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EVALUATION OF THE NUTRITIONAL VALUE OF EISENIA FETIDA CULTIVATED ON KITCHEN WASTE AS A PROTEIN SOURCE FOR POULTRY

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Abstract
Broiler chicken is one of the major lean sources of protein. In many countries, its demand is rapidly increasing. Soybean and fishmeal are commonly used in poultry feed; however due to hype in price and decrease in production rate these feedstuffs become limited and scarce. Protein is one of the major component of poultry feed costs about 60%-70%. However due to high cost of protein, it becomes a challenging factor for farmers to supply enormous amount of protein in poultry feed. These challenging factors led to the discovery of an alternative rich source of animal based poultry feed with enormous amount of protein. Thus, this need led to the discovery an alternative source of protein for poultry that could be red worm (Eisenia fetida). The purpose of this study was the better growth and development yielded with high nutritional composition of red worms reared on cow manure and organic food waste and to introduce earthworm meal as an alternative protein source for Poultry. Red worms have a potential to be used as a protein supplement. Red worms are a good source of protein (58- 71% dry matter). In this case study, 390 red worms were reared on kitchen waste. For rearing of worms, cow manure mixed with soil (1:1) was used as a culture substrate. Cow manure was used because it has high amount of nitrogen which is more nutritious for growth and development of worms than any other culture substrate. The assay was conducted for about 3 months in winter season. Nutritional value of worms was analyzed after their rearing to determine their nutritional content. Proximate analysis was performed to determine the nutritional value of red worms. Kitchen waste was preferably used to overcome the waste pollution as well as it was a cheap and good source of organic matter.

Keywords: *Vermicomposting, poultry, waste, Eisenia fetida.*

Introduction

In today's world, human population is increasing rapidly that demands good quality and quantity of food. Animal based food is high in demand to fulfil nutritional requirement. Among those, animal based-protein is a major source of protein such as broiler, fish etc. Broiler meat is consumed majorly in many countries. To fulfil this requirement, it is important to provide sufficient amount of nutrients especially protein in broiler feed to yield a nutritious chicken meat. Protein is a major constituent of broiler feed. An adequate supply of protein in broiler feed is one of the major goal (1). Protein in broiler feed can be obtained from multiple sources including animal origin, fish meal, soybean meal, cereals, grains, legumes by product etc. (2).

Fishmeal is a conservative feedstuff that is used a protein source for broiler feeds for many years. It has high nutritional content and balanced amount of digestible crude protein, fats, vitamins, minerals, and essential amino acids (3). However, the use of fishmeal has a nutritional constraint as it has high amount of histamine that effect the gizzard of broiler badly. It also causes tainting of chicken meat if its consumption exceeds. Furthermore, the price of fishmeal and soybean meal is very high. Due its high cost it often reduces the profit margin. Also, the worldwide supply of fishmeal dropped by 12% during the last decade (4). Also, trimethylamine is present in fishmeal cause residual fish flavor and smell in eggs and meat (3). Due to the rise in price of these animal feed required for poultry and competition among human and animal husbandry, these feedstuffs are becoming scare and limited.

Thus, there is a need of an alternative source of protein for poultry that fulfil all the nutritional requirements. Earthworm meal emerges as a viable alternative to fish meal due to its protein content ranging from 55 to 70%, readily accessible in nature. The protein found in earthworms comprises both essential and non-essential amino acids. Research indicates that earthworms are abundant in proteins, particularly essential amino acids, making them a promising ingredient for poultry feed formulations (4). Earthworm meal is rich in protein, energy, minerals, and vitamins, making it a valuable component in commercial feed blends. Additionally, its production is cost-effective due to its utilization of organic waste, and it can be easily manufactured. Among earthworm species suitable for meal production, *Eisenia fetida* is particularly noteworthy for its adeptness in utilizing diverse organic residues and its high reproductive capacity (5). The purpose of this study was the rearing of *Eisenia fetida* on kitchen waste (apple, potato peals, spinach) under favorable temperature and humidity. After rearing, the nutritional value of red worms was analyzed such as protein analysis, amino acid analysis, fat content, crude ash etc. and thus to assess the suitability of red worms as a potential source of protein for poultry.

Red worms, scientifically classified as Eisenia fetida, have been identified as a valuable protein source. Belonging to the lumbericidae family and *Eisenia* genus, these worms are also commonly referred to as tiger worms, garlic worms, flatworms, Cadillac worms, and fishing bait worms (2). Red worms belong to the phylum Annelida, which means "ringed." The "rings" around worms are called segments. Red worms have about 95 segments on their body (6). Their coloration ranges from red and purple to brown, with a yellowish hue in their abdominal region (2).

Epigeic species, exemplified by the common redworm (Eisenia fetida), typically inhabit environments abundant in organic material, such as the upper layer of soil beneath forest leaf litter or decaying logs, or within piles of manure, rather than constructing permanent burrows (6). Due to their shallow burrowing behavior and preference for nutrient-rich organic matter, epigeic worms readily acclimate to vermiculture and vermicomposting setups (6). *Eisenia fetida* and *Eisenia andreii* collectively represent approximately 80 to 90 percent of earthworms cultivated on a large-scale commercial level (6).

Red worms have red pigment in their skin that makes them sensitive to ultraviolet rays thus great exposure to sunlight cause paralysis in them and long exposure may result in their death (6). Earthworms are hermaphroditic, possessing both male and female reproductive organs within each individual. To prevent self-fertilization, their eggs and sperm are situated separately (6). During mating, worms align in opposite directions and exchange sperm, with fertilization of the eggs occurring later (6). The mature eggs and sperm are enclosed within a cocoon generated by the clitellum, a swollen, saddle-shaped structure located near the worm's head (6). Within this cocoon, sperm cells fertilize the eggs before the cocoon detaches from the worm and settles into the soil (6). The quantity of worms within each cocoon and the time taken for hatching vary depending on the species of worm and environmental factors (6).

Eisenia fetida grows rapidly as their life cycle is short about 40-60 days also, they have fast reproduction rate and each worm produces 9 cocoons every 14 days and each cocoon contains 20 eggs approximately (2). Red worms reproduce by cross-fertilization and some reproduce by parthenogenesis (2). After sexual reproduction, it takes about four days for the formation of cocoon. Incubation period lasts for about 23 days thus three hatchlings are produced from each cocoon and it takes 40-60 days for juvenile to become adult. Adult worm weight is approximately 1.5g (2).

Resembling grape seeds in size and shape, earthworm cocoons possess a rounded end and are slightly pointed (6). Initially pearly-yellow, the cocoons gradually darken to brown as the developing young inside mature and get ready to hatch (6). Red worms are segmented, bilaterally symmetrical invertebrates that exhibit indeterminate growth following sexual maturity, often attaining lengths of up to 30 cm (7). Eisenia species are favored for vermicomposting purposes (7). Their optimal growth occurs at 25°C with 85% moisture content (7). The hatchability of their cocoons ranges between 72-82%, and young Eisenia earthworms can achieve sexual maturity within 21 to 30 days. In controlled environments, these worms can live for approximately 4.5 to 5 years (7).

Vermicomposting is the process of turning organic debris into worm castings (manure) (6). The earthworm, Eisenia fetida characterized by rapid growth rate, early sexual maturity, high feeding capacity and extensive reproductive capabilities has been extensively used for vermicomposting (8). Red worms live at a temperature between 55 and 85 degrees (6). The optimum temperature for their growth and development is 60 to 80 degrees (6). The temperature of their culturing substrate should be between 60 and 70 degrees (6). If the temperature of substrate raised, it may be lowered by adding water so adequate moisture of the Vermibed should be between 60% to 85% and feel crumbly, not the soggy-wet (6). If the moisture level in Vermibed decreases, it may result in weight loss of worms (9). Red worms can survive in oxygen depleted and high carbon dioxide habitat. If there is not air passage across their bed, they may die. Red worms grow in pH range of about 4.2 to 8.0 (6).

Red worms contain about 58% to 73% protein (2). Researchers found that these red worms have a lot of protein (between 64.5% and 72.9%), important amino acids, fatty acids, calcium, and iron—all good things for chickens (2). The fat content in earth worm meal is 5% to 20% dry meal (DM) including high amount of omega fatty acid (2). Red worms contain a large amount of protein (64.5—72.9%), essential amino acids (4.95–5.70 g/100 g) total fatty acids (6.6 to 10.5 mg/g), calcium (1020–7070 μg/g) and iron (1050–2990 μg/g) for chickens (2). Protein for chicken feed can come from different sources like meat, fish, grains, and soybean (10). Among these, fish meal is often used the most because it has a good content of essential amino acids (10). The cost of the feed for chickens is a big part of the total cost (around 60–70%) (10). Major components of poultry feed are soybean and fishmeal however, chicken feed is becoming more expensive Some researchers suggest using different kinds of animal protein, like earthworms, instead of the usual fishmeal (10).

People can use these worms instead of fishmeal and soybean in poultry feed because they have even more protein, ranging from 64% to 76% (10). This is better than fishmeal (which has 45% protein) and meat meal (which has 51% protein) because using fish meal in poultry feed is quite expensive (11). Also, fish meal causes inadequate smell in broiler's meat. So, these worms are a nutritious alternative source of protein for making poultry feed (11). Many mono and polyunsaturated fatty acids are high in concentration in worm meal as they are used to fed on organic material (11). Thus, these worms are essential source of fats and provides nutritional benefit to broilers when added in poultry feed (12). Several studies showed that the addition of earthworm meal in broiler feed affects broiler performance, weight gain, FCR, and feed consumption (12). Adding earthworm meals to the broiler diet can also affect final weight (g/per bird), respectively (12).

Red worms have a good amount of minerals and vitamins that are useful for chicken feed. They contain important elements like Copper (Cu), Manganese (Mn), Zinc (Zn), and Iron (Fe) (13). The iron in red worms is especially high, ten times more than in soybean and fishmeal (13). This special iron in red worms could be used to make special iron supplements for poultry feed (13). Red worms also have a good amount of vitamin A and vitamin B compounds, making them a great addition for providing minerals, vitamins, and protein in chicken feed (13). So, using red worms in poultry feed can give them the extra nutrients they need (13).

Nutritional value of red worms can be analyzed by proximate analysis defined by AOAC. Proximate analysis is defined as the accumulation of experiments which are used to check the nutrient profile of feed stuff. This system as developed by Weende. This analysis includes the determination of moisture, ash, crude protein, crude fat, crude fiber, nitrogen free extract and gross energy (14). Moisture content determines the amount of moisture present in feed sample (15). Crude protein is estimated from nitrogen present in a sample by kjeldhal method as nitrogen is obtained from protein containing 16% nitrogen and then multiplying the figure by factor 6.25. crude fat is determined by using ether extraction method and by using Soxtherm apparatus. Carbohydrate of sample is divided into two fractions: nitrogen free extract and crude fiber. Crude fiber contains cellulose, hemi cellulose and lignin present in sample (14). Gross energy is expressed in MJ/Kg of dry matter and metabolized energy is obtained by subtracting 18% from gross energy (16). Red worms can be raised on leftover organic waste, like kitchen scraps, and magically turn it into high-quality protein (17). The important aspect of these worms is that they have a high content of nutrients, including essential amino acids, especially one called lysine, which is not found in many other types of feed (17). Red worms grow fast, don't need a lot of resources, and can change regular kitchen scraps into top-notch protein food for chickens (17). Red worms can be reared on many cultural substrates such as animal manure, wheat straw, maize straw etc. animal manure is preferably used because it has a lot of nitrogen content that is very nutritious for worms as well as for poultry (17). Red worms have potential to accelerate the waste matter decomposition and can recycle solid waste material into useful nutrients (9). Recent research had showed that growing red worms on cow manure as a substrate shows maximum growth and number of worms compatible to other culturing substrates (8). Red worms are known as natural fertilizer factories (17). Vermicomposting is a simple and inexpensive way to deal with kitchen scraps and other organic waste (17). It's like a natural recycling system that uses special worms to eat and break down the waste (17). The different wastes may favor different worm species to grow up thus huge amount of wastes can be managed by vast population of red worms (17). Red worms in dried form can be used as earthworm meal and they are a great natural protein source for chickens also they're better for the environment than other options and have more of the important building blocks called amino acids (1). Right now, there's not much competition for using these worms in other ways. So, it's possible that red worms could become an important source of protein for the poultry feed (1). Furthermore, when dried earthworm meal is used as protein source in poultry feed, it helps in better growth and production performance of chicken as well as improves immune and act as anti-microbial agent for microbiota in broiler's gut (1)

MATERIALS AND METHODS

Rearing of red worms was conducted at experimental unit by maintaining their habitat and hygiene. Nutritional analysis of worms was conducted in Nutrition Lab, Department of Animal Nutrition, Faculty of Animal Production and Technology, University of veterinary and Animal Sciences, Ravi Campus, Pattoki.

Research design:

390 red worms (*Eisenia fetida*) were brought from online store deal markaz (http://DealMarkaz.pk) and reared on kitchen waste in vermireactors at 25°C, 65-85% humidity. After rearing, their nutritional composition was analyzed in assigned laboratory.

Sample size and technique:

390 red worms (*Eisenia fetida*) were reared in container over animal manure as a substrate and kitchen waste (cabbage, apple, pasta, bread) used as a food source.

390 juvenile red worms (*Eisenia fetida*) weighted 70g were purchased from online Store. For rearing procedure, worms were placed in vermireactors constructed of plastic box with dimensions of 60 cm by 60 cm by 30 cm (13). Culture substrate was a mixture of cow manure and soil (1:1). Cow manure was used as a culture substrate and was collected from dairy farm. Kitchen waste was collected from domestic households. Vermibed will be prepared in vermireactors which consists of animal manure mixed with soil (1:1). The bottom of the vermireactor had tiny holes to let extra water drain out. Worms were put inside a bigger box, with a gap of about 30 mm between them, to collect any extra liquid. In the worm bin, kitchen scraps like boiled cabbage, leaves, potato, and apple waste was provided (13). Worms were fed every 2-3 days a week. Vermireactors was covered with nylon sheet to prevent red worm to escape. Moisture content of substrates was maintained around 70% by sprinkling tap water every 5 days.

Appropriate room temperature 23-25°C was maintained and calculated by using HTC1 temperature, humidity meter (Digilog Electronics). Humidity was maintained about 65-85% and was measured regularly by using HTC1 temperature, humidity meter (Digilog Electronics). As their reproductive cycle stage reaches after 60 days, number of cocoon production was observed at alternative days. Juvenile red worms were become adult and reach their sexual maturity stage after 120 days of rearing. After sexual reproduction, red worms lay cocoons in vermibed. As worms reach their maturity stage, they showed sufficient growth and weighs about 195g after 4 months. After inoculation, cocoons were sorted out by hands and washed by using distilled water. Cocoons of worms were placed in separate vermireactor. Hatchings were monitored every two days by using magnifying glass. Number of cocoon produced, incubation period, number of hatchlings, maturation period of hatchlings was recorded during the experiment. The worms were collected and cleaned by using slightly warm water at 45 °C (1). They were placed in a separate container without any substrate for dying. Worms were dried in direct sunlight at temperature between 22°C to 24°C for 5 days. After drying, worms' weight about 46.7g. The red worms were dried and then crushed into a powder called RWWM using a mortar and pestle and stored at 0 to 20°C for preservation (12). By heating the RWWM at 120°C for one hour helps to reduce the bacterial count with improved growth rate (12).

Fig 1.1: (a)Vermibed of red worms contains soil and cow manure (1:1) with vegetable waste as a food source. (b) Adult red worms after rearing of 120 days.

Fig 1.2: (a) juvenile red worm at day 1. (b) Cocoons of red worms as one of them is black in color showing that it was mature one.

PROXIMATE ANALYSIS:

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The dried red worm sample was brought for proximate analysis at Nutritional lab, Department of Animal nutrition, Faculty of Animal production and Technology, University of Veterinary and Animal sciences, Ravi campus, Pattoki. Water content (by drying the sample in a dryer at a temperature of 103 ± 2 °C to get dry matter) (13). To find the total ash, sample was dried and then burnt in a special furnace at a temperature of (550 ± 25) °C. After it cools down, the mass of the leftover residue was measured (13). Weigh of ash was calculated and the weight of empty crucible was subtracted from the total weigh.

Calculation: Ash content % = Weight of ash/Weight of sample x 100

Dry matter estimation:

To determine the dry matter content, a dry matter analysis was conducted by calculating the disparity between the total weight and moisture content. This process involves using an oven and a desiccator. Initially, a weighing dish was positioned in a dry oven at 105°C for one hour. After this procedure, the dish was transferred to a desiccator and weighed after cooling down. Subsequently, 5g of the sample was placed in the dry dish, and the combined weight of the sample and dish was recorded. The dish, now containing the sample, was returned to the dry oven for one hour at 105°C. The temperature then reduced to 65°C until a constant weight achieved. The dish was then allowed to cool in the desiccator. The total weight of the sample and dish was documented, and this is used to calculate the weight of the empty dish by subtracting it from the combined weight of the sample and dish. This procedure enables the determination of the dry matter content of the sample.

Calculation: Dry matter % = Weight of sample/Weight of sample before drying x 100 (18).

Crude protein analysis:

To check the protein content, Kjeldahl method was used. A sample weighing 1-2 grams is first digested by boiling it with concentrated H_2SO_4 in the presence of a digestion mixture. The resulting (NH4)SO4 is then diluted and distilled with 40% NaOH solution. The evolved NH3 gas is collected in a 2% boric acid solution containing 1-2 drops of methyl red or mixed indicator. The distillate is titrated against N/10 H_2SO_4 to determine the percentage of nitrogen. This percentage of nitrogen is then multiplied by a factor of 6.25 to calculate the percentage of protein in the sample (18). C.p is estimated in three following steps:

- Digestion
- Dilution and distillation
- Titration

Ether extraction:

In the Soxhlet extraction procedure, a 1-2g feed sample was enclosed in a securely stapled, folded filter paper weighing it on a 10 x 10 filter paper. This filter paper bundle, containing the feed sample, was then placed into the thimble of the Soxtherm apparatus, ensuring a tight seal. Subsequently, 30-40 ml of ether was added to the system, and the apparatus was heated on a hot plate. The boiling ether ascends, directing its flow toward the thimble, where it interacts with the feed sample, dissolving its fat content. To prevent overheating, tap water was introduced into the process, facilitating the condensation of the boiling ether. This extraction process was sustained for 30 minutes, and the sequence was repeated 2-3 times to guarantee thorough fat extraction. The warm ether effectively dissolves the fat from the sample, yielding a fat-free material as the end result.

Calculation: Crude fiber %age = Residue weight−final weight/Weight of sample x 100 (18)

Nitrogen free extract:

Nitrogen free extract was determined by subtracting the percentage of ash, crude, fiber, ether extract and crude protein from 100.

Calculation:

NFE%= 100- (ash% age + crude fiber % age+ ether extract % age+ protein %age) (18). **Crude fiber estimation:**

The end product of ether extraction was used as a sample feed for fiber extraction. The sample was boiled with acidic and alkali solutions (1.25% H2SO4, 1.25% NaOH). The feed sample was mixed with

200ml of 1.25% H2SO4 and boiled for 30 minutes. Then solution was filtered and filtrate was collected. Filtrate was mixed with 200ml of 1.25% NaOH and boiled for 30 minutes. Filtrate was collected again. Filtrate was placed in oven for 30 minutes at 105C for drying and weight. The final weight was the residue weight. The residue was placed in muffle furnace for 3-4 hours at 550C until all fiber and organic matter burn. Sample was weighted again and this was the final weight.

Crude fiber % = residue weight – final weight/weight of sample x 100 (18)

Gross energy %:

The gross energy of sample was detected by using bomb calorimeter. First, equipment was turned on and oxygen was supplied. Then 1g sample was prepared and loaded into capsules. Sample was loaded in bomb cylinder and cap was screwed. Oxygen was supplied and bomb was loaded into the pail. Pail was loaded in calorimeter and wires were connected to the terminals on the bomb head.2 liters of 25-27oC water was filled into the pail. Start button was pressed and waited for calorimeter to process. Then, bomb was unloaded and cleaned (19).

pH%:

The broiler feed sample was homogenized. A calibrated pH meter was used to measure the pH directly. The pH reading was recorded, and equipment was cleaned between samples to prevent contamination (19)

Statistical analysis:

To figure out if the results are significant, "ANOVA" will be used. If we find any differences between the treatments, we'll use Tukey's test to take a closer look and see exactly where those differences are (11).

Juvenile red worms were fed on kitchen waste for about 4 months. To reproduce their cocoon till the next life cycle, case study was prolonged for about 120 days. Adaptability, rapid reproduction rate, feeding habits of *Eisenia fetida*, ease of handling. Climate suitability, substrate availability, adequate space, moisture control, ventilation, pH level, protection from predators, light avoidance, waste management.

Ethical considerations:

All the worms and the experimental protocols in this study were approved by the Departmental Animal Care and Use Committee of Superior University, Lahore, Pakistan. Data was collected from human sources, articles, and internet.

RESULTS

After rearing of red worms for about four months on kitchen waste and cow manure, they showed sufficient growth rate. At initial the weight of 400 juvenile red worms were 70 grams and after approximately 120 days, their weight was 195 grams. As per this, an adult red worm weighs about 0.5 g.

Weight of juvenile at initial	0.179 g
Weight of adult worm	0.5-1.09 g
Weight of 390 worms at initial	70 g
Weight of 390 worms at maturity	195 g
Length of juvenile worm	3 cm

Length of adult worm at maturity	8 cm

Table 1: shows the length and weight of juvenile and adult red worms before and after rearing process.

The expected results of the nutritional value shown in table 1 of red worms fed on kitchen waste and cow manure as a substrate. The table shows the dry matter, ash, crude protein, crude fats, NFE, and crude fiber present in red worms.

Dry matter	36.4 ± 2.08 %
Crude ash	22.16%
Crude protein	50.5%
Crude fats	10.0 ± 0.44 %
Nitrogen free extract	11.8%
Crude fiber	2.23%

Table 2: Proximate analysis of red worms (*Eisenia fetida*)

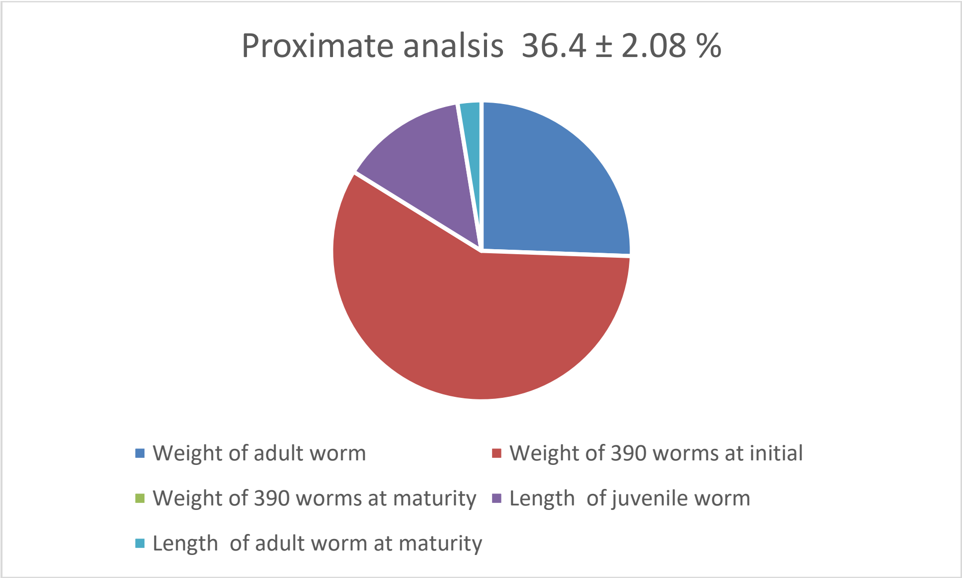

Figure 1 represents the proximate analysis along with length and weight of worm at juvenile stage and adult stage

Also, in this study mortality rate was 100% in two of three case groups as worms were led to face oxygen depletion and very low temperature.

DISCUSSION

The rearing of red worms (*Eisenia fetida*) on kitchen waste involves creating an optimal environment for the worms to thrive and efficiently decompose organic matter. Factors such as temperature, moisture content, pH level, and carbon-to-nitrogen ratio play crucial roles in the success of vermicomposting. Additionally, the selection of appropriate bedding materials and periodic maintenance are essential for sustaining a healthy worm population. At the end of the experiment, it was observed that the rearing of red worms showed sufficient growth on kitchen waste and cow manure. In this study, mortality of red worms was found. At initial stages of the experiment, almost 1000 worms were reared and the temperature provided was about 3°C-7°C. It was observed that worm's growth rate was decreased and their crawling pattern was also slowed down due to decrease in temperature and ultimately all the 1000 worms were died. Thus, it can be concluded that red worms could not survive on low temperature. Then, another case group was studied in which 500 worms were reared at 10°C-15°C. this study group was kept and reared in dark and the Vermibed as covered with nylon sheet in order to observe that either red worms could survive in oxygen depleted area or not. After two days of this procedure, it was observed that all the worms in the Vermibed were died, none of them was alive and mortality rate was 100%. Then, third and final case group was of 390 worms was reared in an appropriate environment. The temperature provided was 15-25°C and that was no oxygen depletion area. In this case, worms showed sufficient growth rate and developed rapidly. Growth rate of few of them was retards and was badly affected by low temperature at a specific time. Mortality rate was zero in this case group and worms become adult and reach their maturity stage after 60 days of rearing of juveniles. Thus, this experiment concluded that there is decline in red worm's growth if they were subjected to low temperature and oxygen depleted area.

The nutritional quality of feed may play an important role in reproductive potential of red worms. Maximum value of cocoon production per worm, wet biomass of earthworm and hatchling per cocoon were reported in kitchen waste plus cow manure bedding rather than any other feed or bedding material (14). The characteristics of red worms are strongly influenced by feeding material, temperature and Vermibed type. These factors can influence their nutritional composition (20). The nutritional values observed in this study are varying from other recent studies as in (13,2). As we are expecting the nutritional value of red worms to be greater from previous studies so if red worms showed high nutritional value than they can be used as an alternative protein source for broiler in future. Recent studies showed that replacement of fishmeal with 50% RWWM showed sufficient growth in Nile tilapia fish as well. As red worms showed high amount of protein and fats, it is concluded that they can be used as a protein source for broiler (21).

Also, it was observed that supplementing broiler chicken diets with earthworms at a rate of 20-60 g/kg resulted in enhanced weight gain, while feed intake remained largely unaffected. Similarly, it was observed that incorporating 3% *Eisenia fetida* into the ration significantly boosted live weight compared to the control group of broiler chickens. Hence, the utilization of earthworms in poultry diets emerges as a crucial protein source for fostering the growth of broiler chickens (22).

The incorporation of soybean meal and fish meal into poultry feed results in escalated ration costs, demanding the exploration of alternative protein sources in poultry production. Moreover, the availability of numerous alternative protein sources, including house fly maggots, termites, snails, grasshoppers, silkworm caterpillars, and earthworms. Several studies have emphasized the suitability of *Eisenia fetida* as a protein source for chickens (22).

CONCLUSIONS/RECOMMENDATIONS

The rearing of red worms on kitchen waste offers a sustainable solution for organic waste management while simultaneously producing nutrient-rich vermicompost. Through a combination of practical experimentation and proximate analysis, this thesis aims to contribute to the understanding of vermicomposting as a viable waste management strategy. By elucidating the processes involved in rearing red worms on kitchen waste and analyzing the proximate composition of vermicompost, this research seeks to promote the adoption of vermicomposting as an environmentally friendly alternative to conventional waste disposal methods as well as red worms showed greater nutritional composition, so it can be used as an alternative protein source in poultry diet.

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