Vol. 17(7), pp.1003-1007, July, 2021
DOI: 10.5897/AJAR2021.15469
Article Number: B9120F367233
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

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African Journal of Agricultural Research

Full Length Research Paper

Antioxidant activity of *Capsicum frutescens* and its effect on sensory and carcass traits of local chickens

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Received 24 Janaury, 2021; Accepted 30 April, 2021

This study determined the antioxidant activity of *Capsicum frutescens* powder and its effect on sensory and carcass characteristics of local chickens fed with either cotton seed cake or sunflower seed diets for thirty seven days. The birds were randomly assigned to four dietary treatments (0, 1.1, 2.2 and 4.4%) of *C. frutescens* powder. For cotton seed cake diets, 15 birds were replicated thrice per treatment whereas the replication was twice for sunflower seed cake diets. The antioxidant activity scores based on 1,1-diphenyl-2-picryl-hydrazyl (DPPH•) radical scavenging activity at concentrations 100, 200, 400, and 500 µg/ml were 17.1, 20.8, 29.8, and 33.3%, respectively. Further, sunflower diets with 2.2% inclusion level increased carcass yield with respect to heart weight (4 g, p=0.01), proventriculus weight (4.25 g, p=0.02) and intestine weight (82.5 g, p=0.01). In contrast, no improvement but negative effects were observed when *C. frutescens* was included in cotton seed cake diets. Furthermore, results showed that none of the inclusion levels of *C. frutescens* had an effect on texture, taste, juiciness and overall acceptability of chicken meat. This study suggests that the carcass yield of local chicken can be improved through including *C. frutescens* at a level of 2.2% in diets constituted with sunflower seed cake.

Key words: Flavor, taste, texture, performance, sunflower.

INTRODUCTION

Chicken production has highly increased globally, rising by 25% in the last decade with Africa and Asia accounting for more than three quarters of this increase (FAO, 2019). From 2007 to 2017, the global numbers of chickens are estimated to have risen from 18.3 to 22.8 billion whereas in Africa the number rose from 1.5 to 1.9 billion (FAO, 2019). Over the same period, the chicken population in Uganda rose from 37.4 to 39.2 million (Uganda Bureau of Statistics, 2020). Further, in Uganda, between 2015 and 2050, chicken production is projected to rapidly increase by more than 400 percent and most chicken will be likely kept in intensive (60%) and semi-intensive (30%) production systems in and around urban centers to serve the meat demands of the 44 percent of the total country population who will live in urban areas (FAO, 2019). Consequently, in Uganda, the per capita

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consumption of chicken meat is expected to increase from 0.8 to 6.5 kg in 2050 (FAO, 2019). Local chicken constitute nearly 80% of Uganda's poultry industry (Katongole et al., 2011, 2012; Mwesigwa et al., 2015). Though slow-growing, the production of such chickens under intensive systems is on the increase especially in urban and peri-urban areas in Uganda despite the challenges including heat stress and diseases such as Newcastle, coccidiosis and necrotic enteritis due to pathogenic bacteria like *Clostridium perfringens* (Nabukenya et al., 2014). Similar challenges have been addressed elsewhere using spices such as cinnamon and oregano with high antioxidant activity as feed additives leading to increased performance (Zeng et al., 2015; Yin et al., 2017; Attia et al., 2019; Torrent et al., 2019). Particularly, spices with high antioxidant activity mitigate heat stress which is prevalent in high temperature environments and can lead to decrease in carcass yield (Torrent et al., 2019).

In Uganda, *Capsicum frutescens* is among the spices locally available and easily accessible for occasional medicinal use by chicken farmers (Bukenya-Ziraba and Kamoga, 2007; Nalubega et al., 2012). Capsicums can potentiate activities of pancreatic and intestinal enzymes, increase bile acid secretion and body weight as well as enhance resistance to enteric diseases such as coccidiosis and necrotic enteritis in chickens (Puvaca et al., 2015; Lillehoj et al., 2018). Based on its wide range of beneficial phytochemicals, capsicum products have been integrated into the first commercially approved botanical feed additive for improving performance in broilers and livestock in the EU (Lillehoj et al., 2018). However, Capsicum use as a feed additive has not yet been adopted and this could be attributed to lack of a standard procedure to guide farmers on how to incorporate it in the chicken diets in Uganda. This study, therefore, determined the antioxidant activity of *C. frutescens* powder and its effect on sensory and carcass characteristics of local chickens. Specifically, the study aimed at identification of appropriate inclusion levels for *C. frutescens* that would result in positive benefits with respect to sensory and carcass characteristics of local chickens.

MATERIALS AND METHODS

Measurement of antioxidant activity of *C. frutescens*

The antioxidant activity of *C. frutescens* was estimated following a modified assay as described by Park et al. (2015). Specifically, this assay involved determining the 1,1-diphenyl-2-picryl-hydrazyl (DPPH) free radical scavenging activity of the samples. L-ascorbic acid was used as the positive control and then diluted to obtain five different concentrations. A quantity of sample (10 µl) and standard were mixed with DPPH solution (100 µl, 0.2 mM DPPH in dimethyl sulfoxide). The mixture was then incubated at 37°C for 30 min. The absorbance was measured by a spectrophotometer (Spectro UV-VIS AUTO PC Scanning Spectrophotometer; LabMed Inc, USA) at 755 nm. The inhibition percentage was calculated from the following equation: Inhibition % = ([absorbance of control – absorbance of sample])/absorbance of control) × 100.

Management of experimental chicken

Experimental local chickens were purchased from commercial suppliers and raised at Makerere University Agricultural Research Station, Kabanyolo (MUARIK). The chickens were vaccinated against New Castle Disease and Gumboro following recommended veterinary schedule. The chickens' diets were formulated on site using maize bran, table salt, cotton seed cake, Vitamin Premix, snail shells and fish(*Rastraneobola argentea*) as ingredients purchased from single supplier to ensure consistency of quality. The chickens had access to water and feed *ad libitum*. The feed ingredients were subjected to nutrient analysis at the Nutrition Laboratory at the College of Veterinary Medicine Animal Resources and Biosecurity, Makerere University. The chickens' starter diets were composed of maize bran (55%), cotton seed cake (26%), fish (15%), shells (3%), table salt (0.5%) and Vitamin Premix (0.5%). From the brooder, at 60 days of age, three hundred chickens were randomly assigned to twenty pens. Chickens in twelve pens were fed grower diets composed of maize bran (58%), cotton seed cake (30%), fish (8%), shells (3%), table salt (0.5%) and Vitamin premix (0.5%) whereas those in eight pens were fed similar grower diet but using sunflower seed cake as major source of lipids instead of cotton seed cake. With effect from 199 days of age, grower diets with 0.0, 1.1, 2.2 and 4.4% inclusion levels of *C. frutescens* powder were given to chickens from twelve pens on cotton seed cake diets (15 birds per inclusion level replicated thrice) and from eight pens on sunflower seed cake diets (15 birds per inclusion level replicated twice). The diets with *C. frutescens* were offered to the chickens for 37 days.

Measurement of body weight and carcass characteristics

The live body weights of the chickens were determined at 236 days of age after completing twelve hours of starvation. Thereafter, the chickens were humanely slaughtered. The slaughter process involved killing by neck cutting with a sharp knife after cervical dislocation to minimize pain. The weights of the eviscerated carcass, heart, liver, proventriculus and intestines were also taken.

Evaluation of organoleptic characteristics

Four sensory characteristics in addition to overall acceptability of local chickens' meat were considered. The characteristics were: texture, taste, juiciness and flavour. One hundred twenty breast meat samples were obtained from chickens from eight treatment groups (15 per group); four groups included chickens raised on cotton seed cake-based diets whereas the other four were from chickens raised on sunflower seed cake based diets. The breast meat samples were heated in the oven at temperatures in range of 170-180°C for one and half hours. Thereafter, the samples were coded and presented to a ten-person consumer panel with instructions of rinsing their mouths prior to chewing a sample and thereafter assign a score based on a hedonic scale ranging from 1-9 in the direction of increasing preference.

Statistical data analysis

Descriptive statistics were produced for live body weight and carcass characteristics using R software (R Core Team 2019). Further, the effects of inclusion levels on the different characteristics were determined using a One-Way Analysis of

Table 1. Mean weight of body, carcass and internal organs of chickens at different inclusion levels of *C. frutescens* powder in cotton seed cake-based diets.

Parameter	Inclusion level (%)				SEM	p
	0	1.1	2.2	4.4		
Body weight (g)	1041[a]	1042[c]	1012	913[b]	17.7	0.03
Carcass weight (g)	661	658	636	592	11.5	0.13
Heart weight(g)	3.67[a]	3.77[b]	2.97[c]	3.87[d]	0.0922	0.002
Liver weight (g)	14.7	12.8	13.3	13.9	0.285	0.09
Proventriculus weight (g)	3.77	3.8	3.7	4.23	0.104	0.25
Gizzard weight (g)	29.7	28.1	27.5	27.7	0.521	0.45
Intestinal weight(g)	79.4[a]	75.9	79.5[b]	65.8[c]	1.49	0.003

[abcd] Means in the same row without common letter are different at P<0.05.

Variance (ANOVA) approach and the treatment effects different from each other were identified by Tukey's HSD statistical test using R software (R Core Team 2019). The significance level for all tests was 0.05. The scores for organoleptic characteristics were subjected to a Wilcoxon Rank-Sum test using R software. For each organoleptic parameter, the scores from samples obtained from chickens on diets with *C. frutescens* were compared against those from the control chickens.

RESULTS AND DISCUSSION

Antioxidant activity of *C. frutescens* powder

The antioxidant activity levels for four concentrations of *C. frutescens* extracts were determined. At a concentration of 100 µg/ml the antioxidant activity level was 17.1% and this rose to 33.3% when a concentration of 500 µg/ml was used. At concentrations of 200 and 400 µg/ml, the antioxidant activity levels were 20.8 and 29.8% respectively. Antioxidants are known for improving health and growth in livestock and enhancing quality of livestock products through affecting antioxidant enzyme activity of glutathione peroxidase and reducing thiobarbituric acid reactive substance values (Park et al., 2015; Luna et al., 2019).

Comparative studies on antioxidant activity have shown that at concentrations of 100 and 500 µg/mL, the antioxidant activity levels are 9.52 and 17.2% respectively for oregano, which makes oregano have higher antioxidant capacity than tocopherol but lower antioxidant capacity than ascorbic acid (Park et al., 2015; Jalal et al., 2018).

This reveals that the antioxidant activity of *C. frutescens* is higher than that of oregano and tocopherol commonly used in chicken diets. Therefore, *C. frutescens* should also be acceptable for use as an antioxidant in feeds with potential to improve health, growth as well as meat quality of chicken. Specifically, this study further investigated the effect of *C. frutescens* inclusion in diets on body weight, carcass and sensory characteristics of local chicken.

Effect of *C. frutescens* on body weight, carcass and sensory characteristics

Body weight and carcass characteristics

The effect on body weight was observed only when *C. frutescens* was included at 4.4% in diets with cotton seed cake resulting in a reduction of body weight (918, p=0.05) by 12% relative to the control (Table 1). Further, cotton seed cake diets with 4.4% inclusion level reduced the mean weights of intestines (65.8 g, p=0.006) by 17% relative to the control (Table 1). Further still, cotton seed cake diets with 2.2% inclusion level decreased the mean heart weight (2.97 g, p=0.03) by 19% relative to the control (Table 1). Similar negative effects on body weight have been reported at 25% inclusion level for ginger rhizome and 6 g/kg for ginger powder (Shewita and Taha, 2018; Helen et al., 2020).

For the case of diets with sunflower seed cake, positive effects were observed with respect to mean weights of intestines, proventriculus and heart (Table 2). The mean intestine weight was increased by 26 and 21% by 1.1% inclusion level (85.4 g, p=0.001) and 2.2% inclusion level (82.5 g, p=0.01) relative to the control, respectively (Table 2). Further, the 2.2% inclusion level increased the mean heart weight (4 g, p=0.01) by 38% relative to the control (Table 2). Furthermore, the 2.2% inclusion level increased the mean weights of proventriculus (4.25 g, p=0.02) by 25% relative to the control (Table 2). This study established that *C. frutescens* has relatively high antioxidant activity and has capacity to improve carcass yield of local chickens when used at 2.2% inclusion level in sunflower seed cake-based diets. Thus, *C. frutescens* can be recommended as an alternative feed additive for use in intensive local chicken production systems in Uganda to mitigate heat stress and increase growth as well as carcass yield.

Sensory characteristics

In this study, no differences were observed when meat

Table 2. Mean weight of body, carcass and internal organs of chickens at different inclusion levels of *C. frutescens* powder in sunflower seed cake-based diets.

Parameter	Inclusion level (%)				SEM	p
	0	1.1	2.2	4.4		
Body weight (g)	1263	1219	1204	1213	22.7	0.81
Carcass weight (g)	673	665	718	627	14.7	0.18
Heart weight(g)	2.9[a]	3.15[c]	4[b]	3.6	0.125	0.01
Liver weight (g)	13.4	13.8	15.3	13.7	0.327	0.15
Proventriculus weight (g)	3.4[a]	3[b]	4.25[c]	3.6	0.112	<0.001
Gizzard weight (g)	29.8	29.6	31.1	28.2	0.682	0.571
Intestinal weight(g)	68[a]	85.4[b]	82.5[c]	71.4[d]	1.77	<0.001

[abcd] Means in the same row without common letter are different at P<0.05.

Table 3. Mean ranks of sensory traits.

Parameter	Cotton seed cake diet				Sunflower seed cake diet			
	Inclusion level				Inclusion level			
	0%	1.1%	2.2%	4.4%	0%	1.1%	2.2%	4.4%
Texture	5.55	4.76	6.41	6.52	6.38	6.25	6.45	6.65
Taste	6.03	5.57	6.73	6.63	6.15	6.05	5.95	6.50
Juiciness	5.67	4.33	6.27	6.26	6.08	5.75	5.68	6.15
Flavor	6.11	5.48	6.78	6.74	6.08	5.95	5.95	6.35
Overall acceptability	5.61	4.95	6.97	6.56	6.23	6.30	5.91	6.70

samples from the non-control groups were compared to those from the control group as shown in Table 3. Phytogenics with antioxidant activity have the capacity to enhance the shelf life and quality characteristics of chicken skin and meat (Naser et al., 2017; Yang et al., 2020). For example, a combination of extracts from *Mentha arvensis* and *Geranium thunbergii* was reported to enhance flavor, texture, acceptability and shelf life of chicken meat (Yang et al., 2020) whereas extracts from turmeric were observed to cause slight yellow skin pigmentation without change in chicken meat color (Johannah et al., 2018).

Importantly, *C. annuum* was observed to influence sensory characteristics of chicken meat including pigmentation of chicken skin and egg yolk (Abou-Elkhair et al., 2018; European Food Safety Authority, 2020; Tashla et al., 2020).

However, for all the five sensory characteristics considered in this study, no differences were observed when meat samples from the non-control groups were compared to those from the control group as shown in Table 3. This was observed in meat samples from both cotton-based and sunflower-based diets. This suggests that the ability of *C. frutescens* powder to influence sensory characteristics (taste, chewiness, softness, juiciness, overall acceptability) may differ from that of other phytogenics including *C. annuum.*

Conclusion

(i) The antioxidant activity levels of *C. frutescens* at concentrations 100, 200, 400, and 500 µg/ml were 17.1, 20.8, 29.8, and 33.3%, respectively.
(ii) *C. frutescens* had no effect on texture, taste, juiciness and overall acceptability of chicken meat.
(iii) *C. frutescens* should be used as feed additive at 2.2% level in diets with sunflower seed cake for local chickens aged 199 days for a duration of 37 days in order to increase carcass yield.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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