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Live Performance, Water Intake and Excreta Characteristics of Broilers Fed All Vegetable Diets Based on Corn and Soybean Meal

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Abstract: A study was conducted to compare live performance and digestive metabolism of broiler chickens fed an all vegetable diet compared to a regular diet having a mix of animal by-products. The all vegetable diet was formulated with corn and soybean meal as major ingredients, whereas the feed with animal by-products had inclusions of 3.0% pork by-product, 2.5% poultry by-product, and 1.5% feather meal. One day old chicks were allocated to battery cages in a temperature controlled room. Feed and water intake, and total excreta produced were measured daily from 21 to 35 days of age. Live performance was similar between groups of birds receiving the different diets in both studies. However, birds fed the all vegetable diet had increased water intake and produced greater amounts of excreta, which were also higher in moisture. Digestibility of the all vegetable diet was poorer when compared to the regular diet. Results of this study indicate that broilers fed all vegetable diets based on corn and soybean meal may express similar live performance responses as long as feed formulation is done with a correct nutrient profile for the ingredients used. However, these type of feeds lead to a greater amount of excreta due to a higher water intake and also to the higher proportion of indigestible components.

Key words: All vegetable diets, digestibility, excreta moisture, vegetarian diets, water consumption

Introduction

Several episodes of Bovine Spongiform Encephalopathy (BSE) have occurred around the world in the last few years, which have raised a great concern on risks for human health due to the BSE human variant, the Creutzfeldt-Jakob disease. This is a fatal disease that causes progressive neurological degeneration and may be acquired after consuming BSE-contaminated cattle products. As a preventative measure designed to stop the transmission of this disease to non-infected animals and to minimize the potential risks to humans, the use of animal by-products in the manufacture of animal feeds given to ruminant animals was prohibited in the European Union. This decision was further extended to all processed animal proteins (except fish meal) given to all farmed animals destined to the production of human food, which included poultry (CEC, 2000). Authorities from other countries, such as Saudi Arabia, a major broiler chicken importer, also adopted this policy.

In several other countries, there has been an increasing trend in marketing broilers as non-traditionally fed or raised, in an attempt to meet a new perception of value to some customers. One of these non-traditionally-grown broiler is fed diets exclusively formulated with plant based ingredients, and therefore it is some times advertised as an "all-veg" broiler. The perceived positive impact of this marketing, relies on the fact that the "all-veg" bird does not eat residues from dead animals, but instead eats a “natural feed” based on cereals and protein meals.

Irrespective of the reasoning, feeding chickens only with ingredients of plant origin is a practice that does not resemble their eating habits in the wild. The chicken is not expected to be entirely herbivore because it lacks anatomic adaptations to support processes of fermentation, which would support their nutrient needs from forages, such as those placed in ruminants or even in the omnivorous swine. In the adult chicken, the ceca are the only place where digestion of plant fibers takes place and where the major concentration of intestinal microorganisms and volatile fatty acids are found in mature birds (Johansson *et al*., 1948; Annison *et al*., 1968). Besides, the ceca are only a small part of the entire gastrointestinal tract and is located at its end (McNab, 1973), which leaves reduced time for the eventual absorption of the fermentation products. Recently, it has also being shown that no more than 25% of the total dry matter passing through the intestines enters the ceca (Son *et al*., 2002). Therefore, the chicken can not rely entirely on nutrients originated from high fiber ingredients or other plant components that need microbial fermentation to its production. This justifies its natural habit of eating seeds and insects.

One major alteration in feed formulation to feeds entirely based on plant ingredients is related to a greater

inclusion of plant proteins, which in the majority of the cases is soybean meal. Soybean meal dry matter is composed of high quality protein, but low digestible carbohydrates, such as oligosaccharides derived from sucrose, but also more complex ones: pectins, hemicelluloses and cellulose (Eldridge *et al*., 1979; Honig and Rackis, 1979; Knudsen, 1997). Some of this fiber type components are water soluble and are entirely separated in the Nitrogen Free Extract fraction (NFE) of proximal analysis. In cereal grains NFE is mostly composed of starch; however, soybean meal has practically no starch and its NFE has a very poor digestibility with chickens (Potter and Potchanakorn, 1985). Soybean meal has also a high content of potassium, which is an electrolyte known to induce water consumption (James and Wheeler, 1949). Corn-soybean meal diets without animal proteins can have three times more potassium than its requirement, and can be about 20% higher than a regular broiler diet including animal by-products.

The present study was conducted to compare live performance, water intake and digestive metabolism of broilers fed an all vegetable diet compared to a regular diet having a regular inclusion of animal by-products.

Materials and Methods

One-day-old male broiler chicks (Ross X Ross 308) were placed in 40, 1.0 m^2 steel battery cages (12 birds per cage), located in a temperature-controlled room, regulated to maintain bird comfort, until 21 d of age. During this period all birds were fed a corn-soybean meal diet formulated to meet or exceed NRC (1994) recommendations. At 21 days of age all birds were weighed, and those having weights in a range greater than 1 standard deviation of each cage mean, and also the females, were removed. All the remaining birds were assigned to the 40 cages in groups of 6 birds per cage. Experimental treatments were composed of two different types of feeds: a regular diet (Regular), formulated with 3% pork by-product, 2.5% poultry by-product and 1.5% feather meal, or a diet formulated only with ingredients of plant origin (All-Veg). Both diets were formulated to have the same nutrient profile on the basis of total amino acids, to meet or exceed NRC (1994) recommendations and were given to the birds from 21 to 35 d-of-age (Table 1).

Prior to preparing the experimental feeds, each ingredient was analyzed for protein, Ca and P. Amino acid profile and other nutrients used in the feed formulation were based on the ingredient supplier's data bank (Perdigão Agroindustrial, Videira, SC, Brazil), which is frequently updated. Feeds were provided in the mash form. Water and feeds were provided for *ad libitum* consumption in a completely randomized design of 2 treatments having 20 replicates each. Light was continuous throughout the experiment.

Table 1: Composition of experimental diets provided from 21 to 35 day of age[1]

Ingredient, %	Regular	All Vegetable
Corn	67.54	60.75
Soybean Meal	22.40	32.10
Pork By-Product	3.00	-
Poultry By-Product	2.50	-
Feather Meal	1.50	-
Dicalcium Phosphate	-	1.10
Limestone	0.67	1.10
Salt	0.34	0.41
Soybean Oil	1.62	4.18
Choline Chloride	0.05	0.05
DL-Methionine	0.15	0.16
L-Lysine HCl	0.08	-
Mineral Premix[2]	0.10	0.10
Vitamin and Additive Premix[3]	0.05	0.05
TOTAL	100.00	100.00
Energy and Nutrients [4]		
ME_n, kcal/kg	3,150	
CP	20.0	
Total Methionine	0.48	
Total SAA	0.81	
Total Lysine	1.06	
Ca	0.90	
Av. P.	0.42	
Na	1.8	
K	0.68	0.82
Cl	0.30	0.31
DEB ($Na^+ + K^+ - Cl^-$), mEq/kg	168	201

[1]Regular: feed containing animal by-products, All Vegetable: feed not containing animal by-products.

[2]Supplemented per kg of feed: Fe 40 mg, Zn 80 mg, Mn 80 mg, Cu 10 mg, I 0.7 mg, Se 0.3 mg.

[3]Supplemented per Kg of feed: vitamin A 8,000 UI, vitamin D_3 2,000 UI, Vitamin E 30 mg,
vitamin K_3 2.0 mg, vitamin B_1 2.0 mg., vitamin B_2 6.0 mg, vitamin B_6 2.5 mg, vitamin B_{12}
0.012 mg, pantothenic acid 15 mg, niacin 35 mg, folic acid 1.0 mg, biotin 0.08 mg, Avilamycin
10 mg, Lasalocide 90 mg.

4 As a percentage or else noted.

Birds in each replicate were group weighed at 21, 28 and 35 d-of-age. Body weights and feed consumption were recorded weekly, when feed conversions corrected for the weight of dead birds was calculated. Water consumption was recorded daily to 35 days of age by checking the volume of water left in the drinkers at the end of each day and subtracting this from all water allocated to each drinker in the preceding 24 hour period. The amount of water evaporated from the drinkers was calculated using the average water loss from 3 blank drinkers. This values were added to the amount of water left in the cage drinkers in the same period, in the calculation of water consumed. The operation was manually conducted with caution avoiding water spillage.

All excreta produced in each battery was collected three times a day (8:00 AM, 12:00 Noon, and 4:00 PM) and then homogenized at the end of each day when the daily

Table 2: Live performance and metabolism responses of broilers fed diets having animal by-products or an all vegetable diet formulated with corn and soybean meal from 21 to 35 days of age[1]

Response	Regular	All Vegetable	Probability ≤
Weight gain, g/bird	1,035±12.9	1,030±12.2	0.761
Feed intake, g/bird	1,728±10.8	1,759±27.0	0.463
Feed conversion	1.675±0.026	1.710±0.025	0.279
Water intake, ml/bird	3,334±51.8	3,763±80.0	0.002
Excreta moisture, %	74.6±0.17	75.9±0.19	0.0001
Feed digestibility, %	77.6±0.31	75.0±0.30	0.0001
Excreta produced, g/bird	1,841±0.028	2,171± 0.029	0.0001

[1]Mean ± SE with 20 observations.

total was weighed. A sample of each daily composite averaging 100 g was oven dried for 12 hours at 105°C for determination of excreta dry matter. Feed digestibility was assessed for both treatments by calculating the percentage of retained feed (feed consumed less excreta produced) to feed consumed in each week.

All data collected were analyzed using the ANOVA procedure of SAS (1998) and treatment means were considered statistically different when the main effect F-test was equal or lower than 5%.

Results and Discussion

Table 2 shows live performance and metabolism responses obtained with birds fed the two experimental diets. Body weight gain, feed intake and feed efficiency were not affected by the dietary treatments. Birds fed the All-Veg diet had a higher water intake ($P < 0.002$), and produced more excreta ($P<0.0001$), which had increased moisture content ($P<0.0001$) when compared with the regular diet. Digestibility of the All-Veg diet was poorer than the regular one ($P<0.0001$).

The lack of response between treatments for live performance is an indication that the nutrient profiles of ingredients utilized to formulate both feeds were reliable and the birds were able to compensate for any small differences. As long as the birds could retrieve enough energy and nutrients to support growth, they should be able to respond in weight gain, regardless of nutrient origin. Water intake was increased in birds fed the All-Veg diet. Water intake may be affected by several factors, including changes in levels of some nutrients. Basal nutrient profile of the two diets was very similar, with the exception of potassium, which was 20% higher in the All-Veg diet. Soybean meal can have up to four times more potassium than the animal by-products used in poultry feeds, such as meat and bone meal, poultry and pork by-product, and feather meal. Potassium, as well as sodium are recognized to positively affect water intake and increase moisture of excreta, whereas chloride is less important with levels present in regular corn-soybean meal feeds. A clear linear relationship between potassium and water intake, from which an increase of 3.29 ml of water is expected for each mEq of potassium intake from the feed in a per bird daily basis (James and Wheeler, 1949). More recent results support similar effects of potassium in feed and water intake with poultry (Smith *et al*., 2000).

Any dietary change that increases water intake of birds will lead to an increase in excreta moisture. In this study there was an increase of 1.3% in the moisture content of excreta produced by birds fed the All-Veg diet, which also had a reduction of 2.6% in dry matter digestibility. Together, these two responses led to an increase in the total amount of excreta produced per bird (2,171 vs. 1,841 grams). Increase in the amount of excreta is expected to contribute to the deterioration of environmental conditions, thereby raising the microbiological challenge to bird health. This situation may gain extra evidence in systems of production with high bird density in open broiler houses where air moisture is difficult to control, but also when there is a limitation for the use of antibiotics. Situations such as those are being experienced currently by the Brazilian producers.

The lower digestibility of the All-Veg diet can be explained by the increased inclusion of soybean meal when compared to the Regular diet. Soybean meal has a reduced digestibility when compared to other protein sources because of the type and amount of carbohydrates present in it. Soybean meal has practically no starch, instead it has an amount of other carbohydrates that may represent more than 30% of its total dry matter (Eldridge *et al*., 1979; Honig and Rackis, 1979). These all have a very poor utilization by poultry (Potter and Potchanakorn, 1985). Roughly, one third of them are oligosaccharides, which quickly ferment producing gas inside of the gastrointestinal tract (Cristofaro *et al*., 1974; Steggerda, 1968), but are also implicated in the acceleration of feed transit in intestines (Coon *et al*., 1990). Other two-thirds are pectins plus hemicelluloses, which have shown ability to increase excreta viscosity and reduce nutrient availability (Shah *et al*., 1982; Langhout *et al*., 2000).

At the present there are good evidences that the negative impact of the use of All-Veg diets for broilers is related to the increase in moisture and total excreta per square area and to the increase in bird's microbiological challenge. An increased frequency of surges of

incompletely digested feed and also of gaseous feces has been observed in operations complying with importer regulations requiring All-Veg diets and also with limitations in growth promotant antibiotics utilization. In recent field observations, the authors have noticed that this situation is not so serious with broilers fed diets with restrictions in the use of growth promotant antibiotics, but not requiring All-Veg diets.

In conclusion, it was possible to demonstrate in this study that broilers fed an All-Veg diet, having soybean meal as the major protein source, may provide a similar live performance to those fed a Regular diet including animal by-products. However, water intake and total excreta produced was higher than those fed a Regular diet. The findings from this experiment are not new and the intention was not just to repeat what has already been demonstrated in past experiments. There is undoubtedly a new trend in the international poultry meat market, which has been pushed by legislation but also by changes in customer attitude. All-Veg diets based on corn and soybean meal presently cost 10% more in average than the Regular diets including animal by-products. Numeric estimations of metabolism differences are important because they impact the cost of production but also the environment. Therefore, society and policy makers should be aware of them.

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