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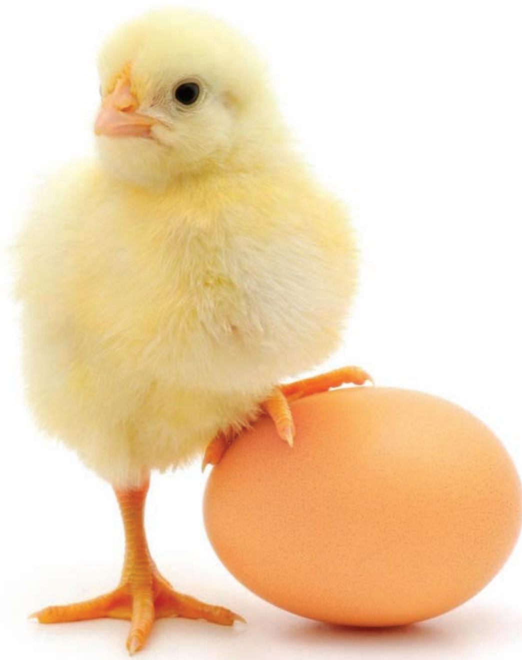

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Research Article
Effect of Feeding Sweet Potato and/or High-Oleic Peanuts to Laying Hens on Ileal Nutrient Digestibility

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Abstract
Objective: The study's goal was to compare, apparent metabolizable energy corrected for nitrogen, apparent nitrogen retention, apparent fat digestibility and apparent protein digestibility (APD). **Materials and Methods:** Four isocaloric and isonitrogenous diets were fed to 80 Shaver hens for six weeks. Diets had a 2% inclusion of Celite indigestible marker. The four diets were (1) Conventional corn-soybean control, (2) 8% inclusion of high oleic peanut, (3) 4% inclusion of sweet potato by-product and (4) 4% sweet potato by-product +4% high-oleic peanut inclusion. **Results:** Control and birds fed a high-oleic peanut containing diet had greater apparent metabolizable energy values than other treatments, while diets containing sweet potatoes and high oleic peanuts had the least ($p<0.0001$). Apparent nitrogen retention for hens fed a diet containing sweet potatoes was significantly lower ($p<0.0001$) than other treatments. The diet containing both sweet potatoes and high oleic peanuts had highest apparent fat digestibility ($p<0.0001$) than other treatments. Control had the lowest apparent fat digestibility with the high oleic containing diet being slightly higher. The apparent protein digestibility of the diet containing sweet potatoes was higher than all treatments ($p<0.0001$). Control and the birds fed a diet containing high oleic peanuts were lower than the birds fed a diet with sweet potatoes included. **Conclusion:** This study implicated that diets containing sweet potato are a reasonable alternative feed ingredient for layers and sustainable utilization of a considerable agricultural waste by-product.

Key words: Alternative feed ingredients, high-oleic peanuts, sweet potatoes, layers, digestibility

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The search for viable alternative feed ingredients for poultry continues as the prices for conventional feed ingredients like corn and soybean meal rise. However, for developing countries the use of these feed ingredients is cost-prohibitive and alternative locally grown feed ingredients such as sweet potato meal, cassava and peanut meal are often utilized. Hence it is important to understand that these feed ingredients can replace corn fully or partially, without having negative effects on production performance[1]. Some research has examined how feeding high-oleic peanuts affects production performance of both broilers and laying hens[2,3], while others have evaluated how feeding sweet potato roots, vines and peels would affect poultry performance[3]. Most feeding trials have only examined the performance and production aspects of these alternative feed ingredients but it is also important to understand the nutrient digestibility of these ingredients when fed.

In a study conducted by Toomer *et al.*[2] three diets were compared (1) A conventional control, (2) A control diet supplemented with 6% oleic acid and (3) A high-oleic peanut diet to determine apparent ileal nutrient digestibility as well as apparent metabolizable energy (AMEn) when fed to broilers[2]. They reported that there were no significant differences in apparent ileal fat or apparent protein digestibility between treatments. However, the high-oleic peanut (HOPN) treatment group had a significantly higher AMEn than the other two treatments[2]. In parallel, Redhead *et al.*[3] reported significantly higher AMEn levels for their high oleic peanut dietary treatment group as compared to the conventional control in a layer feeding trial. The ileal protein digestion was also greater in hens fed the high oleic peanut-containing diets compared to the conventional controls. With both studies reporting higher AMEn when feeding HOPN, this implies that HOPN could be a good energy source to feed to poultry because of how accessible the energy is to the bird.

Other researchers have looked at how feeding sweet potatoes may affect poultry. In a previous study, sweet potato roots at different inclusion levels (100, 200 and 300 g kg^{-1}) in starter, grower and finisher phase were fed to broilers and observed that there were no significant treatment differences in total feed intake or the final live weights[5]. Conversely, the feed conversion ratio of birds fed sweet potato roots were improved as compared to the control birds[5]. Agwunobi[6] replaced 75% of corn with peeled sweet potato meal in a layer diet and showed no effect on performance. Nevertheless, few studies have examined[5,6] the nutrient digestibility of sweet potatoes in laying hen diets.

In a study that examined the AMEn of broilers fed a sweet potato cultivar (tubers and roots) the apparent metabolizable energy was reported as 15.39 MJ/kg[7], which was higher than the corn (14.34 MJ/kg[8]). Other studies have reported the apparent metabolizable energy for dehydrated sweet potato roots in a broiler feeding trial as 15.9 MJ/kg[9]. Hence, feeding trials have reported similar levels of metabolizable energy in corn, sweet potato and dehydrated sweet potato roots. However, there are still very few feeding trialson poultry nutrient digestibility. Thus, in this study, we aimed to determine the nutrient digestibility of a diet containing sweet potato by-products, a diet containing unblanched high oleic peanuts and a diet containing both sweet potato by-products and unblanched high oelic peanuts, by analyzing the apparent protein and fat digestibility and the apparent metabolizable energy.

MATERIALS AND METHODS

This trial was conducted in the bird wing of Scott Hall in the Prestage Department of Poultry Science at North Carolina State University (Raleigh, NC). All methods and procedures used for animal research in this digestibility trial were approved by the North Carolina State University Institutional Animal Care and Use Committee (IACUC No.19-761-A). Sixty-four Shaver white hens (36-42 weeks) were housed individually in a PVC coated wire cage which were 30.5 cm × 45.7 providing 1393.9 cm^2/hen. One week was allowed for acclimation before being fed the experimental diets. Hens were randomly assigned to one of four different treatment groups with sixteen replicates per treatment. Birds had access to feed and water *ad libitum* and were on a 14:10 L:D schedule.

To formulate these four experimental treatments, Concept 5 (level 2, version 10) was used. All diets were formulated to be isocaloric (2,928 kcal kg^{-1}) and isonitrogenous (19.5% crude protein) with an estimated particle size of the ingredients were between 800 and 1000 µm (Table 1). All diets were manufactured with yellow corn and solvent extracted defatted soybean meal. The diet containing only sweet potato by-product as an additional feed ingredient (SWP) was manufactured using dried Covington sweet potato by-products added at a 4% inclusion. The sweet potato by-products used in these diets included peelings, skins and small tubers and were donated from Yamco LLC. (Snow Hill, NC) frozen. These by-products were allowed to thaw at 4°C and were then ground using a Buffalo meat grinder. They were dried utilizing blowers at ambient temperatures to obtain a moisture level below 10%.

Analysis for nutritional content of the dehydrated, ground Covington sweet potato by-products were done by ATC Scientific (Little Rock, AR, USA) before formulating and manufacturing the experimental diets. The analysis results for the sweet potato are as follows: 0.96% crude fat, 11.0% crude protein, 10.4% ash and 66.8% carbohydrates, with 102 ppm B-carotene and a gross energy of 3447 kcal kg^{-1}.

The treatment with high oleic peanuts only and no sweet potatoes (HOPN) was made with 8% unblanched (skin-intact) high-oleic peanuts. The combination diet that contains both sweet potatoes and high oleic peanuts, used 4% sweet potatoes and 4% high oleic peanuts. Only aflatoxin-free unblanched peanuts were used in all experimental diets prepared using peanuts. Peanuts were ground using a Roller Mill forming crumbles before they were included in the completed diet. Diets were supplemented with selenium, vitamin and mineral premixes that were prepared at the North Carolina State University Feed Mill (Raleigh, NC, USA) adhering or surpassing poultry requirements for those premixes. All experimental diets were analyzed by the North Carolina Department of Agriculture and Consumer Services and the Food and Drug Protections Division Laboratory (Raleigh, NC, USA) for aflatoxin and microbiological contaminants. All feed ingredients and feed sampled were without aflatoxin or microbiological contaminants. Diets were analyzed for crude protein and crude fat values by an AOAC-certified lab, ATC Scientific (Little Rock, AR, USA), using AOAC 990.03[10] and 920.39-1920[11] standard methods respectively. All diets contained 2% of CELITE (Diatomaceous Earth, Celite Corp, Lompoc, CA) to be an insoluble ash marker in the diets, to evaluate the nutrient digestibility with partial excreta collection[12].

Determining ileal nutrient digestibility: Birds were fed experimental dietary treatments for six weeks with excreta being collected from hens one week before trial termination. The excreta samples were collected using catch pans underneath each bird for three days. The crude protein (CP) values of both the feed and excreta samples were analyzed by ATC Scientific (Little Rock, AR, USA), using AOAC 990.03[10] methods. Using the excreta, the apparent metabolizable energy (AMEn), the apparent nitrogen retention (ANR), as well as the gross energy of the fecal was determined. At the termination of the study, ileal contents from all the birds were sampled by removal of the gut from the Meckel's diverticulum down to the ileal-cecal junction. The ileum contents were then gently expressed into conical tubes. Ileal contents and excreta were dried at 70°C for 48 hrs in a drying oven and ground through a 1 mm screen allowing for further analysis. Gross energy of excreta samples was analyzed using an adiabatic oxygen bomb calorimeter (IKA model C5003 connector to compressed oxygen with NESLAB Refrigerated Re-circulator, CFT-25). Using a pellet press, fecal samples were compacted down and weighed prior to being placed in a metal thimble with IKA brand 50J cotton twist added for combustion and then placed in the combustion container. The combustion container was sealed and the contents were combusted. The acid insoluble ash (AIA) of the feed, ileal contents and excreta samples were analyzed using modified methodology of Vogtmann *et al.*[13].

Two grams of each sample was boiled in 25 mL of HCl, washed with DI water and then filtered through ash-less filter paper. The filter paper and residue were placed in pre-weighed crucibles and placed in a muffle furnace at 600°C for 6 hrs. Samples were allowed to cool, then were weighed.

$$AME_n = GE_{feed}\text{-}(GE_{fecal}\times AIA_{feed}/AIA_{fecal}) - (8.22\times CP_{fecal}/6.25)$$

Where:

AME_n = Apparent metabolizable energy
GE = Gross energy (bomb calorimeter)
AIA = Acid insoluble ash recovery

$$ANR = 100\times[1\text{-}\{(AIA_{feed}/AIA_{fecal})\times(CP_{fecal}/CP_{feed})\}]$$

Where:

ANR = Apparent nitrogen retention
CP = Crude protein

$$\text{Digestibility (\%)} = 100\times[1\text{-}\{(z\text{ ileum }\%/\text{AIA ileum}\%)/(z\text{ diet}\%/\text{AIA diet }\%)\}]$$

Where:

z = one of the measure elements such as protein, fat, etc.
AIA = Acid Insoluble Ash recovery

Total fat content was determined using Soxhlet extraction. Two grams of ground samples of the ileal contents were weighed and placed on filter paper. Samples were then placed in Whatman Cellulose extraction thimbles (26 mm×60 mm) and placed into the Soxtec System HT 6 1043 extraction unit Foss Tecator (Sweden). One hundred milliliter metal canisters were labeled, weighed and approximately 50 mL of diethyl ether was added. These canisters were sealed underneath the thimbles and were boiled at 60°C for 40 min. Samples were then rinsed for another 40 min with the valves open and another 20 min with the valves closed which allowed for ether collection. Ether that was collected in the metal canisters was weighed and recorded.

Statistical analysis: Each bird served as an experimental unit and all analysis was done using JMP SAS statistical software (version 9.0) for significance by one-way analysis of variance (ANOVA) with a $p<0.05$ being the level of significance. If ANOVA results were significant, a Tukey's multiple comparisons t-test was run to compare the means of the treatments.

RESULTS

Table 1 shows the analysis of the four isocaloric and isonitrogenous diets containing sweet potato and the high oleic peanut. The Proximate analysis demonstrates that the diets contained acceptable levels of calcium and phosphorus (Table 2). No performance parameters measured were significantly different, except for the feed conversion ratio (FCR) of the birds. Hens fed the diet that was formulated to incorporate only sweet potatoes had a poorer FCR compared to the control (Table 3). The FCR was calculated in such a way where the greater number is the better FCR. The control and the treatment containing high-oleic peanuts had the greatest apparent metabolizable energy (nitrogen corrects), while the treatment containing both sweet potatoes and high-oleic peanuts had the lowest values when calculated (Fig. 1, $p<0.0001$). As shown in Fig. 1, the diet containing both sweet potatoes and high oleic peanuts was significantly lower than all treatments in terms of apparent metabolizable energy levels. When the apparent nitrogen retention was analyzed, all treatments had similar apparent nitrogen retention with the exception of the birds that were fed only sweet potato (SWP) (Fig. 2, $p = 0.0002$). The apparent ileal fat digestibility of birds

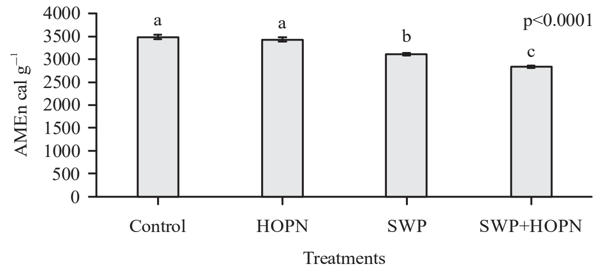

Fig. 1: The effect of feeding sweet potato and/or high oleic peanuts on apparent metabolizable energy correct for nitrogen[1]

[1]Four isonitrogenous, isocaloric treatments with a 2% inclusion of celite were fed, a corn-soybean control, an 8% inclusion of high-oleic peanuts (HOPN), a 4% inclusion of sweet potato (SWP) and a 4% inclusion of sweet potato + 4% inclusion of high-oleic peanuts (SWP+HOPN), to eighty shaver white laying hens for 6 weeks, each bar graphs represents the average±SE.ANR = 100× [1-{(acid insoluble ash_{feed}/acid insoluble ash_{fecal})×(crude $protein_{fecal}$/crude $protein_{feed}$)}], [a,b]Bar graphs with different superscripts are significantly different

Table 1: Composition of formulated experimental laying hen diets

	Treatments[1]			
	Control (%)	HOPN (%)	SWP (%)	SWP+HOPN (%)
Feed ingredient				
Yellow corn	51.8	51.8	46.5	46.7
Soybean meal	32.2	27.8	32.2	30.0
Calcium carbonate	9.6	8.9	9.6	9.4
Dicalcium phosphate	1.8	2.6	1.8	2.0
SWP	0.0	0.0	4.0	4.0
HOPN	0.0	8.0	0.0	4.0
Sodium chloride	0.25	0.25	0.25	0.25
L-lysine	0.0	0.08	0.0	0.03
DL-methionine	0.18	0.2	0.19	0.19
Soybean oil	3.7	0.0	5.1	3.1
Santoquin®[2]	0.05	0.05	0.05	0.05
Choline chloride	0.05	0.05	0.05	0.05
Mineral premix[3]	0.2	0.2	0.2	2.0
Vitamin premix[4]	0.05	0.05	0.05	0.05
Selenium pemix[5]	0.05	0.05	0.05	0.05
ME (kcal kg^{-1})	2922	2922	2922	2922

[1]Four experimental isonitrogenous (19.5% crude protein) diets were formulated: Control: Conventional diet containing defatted soybean meal+corn, HOPN: Diet containing 8% unblanched (skin intact) high-oleic peanuts+defatted soybean meal+corn, SWP: Diet containing 4% sweet potato by-products (peelings, small tubers)+defatted soybean meal+corn, SWP+HOPN: Diet of 4% sweet potato by-products +4% HOPN+defatted soybean meal+yellow corn, Aflatoxin-free peanuts were used in the preparation of all peanut-containing diets, [2]Santoquin®: Feed antioxidant and preservative to prevent fat oxidation in stored feed (Novus International, St. Charles, MO, USA), [3]Mineral premix provides per kg of diet: Manganese: 120 mg, Zinc: 120 mg, Iron: 80 mg, Copper: 10 mg, Iodine: 2.5 mg and cobalt, [4]Vitamin premix provides per kg of diet: Vitamin A: 13,200 IU, Vitamin D3: 4000 IU, Vitamin E: 33 IU, Vitamin B_{12}: 0.02 mg, Biotin: 0.13 mg, Menadione (K3): 2 mg, Thiamine: 2 mg, Riboflavin: 6.6 mg, d-pantothenic acid: 11 mg, Vitamin B_6: 4 mg, Niacin: 55 mg and Folic acid: 1.1 mg, [5]Selenium premix: 1 mg Selenium premix provides 0.2 mg Se (as Na_2SeO_3) per kg of diet, ME: Metabolizable energy

Table 2: Proximate analysis of experimental control, high-oleic peanut, or sweet potato by-product containing diets for laying hens[1]

	Treatments[1]			
	Control (%)	HOPN (%)	SWP (%)	SWP+HOPN (%)
Nutrient				
Crude fat[2]	5.60	8.10	6.90	8.10
Crude protein	19.97	19.75	19.99	20.55
Calcium	2.82	3.34	2.95	2.17
Phosphorus	0.63	0.76	0.69	0.57
Palmitic acid (16:0)*	12.20	9.50	11.10	9.90
Palmitoleic acid (16:1)*	0.75	0.69	0.20	0.26
Stearic acid (18:0)*	4.30	3.10	4.20	3.60
Oleic acid (18:1)*	23.00	59.30	20.80	35.60
Elaidic acid (18:1 trans)*	0.05	0.08	0.03	0.06
Linoleic acid (18:2)*	51.00	19.80	54.10	41.60
Linolenic acid (18:3)*	6.20	1.30	7.10	5.0
Homo-ɣ-linolenic (18:3n-6)*	0.04	0.07	0.04	0.06
Gross energy (kcal kg^{-1})	4384	4082	3924	4279

[1]Dietary treatments: Control: Conventional diet containing defatted soybean meal and corn, HOPN: Diet containing defatted soybean meal, corn and 8% unblanched (skin intact) high oleic peanuts, SWP: Diet containing 4% sweet potato by-products (peelings, small tubers)+defatted soybean meal +corn, SWP+HOPN: Diet of 4% sweet potato by-products +4% HOPN+defatted soybean meal+yellow corn. Aflatoxin-free peanuts were used in the preparation of all peanut-containing diets. Four dietary treatments were chemically analyzed by AOAC-certified lab, (ATC Scientific, Little Rock, AR, USA) using standard AOAC-approved methods,

[2]Crude fat content = $\frac{\text{g crude fat}}{\text{g total sample weight}} \times 100$, *Fatty acid content = $\frac{\text{g of fatty acid}}{\text{g total lipid content}} \times 100$

Table 3: Production performance and body weights per hen when fed a control, peanut, or sweet potato by-product diets for laying hens[1]

Treatments	Total dozen eggs produced	Total amount feed consumed (kg)	FCR[2] (kg total feed consumed/ total dozen eggs produced)	Body weights (kg)
Control	2.97	3.44	1.16[a]	1.56
HOPN	2.95	3.29	1.12[ab]	1.55
SWP	3.02	3.21	1.06[b]	1.47
SWP+HOPN	2.97	3.3	1.11[ab]	1.55
SEM	0.04	0.06	0.02	0.03
p-value	0.52	0.09	0.03	0.12

[1]Dietary treatments: Control: Conventional diet containing defatted soybean meal and corn, HOPN: Diet containing defatted soybean meal, corn and 8% unblanched (skin intact) high oleic peanuts, SWP: Diet containing 4% sweet potato by-products (peelings, small tubers) +defatted soybean meal+corn, SWP+HOPN: Diet of 4% sweet potato by-products +4% HOPN+defatted soybean meal+yellow corn, 80 white Saver laying hens (36-42 weeks of age) were assigned to one of three treatments with 16 replicates/treatment and provided feed and water *ad libitum* for 6-weeks. Body weights were measured three times over the trial (One bird per pen), Feed intake was calculated for each bird, Eggs were collected and recorded daily for each bird, [2]FCR: Feed conversion ratio calculated using total feed consumed over the 6-week trial kg $total^{-1}$ dozen of eggs produced over the 6 weeks trial for each bird. *p-value: Statistically significant differences p<0.05 by analysis of variance (ANOVA), [a,b]Superscripts identify significant differences between treatments

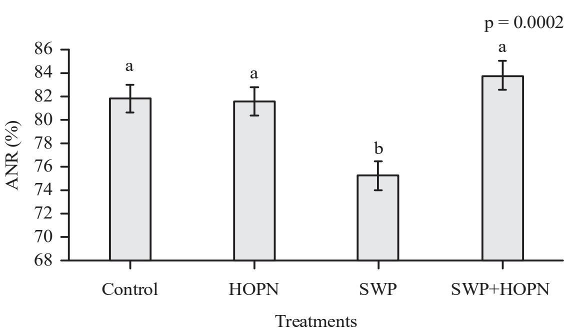

Fig. 2: The effect of feeding sweet potato and/or high oleic peanuts on apparent nitrogen retention percentage[1]

[1]Four isonitrogenous, isocaloric treatments with a 2% inclusion of celite were fed, a corn-soybean control, an 8% inclusion of high-oleic peanuts (HOPN), a 4% inclusion of sweet potato (SWP) and a 4% inclusion of sweet potato + 4% inclusion of high-oleic peanuts (SWP+HOPN), to eighty shaver white laying hens for 6 weeks, Each bar graphs represents the average±SE, ANR = 100×[1-{(acid insoluble ash_{feed}/acid insoluble ash_{fecal})×(crude $protein_{fecal}$/crude $protein_{feed}$)}], [a,b]Bar graphs with different superscripts are significantly different

fed diet containing both sweet potato and high-oleic peanuts was greater than those of the other treatment groups (Fig. 3, p<0.0001).

In Fig. 3, the birds fed control diet had the lowest fat digestibility whereas the birds fed diet containing high-oleic peanut were the second lowest (p<0.0001). The apparent digestible fat was lower in the diet containing sweet potato as compared to the diet containing both sweet potato and high oleic peanuts. While this digestible fat content was greater than high oleic peanut diet and control. The apparent ileal protein digestibility was significantly higher (51%) in the sweet potato treatment group relative to the other treatments (Fig. 4, p<0.0001). While the control and high-oleic peanut containing diet had significantly lower apparent ileal protein digestibility (36% each) as compared to the diet containing sweet potato, the protein digestibility for both treatments were higher than the diet containing both sweet potatoes and high oleic peanuts(34.3%).

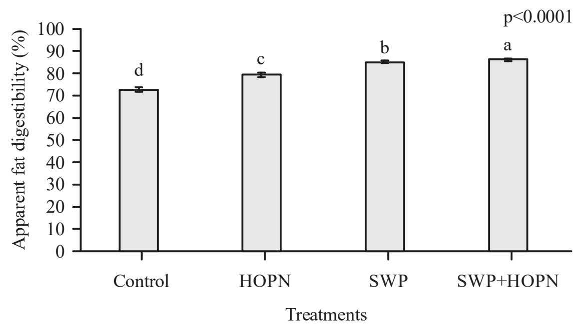

Fig. 3: The effect of feeding sweet potato and/or high oleic peanuts on apparent fat digestibility percentage[1]

[1]Four isonitrogenous, isocaloric treatments with a 2% inclusion of celite were fed, a corn-soybean control, an 8% inclusion of high-oleic peanuts (HOPN), a 4% inclusion of sweet potato (SWP) and a 4% inclusion of sweet potato+4% inclusion of high-oleic peanuts (SWP+HOPN), to eighty shaver white laying hens for 6 weeks, Each bar graphs represents the average±SE, AFD (%) = 100×[1-{(crude fat_{ileum}/acid insoluble ash_{ileum})/crude fat_{feed}/%$celite_{feed}$)}]. [a-d]Bar graphs with different superscripts are significantly different

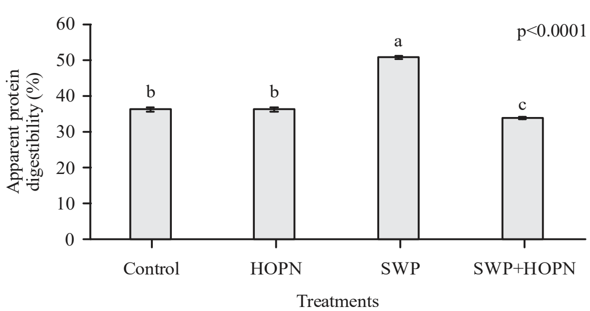

Fig. 4: The effect of feeding sweet potato and/or high oleic peanuts on apparent protein digestibility percentage[1]

[1]Four isonitrogenous, isocaloric treatments with a 2% inclusion of celite were fed, a corn-soybean control, an 8% inclusion of high-oleic peanuts (HOPN), a 4% inclusion of sweet potato (SWP) and a 4% inclusion of sweet potato + 4% inclusion of high-oleic peanuts (SWP+HOPN), to eighty Shaver white laying hens for 6 weeks. Each bar graphs represents the average±SE, APD (%) = 100×[1-{(crude $protein_{ileum}$/acid insoluble ash_{ileum})/crude $protein_{feed}$/% $Celite_{feed}$)}]. [a-c]Bar graphs with different superscripts are significantly different

DISCUSSION

Limited research has been conducted on the digestibility of diets that contains sweet potato by-products, or high-oleic peanuts. Toomer *et al.*[2] observed that in broilers there were no significant differences in apparent ileal fat or protein digestibility between the HOPN and control treatment groups. However, the apparent metabolizable energy was the same for both the conventional control and diet containing high-oleic peanuts. These results showed that both control and the diet containing high-oleic peanuts have higher digestible energy compared to the other experimental treatments. The sweet potato+high-oleic peanut containing diet had the lowest apparent metabolizable energy indicating that this diet had the least amount of dietary energy available for digestion. Pandi *et al.*[7] reported apparent metabolizable energy values of sweet potato cultivar fed to broilers at 15.39 MJ.kg (3678 cal g^{-1}) which is greater than that of the diet that contained sweet potato by-products used in this feeding trial and might be due to the difference in energy utilization of broilers and layers. To date, no research has shown the effects of feeding diets that are formulated using sweet potatoes or high-oleic peanuts on apparent nitrogen percentages. The treatment with only sweet potatoes had the lowest apparent nitrogen retention, suggesting that these birds had a lower ability to retain, or obtain the nitrogen from this diet to utilize. All other diets had similar apparent nitrogen retentions.

The control group has the least apparent fat digestibility implying that dietary fat in this treatment groups was not as readily accessible to the hens compared to the other diets. The diet containing sweet potato+high-oleic peanut had the most available dietary fat for digestion and utilization whereas the diet containing sweet potatoes had slightly lower available fat. Hens fed a diet containing high-oleic peanuts had better fat digestibility than the conventional control treatment group. The diet containing sweet potatoes had the greatest apparent protein digestibility percentages, which implicates that the protein in this diet was more easily digestible for the hens than the other diets were. The control and high-oleic peanut containing diet's protein digestibility were next best at having protein available for digestion, similar results were reported by Toomer *et al.*[2].

CONCLUSION

Overall, feeding only sweet potato by-products results in high protein and fat digestibility and an intermediate metabolizable energy. Diet containing high-oleic peanuts also had great benefits, however the sweet potato+high-oleic peanut diet resulted in improved dietary fat digestibility, a limited amount of dietary protein digestibility and apparent metabolizable energy compared to the other treatment groups. Feeding high-oleic peanuts and sweet potato by-products separately would be suitable alternatives for laying hens due to the high levels of nutrient digestibility and the sweet potato+high-oleic peanut combination treatment had modest levels of nutrient fat and protein digestibility and would require supplementation with another dietary energy source. This study demonstrated that high oleic peanuts and sweet potato by-products fed individually have comparable fat and protein nutrient digestibilities and could be a value-added alternative feed ingredient for layers and sustainable utilization of a considerable agricultural waste by-product.

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REFERENCES

1. Ojewola, G.S., O.E. Opera and O. Ndupu, 2006. The substitutional value of cassava meal, supplemented and unsupplemented with palm oil for maize in broiler diets. J. Anim. Vet. Sci., 5: 478-482.
2. Toomer, O.T., E. Sanders, T.C. Vu, R.D. Malheiros and A.K. Redhead *et al*., 2020. The effects of high-oleic peanuts as an alternative feed ingredient on broiler performance, ileal digestibility, apparent metabolizable energy and histology of the intestine. Transl. Anim. Sci., Vol. 4, 10.1093/tas/txaa137.
3. Redhead, A.K., E. Sanders, T.C. Vu, R.D. Malheiros, K.E. Anderson and O.T. Toomer, 2021. The effects of high-oleic peanuts as an alternate feed ingredient on performance, ileal digestibility, apparent metabolizable energy and histology of the small intestine in laying hens. Transl. Anim. Sci., Vol. 5, 10.1093/tas/txab015.
4. Afolayan, S.B., 2010. Evaluation of sweet potato meal as a source of energy in the diets of chickens. Ph.D. Thesis, Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria.
5. Beckford, R.C. and J.R. Bartlett, 2015. Inclusion levels of sweet potato root meal in the diet of broilers i. effect on performance, organ weights and carcass quality. Poult. Sci., 94: 1316-1322.
6. Agwunobi, L.N., 1993. Sweet potato [*Ipomoea batatas* (L.) Lam.] meal as a partial substitute for maize in layers ration. Trop. Agric., 70: 291-293.
7. Pandi, J., P. Glatz, R. Forder and K. Chousalkar, 2019. Effects of different papua new guinea sweet potato varieties on performance and level of enteric pathogens in chickens. Animals, Vol. 9, 10.3390/ani9040188.
8. Ravindran, V., G. Ravindran, R. Sivakanesan and S.B. Rajaguru, 1995. Biochemical and nutritional assessment of tubers from 16 cultivars of sweet potato (*Ipomoea batatas* L.). J. Food Chem., 43: 2646-2651.
9. Heuzé V., G. Tran, P. Chapoutot, J. Noblet, D. Renaudeau, M. Lessire and F. Lebas, 2015. Poultry by-product meal. Feedipedia, a programme by INRAE, CIRAD, AFZ and FAO. https://www.feedipedia.org/node/214.
10. AOAC., 2006. AOAC Official Method 990.03, Protein (Crude) in Animal Feed, Combustion Method. In: Official Methods of Analysis of AOAC International, AOAC (Eds.). 18th Edn., Rev. 1, Chapter 4, ASA-SSA Inc., Gaithersburg, MD., USA., pp: 30-31.
11. AOAC Official Method of Analysis, 2005. Method 920.39, Fat (crude) or ether extract in animal feed. 18th Edition, AOAC Int., Gaithersburg, MD.
12. Huang, K.H., X. Li, V. Ravindran and W.L. Bryden, 2006. Comparison of apparent ileal amino acid digestibility of feed Ingredients measured with broilers, layers and roosters. Poult. Sci., 85: 625-634.
13. Vogtmann, H., H.P. Pfirter and A.L. Prabucki, 1975. A new method of determining metabolisability energy and digestibility of fatty acids in broiler diets. Br. Poult. Sci., 16: 531-534.

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