolates on the plates of MacConkey agar. Bacteria colony that appeared on the surface of the medium examined, indicated aerobic cells while those that appeared underneath the surface indicated anaerobic cells.

Identification of Mould: Mould placed on the glass slide was smeared with lactophenol using cotton wool. The mycelia was teased with needle cover slip and placed under microscope for observation. The morphological characteristics were observed under ×40 magnification.

Boiling the Materials: The frozen samples were boiled using small pans. Samples were constantly stirred during boiling to prevent the samples from getting burnt from the sides and bottom parts of the pans. Boiling continued until the materials were well cooked and considerable amount of water evaporated from the samples. Cooked samples were oven-dried for 24 hours at 65 °C to further eliminate surviving microbes. Oven-dried samples were allowed to cool and sun dried for 48 hrs at an average atmospheric temperature of 30 °C during intense summer period. Dried samples were serially diluted to form suspension before they were grown on the culture medium. Examination was carried out after 72 hrs to identify any surviving microbe in the dried samples.

Chemical Analysis: The dried materials were subjected to laboratory analysis for the determination of crude protein, crude fibre, crude fat and ash contents [30].

Statistical Analysis: Data collected were subjected to Analysis of variance to identify the statistical significance of treatment effects. Duncan's multiple range Test [31] was used to separate treatment means (p<0.05).

RESULTS

Dry Matter, Crude Protein, Crude Fat, Crude Fibre and Ash of Rumen Content: Relative to different days of decomposition, nutrients in the cattle rumen content exemplified a remarkable difference in quality of the product as shown in figure 1. The trend was for dry matter percentage to increase from 92.18 to 92.36% as decomposition proceeded from day 1 to day 3, decline to 92.12% at day 5 and increase progressively to 93.32% at day 11 as indicated in figure 1. The crude protein increased progressively from 13.19 to 15.75% with increasing number of days of decomposition from day 1 to day 7 and declined to 7.31% on the 11th day of decomposition which was clearly evident as indicated in figure 2. The crude fat increased from 9.00 to 12.00% from day 1 to day 7 and reduced dramatically to 6.00% on day 9 and day 11 as illustrated in figure 3. The crude fibre decreased linearly from 12.00 to 9.00% with increasing day of decomposition of the rumen content from day 1 to day 11 (figure 4) Similarly the ash content decreased systematically from 12.00 to 9.00% as decomposition proceeded from day 1 to day 11 (figure 5).

Dry Matter, Crude Protein, Crude Fat, Crude Fibre and Ash of Abomasum Content: The nutrients in abomasum content also demonstrated a significant transformation which had influence on the quality of the waste with respect to different days of decomposition, as illustrated in figures 6-10. Notably was for dry matter to increase from 92.23 to 93.98% with a corresponding increase in the days of decomposition from day 1 to day 11, as shown in figure 6. The crude protein increased progressively from 14.11 to 16.30% as the animal waste decomposed from day 1 to day 7 but decreased to 11.5 and 8.71% at days 9 and 11 respectively (fig. 7). The crude fat increased linearly

Table 1: bacteria cell and their characteristics

Colony morphology			Cell Morphology				
Colony	Colour	Shape	Surface elevation	Catalase Test	Oxygen relationship	Optical Character-istics	Gram stain reaction
A	White	Irregular	Raised	Negative catalase. No bubble formation	Aerobic	Opaque	Gram positive.Short rods Bacillus Dark purple
B	Milky white	Circular	Raised	Positive catalase. Bubble formed	Aerobic	Opaque	Gram positive extremely tiny rods. Dark blue
C	Reddish Brown	Circular	Flat	Positive catalase. Bubble formed	Aerobic	Opaque	Gram positive.Spherical cocci. Dark purple
D	White	Circular	Flat	Gram positive catalase	Aerobic	Translucent	Gram positive. Wide spreading short rods. Stained red.
E	Light red	Irregular	Convex	Positve catalase.No bubble formation	Aerobic	Translucent	Gram negative. Short rods. Stained red

*Bacteria cells identified in cultured medium

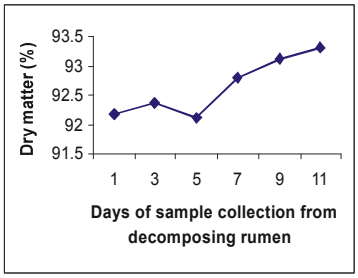


Fig. 1

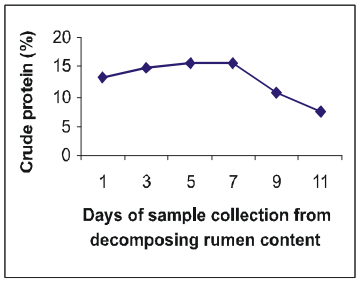
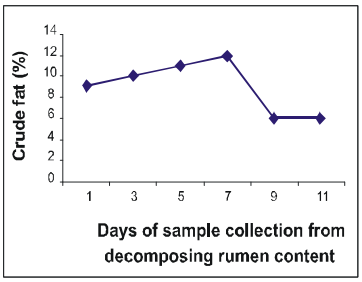


Fig. 2



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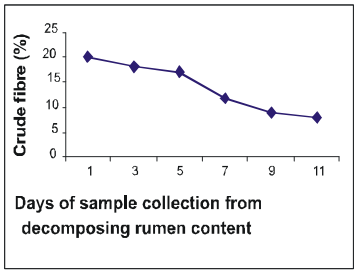

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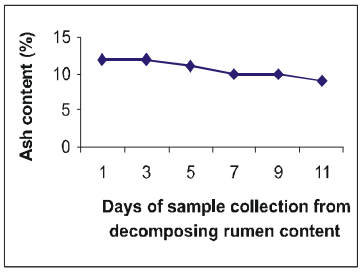


Fig. 5

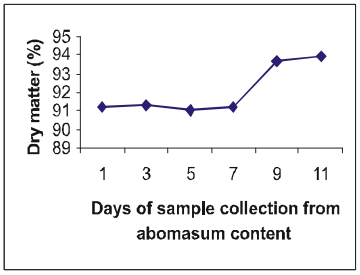


Fig. 6

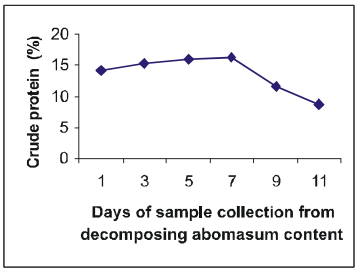


Fig. 7

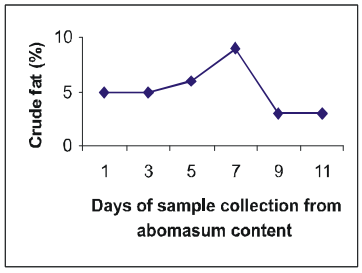
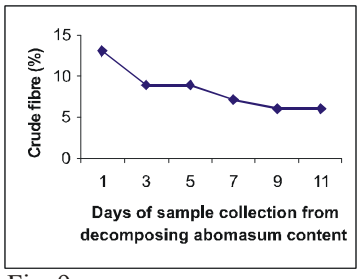


Fig. 8



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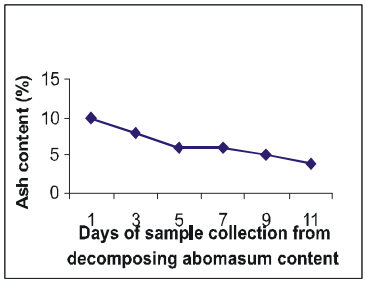
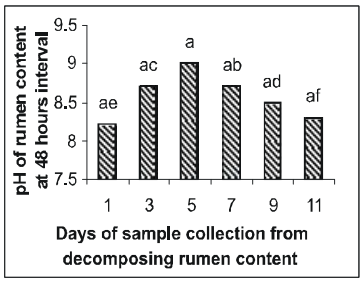


Fig. 10



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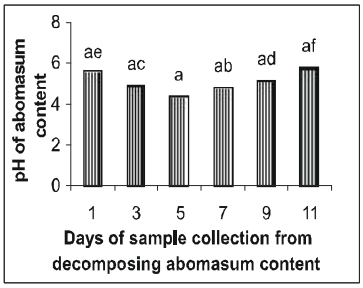

Fig. 12

Fig. 1: Rumen content dry matter % relative to days of decomposition
Fig. 2: Rumen content crude protein % relative to days of decomposition
Fig. 3: Rumen content crude fat % relative to days of decomposition
Fig. 4: Rumen content crude fibre % relative to days of decomposition
Fig. 5: Rumen content crude ash % relative to days of decomposition
Fig. 6: Abomasum content dry matter % relative to days of decomposition
Fig. 7: Abomasum content crude protein % relative to days of decomposition
Fig. 8: Abomasum content crude fat % relative to days of decomposition
Fig. 9: Abomasum content crude fibre % relative to days of decomposition
Fig. 10: Abomasum content ash % relative to days of decomposition
Fig. 11: Rumen content pH relative to days of decomposition
Fig. 12: Abomasum content pH relative to days of decomposition

from 5.00 to 9.00% as the decomposition process proceeded from day 1 until day 7 and thereafter, the crude fat declined to 3.00% on day 9 and this remained at 3.00% on day 11, as illustrated in fig. 8. Referring to fig. 9, the crude fibre reduced dramatically from 13.00 to 6.00% as decomposition proceeded from days 9 to day 11. Fig 10 indicates a systematic decrease in the ash content from 10.00 to 4.00% as decomposition proceeded from day 1 to day 11.

pH of Rumen and Abomasum Contents: The pH data obtained from the rumen and abomasum contents at different periods of decomposition had no significant effect on quality of wastes, statistically. The pH of rumen and abomasum contents is shown in figures 11 and 12. Mean pH of rumen increased progressively from 8.2 to 9.0 as decomposition proceeded from day 1 to day 5 but reduced dramatically to 8.3 on the 11th day of decomposition (fig. 11).

On further analysis using the Duncan's Multiple Range Test (DMRT) to compare the means of pH in different treatments, which were represented by the days of decomposition, the pH mean achieved at day 5 tended to be higher than the pH mean of all other days but the differences in the pH means of all the days of decomposition were statistically not significant (p>0.05), as illustrated in figure 11. In figure 12, mean pH of abomasum content dropped off from 5.6 to 4.4 from day 1 to day 5 and increased progressively from 4.4 to 5.8 between day 5 to day 11. As indicated in fig. 12, the mean pH of day 11 tended to be the highest in all the days of sample collection, followed by that of day 1, which had a slightly higher value than the pH of other days but statistically, the differences in mean pH of the different treatments (days) were not significant (p>0.05), using the DMRT.

Maggot Population: Statistically, the growth of maggot in the abattoir wastes had a highly significant effect on the quality of the products.

In figure 13, initially, the trend was for maggot population to rise with increase in the period of decomposition and to decline at a particular stage as decomposition proceeded in the rumen. In the case of abomasum (fig.14), maggot population increased and receded during the period of decomposition. In the rumen content, maggot population on day 3 was 1,742 maggots per 500 g of the waste; day 5 had 3,726 maggots per 500 g of rumen content, which declined to 3,404, 1,153 and 355 maggots on days 7, 9 and 11 respectively as shown in fig.13. In the case of abomasum content (fig. 14), maggot population increased from 72 maggots per 60 g of the animal by-product on day 3 to 321 maggots on day 5 but on day 7, there was a reduction in population of maggot to 269 maggots which later increased to 383 maggots per 60 g of the waste on day 9, followed by a consequent reduction to 53 maggots on day 11.

Statistically, in the rumen waste, mean maggot population obtained on day 5, which occurred to be the highest of all treatments (days) was significantly different (p<0.05) from the mean maggot population obtained from day 7, which was next to the highest population of maggot achieved in the experiment, using the Duncan's Multiple Range Test (DMRT), as indicated in fig. 13. In fig.14, means of maggot population relative to days of decomposition was significantly different (p<0.05) in all treatments (days) employed in the experiment that involved the use of abomasum waste. The mean maggot population obtained from day 9 was significantly the highest (p<0.05), followed by the mean maggot population achieved from day 5. The mean maggot population obtained at day 7 was in between those of days 5 and 9 but had a significant difference from mean maggot population of day 3, which had no significant difference (p>0.05) from maggot population obtained on the last day of decomposition (day 11).

Total Cell Count: Period of decomposition had a significant effect on the population of microorganisms in the abattoir wastes. Estimates of the total cell enumerated in wastes are illustrated in figures 15 and 16. Total cell in slaughtered bull rumen waste is shown in figure 15. The trend was for mean total cell to increase progressively from 41.8 million cells to 76.5 million cells per 10^{-3} dilution of rumen waste from day 1 to day 7 and to decrease on days 9 and 11 with the population estimated on day 11 being 17.5 million cells. Similarly, total cell increased from 19.6 to 47.5 million from day 1 to day 7 in abomasum waste and declined dramatically to 11.0 million cells per 10^{-3} on the 11th day of decomposition as illustrated in fig. 16.

Statistically, difference in mean total cell in rumen waste at day 7 was significantly the highest (p<0.05), relative to other treatments, that is, other days of decomposition. Although the total cell population obtained from day 9 tended to be higher than the total cell achieved at day 11 but the difference between mean total cell estimates of the two treatments (days) had no statistical significance (p>0.05). Using DMRT, in fig. 16, where total cell count on abomasum featured, the mean total cell estimate of day 7, was significantly higher

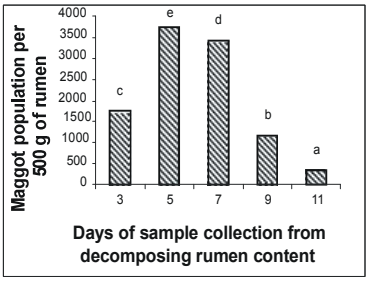

Fig. 13

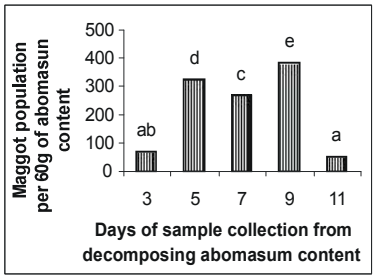

Fig. 14

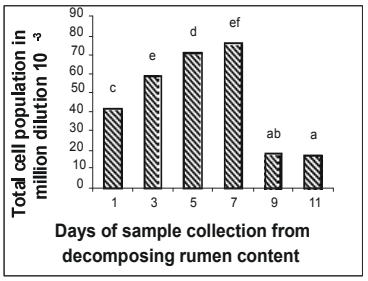

Fig. 15

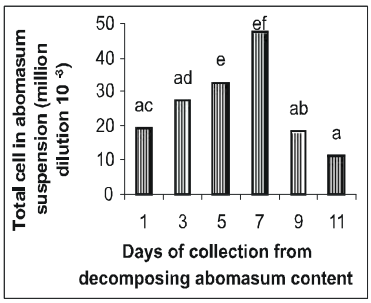

Fig. 16

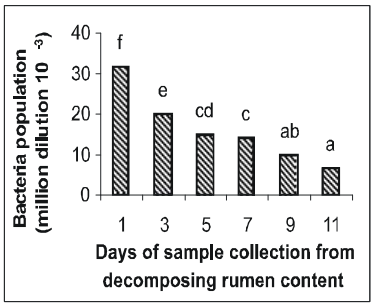

Fig. 17

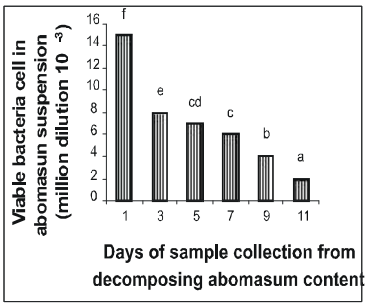

Fig. 18

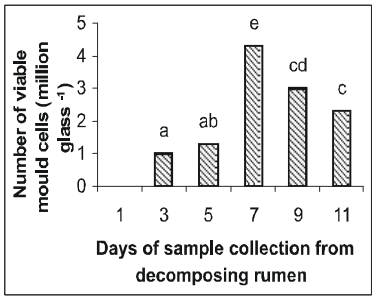

Fig. 19

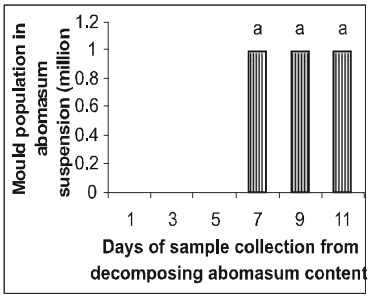

Fig. 20

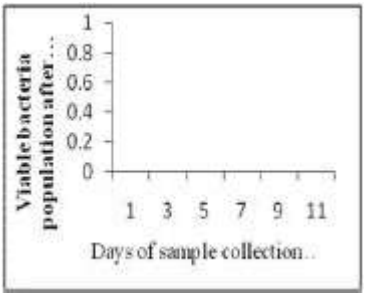

Fig. 21

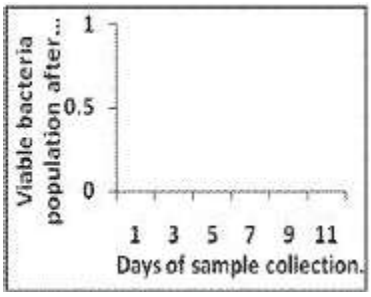

Fig. 22

Fig. 13: Rumen content maggot population relative to days of decomposition
Fig. 14: Abomasum content maggot population relative to days of decomposition.
Fig. 15: Rumen content total cell population relative to days of decomposition
Fig. 16: Abomasum content total cell population relative to days of decomposition
Fig. 17: Rumen content viable bacteria cell population relative to days of decomposition
Fig. 18: Abomasum content viable bacteria cell population relative to days of decomposition
Fig. 19: Rumen content viable mould cell population relative to days of decomposition
Fig. 20: Abomasum content viable mould cell population relative to days of decomposition
Fig. 21: Viable bacteria cell population of rumen and abomasum contents relative to days of decomposition
Fig. 22: Viable mould cell population of rumen and abomasum contents relative to days of decomposition

(p<0.05) than the mean total cell estimate obtained from all other days of decomposition with the exception of mean total cell obtained on day 5. However, in abomasum waste, the total cell estimate obtained at day 3 tended to be higher than total cell at days 1, 9 and 11.

Viable Bacteria Population: The effect of period of decomposition was highly significant on viable bacteria cells of the wastes. The viable bacteria cell population with the respective number of days of decomposition in the rumen and abomasum wastes are shown in figures 17 and 18. In the rumen content, viable bacteria cells decreased dramatically from about 32 million cells on day 1 to about 7.5 million cells on day 11 (Fig. 17). Similarly, in the abomasum content, there was a decrease in population of viable bacteria cell from day 1 to day 11 with day 1 having a population estimated as 15 million cells and day 11 with about 2 million bacteria cells (Fig.18).

Statistically, the differences between the mean viable cell population obtained at days 1, 3 and 5 were significant (p<0.05), using the DMRT. The difference in the mean viable cell between day 5 and day 7 was not significant statistically (p>0.05) but mean viable cell population of day 7 was significantly different (p<0.05) from the mean viable cell population of day 9 (Fig 17). Similarly in Fig. 18, mean viable bacteria cell population at day 1 was statistically higher (p<0.05) than mean viable bacteria population for all other days with the viable bacteria population on day 11 being significantly the least.

Viable Mould Population: Period of decomposition had a significant effect on viable mould population. Relative to different treatments (days of decomposition) of the wastes, viable mould cell population showed a remarkable difference in the growth pattern of organisms in rumen wastes as compared to the trend in abomasum content (figures 19 and 20). Mean mould population in rumen content increased from an estimate of 1 million cells on day 3 to 4.3 million cells on day 7 but reduced to 2.3 million cells on day 11 as illustrated in fig.19.

For abomasum content, the trend was for mould not to grow yet from day 1 to day 3 but for the mould to grow to an approximate population of 1.0 million cells on day 7, which remained the same on days 9 and 11, as indicated in fig 20. Statistically, the mould colonies in the rumen content was significantly higher (p<0.05) on day 7 than those of all other days (Fig 19). The difference in mould colonies formed in abomasum content in between days 7, 9 and 11 was not significant statistically (p>0.05).

Viable Bacteria Cell Population after Treatment: The viable bacteria cell population after parboiling, oven-drying and sun-drying showed no growth of bacteria colony in the culture medium for both the rumen and abomasum contents. This was clearly evident in fig. 21, which indicates zero level of bacteria cell growth throughout the period of decomposition after boiling and drying.

Viable Mould Cell Population after Boiling and Drying: Similarly, the viable mould cell population after parboiling, oven-drying and sun-drying showed no growth of mould colony in the culture medium for both the rumen and abomasum contents. Evidence of the occurrence is shown in fig. 22, which indicates zero level of mould growth throughout the period of decomposition after boiling and drying.

DISCUSSIONS

The results of this study indicated a gradual reduction of viable bacterial population in the wastes as the period of decomposition increases. The rumen is an exceptional habitat, as it provides constant condition of moisture, pH, temperature, anaerobiosis and food. Owing to the viable cell count conducted on the intestinal bacteria present in the decomposing abattoir wastes, the decrease in the population of the microorganisms could probably due to change in the natural environmental condition of the microbes, especially bacteria and lack of additional nutrient to the wastes, which the microorganisms could live on after the removal from their natural habitat. This was in agreement with the previous findings [32] who postulated that the growth of microbes in rumen depends on addition of nutrients and to some extent saliva which form the main liquid flowing through the rumen and the concentration of bacteria rise and fall in correspondence to these additions.

From the result obtained, it was found that the total population of organisms increased from day 1 to day 7 and declined from day 9 to day 11. The decline could be associated with the gradual utilisation of the nutrients available in the decomposing wastes, due to their consumption by houseflies, other arthropods, their larvae and pupae together with the surviving microorganisms which perhaps must have been introduced from the externally environment into the waste exposed for house fly infestation. Consequently, the rate of growth declined and growth eventually seized. At this point,

the microbes were in death phase which was a significant decrease in the number of viable cells and this could probably be associated with the depletion of the cellular reserves.

There was no mould on the Petri-dishes of the fresh rumen and abomasum wastes of the first day. This could probably be due to the low temperature; the materials were subjected to during the storage process, as the freezing could have destroyed the moulds and prevented further growth of any fungi in the wastes during the preservation process. The mould population gradually increased as the decomposition process proceeded. However, the increase in the mould population could probably be attributed to the introduction of different types of fungi with varying temperature adaptability through the atmosphere which might have promoted the survival of some of the organisms during the process of preservation.

The pH value of the abomasum content was found to be acidic in all the stages of decomposition while the pH values of the rumen content was observed to be alkaline and there was no significant difference in the pH values of both of the decomposing wastes. The pH of the rumen content confirmed the previous findings [33] who pointed out that the rumen waste contained a large volume of saliva with dissolved urea which may result in the alkaline nature of the rumen content. The pH of the fresh cattle rumen was reported to be 8.2 [34], which provided an explanation as to why the rumen has more microbial activities than the abomasum content and this relates to the revelation from several scientific works which reported that high acidity level in any microbial environment reduces the activities of microorganisms in such habitat.

The parboiled, oven-dried and sun-dried materials were found to contain no bacteria in all the days, suggesting that the microorganisms in the wastes could probably not be able to survive in any habitat that have been deprived of water. In addition, the elimination of the decomposers of the waste could perhaps be associated to the different conditions of temperature the rumen and abomasum contents were subjected to. However, bacteria have a precise minimum threshold temperature at which growth could be withheld regardless of the longevity of incubation period. Also numerical values of the cardinal temperature (minimum, optimum and maximum) and the range of temperature over which growth is possible vary widely among bacteria. In line with this, the freezing in which the materials had been subjected to, could probably have destroyed some of the bacteria cells that cannot withstand very low temperature for example, the thermophiles (the heat loving bacteria) and the parboiling, oven-drying and sun-drying could probably have destroyed some cold loving bacteria such as the psychrophiles and the mesophiles.

The absence of mould in the parboiled, oven-dried and sun-dried materials in all the stages of decomposition could perhaps be due to the fact that the physical treatments completely eradicated the mould cells in the decomposed animal by-products.

The crude protein content of the fresh rumen and abomasum contents were 13.19 and 14.11%. This high crude protein level could probably be due to the transformation of the cellulose and non-protein nitrogen to microbial proteins as a result of the activities of the microorganisms which make the rumen acts as a natural and continuous system for the production of cell proteins. This confirmed the previous findings reported [35] that crude protein content of the bovine stomach was in the range of 12-25%. The crude protein and crude fat increased proportionately with increase in maggot population and declined with a concomitant drop off in maggot population. The increase could probably due to the high protein value of maggot as housefly larva have been found to contain high protein content. This confirmed the previous postulation [36] that the protein quality of housefly maggot or larva was high and comparable to that of meat.

Maggot population was observed to attain its maximum number on days 5 and 7 of decomposition and this was similar to the experiment conducted [26] when house fly eggs were cultivated on urban refuse and after 5-7 days, the larvae produced were dried and ground to give a meal containing 59% crude protein and 18% crude fat. The larvae population dropped off dramatically from day 9-11, reason being that most of the larvae have developed into pupae because the series of developmental changes from egg to larva and larva to pupa in housefly takes about 9 days. It was also found that the crude fibre and ash contents had a dramatic reduction from day 1 to day 11 in both the rumen and abomasum contents. The reduction of the crude fibre content could probably due to degradation of the wastes constituent by maggot during feeding and reduction of ash content could probably due to the utilisation of the minerals along with nutrients by the maggots.

Based on the identification of bacteria culture in the materials, it was observed that a higher proportion of the aerobic bacteria in the wastes survived than the

anaerobes during decomposition. Also, most of the bacteria were gram positive and a higher proportion of the colonies were white in colour.

It could be suggested that the collection of the wastes and sun-drying by spreading on polythene materials to eliminate water and at the same time preventing nutrients from leaching to the soil during the process of drying, would make the abattoir wastes good organic nutrients' sources in organic farming because of their high nutrient value especially potassium derived from the fodder fed to the animals and nitrogen from the protein produced from the activities of the microorganisms aiding the processes of digestion and decomposition. The wastes could perhaps be used as alternative and cheaper sources of protein after a few days of decomposition, when the growth of maggots must have concomitantly enhanced the nutritive value of the decomposed materials. This is feasible where these animal wastes are considered as wastes, disposed off in peats or running streams, thereby causing environmental pollution, despites their potential for conversion into useful products. However, the decomposed materials could serve as a useful, convenient and more economical means of breeding housefly larva or maggot, which had been found useful in medicine as scientists have discovered that maggot facilitates the healing of long term wounds as a result of its ability to digest surface tissues of the wound, engulf or feed on the bacteria together with other microorganisms in the wound, thereby hastening the effectiveness of drugs applied to wounds [24]. However, the absence of microbes in the wastes subjected to drying process suggested that the microorganisms in the wastes would have no detrimental effect, if used as meal for herbivorous animals in zoological gardens; as meal in fish ponds; as protein source for goats and chickens scavenging in rural households after thorough boiling, oven drying and sun drying. It is of no doubt that these organic wastes could serve as soil amendment materials to small scale and emerging organic farmers who have no access to animal manures due to lack of proximity to animal farms at times, because these potential nutrient sources are readily available in the abattoir as these animals are slaughtered every day in the abattoir coupled with the collection of the material from slaughter fields or houses at no cost in most developing countries. From a practical perspective it could be suggested that the drying these wastes were subjected to, significantly reduced the odour and increased the storage quality.

It can be concluded that decomposition improved the quality of these wastes. Boiling and drying processes arrested the growth of most of the decomposers effectively for safety use as organic input source in vegetable crop production; as protein and fibre source for domestic animals; zoological and aquatic animals after the 6^{th} day of decomposition. It could be recommended that the wastes be used for massive maggot production. Study should be conducted on the nutrients potential of the wastes for crop growth and yield, the palatability to zoologicals, aquatics, together with poultry and goats scavenging for feed in rural households.

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