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RESEARCH ARTICLE

Improving Tenderness of Spent Layer Hens Meat Using Papaya Leaves (*Carica papaya*)

H. O. Abdalla, N. N. A. Ali, F. S. Siddig and S. A. M. Ali*

[1]Department of Animal Science, Faculty of Agricultural Sciences, University of Gezira, Wad Medani, P.O. Box 20, Sudan

*Corresponding author: saydamhmmd@yahoo.com

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ABSTRACT

Two experiments were performed to study the use of papaya leaves as a meat tenderizer. The first experiment was to evaluate the effect of papaya dry leaves added to hen's diet before slaughter. Spent hens (n=48) were used, half of them were fed a concentrate ration containing10% dried papaya leaves powder (DPLP) while others received layer ration (Control), for 10 days. The second experiment involved a comparison between papaya leaves juice (PLJ), fresh papaya leaves (FPL) and vinegar solution (VS) as marinades applied to meat for one or two hours before cooking. Spent layer hens (n=42) were used for tenderness evaluation method. After slaughtering and preparing the chickens two methods of cooking were used (oven and moist cooking). The cooked parts (breast, thigh and drumstick) were subjected to a panel test evaluation according to a designed questionnaire. Addition of dried papaya leaves powder to spent layer hens ration significantly ($P \leq 0.05$) increased the level of meat tenderness. Moist cooking had significantly ($P \leq 0.05$) improved meat tenderization compared to oven cooking. Meat treated with fresh papaya leaves had significantly ($P \leq 0.05$) improved tenderness. It was concluded that wrapping the tough meat of spent layer hens with fresh papaya leaves for one hour and moist cooking improve tenderness of meat.

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INTRODUCTION

Globally, there are about 2.6 billion spent hens that are used in the pet food industry and not much for human consumption (Navid *et al*., 2011). Meat from spent hens tends to be tough, non-juicy and low in fat. Because of unacceptable toughness and brittle bones, the use of spent chicken meat has long been a problem for the poultry industry.

Tenderness is considered to be the most important organoleptic characteristic of meat (Lawrie, 1991). The toughness associated with spent chicken meat is primarily due to the increased cross-linking in the connective tissue of older animals (Archile-Contreras *et al*., 2011). Culled hens which were being used for meat purpose are going to be discarded by the quality conscious consumers due to inherent quality differences especially tenderness of spent hen meat. Therefore, the farmers are facing a problem in disposing their old-unproductive layers at a minimum price. Chlorides, phosphates have been reported to be used for tenderizing aged and tough meat (Sachdev and Verma, 1990).

Papaya plant, *Carica papaya* (family Caricaceae) native to tropical South America and is found in other tropical countries like Sudan.. The latex is a complex mixture of chemical compounds with diverse chemical activities (El Moussaoui *et al*., 2001) and serves as an excellent meat tenderizer (Huet *et al*., 2006). The latex is rich in enzyme known as cysteine proteinase and constitutes as much as 80% of the enzyme fraction in papaya latex, which is used widely for protein digestion (El Moussaoui *et al*., 2001).

Papain is used in biochemical research involving the analysis of proteins, preparations of various remedies for indigestion, tenderizing meat, and in enzyme action cleaning for soft contact lenses. It is used to shrink or dissolve ruptured disks in certain kinds of lumbar spine injures, and otherwise as a digestant of protein (Encyclopedia Britannica, 2009). It was suggested that papain with 0.025% concentration at 3% level (w/w) can be used to improve the tenderness and functional properties of spent hen meat cuts for efficient utilization (Khanna and Panda, 2007).

Sensory evaluation of papain treated spent hens revealed significantly higher score for juiciness,

tenderness and overall acceptability (Mendiratta *et al*., 2002). They added that there were no significant differences in percent cooking loss, pH, moisture, protein and fat percentage. It was concluded that dietary supplementation of 2% papaya leave meal in spent layer hens for a few days before slaughter improved meat quality in terms of meat tenderness and juiciness (Navid *et al*., 2011).

Vinegar is an acidic liquid processed from the fermentation of ethanol that yields its key ingredient as acetic acid. It is a weak carboxylic acid containing 6-10 acetic acid (AL-Jalili *et al.*, 2004).

It may be essential and economically viable to improve the meat quality of these birds. Attempts to improve meat quality through improving tenderness through post-slaughter are either costly, labor intensive, need large storage area and require longer storage time. Therefore, they are impractical and not economically viable. Two experiments were therefore performed with a general objective to determine whether papaya leaf meal (PLM) supplementation in layers diets fed for ten days before slaughter could improve meat quality especially tenderness of spent layer hen. The specific objectives were to compare the level of tenderness meat of spent layers' hens using papaya leaves pre- and post-slaughter; to compare the level of improvement on tenderness of spent layer hens meat treated with papaya leaves or vinegar.

MATERIALS AND METHODS

Experiment I: This experiment was carried out to study the effect of feeding spent layer hens with a diet containing 10% of dried papaya leaves powder. Forty eight spent layer hens were randomly selected with average body weight (1250 gm) from the Poultry Unit at the University of Gezira Farm at Elnisheshieba. The hens were randomly divided into two equal treatments with three replicates each. Rations were formulated according to NRC (1994) nutrients requirements. One group received a normal layer ration (0% dried papaya leaves); while the other group received a diet containing 10% dried papaya leaves powder (Table 1). The feeding period extended for 10 days. The two groups were fed *ad-libitum*. Feed intake was recorded daily. The total egg production and total egg weight for each group was recorded. At the end of the feeding period, the average body weight and body weight gain were obtained. From each group, 12 randomly selected hens were killed humanely. After de-feathering the carcasses, internal organs were weighed and percentage of the different weights based on carcass weight was calculated.

Preparation and cooking of the meat: Breast, thigh and drum stick were chosen from the carcass to test the effect of papaya leaves fed before slaughter on meat tenderness. These different parts were cooked by two methods, braising in an electric oven and moist cooking in a pot using a gas burner. Breasts, thighs and drum sticks of six hens were prepared by adding little salt and cooking oil were cooked in oven at 275^{o}C for 1 hour. The three different parts of the other six hens were prepared and then transferred into a cooking pot which contained a cooked onion with a little amount of salt. Cooking was continued for one hour on gas burner.

Sensory evaluation of meat: A questionnaire was prepared to facilitate the evaluation on color, flavor, juiciness and tenderness of cooked meat. Thirty people were randomly selected according to their ages and sex to contribute in the evaluation. They were then divided into three equal groups. Thigh, breast and drum stick were cut into small pieces (10g). Each group evaluated the three parts of one hen from each treatment, which represented one replicate for each treatment. The same sensory evaluation was done for both methods of cooking.

Experiment II: Fresh papaya leaves and vinegar were used to know their affects on the tenderness of spent layer hen's meat. Fresh papaya leaves (FPL) were cut into small parts and 250 g minced leaves were mixed with 250 ml tap water and blended. After settling heavy particles, it was sieved to papaya leaves juice (PLJ).

Forty two spent layer hens of similar average weight (60 weeks old) were selected randomly. The hens were divided randomly into seven equal groups and each group was assigned to specific treatment with three replicates of two hens each (Table 1). Birds were fed separately for 20 days on layer's diet. At the end of the feeding period, six hens from each group were selected randomly and killed humanely. The breast, thigh and drum stick in each treatment were prepared. Some scratches or incisions were made in the papaya leaves to facilitate the quick exudation of the leaf contents (juice). Papaya leaves juice, or the vinegar juice (5 ml), were added to each part and coated thoroughly. Evaluation of meat was carried out as mentioned in experiment I.

Table 1: The substance used for the treatment of meat before cooking in experiment II

Group	Substance used	Left before cooking (hour)
T1	PLJ	1
T2	PLJ	2
T3	FPL	1
T4	FPL	2
T5	Vinegar	1
T6	Vinegar	2
T7	Control	-

FPL= Fresh papaya leaves; PLJ=papaya leaves juice.

Statistical analysis: Data collected in experiment I were subjected to analysis using the T test and in experiment II were subjected to analysis of variance (ANOVA) test under completely randomized design using MSTAT-C. Duncan's multiple range tests was used to determine the differences among the treatments means.

RESULTS AND DISCUSSION

Experiment I: The inclusion of dried papaya leaves powder in feed of spent layer hens had non-significant effect on feed intake (Table 2) and on organs (liver, gizzard) weight, breast, thigh and drumstick. However, the hens fed on diets supplemented with papaya leaves had significantly ($P \leq 0.05$) higher live body weight, carcass and abdominal fat pad weights and dressing percentage. These results might be attributed to the effect of proteolytic enzyme found in the papaya leaves (papain

enzyme) which may lead to more degradation and availability of dietary protein. It might be as well attributed to some chemical substances that increased the appetite and enhanced DMI resulting in more available nutrients for the birds, hence better performance (El Moussaoui *et al*., 2001).

Table 2: Ingredient and chemical composition of the layers rations

Ingredient%	Control	DPLP
Sorghum	59	53.5
Groundnut cake	16.5	15
Wheat bran	9	7
Oyster shell	9	8.5
Salt	0.5	0.5
Vegetable fat	1.0	1.0
Papaya	0	10
Super concentrate*	5	4.5
Total	100	100
Calculated Chemical Composition		
Dry matter (DM)%	94.4	94.5
Crude protein (CP)%	18.8	18.6
Crude fibre (CF)%	4.5	4.8
Ether extract (EE)%	4.6	4.5
Ash	12.1	12.0
NFE	54.4	54.6
Metabolisable energy (ME) kcal/kg	2722	2716
Calcium (Ca)%	3.5	3.5
Phosphorus available (Pav.)%	0.40	0.45

* Super concentrate contains the following: 35% CP, 2% EE, 4% CF, 10% calcium, 4.5% available phosphorus, 5.7% lysine, 4.5% methionine and 4.9% methionine + cystine. Metabolisable energy 2000 kcal/kg, 2.6% Sodium with added vitamins and minerals.

Among the oven cooked meat parts of spent layers (Table 3), the breast had significantly (P≤0.05) the best quality attributes followed by the thigh and drumstick in both treatments. The highest points for color received by the breast might be attributed to the fact that the breast muscles contain only white muscle fibers, compared with the thigh and the drumstick muscles which contain a mixture of white and red muscle fibers (Sams *et al*., 1991).

Table 3: Average carcass weight of selected internal organs weight and some selected carcass parts of spent layer hens

Item	Control Mean (95% CI)	DPLP Mean (95% CI)
Total feed intake (g)	1150±20	1100±30
Final body weight (g)	1427±30.5 b	1500±20a
Carcass weight (g)	845±32.2 b	885±5.69a
Dressing %	59.5±1.0	59.0±0.58
Liver (g)	20±2.0	21±2.0
Gizzard (g)	30±1.0	31±1.0
Abdominal Fat pad (g)	25±1.0 b	28±1.0a
Breast (g)	245±5.0	250±10
Thigh (g)	140±10	150±10
Drumstick (g)	120±7	125±10

Mean values bearing different letters in a row differ significantly (P<0.05).

There was non-significant difference between the two treatments with regard to flavor, juiciness and tenderness of the different parts in the present study. However, there was a significant difference (P≤0.05) among the different parts within each treatment. The flavor of the cooked meat depends on the amount of fat present in each part. The breast contains reasonable amounts of fat associated with the skin, while the drumstick is devoid of fat. Thus, the breast received the highest points of flavor, while the drumstick received the lowest points. The juiciness of the cooked meat is largely affected by water holding capacity, which is in turn affected by marbling and the water contents of the muscle (Monika, *et al*., 2012) Hence, the breast received the highest points for juiciness, while the drumstick was given the lowest evaluation of juiciness. However, the breast received the highest degree of tenderness while the drumstick received the lowest degree of tenderness. Legs usually contain more collagen of connective tissue and more contractile apparatus of myofirillar proteins, these results are in line with Gerrard and Grant (2003) and Archile-Contreras *et al*. (2011). This can explain why the drumstick received the lowest evaluation for tenderness (Table 3).

As shown in Table 4, spent layers fed on a diet supplemented with dried papaya leaves before slaughter, had significant (P≤0.05) differences among the different parts (breast, thigh and drumstick) and between different treatments for the different sensory attributes and cooking methods. Nevertheless, almost all sensory attributes of all parts received significantly (P≤0.05) more points with moist cooking in both treatments. These findings are in accord with that of Navid *et al*. (2011) who concluded that some merits in the dietary supplementation of 2% papaya leave meal in spent layer hens for a few days before slaughter, improved meat quality in terms of meat tenderness and juiciness. The effect of moist cooking on tenderness and other related traits might be attributed to the fact that moist cooking affects the structural proteins and it results in less cooking loss than most other cooking methods (Navid *et al*., 2011). Also, juiciness is reported to increase with moist cooking, while the dry hot temperature of the oven leads to denaturing of proteins and hence less tender meat (Table). These results are in line with that of Monika *et al*. (2012) who concluded that the cooking method and temperature influenced moisture and cooking loss. These results as well agree with that of Navid *et al*. (2010) who indicated that both vitamin D_3 and papaya leaf meal were potent additives to improve tenderness, drip loss, cooking loss and meat color. Recently it was concluded that Papain has revealed to be an enzymatic protein of significant biological and economic importance. It is through the unique structure of papain helps explain how this proteolytic enzyme works and also makes it valuable for a variety of purposes (Mamboya, 2012).

Experiment II: The number of chewing of meat prepared by oven cooking (2 hours) of the different marinades used before cooking was significantly (P≤0.05) different among the treatments (Table 5). There was no significant difference in the number of chewing between the two applications' time of the different marinades and cooking of spent layer hens times (Table 5). Thus, the application of marinades one hour before cooking was quite enough. However, for frying or braising of other types of tough meat the average time required after application of a marinade is 30 minutes. As expected, the drum stick was the least tender among the three parts.

The improvement in tenderness using the leaves was about 20% on the thigh, and about 30% on breast and drum stick compared with the control. These results are in line with that of Monika *et al*., (2012) who indicated that temperature affected tenderness and juiciness, whereas muscle type influenced juiciness.

Table 4: Effect of dried papaya leaves dietary supplementation to spent layers on the sensory attributes of meat prepared by oven and moist cooking

Sensory attributes		Control			DPLP		
		Breast	Thigh	Drum Stick	Breast	Thigh	Drum Stick
CL	OC	17± 0.44b	15±0.44d	14±0.26e	16±0.20c	14±0.36e	11±0.26f
	MC	16±0.53c	15±0.92d	16±0.64c	18±a	16±b	16±b
FL	OC	15±0.5b	15±0.46b	13±0.56c	16±0.6ab	13±0.75c	12±0.55c
	MC	16±0.62ab	15±0.62b	15±0.72b	17±0.76a	16±0.75b	15±1.25b
JU	OC	16±0.56b	14±0.82d	12±0.56e	15±0.4c	12±0.2e	11±0.56e
	MC	16±0.53b	15±1.25c	15±0.72c	17±0.89a	16±0.55b	16±0.3b
TN	OC	17±0.92a	15±0.56bc	14±0.72cd	15±0.46bc	15±0.53bc	11±0.72e
	MC	15±0.72bc	14±0.5cd	13±0.62d	17±0.44a	16±0.56b	1±0.62bc
TP	OC	65±1.82b	59±1.71c	54±2.12d	62±1.29ab	54±0.7d	45±1.79e
	MC	63±2.4b	59±2.48c	59±0.45c	69±2.61a	64±1.36b	62±2.23bc

Mean values bearing different letters in a row differ significantly (P<0.05); DPLP = Dried Papaya Leaves; O C = Oven Cooking; M C = Moist Cooking; CL = Color; FL = Flavor; JU = Juiciness; TN = Tenderness; TP = Total Points

Table 5: The effect of different marinades and application time on number of chewings of different parts of spent layer hens meat prepared by oven cooking

Carcass parts	Treatments						
	Control	PJ (1 hr)	PL (1hr)	Vin (1hr)	PJ (2hr)	PL (2hr)	Vin (2hr)
Thigh	24.7±1.85a	21.8±1.25b	20.2±0.93bc	19.6±1.68bc	22.2±1.15bc	18.4±1.25c	20.3±2.47bc
Breast	23.6±1.44a	24.2±1.01a	22.8±2.04a	23.4±0.60a	22.9±1.79b	17.0±1.25a	22.4±1.25a
Drum stick	32.8±3.16a	30.8±2.35ab	16.3±1.00d	32.3±1.62a	28.2±2.15b	13.4±1.35d	28.2±2.15c

Mean values bearing different letters in a row differ significantly (P<0.05); PJ (1 hr/2 hr) = Papaya Juice soaked for one/two hours; PL (1hr/2 hr) = Papaya Leaves wrapped for one/two hours; Vin (1hr/2 hr) = Vinegar soaked for one/two hours

Papaya leaves juice and the vinegar had almost the same effect on tenderness. Wrapping the meat with the papaya leaves resulted in acceptable taste and flavor, while the leaves juice resulted in tardy taste and greenish color. Accordingly, wrapping the meat with fresh papaya leaves was considered as the best method used to tenderize tough meat compared with marinades (papaya and vinegar juice).

Conclusion: It can be concluded that adding 10% papaya leaves powder to the feed of the spent layer hens had a positive effect on their meat tenderness. Wrapping the spent layer hens' meat with fresh papaya leaves for one hour before cooking increased its level of tenderness. Papaya leaves juice or extract and vinegar had lower effect on tenderness compared with papaya leaves. Moist cooking had greater effect on tenderness compared with oven cooking using all marinades. Application of marinades one hour before cooking was enough for meat tenderization.

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