ISSN 1682-8356
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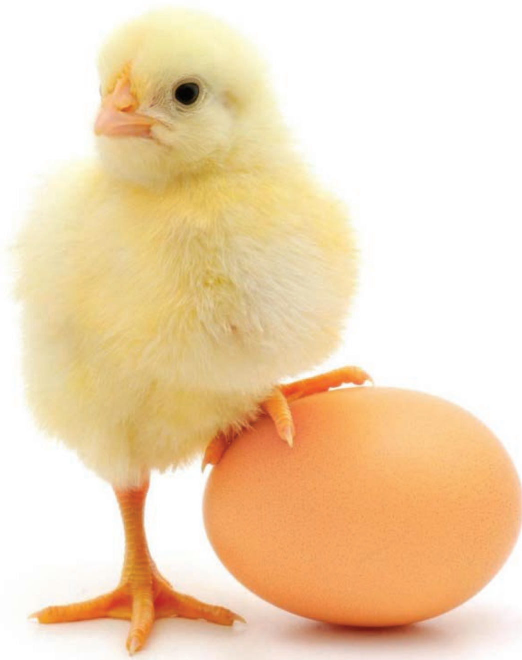

INTERNATIONAL JOURNAL OF POULTRY SCIENCE

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OPEN ACCESS International Journal of Poultry Science

ISSN 1682-8356
DOI: 10.3923/ijps.2022.166.173

Research Article
Effect of Feeding Whole-In-Shell Peanuts and High-Oleic Peanuts to Laying Hens on Ileal Nutrient Digestibility

[1]Kari L. Harding, [1]Dimitri M. Malheiros, [2]Thien Vu, [1]Rebecca Wysocky, [1]Ramon Malheiros, [1]Kenneth E. Anderson and [2]Ondulla T. Toomer

[1]Prestage Department of Poultry Science, NC State University, Raleigh, NC 27695, United States
[2]Food Science and Market Quality and Handling Research Unit, ARS, USDA, Raleigh, NC 27695, United States

Abstract
Objective: The present is study was conducted to determine the effect of feeding whole-in-shell peanuts or high-oleic peanuts to laying hens on ileal nutrient digestibility. **Materials and Methods:** A total of 16 birds per treatment were utilized for 6 weeks with ileal and fecal content being collected at trial termination. Apparent metabolizable energy corrected for nitrogen, apparent nitrogen retention, and apparent protein and fat digestibility were examined. **Results:** There were no significant differences in egg production, feed intake, or feed conversion between treatments. Apparent metabolizable energy and the apparent nitrogen retention was significantly lower in diets containing whole in shell peanuts than the other two treatment diets. Apparent fat digestibility was significantly higher for the treatment with whole in shell peanuts than the other diets, and the high oleic peanut containing diet was significantly higher than the control. Apparent protein digestibility was greater for control diet than the other treatments and the diet containing whole in shell peanuts had significantly lower protein digestibility compared to the diet with high oleic peanuts in it. With the apparent metabolizable energy and the apparent nitrogen retention for high oleic peanut containing diet being statistically the same as the control diet results could indicate that these hens can use the energy and nitrogen for their production. **Conclusion:** Results indicate that 8% inclusion of high oleic peanuts in diet could be beneficial however feeding whole in shell peanuts may have poorer digestibility results, but not reduce production performance. Both high oleic and whole in shell peanuts could be good alternative feed ingredients.

Key words: Alternative feed ingredients, high-oleic peanuts, whole-in-shell peanuts, layers, digestibility

Citation: Harding, K.L., Dimitri M. Malheiros, Thien Vu, Rebecca Wysocky, Ramon Malheiros, Kenneth E. Anderson and Ondulla T. Toomer, 2022. Effect of feeding whole-in-shell peanuts and high-oleic peanuts to laying hens on ileal nutrient digestibility. Int. J. Poult. Sci., 21: 166-173.

Corresponding Author: Kari Harding, Prestage Department of Poultry of Poultry Science, NC State University,309 Scott Hall, 2711 Founders Drive, Raleigh, NC 27695, United States Tel: (919) 515-2621 Fax: (919) 515-7070

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

As demands for corn and corn by-products continue to rise, so does the cost of poultry feed ingredients resulting in increased costs of chicken products for the consumer. These poultry feed ingredients are often cost prohibitive in developing countries and consequently other local feed ingredients such as cassava meal, peanut meal, and fish meal are utilized. Studies have shown that feeding peanut meal prepared from normal-oleic peanuts as a good alternative that does not hinder performance[1-3]. Some research has shown that feeding a diet containing high-oleic peanuts could also be a viable alternative in both laying hens as well as broilers[4-7]. However, there is very little research on how digestible a diet including peanuts is for poultry and specifically laying hens.

Toomer *et al.*[6] examined how feeding a diet with a ten percent inclusion of high-oleic peanuts (HOPN) affected the apparent ileal nutrient digestibility as well as the apparent nitrogen corrected metabolizable energy (AMEn) when fed to broilers. They found no significant difference in apparent ileal fat, or protein digestibility when comparing a conventional control corn and soybean meal diet, a 10% high-oleic peanut diet and a control diet supplemented with 6% oleic acid. The AMEn for the high-oleic peanut treatment was greater than the other two treatments, allowing the authors to conclude that this diet had more apparent digestible energy. Another trial feeding a diet with a twenty percent inclusion of high-oleic peanuts to laying hens reported a higher AMEn compared to those fed a conventional control corn and soybean meal diet[7]. The apparent ileal protein digestibility was also significantly higher for the diet containing high-oleic peanuts compared to the control[7]. A study analyzing the crude protein digestibility demonstrated that the crude protein digestibility of peanut flour was comparable to both soybean meal-43 and soybean meal-49 (SBM)[8].

Most studies examining the nutrient digestibility of diets containing peanut by-products like shells and skins have focused on ruminants, namely cows. As lactating Jersey cows were fed different diets with increasing percentages of peanut skins (0, 8, 16 and 24% inclusions), it was determined their crude protein digestibility decreased as the inclusion percentages increased[9]. Lactating cows were fed peanut cake (pressed seeds during oil extraction) in place of a soybean meal (0, 110, 220, and 330 g kg^{-1} of dry matter). It was determined that total digestible nutrients and the digestibility of crude protein, dry matter, and fat were not affected by the substitution at any level of inclusion[10]. However, no studies to date have examined the digestibility of a diet containing whole-in-shell peanuts in laying hens, which may have a benefit in cage free and free-range systems due to the higher heat increment of the feed. Research has been conducted and shows that parameters such as the metabolizable energy of peanuts can differ. One study feeding pigs peanut meal from twelve different locations showed significant differences in metabolizable energy[11]. Therefore it is important to keep things like, location, season, as well as soil being used when purchasing peanuts to feed to poultry.

While previous studies have demonstrated the effective utilization of diets including whole in shell and high oleic peanuts as an alternative feed ingredient in layers[12], no studies to date have examined the apparent digestibility of the diets for layers. In this study, the objective was to determine the apparent ileal protein digestibility, the apparent metabolizable energy (AMEn) and the apparent fat digestibility of diets containing a 4% inclusion of whole-in-shell peanuts or an inclusion of 8% of high-oleic peanuts when fed to laying hens. To meet these objectives, hens were fed three different diets each with a 2% inclusion of an insoluble marker to help calculate digestibility. At the end of the six-week trial, fecal, and intestinal samples were collected to analyze in order to meet the objectives of this study.

MATERIALS AND METHODS

Experimental design, animal husbandry, and dietary treatments: This study was conducted in the bird wing of Prestage Department of Poultry Science at North Carolina State University. 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). Forty-eight white Shaver laying hens (36-42 weeks) were randomly assorted into single bird cages. The wire cages were PVC coated with dimensions of 30.5×45.7 cm x 53.34 cm providing 1393.9 cm^2/hen. A one-week acclimation period was provided before transferring to treatment feed. Hens were assigned to one of three treatment groups in a random manner with sixteen replicates per treatment. The hens were placed on a lighting program of 14:10 L:D and provided feed and water *ad libitum*. Lighting intensity was 30-60 lux using fluorescent white lighting. The average humidity was 77% with an average temperature being 25°C. Hen body weights were measured at weeks 0, 3, and 6. Eggs were collected daily and enumerated through the course of the study. Feed weights recorded weekly with a final weigh back at the trial termination using an Ohaus Defender® 3000 Digital Scale (Parsippany, NJ, USA). The total number of eggs produced per hen was calculated for the course of the six-week study. The average feed conversion ratio (FCR) was calculated using the total feed consumed over the six-week study (kg)/the total dozen of eggs per each hen produced over the trial with the dozen eggs being large eggs with a weight of 24 oz per dozen.

Concept 5 (level 2, version 10.0) was used to formulate the three experimental diets to be isonitrogenous (19.5% crude protein) and isocaloric (2,928 kcal kg^{-1}) with an estimated particle size around 800 and 1000 µm (Table 1). A basal control diet (control) was manufactured using yellow corn and solvent extracted defatted soybean meal. The whole-in-shell peanut (WPS) diet used 4% whole-in-shell high-oleic peanuts replacing some of the yellow corn and solvent extracted defatted soybean meal included compared to the control. The last treatment was manufactured using 8% unblanched (skin intact) high-oleic peanuts (HOPN), which replaced a percentage of solvent extracted defatted soybean meal compared to what the control used. The unblanched high-oleic peanuts and whole-in-shell peanuts were run through a Roller mill to reduce particle size to crumbles before their inclusion in their respective diets. All peanut-containing diets were prepared with aflatoxin-free peanuts. All diets were utilized with NC State University (Raleigh, NC, USA) selenium, vitamin, and mineral premixes that were formulated to adhere or surpass the poultry requirements for these components. All diets were analyzed for both aflatoxin and microbiological contaminants by NC Department of Agriculture and Consumer Services and the Food and Drug Protections Division Laboratory (Raleigh, NC, USA). All the feed ingredients and all feed sampled was proven to be free of any mycotoxin contaminants. Each analysis of experimental diets for crude fat and crude protein values were done by an AOAC-certified lab, ATC Scientific (Little Rock, AR, USA), using AOAC (Association of Official Analytical Chemists) approved standard methods. All experimental diets contained 2% of CELITE (Diatomaceous Earth, Celite Corp, Lompoc, CA, USA) to be an insoluble ash marker in the diets. This was to evaluate the nutrient digestibility with partial excreta collection[13].

Ileal digestibility: Treatment diets were fed to the hens for six weeks and ten birds per treatment were randomly selected for fecal collection using pans placed underneath each cage and collected after three days of fecal accumulation. The crude protein (CP) of the feed and excreta was analyzed by ATC Scientific (Little Rock, AR, USA), using AOAC 990.03 methods[14]. Fecal samples were collected to determine the AME_n, or apparent metabolizable energy corrected for nitrogen, the Apparent Nitrogen Retention (ANR), as well as the gross energy of fecal samples. At the end of the experiment, all sixteen birds per treatment were sampled for ileal contents. The ileal contents were collected after separating the gastrointestinal tract from the Meckel's diverticulum to the ileal-cecal junction. The ileum contents were then gently expressed into conical tubes placed on ice. Ileum contents and fecal samples were placed in a drying oven at 70°C for 48 hrs, then subsequently ground and sieved through a 1 mm screen to be stored at room temperature for further analysis. Gross energy of the fecal samples was determined using an adiabatic oxygen bomb calorimeter (IKA model C5003 connecter to compressed oxygen with NESLAB Refrigerated Recirculator CFT-25). Fecal samples were compacted into a pellet using a pellet press. Compacted fecal pellets were weighed and placed into a metal thimble and IKA brand 50J cotton twist for combustion. Samples were sealed in the combustion container and then combusted. Acid Insoluble Ash (AIA) of feed, ileal contents, and fecal samples were determined[15]. A 2 gram sample was collected then boiled in 25 mL of HCl, washed with DI water and filtered using ash-less filter paper. The filter paper and residue were placed into pre-weighed porcelain crucibles and placed in a muffle furnace at 600°C for 6 hrs. Samples were allowed to cool slowly then weighed. Apparent metabolizable energy was calculated using the following equation[16,17]:

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

Where:

AME_n	=	Apparent metabolizable energy, corrected for nitrogen
GE	=	Gross Energy (Bomb Calorimeter)
AIA	=	Acid Insoluble Ash Recovery

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

Where:

ANR	=	Apparent nitrogen retention
CP	=	Crude protein

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

Where:

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

Total fat content was determined via soxhlet extraction. Approximately 2 g of dried ileal content samples were weighed out onto filter paper and placed in Whatman Cellulose extraction thimbles (26×60 mm) and were then put into the Soxhtec System HT 6 1043 extraction unit

(Foss Tecator, Sweden). One hundred mL metal canisters were weighed and approximately 50 mL of diethyl ether was added. The canisters were sealed in place under the thimbles and were boiled at 60°C for 40 min. Afterwards, the samples were rinsed for another 40 min with valves open and another 20 min with the values closed to allow for ether collection. The ether collected in the metal canisters was weighed and recorded.

Statistical analysis: Each bird served as one experimental unit and all data was analyzed using JMP SAS statistical software (version 9.0)[18] for significance by one-way analysis of variance (ANOVA) with a significance level of $p<0.05$. If ANOVA results were found to be significant, a Tukey's multiple comparisons t-test was run to compare the means of the treatments against each other.

RESULTS

The diets were formulated to be isonitrogenous and isocaloric utilizing analyzed values of whole in shell peanuts and high oleic peanuts which included crude protein, fat and gross energy. The gross energy was utilized to calculate the metabolizable energy using equations published by Fung *et al.*[19] (Table 1). The proximate analysis of the three dietary treatments showed there were adequate levels of calcium and phosphorus for laying hens (Table 2). There were no significant differences between body weights of hens fed any of the three treatments (Table 3). Analysis of the total kg of feed consumed over the study was not significantly different between treatments (Table 3). The dozens of eggs produced over the study was not significantly different between treatments over the six-week trial. The feed conversion ratio for all three treatments showed no statistical differences when compared to each other (Table 3).

Analysis comparing the metabolizable energy of all treatments showed that the control and diet containing 8% high-oleic peanuts (HOPN) had significantly higher metabolizable energy corrected for Nitrogen (AMEn) ($p<0.0001$) than the diet with a 4% inclusion of whole-in-shell peanuts (WPS) in Fig. 1. The whole-in-shell peanut containing diet had the lowest AMEn as compared to all treatment groups. Moreover, the apparent nitrogen retention (ANR) was significantly lower ($p<0.05$) for the diet with the whole-in-shell peanuts (WPS) than the other two treatments analyzed. There were no significant treatment differences in the apparent nitrogen retention between the control and the diet with high-oleic peanuts (Fig. 2).

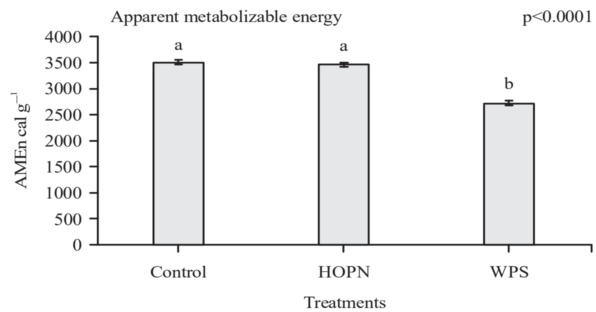

Fig. 1: The effect of feeding diets containing whole-in-shell peanuts and/or high-oleic peanuts to laying hens on apparent metabolizable energy corrected for nitrogen[1]

[1]Three isocaloric, isonitrogenous experimental diets containing 2% celite were fed to 48 laying hens for 6 weeks. Conventional corn-soybean diet (control), inclusion of 8% unblanched high-oleic peanuts and corn-soybean diet (HOPN) and 4% inclusion of whole-in-shell high-oleic peanuts and corn-soybean diet (WPS). Each bar graphs represents the average±SE. $AME_n = GE_{feed}-(GE_{fecal} \times \text{acid-insoluble ash recovery}_{feed})-(8.22 \times \text{crude protein}_{fecal}/6.25)$, [a-c]Bar graphs with different superscripts are significantly different

Table 1: Composition of formulated experimental laying hen diets

	Treatments[1]		
	Control (%)	HOPN (%)	WPS (%)
Feed Ingredients			
Corn (yellow)	51.8	51.8	51.3
Soybean meal	32.2	27.8	30.2
Calcium carbonate	9.6	8.9	9.5
Dicalcium phosphate	1.8	2.6	1.9
Whole in-shell PN	0.0	0.0	4.0
High-oleic PN	0.0	8.0	0.0
Sodium chloride	0.25	0.25	0.25
L-lysine	0.0	0.08	0.14
DL-methionine	0.18	0.20	0.19
Soybean oil	3.73	0.0	2.26
[2]Santoquin®	0.05	0.05	0.05
Choline chloride	0.05	0.05	0.05
[3]Mineral premix	0.20	0.20	0.20
[4]Vitamin premix	0.05	0.05	0.05
[5]Selenium premix	0.05	0.05	0.05
ME (kcal kg^{-1})	2928	2928	2928

[1]Three experimental isocaloric (2,928 kcal kg^{-1}) and isonitrogenous (19.5% crude protein) diets were formulated: Control: Conventional diet containing defatted soybean meal and corn; HOPN: Diet containing defatted soybean meal, corn and 8% unblanched (skin intact) high oleic peanuts, WPS: Diet containing defatted soybean meal, corn and 4% whole in shell high-oleic peanuts, 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: 13,200 IU, Vitamin A: 4000 IU, Vitamin D3: 33 IU, Vitamin E: 0.02 mg, Vitamin B_{12}: 0.13 mg, Biotin: 2 mg, Menadione (K3): 2 mg, Thiamine: 6.6 mg, Riboflavin: 11 mg, d-pantothenic acid: 4 mg, Vitamin B_6: 55 mg and Niacin: 1.1 mg folic acid, [5]Selenium premix: 1 mg, Selenium premix provides: 0.2 mg Se (as Na_2SeO_3) per kg of diet, ME: Metabolizable energy

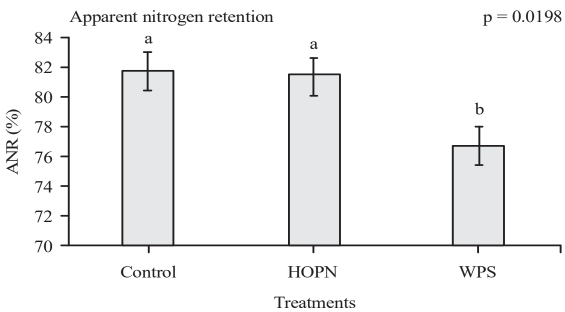

Fig. 2: The effect of feeding diets containing whole-in-shell peanuts and/or high-oleic peanuts to laying hens on apparent nitrogen retention[1]

[1]Three isocaloric, isonitrogenous experimental diets containing 2% celite were fed to 48 laying hens for 6 weeks. Conventional corn-soybean diet (control C2), inclusion of 8% unblanched high-oleic peanuts and corn-soybean diet (HOPN) and 4% inclusion of whole-in-shell high-oleic peanuts and corn-soybean diet (WPS). 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

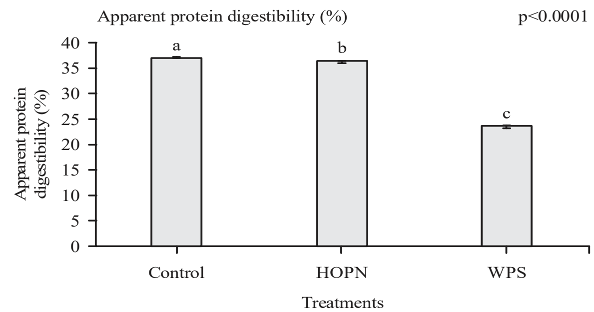

Fig. 4: The effect of feeding diets containing whole-in-shell peanuts and/or high-oleic peanuts to laying hens on apparent protein digestibility[1]

[1]Three isocaloric, isonitrogenous experimental diets containing 2% celite were fed to 48 laying hens for 6 weeks. Conventional corn-soybean diet (control), inclusion of 8% unblanched high-oleic peanuts and corn-soybean diet (HOPN) and 4% inclusion of whole-in-shell high-oleic peanuts and corn-soybean diet (WPS). Each bar graphs represents the average±SE. APD (%) = 100×[1-{(crude $protein_{ileum}$/acid insoluble ash_{ileum})/(crude $protein_{feed}$/% $celite_{feed}$)}]. [a-d]Bar graphs with different superscripts are significantly different

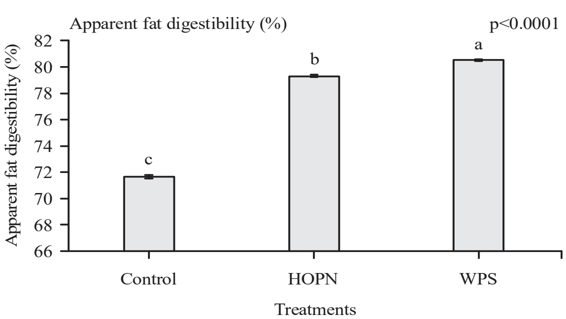

Fig. 3: The effect of feeding diets containing whole-in-shell peanuts and/or high-oleic peanuts to laying hens on apparent fat digestibility[1]

[1]Three isocaloric, isonitrogenous experimental diets containing 2% celite were fed to 48 laying hens for 6 weeks. Conventional corn-soybean diet (control), inclusion of 8% unblanched high-oleic peanuts and corn-soybean diet (HOPN) and 4% inclusion of whole-in-shell high-oleic peanuts and corn-soybean diet (WPS). 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

Table 2: Proximate analysis of experimental control and peanut-containing diets for laying hens

	Treatments[1]		
	Control (%)	HOPN (%)	WPS (%)
Nutrient			
Crude protein	19.97	19.75	20.02
Calcium	2.82	3.34	3.50
Phosphorus	0.63	0.76	0.68
Gross energy (kcal kg^{-1})	4384	4082	4103

[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, WPS: Diet containing defatted soybean meal, corn and 4% whole in shell high-oleic peanuts, Three dietary treatments were chemically analyzed by AOAC-certified lab, (ATC Scientific, Little Rock, AR, USA) using standard AOAC-approved methods

The apparent fat digestibility was the highest ($p<0.0001$) for the diet with 4% WPS compared to all other treatments with an apparent fat digestibility percentage of 80.69% in Fig. 3. While the apparent fat digestibility of the control diet was significantly lower than both treatment diets ($p<0.0001$). Hens fed the conventional control diet had higher ($p<0.0001$) apparent protein digestibility percentages than the other treatments (Fig. 4). Interestingly, the HOPN containing dietary treatment had significantly higher apparent protein digestibility than WPS containing diets. The diet with whole in shell peanuts included had the lowest ($p<0.0001$) apparent protein digestibility in comparison to the other treatments analyzed.

DISCUSSION

Very few studies have analyzed that digestibility of diets containing high-oleic peanuts in laying hens[6,7] and currently none have focused on the digestibility of diets containing whole-in-shell peanuts. Others have interestingly examined the digestibility of diets that include peanut components such as the skins, to other animals such as goats[20]. The apparent metabolizable energies for both control and high oleic peanut containing diets were similar and were higher than the 4% inclusion of whole in shell treatment group, leading to the

Table 3: Production performance and body weights per hen when fed a control or peanut-containing diet[1]

Treatments	Total dozen eggs produced	Total amount feed consumed (kg)	FCR[2] (kg total feed consumed/ total dozen eggs produced)[2]	Body weights (kg)
Control	2.97	3.44	1.16	1.56
HOPN	2.95	3.29	1.12	1.55
WPS	2.96	3.37	1.12	1.58
SEM	0.04	0.06	0.02	0.02
p-value*	0.93	0.21	0.36	0.42

[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, WPS: Diet containing defatted soybean meal, corn and 4% whole in shell high-oleic peanuts. 48 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 week trial for each bird, *p-value: Statistically significant differences p<0.05 by analysis of variance (ANOVA)

conclusion that these diets have more accessible dietary energy for the bird to digest compared to the other two treatments, which parallels previous research conducted by Toomer *et al.*[6] and Redhead *et al.*[7]. The energy from the peanuts could be coming from the fats and carbohydrates, because it has been reported that whole peanuts have around 22-30% crude protein levels[21], with 50% fat[22] and levels that are about 21% in carbohydrates[23]. These results could be due to the fact that the control and the diet that contained high oleic peanuts have greater apparent metabolizable energies, the birds fed these would have greater egg production. However, as Table 3, there is no difference in total dozen of eggs produced over this study. A recent study that fed a 4% whole-in-shell peanut diet or an 8% inclusion of high-oleic peanuts showed no differences in total dozen of eggs produced compared to a conventional control[10]. The apparent nitrogen retention percentages were similar between treatments, with the exception of the treatment containing whole in shell peanuts, which implies that the laying hens fed whole-in-shell high-oleic peanuts containing diet had poorer nitrogen retention when compared to the two other treatments. With a lower nitrogen retention, it would be expected that diets containing whole in shell peanuts would have reduced egg production, but as seen in Table 3, there was no effect. The shortness of the trial could be why there was no differences in total dozen of eggs produced. Other trials have shown that over time with reduced nitrogen retention, egg production has dropped compared to what they were in the beginning of the trial[24]. Other studies have demonstrated that the nitrogen required for egg production comes mostly, or fully, from the hen's diet, therefore the nitrogen retention is greatly important[25,26].

Apparent fat digestibility was greater in the high oleic peanut containing treatment as compared to the control diet, implying that the dietary fat in the diet formulated with high oleic peanuts was more readily digested and consumed in comparison to the control and the diet with a 4% inclusion of whole in shell peanuts. The 8% of high oleic peanut diet may have more available fat to digest compared to the other two treatments analyzed. However, a previous study reported no differences in apparent fat digestibility between a treatment with a 20% inclusion of high oleic peanuts and conventional control layer diet[7]or a diet containing 10% of high oleic peanuts and conventional control broiler diets[6]. While layer production and performance parameters were not adversely affected by the diet formulated to include whole in shell peanuts[12], the AMEn, fat and protein digestibility were compromised as compared to the other treatment groups. Studies have shown that with increased fat digestibility from feed can result in better body weights in broilers[27], however another study showed that age affected how easily digested the fat was, therefore the age also be a contributor in reduced fat digestibility[28]. The reduction in protein digestibility in the whole in shell peanut containing diet compared to the other two could be because of the dietary fiber content. Dégen *et al.*,[29] reviewed the effects of dietary fiber content on fattening pigs and explained that dietary fiber increases endogenous protein loss therefore reducing the ileal digestibility. The dietary fiber could also influence apparent ileal digestibility depending on how soluble the fiber is, because it changes the viscosity of the digesta[29].

CONCLUSION

Feeding a diet that includes high oleic peanuts could be beneficial for providing highly digestible dietary energy, protein and fat. Also feeding a whole in shell peanut containing diet could need supplemental protein because of how low the apparent protein digestibility was. This diet may also need supplemented energy to equate to the AMEn of a conventional control diet. Feeding a diet containing either high oleic peanuts or whole in shell peanuts may result in comparative production as feeding a conventional control. Further research needs to be completed before fully ruling out whole-in-shell peanuts since they may have greater value in extensive production systems, which are cooler due to the high heat increment.

ACKNOWLEDGMENTS

The authors would like to acknowledge the following for their help and support for this project. The North Carolina Peanut Growers' Association, the staff of the Prestage Department of Poultry Science-North Carolina State University, the staff of the North Carolina State University Feed Mill, Birdsong Peanuts and Jimbos Jumbos for their donation of peanuts for these research trials, and the Food Science and Market Quality Handling Research Unit-ARS for their contributions to this study. This study was financially supported by the North Carolina Peanut Growers' Association (Funding Source 572099-87361).

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