Comparison of slaughter yields and some meat quality parameters in broilers reared on sepiolite-supplemented wood shavings and rice hulls

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ABSTRACT Many bedding materials have been tested in broiler industry for their suitability. However, little knowledge is available regarding the usage of different bedding materials supplemented with sepiolite and their effects on animal performance and final product quality. For this purpose, a total of 288 day-old male broiler chicks were randomly allocated into two types of bedding materials (wood shavings and rice hulls). Each bedding material group was divided into 3 subgroups: control with 0% sepiolite, 25%-sepiolite group, and 50%-sepiolite group. Each sub-group was placed in 6 pens with 8 chicks per pen. The effects of bedding materials and sepiolite additions on slaughter yields and some meat quality parameters in broilers were evaluated. Slaughter parameters including hot carcass yield and relative weights of thigh and breast meat, heart, liver, gizzard and bursa Fabricius in broilers were not affected by bedding materials and sepiolite additions ($P > 0.05$). Also, no significant differences were observed among experimental groups for cooking loss and nutritional profile of breast and thigh meat of broilers ($P > 0.05$). The freshly measured pH_0 of breast and thigh meats was significantly affected by the bedding material and was higher for wood shavings group ($P < 0.01$). Breast and thigh meats of broilers reared on rice hulls were lighter ($P < 0.01$), less red, and less yellow in color than those reared on wood shavings, whereas no effect of sepiolite additions was observed on the color of both meat cuts. No substantial effect of bedding material and sepiolite additions was observed on white stripping; however, their occurrence rate found was very high for meat of broilers reared on rice hulls than those reared on wood shavings ($P > 0.05$). In conclusion, broilers reared on either wood shavings or rice hulls with or without sepiolite additions did not show any negative effects on slaughter yields and meat quality parameters. Furthermore, sepiolite can be an option as a bedding material for broiler industry, but further research with thorough economic analysis is required.

Key words: broiler, bedding material, sepiolite, carcass, meat quality

2019 Poultry Science 98:1678–1683
http://dx.doi.org/10.3382/ps/pey536

INTRODUCTION

Broiler chickens have been reared on various types of bedding materials with different structural, absorbent, and other hygiene-related characteristics. Poor-quality bedding material can result in increased moisture and ammonia levels in the litter, higher incidences of footpad and breast burns along with other diseases, reduced feed efficiency, increased respiratory tract injuries, and eventually poor welfare of animals (Caveny et al., 1981; Olanrewaju et al., 2007; Hashani and David, 2018). Different amelioration techniques have been used to control the litter deterioration, thus improving animal welfare. For example, rock minerals such as zeolite and vermiculite have widely been used in litter management. When such materials were added to the bedding, they lowered the pH value of litter thus reducing the ammonia volatilization and converting NH_4^+ to NH_3 (Li et al., 2006; Turan, 2009; Schneider et al., 2016; Naseem and King, 2018). Like these minerals, sepiolite is also a rock mineral having a high porosity and absorptive properties (Eser et al., 2012; Yalçın et al., 2016; 2017). It is a natural mineral belonging to the group of phyllosilicates. Along with high porosity and strong absorptive power, sepiolite also possesses the characteristics of larger surface area, high structural stability, and chemical inertia (Wolter et al., 1990; Yalçın et al., 2017). It has been used widely and safely in many industries for different purposes (Galan, 1996). Varol Avcılar et al. (2018) reported that the addition of sepiolite (at the levels of 25 and 50%) into different bedding

Received September 12, 2018.
Accepted November 2, 2018.
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Table 1. The chemical composition of sepiolite (%).

SiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	Na_2O	K_2O	Mn_2O_3	TiO_2
41.3	1.09	24.44	11.39	0.48	0.23	0.30	0.01	0.08

Sepiolite (Exal T, Tolsa Turkey-Polatlı, Turkey) consists of 74% sepiolite, 18% dolomite, and 8% dolomite.

materials had no negative effects on broilers performance and welfare.

Environmental conditions and genotype are the key factors affecting the carcass and meat quality of broilers. One of the main parts of body in broiler animals is their skeletal muscles, especially the pectoralis major and minor. These body cuts possess a great value in food industry. Important traits of these muscles are their external features, nutritional profiles, and chemical properties (Zhao et al., 2018). Nowadays, consumers are also more interested in the nutritional value of the foods they eat (Mir et al., 2017). Along with the nutritional composition, the pH and cooking losses are also some of the important parameters of meat quality evaluation that can help in ensuring a final product of exceptional quality and profitability (Allen et al., 1998; Mir et al., 2017). Good rearing conditions including the type of bedding material, its quality, and composition can provide greater comfort thus improving the welfare conditions of animals. In broiler production, little scientific information is available regarding the usage of different bedding materials with supplemental sepiolite and its effect on meat quality. Therefore, the aim of the present study was to evaluate the effects of sepiolite-added wood shavings and rice hulls on slaughter yields and some meat quality characteristics in broilers.

MATERIALS AND METHODS

Experimental Design and Animals

This study was approved by the Ankara University Animal Care and Use Committee (2015-14-156). A total of 288 day-old male broiler chicks (Ross 308) were used in this study. Two types of bedding materials (wood shavings and rice hulls) with supplemental sepiolite were used for the experiment. Each bedding material was divided into 3 sub-groups: control with 0% sepiolite added (only 4.32 kg bedding material per pen), 25%-sepiolite added group (3.24 kg bedding material and 1.08 kg sepiolite per pen), and 50%-sepiolite added group (2.16 kg bedding material and 2.16 kg sepiolite per pen). Each sub-group was placed in 6 pens (80 × 90 cm, width × length, respectively) with 8 chicks per pen. The composition of the sepiolite is shown in Table 1. Feed and water were provided ad libitum. Broilers were fed with a commercial starter diet (3025 kcal/kg ME, 23%CP) and commercial growth diet (3200 kcal/kg ME, 20.2% CP) from day 1 to 21 and day 22 to 42 of age, respectively.

Slaughtering and Meat Sample Collection

On day 42, 1 animal from each pen (6 animals per group) with a body weight closest to the mean body weight of the group was selected and slaughtered. After evisceration, hot carcass weights were recorded and expressed as hot carcass yield. Breast and thigh parts of carcasses were properly separated, weighed, and expressed as percentages of the hot carcass weights. The remaining part of the breast and thigh meats was separated for the further analyses. The internal organs (heart, liver, gizzard, and bursa Fabricius) were also weighed and expressed as percentages of the slaughter weight of animals.

White Strips on Breast Meat

Breast meat was visually screened and separated according to the degree of white striping as 1, 2, 3, and 4. Breast meat classified as 1 did not show any distinct white lines, 2 exhibited white lines in $\leq$5 number and <1-mm thick, parallel to the muscle fibers, 3 exhibited white lines in >5 numbers and <1-mm thick, parallel to the muscle fibers, and 4 exhibited white lines, parallel to the muscle fibers, generally >1-mm thick and very much visible on the breast surface (adapted from Kuttappan et al., 2009).

Meat Color Evaluation, pH Measurement, Cooking Loss, and Chemical Composition

The color profile (lightness-L^*, redness-a^*, and yellowness-b^*) of breast and thigh meats was measured within 10 min postmortem using a colorimeter (Konica Minolta CR-400). The pH of meat samples (breast and thigh) was measured using a pH meter (Selecta, pH-2004, Barcelona, Spain). For breast meat, the pH was measured from the same place such as right upper third of all breast samples. Each meat sample was measured 3 times, and thus the average pH value of meat samples was calculated. pH values were measured at 2 different time intervals i.e., freshly (pH_0) and 24-hour (pH_{24}) post-slaughter (stored at 4°C). For cooking loss determination, breast and thigh meat samples were weighed and individually placed into plastic bags. These bags were immersed in a water bath (80°C) for 20 min, cooled, and weighed. Cooking loss was calculated as the ratio of the difference in weight between the raw and cooked meat relative to the weight of the raw meat (Honikel, 1998).

For nutritional composition, skinless breast and thigh meat samples were used and dry matter, ash, protein,

Table 2. Effects of sepiolite additions to the wood shavings and rice hulls on hot carcass yield, breast, and thigh cuts and some organ ratios in broilers.

Bedding material	Sepiolite (%)	Hot carcass yield (%)	Thigh weight (%)	Breast weight (%)	Heart weight (%)	Liver weight (%)	Gizzard weight (%)	Bursa Fabricius weight (%)
Wood shavings	0	71.2	29.2	29.2	0.65	2.28	1.18	0.20
	25	70.4	27.9	30.1	0.56	2.54	1.15	0.20
	50	70.7	29.0	28.9	0.60	2.47	1.09	0.16
Rice hulls	0	71.4	28.0	29.2	0.63	2.31	1.22	0.18
	25	71.2	28.0	29.0	0.62	2.28	1.20	0.18
	50	70.8	28.3	29.5	0.65	2.18	1.20	0.21
Wood shavings		70.8	28.7	29.4	0.60	2.43	1.14	0.19
Rice hulls		71.1	28.1	29.2	0.63	2.26	1.21	0.19
	0	71.3	28.6	29.2	0.64	2.29	1.20	0.19
	25	70.8	28.0	29.5	0.59	2.41	1.18	0.19
	50	70.7	28.6	29.2	0.62	2.33	1.14	0.18
SEM		0.212	0.308	0.431	0.011	0.047	0.021	0.007
Bedding material		NS	NS	NS	NS	NS	NS	NS
Sepiolite additions		NS	NS	NS	NS	NS	NS	NS
Bedding material X Sepiolite additions		NS	NS	NS	NS	NS	NS	0.049

NS: Non-significant.

and fat contents were determined according to AOAC (1990) methods. These contents were expressed as a percentage of the raw meat.

Statistical Analysis

Statistical analysis was conducted using SPSS version 23.0 for Windows software (SPSS Inc., Chicago, IL). Data were tested for normal distribution and homogeneity of variance. Two-way ANOVA was used to determine the differences between bedding material and sepiolite groups as well as their interactions with examined parameters except for white strips. Comparisons among means were made by the Tukey test. White striping phenomenon was assessed by the chi-square test (Dawson and Trapp, 2000). A value of $P < 0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

Broilers spend most of their lives in direct contact with the bedding material, and improvement in the quality and management of this material can result in the advancement of broiler performance and cleanliness and irritation of breast (de Jong et al., 2014). The quality of meat in broilers is of great importance both for producers and consumers.

Different types of bedding materials and sepiolite additions to these bedding materials had no significant effect on hot carcass yield and relative weights of breast and thigh meat including various body organs (Table 2). Also, no interaction effects were observed for these examined post-slaughter parameters except the weight of bursa Fabricius. Hot carcass yields, thigh, and breast meat percentages of broilers reared on wood shavings and rice hulls were 70.8, 28.7, 29.4%, and 71.1, 28.1, 29.2%, respectively. Therefore, hot carcass yields, thigh, and breast meat percentages of broilers reared on 0, 25, and 50% sepiolite-added bedding materials were 71.3, 28.6, 29.2%, 70.8, 28.0, 29.5%, and 70.7, 28.6, 29.2%, respectively. Previously, studies have showed that environmental factors (e.g. production system, stocking density, etc.) have affected the carcass yield (Ricard, 1977; Castellini et al., 2002; Fanatico et al., 2005; Sikder et al., 2012). Varol Avcılar et al. (2018) showed that the sepiolite addition (0 to 50%) to the bedding material had reduced the pH, moisture, and ammonia levels of the litter ($P < 0.05$). However, besides aforementioned positive effects of sepiolite addition to bedding materials on environment conditions, no significant differences for post-slaughter parameters were found among experimental groups of the present study. Toghyani et al. (2010) and Ramadan et al. (2013) also reported non-significant differences in carcass yield and some organ weights of broilers reared on different types of bedding materials. Hashani and David (2018) have also stated that there was no effect of bedding material amended with boric acid on relative weights of heart and liver organs of experimental animals except that of gizzard that differed significantly among groups.

Meat quality is one of the important features for producers and consumers. Nowadays, attempts have been made by researchers not only for the betterment of animal performance and welfare but also for meat quality enhancement. However, improvement of quality parameters of meat depends on many factors (e.g. pH, color, water holding capacity, etc.) that play an important role in the economics of the meat production as well as in public health. pH of the meat has the direct relation with other characteristics like tenderness, water holding capacity, color and shelf life (Mir et al., 2017). Low water holding capacity, which results in increased cooking and drip losses, low shelf life, and decreased tenderness, has been associated with low pH (Barbut, 1993).

Table 3. Effects of sepiolite additions to the wood shavings and rice hulls on some quality characteristics of breast meat in broilers.

Bedding material	Sepiolite (%)	pH_0	pH_{24}	Cooking loss (%)	Dry matter (%)	Ash (%)	Protein (%)	Fat (%)
Wood shavings	0	7.31	5.43	20.76	26.25	1.29	23.01	1.90
	25	3.32	5.61	21.82	26.36	1.51	22.95	1.90
	50	7.33	5.49	20.23	26.66	1.21	23.48	1.95
Rice hulls	0	7.26	5.59	19.46	26.83	1.42	23.17	2.19
	25	7.27	5.52	20.69	27.25	1.18	23.93	2.13
	50	7.26	5.71	20.74	26.82	1.30	23.14	2.38
Wood shavings		7.32	5.51	20.94	26.43	1.34	23.15	1.91
Rice hulls		7.26	5.62	20.30	26.97	1.30	23.41	2.23
	0	7.28	5.51	20.11	26.54	1.36	23.09	2.04
	25	7.29	5.58	21.25	26.81	1.34	23.44	2.01
	50	7.29	5.60	20.49	26.74	1.26	23.31	2.16
SEM		0.008	0.056	0.327	0.161	0.054	0.152	0.081
Bedding material		0.003	NS	NS	NS	NS	NS	NS
Sepiolite additions		NS	NS	NS	NS	NS	NS	NS
Bedding material X Sepiolite additions		NS	NS	NS	NS	NS	NS	NS

NS: Non-significant.

Table 4. Effects of sepiolite additions to the wood shavings and rice hulls on some quality characteristics of thigh meat in broilers.

Bedding material	Sepiolite (%)	pH_0	pH_{24}	Cooking loss (%)	Dry matter (%)	Ash (%)	Protein (%)	Fat (%)
Wood shavings	0	7.36	5.65	20.95	24.70	1.39	20.25	3.03
	25	7.33	5.81	21.16	25.30	1.22	20.61	3.42
	50	7.33	5.57	20.21	25.55	1.35	20.72	3.43
Rice hulls	0	7.28	5.68	19.81	24.66	1.35	20.29	3.00
	25	7.28	5.73	19.31	25.36	1.17	20.36	3.83
	50	7.27	5.79	21.54	24.23	1.19	20.20	2.83
Wood shavings		7.34	5.68	20.77	25.18	1.32	20.53	3.29
Rice hulls		7.28	5.73	20.23	24.75	1.24	20.82	3.22
	0	7.32	5.67	20.38	24.68	1.37	20.27	3.01
	25	7.31	5.77	20.24	25.33	1.19	20.49	3.63
	50	7.30	5.68	20.88	24.89	1.27	20.46	3.13
SEM		0.006	0.056	0.317	0.175	0.037	0.144	0.145
Bedding material		<0.001	NS	NS	NS	NS	NS	NS
Sepiolite additions		NS	NS	NS	NS	NS	NS	NS
Bedding material X Sepiolite additions		NS	NS	NS	NS	NS	NS	NS

NS: Non-significant.

The pH_0 of breast ($P < 0.01$, Table 3) and thigh meats ($P < 0.001$, Table 4) were significantly affected by bedding materials; however, no effect was observed on pH_0 with sepiolite addition. The pH values 24 h post-slaughter (pH24) for both meat cuts were neither affected by bedding materials nor sepiolite additions. Moreover, no interaction effects were observed for pH_0 and pH_{24} values of breast and thigh meats.

Cooking loss is one of the important indices to evaluate the water holding capacity of meat (Fanatico et al., 2007; Cheng and Sun, 2008). Neither significant differences were observed among experimental groups for cooking loss in breast and thigh meats of broilers nor an interaction was found between bedding materials and sepiolite additions in the present study. In an experiment with broilers (Meluzzi et al., 2008), bedding material had no effect on meat cooking loss but rearing conditions like stocking density and light period had affected the cooking loss. In another experiment with broilers with and without access to pasture, Woo-Ming et al (2018) have reported no difference in cooking loss in breast meat of broilers.

With the increasing awareness of health, consumers are more interested in the nutritional quality of meat (Mir et al., 2017). Present study showed no effect of different treatments on the nutritional profile of breast and thigh meats. Also, no significant interaction effects were observed between bedding material and sepiolite additions for meat nutritional profiles. Woo-Ming et al. (2018) reported that physiochemical properties of the meat, including percent moisture, fat, protein, and ash were not affected significantly in broilers with or without pasture access. Similarly, Michalczuk et al. (2014) also reported that the rearing systems had no or minor effect on quality attributes of the poultry meat.

Color is another most important quality attribute of meat because it has great influence on consumers' decision whether to buy the product or not (Mir et al., 2017). Different factors affecting broiler meat color may include age, genetics, stress, slaughtering method, etc.

Table 5. Effects of sepiolite additions to the wood shavings and rice hulls on the color of breast and thigh meats in broilers.

		Breast meat			Thigh meat		
Bedding material	Sepiolite (%)	L*	a*	b*	L*	a*	b*
Wood shavings	0	50.77	3.46	5.09	54.21	7.12	6.54
	25	50.98	4.27	5.47	57.84	7.38	6.54
	50	53.46	4.27	6.61	53.69	6.80	6.74
Rice hulls	0	54.90	4.80	5.99	57.55	7.00	5.92
	25	56.85	3.32	3.85	59.87	5.78	5.83
	50	56.68	2.83	5.40	62.03	6.92	5.13
Wood shavings		51.74	4.00	5.72	55.24	7.10	6.60
Rice hulls		56.15	3.65	5.08	59.81	6.57	5.63
	0	52.84	4.13	5.54	55.88	7.06	6.23
	25	53.92	3.79	4.66	58.85	6.58	6.18
	50	55.07	3.55	6.00	57.86	6.86	5.94
SEM		0.691	0.226	0.223	0.799	0.281	0.193
Bedding material		0.003	NS	NS	0.008	NS	0.016
Sepiolite additions		NS	NS	NS	NS	NS	NS
Bedding material X Sepiolite additions		NS	0.040	NS	NS	NS	NS

NS: Non-significant.

Table 6. Effects of sepiolite additions to the wood shavings and rice hulls on the degree of white striping in the breast meat of broilers.

		Degree of white striping				
Bedding material	Sepiolite (%)	1	2	3	4	2+3+4
Wood shavings		61.11	33.33	–	5.56	38.89
Rice hulls		44.44	44.44	5.56	5.56	55.56
X^2						1.003
P						0.317
	0	58.33	25.00	8.33	8.33	41.67
	25	50.00	41.67	–	8.33	50.00
	50	50.00	50.00	–	–	50.00
X^2						0.223
P						0.895

Breast cuts classified as 1 did not show any distinct white lines; 2 exhibited white lines in ≤5 number and <1-mm thick, parallel to the muscle fibers; 3 exhibited white lines in >5 numbers and <1-mm thick, parallel to the muscle fibers; and 4 exhibited white lines, parallel to the muscle fibers, generally >1-mm thick and very much visible on the breast surface (adapted from Kuttappan et al., 2009).

(Froning, 1995). The poor litter condition can be considered one of the stress factors in broiler production. In this experiment, bedding material significantly affected the lightness (L*) of breast and thigh meats, and values were higher for the broilers reared on rice hulls ($P<0.01$, Table 5). No significant effect of bedding material was observed on redness (a*) of both meat cuts; however, breast and thigh meat of broilers reared on wood shavings tended to be redder than those reared on rice hulls. Yellowness (b*) of thigh meat was significantly affected ($P < 0.05$) by bedding material, whereas for breast meat the effect was non-significant; however, values of yellowness of both meat cuts were higher for broilers reared on wood shavings. Thus, from results it was inferred that the meat of broilers reared on rice hulls was lighter, less red, and less yellow in color than those reared on wood shavings. Furthermore, no effect of sepiolite additions was observed on the color of both meat cuts. Also, no interaction effect of bedding materials and sepiolite additions was observed on meat color except for the redness of breast meats.

White striping in meat industry is characterized by the occurrence of white striations in varying degrees on the muscle surface of breast meat along the pectoralis major muscle (Sihvo et al., 2014; Zanetti et al., 2018). This problem has raised serious concerns affecting the acceptance of meat by consumers. Results obtained in the study showed that bedding materials and sepiolite additions had no significant effect on the occurrence of white stripping in breast meat (Table 6). However, their occurrence rate found was very high for meat of broilers reared on rice hulls than on wood shavings (55.56 and 38.89%, respectively). The addition of sepiolite (50 and 25%) to bedding materials had also resulted in higher occurrence of white stripping in broilers meat than no added sepiolite (50, 50, and 41.67%, respectively).

In conclusion, broilers reared on either wood shavings or rice hulls with or without sepiolite additions did not show any negative effects on slaughter yields and meat quality parameters. Also, sepiolite can be used as a bedding material in broiler production; however, a thorough analysis is required from the economic point of view.

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