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Sensory Characteristics and Skin Color Evaluation of Meat from Broiler Chickens Fed Sweet Potato Root Meal

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Abstract
The feed consumed by broilers have a direct impact on the nutritional and physical properties of the meat produced. Most livestock diets are formulated using corn as the major energy ingredient; however, with the diversion of corn to ethanol production, alternative ingredients are being studied. This study utilized sweet potato root meal (**SPRM**) as partial replacement for corn in the diet of broilers to determine its effect on meat color and consumers' sensory perception. Rations were formulated replacing 0%, 10%, 20%, and 30% of corn. Three hundred and sixty 1-day-old Cornish Rock male broiler chickens were fed diets ad libitum for 49 days and slaughtered on day 50. Breast, leg, and thigh were evaluated for skin color (L* (lightness), a* (redness), b* (yellowness)) and sensory attributes. Sixty two consumer panelists evaluated meat for juiciness, tenderness, flavor, and acceptability. Results showed a* and b* in leg were not different among treatments, however, L* was lowest ($P < 0.02$) in the 20% diet. Thigh and breast showed no color differences among treatments. Sensory attributes were not affected by income, gender, age, or education status for dark meat. Those earning <$10,000 found 20% SPRM white meat less juicy and tender ($P < 0.05$). Males had similar scores for tenderness, flavor, and acceptability of white meat, however; 20% diet was less ($P < 0.04$) juicy. Females found meat from the 20% diet less tender ($P < 0.03$), less juicy ($P < 0.01$), less flavorful ($P < 0.03$), and less acceptable ($P < 0.02$) than the other diets. Those with and without a college degree found white meat from 20% diet less juicy ($P < 0.02$), while those without a college degree scored low for tenderness and acceptability ($P < 0.004$). The 18 – 29 year olds rated white meat from 20% diet less tender ($P < 0.03$), less juicy ($P < 0.03$), and acceptable ($P < 0.001$). The SPRM could be an acceptable alternative to corn in broiler diets.
Keywords: Broiler, Sweet potato root meal, Sensory evaluation, Skin color

1. Introduction

Corn is one of the major energy ingredients in poultry diets. However, over the past several years, corn has been diverted to ethanol production causing an increase in corn prices leading to higher prices for feeds (Welch, 2011). This situation has created an opportunity for researchers to evaluate alternative ingredients that can be substituted for corn and provide the same, if not better quality, of the meat produced. The feed consumed by broilers has a direct impact on the physical properties of the meat produced (Bavelaar and Beynen, 2003). These properties include, but are not limited to, color and sensory properties (flavor, juiciness, tenderness) which influences consumers' decision to purchase the meat. Consumers expect meat to be healthy, nutritious, tender, and have a typical flavor (Ruiz et al., 2001), therefore, it is necessary to ensure that ingredients fed to broilers are of the best quality, ensuring that the meat products meet these expectations.

It is often said that color is important for both the consumer's initial selection of a raw meat product in the marketplace and for the final evaluation and ultimate acceptance (Fletcher, 1999; Ponsano et al., 2004). According to Qiao et al. (2002) and Petracci and Fletcher (2002), color and uniformity of poultry skin and meat, and consistency of color, are important attributes by which consumers select poultry products, and how they assess the final quality of the product at consumption. Color of poultry skin is provided by carotenoid pigments present in the diet that are deposited in the skin and subcutaneous fat. Carotenoids are a group of more than 500 pigments spread throughout the plant and animal kingdom (Vendrell et al., 2001). They include xanthophyll, beta-carotene, capsanthin, canthaxanthin, and lutein, to name a few. These pigments cannot be synthesized by poultry but can be transformed and metabolized, therefore, they must be obtained from the diet (Liu et al., 2008). They can be found naturally in feed ingredients such as yellow corn, alfalfa meal, and marigold flowers and/or meal (Froning, 1995).

Utilization of these compounds depends on the health and genetics of the bird, and availability of the compounds. Some carotenoids act as antioxidant and precursors for vitamin A; therefore, they play an important role in disease prevention (Burton, 1989). Unhealthy birds use these compounds to fight against diseases, while healthy birds absorb pigments from their diet, which are transported in blood to the subcutaneous fat tissues and skin, where they are stored (Tyczkowski et al., 1991). Hence, consumers are of the perception that birds with a heavily pigmented skin are healthier than those with a lighter pigmentation.

Sensory evaluation is a process used to measure, analyze, and interpret human responses to food products. Their perception occurs through their senses of touch, taste, sight, smell and sound (Meilgaard et al., 1999). This allows one to understand consumers' reactions to a new or existing product. It is important to

measure the sensory characteristics of a new or modified product since consumers' acceptance is driven mainly by the quality of the product (Chapman et al., 2001). Consumer preference and acceptability of foods is based on a number of factors including appearance, color, juiciness, and tenderness (Droval et al., 2012). Their choice may be influenced by factors such as age, gender, income, and ethnicity (Glanz et al., 1998; He et al., 2003). An individual's perception of texture and flavor changes as they get older, as taste and olfactory functions are shown to decrease with aging and difficulties in texture perception may occur (Fillion and Kilcast, 2001). Therefore, because there is a decrease in taste function with age, older individuals may prefer higher taste concentration than younger individuals (Zandastra and de Graff, 1998). Similarly, education and socioeconomic levels may play a role in an individual's sensory perception. Szczeniak (1990) suggests that higher socio-economic class is usually related to a greater degree of schooling. This may be related to level of exposure to different experiences and different foods. Hence, these individuals may have a better understanding of the parameters being evaluated. Therefore, a sensory evaluation must take these factors into consideration.

Sweet potato (*Ipomoea batatas* L. Lam) is a root crop that is produced in more than 100 countries with an annual production of more than 100 million metric tons and is one of the most important food crops in developing countries (Scott, 1992). Different sweet potato cultivars vary in nutrient content and also flesh color. Colors include orange, white, purple and yellow. The roots, leaves and vines of the sweet potato have been evaluated in poultry and other livestock diets with conflicting results. The roots are a rich source of natural pigment, ß-carotene, while the foliage is rich in xanthophyll. Thus, sweet potato is not only an important food for humans, but also for poultry (Kaya and Yildirim, 2011). Studies indicated that the yellow, dark (purple) or orange flesh sweet potato cultivars contain between 80 and 90% beta carotene (Kays and Wang, 2002). According to Burgos et al. (2001), the beta carotene content of orange flesh sweet potato ranges from 4.29 mg/100g to 18.55 mg/100g. This characteristic of sweet potato makes it possible to influence the pigmentation of the chicken meat. Some studies have been conducted utilizing sweet potato meal in the diet of broilers; however, the literature mostly reports on the feeding of the sweet potato leaves and vines and its effect on egg yolk and broiler skin. Garlich et al. (1974) reported that sweet potato leaves and vines have been shown to enhance the yellow pigmentation of broiler skin and egg yolks.

Very little information is available on the effect of the sweet potato root meal on color of broiler skin and meat sensory properties. Therefore, the objective of this experiment was to evaluate the effect of replacing different levels of sweet potato root meal (SPRM) for corn on skin color and sensory properties of white and dark meat of broiler chickens.

2. Methods and Procedures

2.1 Experimental Diet Preparation

Discarded orange flesh sweet potato roots from the Tuskegee University Small Model Farm were collected, dried and processed into a meal. The SPRM was then analyzed for nutrient composition. Based on the results of the nutrient analysis, starter, grower, and finisher rations were formulated according to NRC (1994) requirements for broiler chickens, using SPRM to replace 0, 10, 20, and 30% of the corn in the diet (Table 1). The SPRM was also analyzed for beta carotene (AOAC, 2005) and ranged from 4.53 mg/100 kg to 8.32 mg/100 kg.

2.2 Experimental Animals and Treatments

This study is part of a larger experiment where 360 1-day-old Cornish Rock male broiler chickens (Murray McMurray Hatchery, 191 Closz City, Webster City, IA 50595) were utilized. The birds were wing-banded, weighed, and randomly assigned to one of four dietary treatments; 0% SPRM (control), 10% SPRM, 20% SPRM, and 30% SPRM.

2.3 Experimental Procedure

The study was conducted over a 49 day period utilizing the four treatments mentioned above. Each treatment was replicated three times (30 birds per replication = 90 birds per treatment). There was no restriction on feed and water consumption. Feed intake and body weight were recorded weekly. On day 50, the birds were sacrificed and carcass separated into quarters. A subsample of 15 birds from each treatment were randomly selected and used for the skin color evaluation (n=60) before the rest of the carcasses were vacuum sealed and placed in the freezer for further analyses. Six birds from each treatment were randomly selected for sensory evaluation (n=24).

Table 1. Composition of Experimental Rations

Ingredients	[1]Diets (%)											
	Starter Ration				Grower Ration				Finisher Ration			
	0	10	20	30	0	10	20	30	0	10	20	30
Corn, ground yellow (8.7%)	56.19	48.49	42.06	35.74	61.17	54.25	47.03	39.97	70.87	62.39	54.35	46.37
Soybean Meal (49%)	37.07	37.62	37.97	38.35	32.21	32.47	32.82	33.26	24.22	24.78	25.10	25.66
SPRM	-	5.39	10.52	15.32	-	6.03	11.76	17.13	-	6.93	13.59	19.88
Fat	3.80	5.23	6.27	7.35	3.40	4.40	5.59	6.79	1.68	2.97	4.23	5.53
Dicalcium phosphate	0.19	0.32	0.48	0.49	1.03	0.39	0.19	0.38	1.49	0.92	0.90	0.90
Limestone	0.26	0.36	0.29	0.25	0.28	0.70	0.60	0.40	1.10	1.42	1.20	1.10
Salt	0.35	0.35	0.36	0.37	0.26	0.28	0.19	0.20	0.33	0.34	0.34	0.35
Vitamin premix[2]	0.20	0.30	0.25	0.26	0.15	0.12	0.12	0.14	0.16	0.16	0.16	0.16
Methionine (99%)	0.14	0.13	0.14	0.14	0.06	0.06	0.11	0.11	0.09	0.04	0.08	0.08
Coban 90	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-	-
Trace Mineral	0.10	0.12	0.01	0.08	0.09	0.07	0.08	0.11	0.09	0.04	0.08	0.08
Defluorinated phosphorus	1.69	1.68	1.65	1.64	1.39	1.20	1.50	1.50	-	-	-	-
Calculated Nutrient Composition												
CP (%)	23.00	23.00	23.00	23.00	21.00	21.00	21.00	21.00	18.00	18.00	18.00	18.00
Fat (%)	6.29	7.46	8.29	9.16	6.04	6.82	7.77	8.73	4.64	6.00	6.65	7.69
ME (kcal/kg)	3175	3175	3175	3175	3197	3197	3197	3197	3197	3197	3197	3197
Calcium (%)	1.00	1.00	1.00	1.00	0.92	0.91	0.94	0.92	0.89	1.00	0.82	0.81
Sodium (%)	0.22	0.22	0.22	0.22	0.17	0.17	0.15	0.15	0.14	0.16	0.14	0.14
Methionine (%)	0.50	0.50	0.50	0.50	0.40	0.42	0.44	0.44	0.39	0.35	0.37	0.37
Ca/P (%)	2.22	2.22	2.22	2.22	2.42	2.54	2.25	2.20	2.24	2.84	2.75	2.65

[1]Diets = 0% Sweet potato root meal (SPRM); 10% SPRM; 20% SPRM; 30% SPRM.

[2] Supplied per kg of diets: Copper, 8 mg; Iodine, 0.4 mg; Iron, 100 mg; Selenium, 0.3 mg; Vitamin A (retinyl acetate), 4540 IU; Vitamin D_3, 1543 IU; Vitamin E, 15.4 IU; Choline, 284 mg; Niacin, 34 mg; d-Pantothenic acid, 5.7 mg; Riboflavin, 3.4 mg; Menadione, 0.85 mg; Vitamin B_{12}, 0.01 mg; Biotin, 0.1 mg; Folic acid, 0.5 mg; Thiamine, 0.6 mg.

2.4 Skin Color Evaluations of 'dark meat' and 'white meat' from broilers fed different levels of sweet potato root meal

The skin color of meat samples from each treatment were determined using a Konica Minolta CR-300 Chromameter (Konica Minolta Sensing America, Inc., 101 Williams Dr., Ramsey, NJ 07446) and is reported according to the CIELAB (Commission Internationale de Enluminure) system values of L*, a*, and b* (CIE, 1978). Leg and thigh samples (dark meat), and breast samples (white meat) of five birds from each replication (15 samples/treatment x 4 treatments- n=60) were randomly selected and analyzed for skin color on the day of slaughter. Readings were obtained on fresh meat samples immediately after slaughter. The Chromameter was calibrated after each reading by using a standard white ceramic tile. The color measurements were carried out by taking the average of three readings from each sample. Readings were taken from parts of the meat that had no bruises, and with the skin intact.

2.5 Sensory Evaluation of 'dark meat' and 'white meat' from broilers fed different levels of sweet potato root meal

The protocol for this evaluation was approved by the Tuskegee University Human Participant Review Committee. Sensory evaluation was carried out on dark meat and white meat separately. Samples were randomly selected from two birds per replication from each of the four treatments (6 birds/treatment x 4 treatments - n=24). They were removed from the freezer and allowed to thaw in the refrigerator overnight. The meat samples were placed in aluminum pans covered with aluminum foil and cooked with skin on in a convection oven at 176.7°C until the meat reached an internal temperature of 73.9°C. The temperature of each sample was determined using a meat thermometer that was placed in the thickest part of the meat. When the desired internal temperature was obtained, the samples were removed from the oven and allowed to cool to room temperature. The skin was removed from the meat samples before they were cut into half inch cubes. Volunteers from the Tuskegee University population were invited to serve on the untrained consumer taste panel and included students, faculty, and staff. Sixty two untrained consumer panelists responded and were asked to provide demographic information (age, education level, income and gender) at the top of the page on the evaluation forms. They were asked to taste samples of dark meat and white meat from the same birds from each treatments (4 samples for dark and 4 for white meat from the 4 treatments- n=8). The samples were number-

coded and participants were asked to conduct the evaluation in chronological order based on the numbers on the sample cups and on the evaluation forms. In this way bias was eliminated since only the researcher knew what the samples were. They were offered all samples at the same time and were given instructions on the evaluation process. Samples were evaluated based on juiciness, tenderness, flavor and acceptability on a 9-Point Hedonic scale (9- like extremely, 8- like very much, 7- like moderately, 6- like slightly, 5- neither like nor dislike, 4- dislike slightly, 3- dislike moderately, 2- dislike very much, 1- dislike extremely. Participants were provided with bottled water and were asked to cleanse their palate before and between samples.

2.6 Statistical Analysis

The experimental design was a Complete Randomized Design with four treatments and three replications per treatment. The data were analyzed using the PROC Mixed procedure of SAS (SAS Insti., Inc., Cary, NC). Where ANOVA showed significance, means were separated using Duncan's Multiple Range test (Steele and Torre, 1980). For sensory data, where f-test indicated significant differences, Tukey's test was used for means separation.

3. Results and Discussion

3.1 Color Ratings

Not only is it important to evaluate broilers based on their performance, it is very important that the quality of the meat they produce be evaluated (Poste, 1990). The quality of chicken meat can be determined based on various parameters including the color and sensory attributes.

Results reported in Tables 2, 3, and 4 shows L*, a*, and b* values of leg, thigh, and breast, respectively, from broiler chickens fed different levels of SPRM. The L* values represent the lightness and is reported numerically on a scale of 100 to 0, where 100 is white and 0 is black. The L* values for leg (Table 2) were similar for the 0% (69.99), 10% (69.27), and 30% (67.90) SPRM diets, however, the 20% diet was lower ($P<0.02$) (65.71) than the 0% and 10% and not different from the 30% diet. The a* values represent the redness of the meat and ranges from green (-ve a*) to red (+ve a*) on the color spectrum, while the b* values represents the yellowness of the meat and ranges from blue (-ve b*) to yellow (+ve b*) and both were did not differ among treatments. There were no differences for L* a* b* values for the thigh or the breast among the treatments (Tables 3 and 4).

Table 2. Color rating of leg from broilers fed different levels of sweet potato root meal

Diets (%)[1]	Skin Color (Leg)		
	L*	a*	b*
0	69.99[a]	2.21	5.71
10	69.27[a]	2.76	6.48
20	65.71[b]	2.83	4.29
30	67.90[ab]	2.74	5.75
SEM	0.78	0.42	0.54

[ab] Means with the same superscript within columns are not significantly different at the 5% level of P as determined by Duncan's Multiple Range Test.

[1]Diets = 0% Sweet potato root meal (SPRM); 10% SPRM; 20% SPRM; 30% SPRM.

L* = lightness; a* = redness; b* = yellowness.

Data from 15 chickens per treatment: (n-60).

Table 3. Color rating of thigh from broilers fed different levels of sweet potato root meal

Diets (%)[1]	Skin Color (Thigh)		
	L*	**a***	**b***
0	69.64	1.73	6.61
10	66.64	2.10	6.21
20	62.80	2.93	5.80
30	64.87	1.76	5.06
SEM	2.46	0.32	0.77

[1]Diets = 0% Sweet potato root meal (SPRM); 10% SPRM; 20% SPRM; 30% SPRM.

L* = lightness; a* = redness; b* = yellowness.

Data from 15 chickens per treatment: (n-60).

Table 4. Color ratings of breast from broilers fed different levels of sweet potato root meal

Diets (%)[1]	Skin Color (Breast)		
	L*	a*	b*
0	62.50	3.30	8.68
10	61.81	3.05	6.76
20	57.34	3.55	5.90
30	56.87	2.98	5.62
SEM	1.65	0.87	0.77

[1]Diets = 0% Sweet potato root meal (SPRM); 10% SPRM; 20% SPRM; 30% SPRM.
L* = lightness; a* = redness; b* = yellowness.
Data from 15 chickens per treatment: (n-60).

Although there are reports of feeding sweet potato meal to livestock, to date, there has not been any reported information on its effect on color characteristics of meat including broiler meat. Therefore, this manuscript could serve as a reference for future studies using this product.

3.2 Demographic Characterization of Sensory Panel

Table 5 shows the demographic characteristics of the untrained consumer panelists that participated in the sensory evaluation of meat from broilers fed different levels of SPRM. Originally, there were more levels in the age, income and education categories but due to a low number of respondents in some levels, the data were combined and reported as shown in Table 5. Of the 62 participants, 53% were males while 47% were females. Consumers between the ages of 18 - 29 years accounted for the largest percentage (70%). Those who were 30-59 years made up 19%, while 9% were over 60 years old. The <$10,000 income group constituted the highest level (60%) of the respondents, 15% earned $10,000- $60,000, while 18% of the respondents were in the >$60,000 category. Fifty three percent of the respondents did not have a college degree (meaning they did not yet completed their degree), while 47% already completed their degree (s), (meaning they already completed one or more degrees) Two percent of the participants did not respond (NR) to the age category and 7% did not respond to the income level.

Table 5. Demographic Characterization of Consumer Sensory Panel

Gender	%	Age (years)	%	Income ($)	%	Education	%
Male	53	18-29	70	<10,000	60	No College degree	53
Female	47	30-59	19	10,000-60,000	15	College degree	47
		>60	9	60,000>	18		
		NR	2	NR	7		

NR: No Response

3.3 Effect of Respondents' Income Level on Sensory Attributes of 'Dark Meat' and 'White Meat'

Table 6 shows the sensory rating of dark meat from broilers fed SPRM based on the respondents' income. There were no significant differences among respondents of all income levels for overall preference of dark meat based on tenderness, juiciness, flavor, and acceptability among all diets. However, rating values indicated that respondents generally found the meat samples from all treatments to be ' slightly' to 'moderately' tender, juicy, flavorful, and acceptable, with scores ranging from an average of more than 5 to more than 7. James and Berry (1997) indicated that consumer sensory scores of 5.5 was used by the U. S. Army to indicate that a characteristic has reached a minimum level of acceptance. Although the preceding authors were referring to chevon, the same reference has been applied to other meats including broiler meat that uses the same 9-Point Hedonic scale.

Table 6. Sensory rating of Dark meat from broilers fed different levels of Sweet potato root meal based on respondents' income

Income	Diets (%)[1]	Tenderness	Juiciness	Flavor	Acceptability
<$10,000	0	7.00	6.89	6.30	6.59
	10	6.86	6.65	6.68	6.81
	20	7.03	6.51	6.43	6.68
	30	7.24	7.38	6.46	6.73
		0.27	0.31	0.32	0.31
SEM					
$10,000- 60,000	0	6.78	6.56	6.22	6.78
	10	7.00	6.00	6.78	6.78
	20	7.52	7.44	7.11	7.00
	30	7.44	7.78	7.56	7.89
		0.56	0.62	0.64	0.64
SEM					
$60,000>	0	5.91	5.82	5.36	5.36
	10	6.55	6.82	6.27	6.09
	20	6.91	7.09	6.82	6.64
	30	7.82	7.45	6.73	6.82
		0.50	0.56	0.58	0.58
SEM					

[1]Diets = 0% Sweet potato root meal (SPRM); 10% SPRM; 20% SPRM; 30% SPRM
Hedonic scale=9 extremely tender, juicy, flavorful, acceptable, to 1-extremely tough, dry, disliked, unacceptable
Data from 6 chickens per treatment: (n-24).

The effect of income level on the sensory perception of 'white meat' is shown in Table 7. There was no difference among treatments except for juiciness in the <$10,000 income level, with 20% SPRM showing the lowest ($P<0.05$) scores (5.19) compared to the other diets with scores of 6.41, 5.62, and 6.81 for the 0%, 10% and 30% diets, respectively. Similar to the response to dark meat mentioned above, the sweet potato diets received similar or higher scores than the control diet indicating that the meat from the SPRM diets compared well with meat from birds fed a traditional diet that consumers are already accustomed to eating.

Table 7. Sensory rating of White meat from broilers fed different levels of sweet potato root meal based on respondents' income level

Income	Diets (%)[1]	Tenderness	Juiciness	Flavor	Acceptability
<$10,000	0	6.41[ab]	5.68[a]	5.59	5.70
	10	5.62[ab]	5.78[a]	5.19	5.30
	20	5.19[b]	3.92[b]	4.62	4.62
	30	6.81[a]	6.65[a]	5.97	6.19
		0.33	0.35	0.34	0.34
SEM					
$10,000-60,000	0	6.44	6.00	6.00	6.44
	10	6.44	5.89	6.89	6.33
	20	5.00	4.11	5.67	5.33
	30	6.78	7.25	7.22	7.11
		0.67	0.75	0.69	0.70
SEM					
>$60,000	0	5.64	5.18	5.45	5.27
	10	6.55	6.45	6.82	6.64
	20	6.00	5.91	6.18	5.82
	30	7.55	7.55	7.45	7.64
		0.60	0.64	0.63	0.63
SEM					

[1]Diets = 0% Sweet potato root meal (SPRM); 10% SPRM; 20% SPRM; 30% SPRM
Hedonic scale=9 extremely tender, juicy, flavorful, acceptable, to 1-extremely tough, dry, disliked, unacceptable
[ab] Means with the same superscript within columns are not significantly different at the 5% level of P as determined by Tukey's procedure. Data from 6 chickens per treatment: (n-24).

3.4 Effect of Respondents' Gender on Sensory Attributes of 'Dark Meat' and 'White Meat'

The sensory rating of dark meat from broilers fed SPRM based on respondents' gender is reported in Table 8.

There were no differences among treatments for tenderness, juiciness, flavor, and acceptability between male and female respondents for dark meat. However, both genders rated the meat as 'slightly' to 'moderately' tender, juicy, flavorful, and acceptable, regardless of diet. Although the results were not significant, both genders rated the sweet potato diets with higher scores in all sensory attributes when compared to the control diet.

Table 8. Sensory rating of Dark meat from broilers fed different levels of Sweet potato root meal based on respondents' gender

Gender	Diets (%)[1]	Tenderness	Juiciness	Flavor	Acceptability
Male	0	6.88	6.88	6.27	6.42
	10	6.73	6.48	6.82	6.79
	20	6.97	6.48	6.09	6.55
	30	7.61	7.55	7.00	7.18
		0.29	0.33	0.34	0.33
SEM					
Female	0	6.55	6.28	5.79	6.24
	10	6.90	6.66	6.41	6.56
	20	7.07	6.86	6.93	6.79
	30	7.14	7.38	6.31	6.76
		0.31	0.35	0.36	0.36
SEM					

[1]Diets = 0% Sweet potato root meal (SPRM); 10% SPRM; 20% SPRM; 30% SPRM
Hedonic scale=9 extremely tender, juicy, flavorful, acceptable, to 1-extremely tough, dry, disliked, unacceptable
Data from 6 chickens per treatment: (n-24).

Table 9 shows the effect of gender on preference of white meat. There was no difference among male respondents for tenderness, flavor, and acceptability of white meat. However, they found the meat from the 30% SPRM diet (6.81) to be juicier ($P<0.01$) than meat from birds fed the 20% SPRM diet. It was observed that the ratings for the 20% diet were lower than the other diets across sensory attributes. Females preferred meat from birds fed the 30% SPRM diet for all attributes. These results were higher ($P<0.03$) than their preference for meat from birds fed the 20% diet. This trend was seen for both males and females where the 20% diet received ratings of 'dislike slightly' to 'like slightly' by males, and 'dislike moderately'; to 'dislike slightly' by females, across sensory attributes. There is no obvious explanation for the dislike of meat from birds fed the 20% SPRM diet. This trend was seen throughout the study where the 20% SPRM diet did not perform as well as the other diets. It has been reported that gender differences in sensory acuity may affect food preferences since women are more sensitive to sweet and salty tastes (Amerine et al., 1965), and to aroma (Gilbert and Wysocki, 1987). Moreover, women are more likely to recognize which foods are healthier by just tasting the foods, and therefore, rate such foods as more pleasurable (Rappoport et al., 1993). Since the consumers did not know the identity of the samples in the current study, it can only be speculated that the females would be more able to detect differences in the taste of different food samples based on the report by Rappoport et al. (1993).

Table 9. Sensory rating of White meat from broilers fed different levels of Sweet potato root meal based on respondents' gender

Gender	Diets (%)[1]	Tenderness	Juiciness	Flavor	Acceptability
Male	0	6.27	5.85^{ab}	5.82	5.79
	10	6.33	6.06^{ab}	6.12	6.00
	20	6.00	4.79^{b}	5.55	5.36
	30	7.03	6.81^{a}	6.30	6.61
SEM		0.34	0.37	0.37	0.36
Female	0	6.28^{a}	5.31^{ab}	5.28^{ab}	5.69^{ab}
	10	5.34^{ab}	5.66^{a}	5.17^{ab}	5.31^{ab}
	20	4.41^{b}	3.69^{b}	4.48^{b}	4.48^{b}
	30	6.79^{a}	6.93^{a}	6.28^{a}	6.52^{a}
		0.36	0.39	0.40	0.39
SEM					

[1]Diets = 0% Sweet potato root meal (SPRM); 10% SPRM; 20% SPRM; 30% SPRM
Hedonic scale=9 extremely tender, juicy, flavorful, acceptable, to 1-extremely tough, dry, disliked, unacceptable
[ab]Means with the same superscript within columns are not significantly different at the 5% level of P as determined by Tukey's procedure. Data from 6 chickens per treatment: (n-24).

3.5 Effect of Respondent's Education Level on Sensory Attributes of Dark Meat' and 'White Meat'

Respondent's educational level on the sensory rating of dark meat is presented in Table 10. The evaluation was

original done with four educational levels, however, since there were low numbers in some categories, they were combined into two categories ('college degree' and 'no college degree') and the data re-analyzed. There were no differences among respondents for dark meat from all four diets. Scores ranged from 'like slightly' to 'like moderately' regardless of diet and sensory attribute.

There were no differences for tenderness and flavor across education levels among treatments for white meat (Table 11). However, respondents in both education categories thought the meat from the 20% SPRM diet was not as juicy ($P<0.03$) as meat from the other diets with scores indicating 'slightly dislike to 'dislike'. Meat from the 20% diet was the least acceptable ($P< 0.01$) among those with no college degree. According to Dogan et al. (2011), people with higher education tend to have greater expectations from functional foods, and will rate them based on prior knowledge of what these foods should taste like. This report does not apply to this study since it was a blind study and the respondents did not know what to expect.

3.6 Effect of Respondent's Age on Sensory Attributes of 'Dark meat' and 'White meat'

Age of respondents did not have a significant effect on any of the sensory attributes for dark meat across treatment groups (Table 12). Scores were in the categories of 'like' to 'slightly like' although those in the 60 and over age group were more on the border of 'neither like nor dislike', especially for meat from diets A and B across sensory attributes.

Table 10. Sensory rating of Dark meat from broilers fed different levels of Sweet potato root meal based on respondents' education level

Education level	Diets (%)[1]	Tenderness	Juiciness	Flavor	Acceptability
No College degree	0	6.91	6.82	6.00	6.52
	10	7.12	6.73	6.94	7.18
	20	7.03	6.64	6.48	6.61
	30	7.15	7.39	6.48	6.79
		0.31	0.35	0.36	0.36
SEM					
College Degree	0	7.14	6.86	6.58	6.71
	10	6.14	5.86	5.86	5.71
	20	7.00	6.71	6.86	7.14
	30	7.43	7.71	6.43	6.86
		0.67	0.77	0.79	0.77
SEM					

[1]Diets = 0% Sweet potato root meal (SPRM); 10% SPRM; 20% SPRM; 30% SPRM
Hedonic scale=9 extremely tender, juicy, flavorful, acceptable, to 1-extremely tough, dry, disliked, unacceptable
Data from 6 chickens per treatment: (n-24).

Table 11. Sensory rating of White meat from broilers fed different levels of Sweet potato root meal based on respondents' education level

Education level	Diets (%)[1]	Tenderness	Juiciness	Flavor	Acceptability
No College degree	0	6.45	5.52^{a}	5.52	5.70^{ab}
	10	5.45	5.30^{ab}	5.24	5.09^{ab}
	20	5.06	3.76^{b}	4.36	4.55^{b}
	30	6.91	6.64^{a}	5.76	6.30^{a}
		0.37	0.39	0.40	0.38
SEM					
College Degree	0	6.33	5.67^{ab}	6.00	6.33
	10	7.83	8.33^{a}	7.67	8.00
	20	4.71	4.00^{b}	5.14	4.71
	30	7.43	7.86^{a}	7.29	7.43
		0.81	0.91	0.86	0.84
SEM					

[1]Diets = 0% Sweet potato root meal (SPRM); 10% SPRM; 20% SPRM; 30% SPRM
Hedonic scale=9 extremely tender, juicy, flavorful, acceptable, to 1-extremely tough, dry, disliked, unacceptable
[ab] Means with the same superscript within columns are not significantly different at the 5% level of P as determined by Tukey's procedure. Data from 6 chickens per treatment: (n-24).

Table 13 shows the sensory rating of white meat from broilers fed different levels of SPRM based on the respondents' age. The 30–59 and 60> year old groups did not show any differences in preference for meat from any of the diets, but the scores showed that they 'slightly like' to mostly like' the meat. Respondents in the

18 – 29 year old group rated meat from the 20% SPRM diet as less tender ($P < 0.03$), less juicy ($P < 0.001$), and less acceptable ($P < 0.001$) than meat from the other diets. According to Amerine et al. (1965), with increasing age, there is a decrease sensory acuity to tastes, and to aromas (Gilbert and Wysocki, 1987), and this may affect food preferences. Chauhan et al. (1987) postulated that changes in the taste system with age may be related to nutrient intake, which in turn can be influenced by taste. Although very little published research could be located regarding the effects of feeding SPRM to broilers, one report by Mohamed et al. (1974) showed that when corn was replaced by 75% sweet potato meal in the diet of broilers, the flavor of the meat was more acceptable to consumers than those fed the control. However, the birds in their study were fed for 13 weeks. In the present study, the birds were fed for 7 weeks and the highest level of inclusion was 30% SPRM, therefore, a fair comparison could not be made.

Table 12. Sensory rating of Dark meat from broilers fed differ rent levels of Sweet potato root meal based on respondents' age

Age (years)	Diets (%)[1]	Tenderness	Juiciness	Flavor	Acceptability
18-29	0	6.95	6.75	6.07	6.50
	10	6.82	6.41	6.59	6.70
	20	6.84	6.52	6.39	6.52
	30	7.20	7.41	6.45	6.73
		0.25	0.28	0.30	0.29
SEM					
30-59	0	6.08	6.17	6.00	5.92
	10	7.17	7.08	7.08	7.08
	20	7.67	7.33	7.08	6.92
	30	7.58	7.67	7.08	7.58
		0.49	0.54	0.57	0.56
SEM					
60>	0	5.75	6.00	5.25	5.25
	10	6.00	6.75	5.75	5.50
	20	7.00	7.00	6.50	7.00
	30	8.25	7.25	7.25	7.50
		0.84	0.94	0.99	0.96
SEM					

[1]Diets = 0% Sweet potato root meal (SPRM); 10% SPRM; 20% SPRM; 30% SPRM
Hedonic scale=9 extremely tender, juicy, flavorful, acceptable, to 1-extremely tough, dry, disliked, unacceptable
Data from 6 chickens per treatment: (n-24).

Table 13. Sensory rating of White meat from broilers fed different levels of Sweet potato root meal based on respondents' age

Age (years)	Diets (%)[1]	Tenderness	Juiciness	Flavor	Acceptability
18-29	0	6.30^{ab}	5.39^{a}	5.41	5.55^{ab}
	10	5.64^{ab}	5.68^{a}	5.41	5.39^{ab}
	20	4.91^{b}	3.66^{b}	4.57	4.50^{b}
	30	6.86^{a}	6.82^{a}	5.98	6.34^{a}
		0.30	0.60	0.32	0.31
SEM					
30-59	0	6.25	6.25	5.67	6.33
	10	6.75	6.42	6.33	6.50
	20	5.92	5.50	6.25	6.00
	30	7.17	7.09	7.00	7.17
		0.58	0.63	0.62	0.60
SEM					
60>	0	6.50	6.25	6.75	6.25
	10	6.25	6.75	6.75	6.75
	20	6.75	7.00	6.75	6.25
	30	7.50	7.50	8.00	7.75
		1.00	1.04	1.07	1.04
SEM					

[1]Diets = 0% Sweet potato root meal (SPRM); 10% SPRM; 20% SPRM; 30% SPRM
Hedonic scale=9 extremely tender, juicy, flavorful, acceptable, to 1-extremely tough, dry, disliked, unacceptable

[ab] Means with the same superscript within columns are not significantly different at the 5% level of P as determined by Tukey's procedure. Data from 6 chickens per treatment: (n-24).

There was a tendency in all categories for flavor of dark meat to be rated higher on the Hedonic scale than white meat. Stadelman et al. (1988) reported that thighs and legs of broilers are inherently higher in fat than breast meat and are generally rated higher for flavor and juiciness. According to Lindsay (1985), many of the flavor components of poultry are fat-soluble and are found at higher levels in thigh and leg meat than breast meat. The presence of fat also contributes to the juiciness characteristics of meat.

4. Summary and Conclusion

One of the main parameters on which chicken is evaluated is its skin color; hence the effect of SPRM on skin color was determined. Inclusion of SPRM in the diet of broilers resulted in similar effects on the skin color of the legs, thighs, and breasts of broilers as the control diet with no SPRM.

Results also revealed that an inclusion level of SPRM of up to 30% in the diet of broilers was acceptable to consumers. Although in most cases there were no significant differences of diet on the sensory attributes, the sweet potato diets were given higher ratings on the Hedonic scale than the control diet. This shows that the inclusion of sweet potato in the diet of broilers enhanced the flavor, juiciness, tenderness, and acceptability of the meat. The demographic characteristics of age, gender, income, and educational level did not have a significant impact on the overall acceptability of the meat from the sweet potato diets. Moreover, the sensory attributes of dark meat were scored higher on the Hedonic scale than white meat. A thorough search of the literature revealed very little information on the sensory evaluation of feeding sweet potato root meal to broilers or any other livestock.

Based on the results of this experiment, SPRM could serve as an alternative ingredient for corn in the diet of poultry. Although SPRM has been fed to poultry and other livestock, not much has been reported on its impact on the quality of the meat in terms of color and consumers acceptance. Therefore, the results of this study can serve as an important source of reference for further studies. Most of the parameters evaluated showed SPRM either surpassing the performance of the control, or doing as well. However, for it to be accepted as a commercial ingredient, it's inclusion in the diet must be evaluated in totality. Therefore, more studies are required in order to achieve a standard product. Whether included totally or partially, it must not change the quality and consumer acceptance of the meat. Although an economic assessment of the inclusion of SPRM was not evaluated in this study, knowledge of the price of corn should be considered. Future studies will seek to further assess the effect of feeding sweet potato to broilers and its impact on the quality of the meat, nutrient composition, and growth performance. Also, the breeding of sweet potato varieties with higher dry matter content is another future endeavor of the researchers.

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