The effect of *Eisenia foetida* meal as a protein source on sensory attributes of broiler meat

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Abstract

The present study was aimed to evaluate the effect of different inclusion levels of earthworm meal (*Eisenia foetida*) on the sensory attributes of broiler chickens. A total of 180 day-old broiler chicks were assigned to five dietary treatments with three pens per treatment and 12 broiler chickens per pen from 1-35 days. Dietary treatments were as follows: 0% (EWO), 1% (EW1), 3% (EW3), 5% (EW5), and (EW10)10%. At day 35 of age 75 birds, were randomly selected for the determination of sensory attributes of the breast meat. Sensory attributes evaluated were aroma, juiciness, tenderness, flavour and amount of connective tissue and were measured by a semi-trained sensory panel. The findings of this study revealed that chicken aroma and juiciness of meat improved linearly ($p < 0.05$) with the increasing inclusion levels of *E. foetida* meal. Nevertheless, chicken flavour scores reducesd with the increasing inclusion levels of earthworm meal. No dietary effect ($p > 0.05$) was observed on metallic flavour, metallic aroma and chicken aroma. In conclusion, the *E. foetida* inclusion levels positively influenced sensory scores of broiler breast meat, where EW10 showed the best influence as compared to the other dietary treatment groups used in this study.

Keywords: *earthworm, chickens, meat, sensory evaluation*

Introduction

Chicken producers are challenged to produce meat that is of good quality, palatable, accepted, and capable of providing adequate nutrition for humans. Other indicators used in assessing the quality of meat include; aroma, flavour, juiciness, tenderness, and taste. Furthermore, the ultimate pH, colour, water holding capacity and tenderness are also indicators of meat quality evaluation. Despite the knowledge of the meat quality evaluation indicators, meat producers still have to consider the response of sensory attributes towards the product, because of sensory evaluation influences satisfaction, preference, and/or repurchase intent from consumers (Pieterse et al 2014). Thus, sensory evaluation is much important than instrumental meat quality measurements in determining the acceptability of meat.

Coetzee and Hoffman (2003) reported that sensory attributes of chicken meat are directly influenced by their diet. Currently, poultry producers are faced with a challenge of reducing feed costs, especially the cost of protein supplementation. The increased cost and limited supply of conventional protein sources, such as fishmeal, has resulted in research aimed at providing alternative non-conventional protein sources, which could be readily available and cheaper to sustain poultry production. One such alternative protein sources are *E. foetida* earthworm, which has a potential to be a protein source for broiler chickens that is comparable to that of fishmeal.

In poultry, diet provides direct influence on the sensory attributes of meat (Pieterse et al 2014) and information about consumer preferences and limitations for using earthworms as an animal feed is still lacking. However, researchers' interest in using edible insects and earthworms as an alternative source of protein for animal feed has grown due to their high nutrient composition, especially protein content. To date, it is unknown whether adding *E. foetida* meal to broiler diets is also effective in maintaining sensory meat quality of breast meat as other protein sources such as house fly maggots, termites, snails, grasshoppers, silkworm and caterpillars. Furthermore, to our knowledge, there are no studies that have been recorded to compare the effect of *E. foetida* meal inclusion levels on sensory scores of breast meat. Such information is crucial because the assessment of sensory parameters could provide information about the acceptance or rejection of the meat. Therefore, the objective of this study was to determine the effects of inclusion levels of *E. foetida* meal on sensory attributes of broiler meat.

Materials and methods

Birds' management and dietary treatment

A total of 180 day-old Cobb broilers from a commercial hatchery (Belyn, East London, South Africa) were randomly assigned to 5 treatments with 3 replicates. The nutrient composition of earthworm *E. foetida* is presented in Table 1. Basal feeds were split into 5 treatment (EW) groups, fish meal was replaced in the diet with increasing inclusion levels of earthworm meal at 0 (EW0: control); 1% (EW1); 3% (EW3); 5% (EW5) and 10% (EW10). Five dry feeds were formulated based on the protein of the major feed ingredient mainly earthworm meal, canola oil cake, and soya oilcake as shown in Table 2. The feeding program consisted of starter (1 to 21 days of age broilers), finisher (22 to 28 days of age broilers), and post finisher (29-35 days of age broilers), and the basal diets were formulated on Win-Feed 3.0 (Table2).

Animal slaughter

At 35 days of age, 75 birds were randomly selected, 15 birds per treatment and fasted for 6 h with water offered *ad libitum*. The chickens were stunned individually on the head using 70 V prongs, heads were decapitated from the neck using a sharp knife.

Sampling procedure

Seventy-five birds, fifteen per treatment, were submitted for sensory analysis at the end of the feeding trial. The breast meat was harvested from the respective carcasses and skins were removed. Samples were vacuum packed, labelled and stored in a freezer at about -20?C for 24 hours before analysis.

Preparation of chicken

Sensory evaluation was carried out in a Nutrition Laboratory, Department of Livestock Science, University of Fort Hare, with individual booths, which consisted of a countertop with three side walls. The booths were made in such a way that the panellists could not influence one another. Ten panellists were trained for sensory characteristics of meat, by a pre-test before evaluation started.

Training was undertaken in order to familiarise the assessors with attributes before beginning the process of meat evaluation. No information was given to the panellist regarding the treatments used.

Prior to analysis, samples were defrosted in a refrigerator at 4?C for 12h. Each sample was cut into 10 mm thick slices, vacuum packed, labelled and cooked for 50 minutes at 85?C in a water bath with no spices or additives. Samples from each experimental group were served three times from each experimental group, and the serving order was randomised according to sample, replicate and panellist. Prepared samples of chicken breast were served on white glass plates, to each panellist in individual booths. Water was served in between treatments to neutralise the taste.

Sensory analysis

The five treatments were profiled using the quantitative description technique. A semi-trained panel consisting of ten sensory evaluation judges was used to assess meat. Each panellist received 1 cm cubes of meat without skin from five treatments. The panel decided on the following sensory attributes: chicken aroma, juiciness, first bite, and sustainable impression of juiciness, chicken flavour, metallic aftertaste, toughness, and the number of residues. The scale used for evaluation of sensory attributes ranging from the worst of each attribute (score one) to the best of each attribute (score five) as described in Table 3.

Statistical analysis

Data collected on sensory quality traits of different dietary treatments were analysed statistically by one way of variance (ANOVA) using the software SPSS (IBM SPSS Statistics 24). Differences among means were deemed to be significant at P ? 0.05 and were tested using Tuckey's range test. Polynomial contrasts were used to examine the linear and quadratic effects of *E. foetida* inclusion levels

Table 1. Chemical composition of *Eisenia foetida*

Ingredients	**Nutrient composition**
Proximate analysis (%)	
Protein	51.62
Moisture	6.75
Fat	7.76

Fibre	3.80
Ash	19.74
Starch	0.0
Sugar	0.31
NDF	7.70
ADF	2.81
Total fat	8.21
Minerals	
Ca (%)	5.03
P (%)	1.21
Na (%)	1.09
Salt (%)	3.12
Mg (%)	0.25
K (%)	2.04
Cu (mgkg^{-1})	420.91
Mn (mgkg^{-1})	0.0
Fe (mgkg^{-1})	73245

Zn (mgkg^{-1})	183

Table 2. Ingredients of the experimental diets on dry basis

Ingredients	Starter					Finisher					
	EW0	**EW1**	**EW3**	**EW5**	**EW10**	**EW0**	**EW1**	**EW3**	**EW5**	**EW10**	**E**
Maize	65.20	65.68	66.05	65.70	63.81	69.50	69.63	69.90	69.41	65.90	73
Soya	24.26	22.15	20.30	18.25	15.91	18.51	17.80	16.37	14.18	10.50	14
Sunflower	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4
Canola	2.84	3.50	3.27	3.85	0.00	4.85	4.57	4.02	4.85	5.00	5
Worms	0.00	1.00	3.00	5.00	10.00	0.00	1.00	3.00	5.00	10.00	0
Wheat mid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.75	0
Canola Oil	0.33	0.23	0.03	1.21	0.00	0.29	0.23	0.19	0.00	0.56	0
Limest	1.41	1.34	1.27	0.51	1.21	1.10	1.34	1.06	0.96	0.87	0

one											
Monocalcium	0.63	0.61	0.56	0.32	0.38	0.35	0.61	0.34	0.25	0.03	0
Salt	0.34	0.33	0.32	0.20	0.29	0.34	0.33	0.34	0.32	0.29	0
Methionine	0.20	0.21	0.20	0.13	0.19	0.16	0.24	0.16	0.15	0.13	0
Tryptophan	0.03	0.08	0.11	0.05	0.16	0.07	0.08	0.08	0.12	0.09	0
Threonine	0.06	0.06	0.06	0.42	0.04	0.05	0.06	0.05	0.03	0.00	0
Lysine	0.41	0.43	0.43	0.00	0.38	0.42	0.43	0.41	0.39	0.31	0
Choline Chlo	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0
Premix	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0
Aviax plus	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0
Surmax	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0
Gluten	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0

20%

Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1**

Table 3. Description of sensory attributes

Sensory attributes	**Rating**	**Description**
Chicken Aroma	1= Extremely bland 5 = Extremely intense	Intensity of the chicken mea
Metallic aroma	1= Extremely bland 5 = Extremely intense	Intensity of a metallic arom
Initial impression of juiciness	1= Extremely dry 5 = Extremely juicy	The amount of fluid exudes when pressed between thur
First Bite	1= Extremely tough 5 = Extremely tender	The impression that you fo
Sustainable impression of juiciness	1= Extremely dry 5 = Extremely juicy	The impression of juiciness form as you start chewing
Chicken flavour	1= Extremely bland 5 = Extremely intense	Intensity of the chicken flav
Metallic aftertaste	1= Extremely bland 5 = Extremely intense	Intensity of the metallic afte
Toughness	1= Extremely tough 5 = Extremely tender	Toughness/ tenderness of t number of chews before the
Residues	1= Abundant	Amount of connective tissu

	5 = None	in teeth after swallowing

Results

Aroma

The inclusion of *E. foetida* meal in the chicken diet has no dietary influence ($p > 0.05$) was observed in chicken aroma and metallic aroma scores of breast meat (Table 4). Nevertheless, the inclusion of *E. foetida* meal in the diet led to a curvilinear increase in the chicken aroma of breast meat (Figure 1). No relationship was observed on the inclusion of earthworm meal on metallic aroma.

Figure 1. Polynomial contrast of chicken aroma scores of chickens fed different inclusion level of *E. foetida*

Juiciness

Dietary effect ($p < 0.05$) was observed on initial impression of juiciness scores (Table 4). The initial impression juiciness scores of breast meat were improved as the inclusion levels of *E. foetida* increased (Figure 2). Sustainable juiciness scores were found to be influenced ($p < 0.05$) by the inclusion of earthworm meal in the diet of chickens. Sustainable juiciness scores increased linear (positive) with the inclusion of earthworm meal in the diet (Figure 3). Birds that were in EW1 had the dry meat and birds in EW10 had juicy meat though it was not statistically different with birds in EW0.

Figure 2. Polynomial contrast of initial impression of juiciness scores of meat fed different inclusions of *E. foetida*

Figure 3. Polynomial contrast of sustainable of juiciness scores from chicken meat fed different inclusions of *Eisenia foetida*

Tenderness

The inclusion of *E. foetida* meal in the diet influenced ($p < 0.05$) first bite scores of breast meat (Table 4) and no statistical difference was observed among the control group (EW0), EW3, EW5 and EW10. Moreover, there were differences ($p < 0.05$) found in toughness scores of breast meat among the dietary treatments with birds in EW10 having the tender meat and birds from EW3 having the tough meat. No relationship was observed on tenderness of meat and inclusion of earthworm in birds' diet.

Flavour

There were no differences ($p > 0.05$) observed among diets for chicken flavour and metallic flavour scores of breast meat as shown in Table 4. The inclusion of *E. foetida* meal in diet had a negative effect on chicken flavour scores of meat. The inclusion of *E. foetida* meal in diet led to decrease chicken flavour scores (Figure 4).

Figure 4. Polynomial contrast of chicken flavour scores from chickens fed different inclusion levels of *E. foetida*

Residues

Residues were different ($p < 0.05$) across the dietary treatments (Table 4), with birds in EW1 having abundant connective tissues and birds from EW10 having the least amount of connective tissues. The amount of connective tissues scores decreased with increasing the inclusion level of *E. foetida* meal (Figure 9).

Table 4. The effect of *Eisenia foetida* meal inclusion levels on sensory scores of broiler meat

Attributes	Dietary Treatments					SEM
	EW0	EW1	EW3	EW5	EW10	
Chicken Aroma	2.6	2.8	3.1	3.0	3.2	0.25
Metallic Aroma	3.1	2.7	3.4	2.9	2.9	0.25
Initial juiciness	3.1^{ab}	2.5^{a}	3.0^{ab}	3.2^{b}	3.9^{c}	0.24
First bite	3.5^{b}	2.6^{a}	3.2^{b}	3.3^{b}	3.4^{b}	0.22
Sustainable juiciness	3.1^{ab}	2.5^{a}	2.9^{ab}	3.1^{ab}	3.4^{b}	0.21
Chicken flavor	2.6	2.6	3.1	2.8	2.9	0.23
Metallic flavor	2.7	2.6	2.7	2.7	2.6	0.29
Toughness	3.3^{b}	2.3^{a}	3.1^{b}	3.2^{b}	3.5^{b}	0.20
Residues	3.8^{b}	3.0^{a}	3.4^{ab}	3.8^{b}	3.9^{b}	0.26

EW = Treatments (EW0, EW1, EW3, EW5, EW10) means the contents of E .foetida were 0,1, 3, 5 and 10 respectively, in the diet $^{a\ b:}$ *means within the row bearing different superscripts differ at p<0.05*

Discussion

Aroma is an important sensory attribute of meat because it gives the first impression of the product. It has been reported that the palatability of meat is a result of its aroma and taste (Jayasena et al 2013). However, aroma is sensed more easily than taste. This is also affirmed by Winiarska-Mieczan et al (2016) who assert that; aroma is a more important sensory attribute of meat. Thus, Ba et al (2012) also indicate that aroma is crucial in consumption, acceptance, and preference by consumers. In this study, the scores of chicken aroma increased with the increased levels of *E. foetida* meal. This may be due to a high fatty acid composition that was found by Gunya et al (2016) in *E. foetida* worms. The increased fatty acid composition was also reported by Ramarathnam et al (1993) to be directly influencing meat aroma.

In addition, metallic aroma is a sensory attribute that is found by consumers to be undesirable because of its accumulation in meat that has a negative impact on consumer acceptance and is a threat to its marketability (Mahmoud and Buettner 2016). The presence of polyunsaturated fatty acids in meat leads to peroxidation (Winiarska-Mieczan et al 2016) which then results in the metallic aroma. In the current study, no dietary influence observed on metallic aroma scores of breast meat in this study. This differs with the findings by Pieterse et al (2014) who observed the differences on metallic aroma scores of breast meat of chickens fed a diet that contains *Musca domestica*, larvae meal, fish meal, or soya bean meal. This deviation may be due to the different sources of protein used in these studies, and also different types and nature of ingredients insects, fish, and plant, which have different PUFA, in the study of Pieterse et al (2014).

Meat juiciness is also an important attribute of meat because it influences the texture of meat. The juiciness of meat depends on the quality and composition of fat (Muchenje et al 2009). According to Teye et al (2015), juiciness is composed of two organoleptic components including the impression of wetness during first chewing produced by the rapid release of meat fluid and sustainable juiciness largely due to the stimulatory effect of fat on salivation. Both initial impression and sustainable impression of the juiciness of breast meat were significantly influenced by dietary treatment. The juiciness scores of breast meat were improved as the inclusion levels of *E. foetida* increased. Moreover, birds that received the EW10 level of *E. foetida* diet scored the highest initial and sustainable juiciness values, while birds on diet containing EW1 of *E foetida* meal scored the lowest values. These findings are in contrast with Alson et al (2010) who found out that juiciness improved with a decrease in dietary protein level. The high scores of juiciness in birds fed T5 diet may be attributed to the high-fat accumulation in breast muscle, and increased levels of fatty acids in the breast meat of broilers fed with *E. foetida* diet compared to other diets (Overland et al 2005). The current findings differ from reports by Williams and Damron (1998), Pieterse et al (2014) and Winiarska- Mieczan et al (2016) who did not find any dietary effect on the juiciness of breast meat. This deviation may be caused by the different sources of protein included in diets of the chickens used in these studies.

Improvement of tenderness in meat is mainly caused by changes in the structure of connective tissue solubilised by heat, while heat-denaturation of myofibrillar protein causes meat toughness (Barbanti and Pasquini 2005). Tenderness is one of the important sensory attributes that cannot be compromised because it also influences the acceptance of meat. Tenderness of meat in sensory evaluation is determined by scores of first bite and toughness (American Meat Science Association 2015). Furthermore, it can be influenced by several production factors such as genetic makeup, feeding system, and processing techniques that include chilling, marinating, and cooking (Adam and Abugroun 2015).In the current study no relationship was observed with increasing inclusion levels of *E. foetida* meal in birds ‘diet.

Flavour comprises mainly of taste and aroma and it influences consumer purchasing behaviour and preferences (Dinesh et al 2013). It has been reported that flavour is affected by ante- and post-mortem factors, including breed, ageing, cooking method and diet. Poultry flavour could be improved by manipulating the diet (Fanatico et al 2007) positively or negatively (Jayasena et al 2013). Perez-Alvarez et al (2010) reported that the type of diet offered to bird contributes to the flavour of the meat. The inclusion of earthworm in birds' diet reduced the chicken flavor scores of breast meat. Current findings are in line with the report of William and Damro (1989) but contradict the findings by Lyon et al (2004), Pieterse et al (2014) Culler et al. (2017) who found no dietary effect on chicken flavor scores fed with insects.

Conclusions

- *Eisenia foetida* meal inclusion levels influenced sensory scores of breast meat. Sensory scores were improved as the inclusion level of *E. foetida* meal increased in the diet.

- Among the dietary treatments used in the current study, birds that were fed a diet that was supplemented with EW10 inclusion level of *E. foetida* meal beneficially influenced the sensory scores of breast meat.

- Thus, it is suggested that EW10 inclusion level of *E. foetida* meal could be used to replace fishmeal for broiler diets without deleterious effect on sensory scores, but superior to it.

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Conflicts of Interest

Authors declare no conflict of interest.

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