Pasture and Feed Affect Broiler Carcass Nutrition

By Mike Badger, Director, American Pastured Poultry Producers Association (APPPA) (revised 4/22/2015)

The marketing efforts of many pastured poultry producers focus on the health benefits of their pasture-raised broilers. However, very little published information exists to reinforce the pastured broiler nutrition claims. Producers often extrapolate the nutritional benefits found in grass-fed herbivores, but since a pastured poultry's diet consists of grain with supplemental forage, such extrapolations may not be accurate. APPPA's intent in the current study is to expand the testing efforts, adding to the body of research regarding the nutritional qualities of pasture-raised broilers.

In 2000, the American Pastured Poultry Producers Association (APPPA) published a nutritional analysis by Barb Gorski that was conducted by Pennsylvania producers. It showed, among other things, that a 100 gram serving of whole chicken with the meat and skin had an Omega 6:3 ratio of 9:1 and a boneless skinless breast had a ratio of 7:1 [1]. The results from this study appear to have had limited exposure and are only available to APPPA members through the organization's newsletter archives and in the organization's book, *Raising Poultry on Pasture, Ten years of Success*. The Gorski broiler and egg study in 2000, analyzed calories, fatty acid profiles, cholesterol, sodium, vitamin A, vitamin C, calcium and omega 6:3 ratios. This study also showed the pastured eggs had a 6:3 ratio of 7:1 with vitamin A levels of 1100 IU/100g compared to 18:1 and 635 IU/100g of the USDA's reference values [1].

In the fall of 2013, APPPA sourced six skin-on boneless breasts from a no-soy/soy feeding trial conducted by Jeff Mattocks at The Fertrell Company. APPPA sampled three broilers from the group eating a no-soy-based ration and three broilers from the group that ate a soy-based ration. Each group contained one of the following broiler breeds: Cornish Cross, Noll 22, and Barred Silver Cross. In addition, four non-pasture raised birds were purchased from retail outlets in the Williamsport, Pennsylvania area. A free-range, non-organic chicken was purchased from a health food store. The other three samples included a free-range certified organic chicken, a whole chicken, and a split breast purchased from grocery stores in the area. Each purchased sample was sent to the lab for analysis.
The laboratory analyses reported the values for omega 6, omega 3, cholesterol, fatty acids, and vitamins A, D, and E. Analysis was selected based the assumption that omega 6 and 3 and vitamins A, D, and E would be the most likely differences in a pastured poultry production model verses a confined animal feeding operation (CAFO) production model. The cholesterol and fatty acid profiles provide additional points of comparison.

The results indicated that the pasture-raised broilers were higher in vitamins D3 and E and had an Omega 6:3 ratio that averaged 5:1. When the results were examined based on the type of feed the birds consumed, the no-soy-fed broilers had an omega 6:3 ratio of 3:1, while the soy-fed broilers had an Omega 6:3 ratio of 8:1.

A summary of the test results are listed in Table 1 as a percent change in relation to the USDA's National Nutrient Database for Standard Reference values [6].

Table 1: % Change of Pastured Samples to Compared to USDA Standard Reference			
	Pastured Samples	**USDA Values**	**% Change**
Omega 6	1.167 g/100g	1.74 g/100g	32.9 decrease
Omega 3	0.229 g/100g	0.12 g/100g	90.8% increase
Omega 6:3 (all pastured samples)	5:1	15:1	66.7 decrease
Omega 6:3 (soy-fed, pasture)	8:1	15:1	47% decrease
Omega 6:3 (no-soy-fed, pasture)	3:1	15:1	80% decrease
Vitamin D3	17.82 IU/100g	n/a	
Vitamin E	1.86 IU/100g	0.367 IU/100g	406.8% increase
Saturated Fatty Acids	1.28 g/100g	2.66 g/100g	51.9% decrease
Monounsaturated Fatty Acids	1.78 g/100g	3.82 g/100g	53.4% decrease
Polyunsaturated Fatty Acids	1.34 g/100g	1.96 g/100g	31.6% decrease
Total Fatty Acids	4.62 g/100g	9.2 g/100g	49.8% decrease
Cholesterol	71.1 IU/100g	64 IU/100g	11.1% increase

Methods

The broilers were selected from the Dickinson College Farm, one of the three participating farms in the soy/no-soy feeding trials. The farm ran two daily-move hoop houses on a pasture mix of orchard grass, crab grass, and clover. One hoop house contained broilers that ate a soy-based ration while the other group ate the no-soy-based ration with closely matched nutritional analysis. Table 2 shows the feed formulations and nutrient analysis for each type of feed. The feed ingredients were made from non-genetically modified grains using a vitamin and mineral premix from The Fertrell Company; however, the feed was not certified organic.

Each group contained a mixed flock of broilers (Cornish Cross, Noll 22, and Barred Silver Cross). A total of 68 broilers, evenly divided among the two feed groups, were processed at approximately 10 weeks of age. The field trial showed that the soy-fed broilers consumed 810 lbs. of feed with an average live weight of 8.6 lbs. The group consumed a total of 192 gallons of water over the course of the trial. A total of 35 broilers from the soy group were processed. The non-soy fed broilers consumed 916 lbs. of feed with an

average live weight of 8.5 lbs. The non-soy group consumed a total of 174 gallons of water over the course of the trial. A total of 33 broilers from the non-soy group were processed.

Covance Laboratories in Madison, Wisconsin, performed the analysis on 100 g samples that consisted of both meat and skin. Test methods are referenced at the end of the article.

Table 2: Feed Formulas		
	Soy Feed	**No-Soy Feed**
Crude Protein	19.7%	19.7%
Crude Fat	8.1%	4.4%
Crude Fiber	4.5%	4.6%
Energy	1,379 Kcal/lb	1,300 Kcal/lb
Feed Ingredients (weight in lbs)		
	Corn (1015)	Peas (800)
	Soybeans, Roasted (625)	Corn (465)
	Alfalfa Hay (100)	Wheat (300)
	Spelt (100)	Crab Meal (150)
	Fish Meal, 60% (75)	Flax Seed (100)
	PNB* (60)	Fish Meal, 64% (125)
	Argonite (25)	PNB* (60)

Omega Fatty Acid Results

Omega 6 and 3 are essential fatty acids found in polyunsaturated fats. The body cannot produce these nutrients, and they must be consumed through diet. Modern nutrition dictates that we look at the ratio of omega 6 to omega 3 rather than at the individual amounts of one type of fat. Omega 3 is an often prescribed supplement to help even out the 6:3 ratio of the as-fed human diet. According to a study published in the *American Journal of Clinical Nutrition*, the human diet of our ancient hunter/gatherer ancestors was thought to be an even omega 6:3 ratio (1:1), but as the vegetable oil industry was born and the livestock industry used more cereal grains in the feed, the ratio rose dramatically [3].

Research indicates that consuming a diet with a high omega 6:3 ratio promotes inflammation and many diseases, including cardiovascular disease, cancer and autoimmune diseases [5]. The omega 6:3 ratio in the modern Western diet may be as high as 25:1 and optimal recommendations are typically stated at less than 5:1 [3]. The United States does not have dietary guidelines for omega 6 and 3 consumption in the Recommended Daily Allowance data.

The laboratory analysis showed an omega 6:3 ratio of 8:1 for the soy group and 3:1 for the no-soy group. These results are then compared to the 15:1 found in the USDA's National Nutrient Database for Standard Reference [4]. The omega ratios are shown in Table 3. The fatty acid profiles are listed in Table 4, which shows all the fat values are lower for the pastured-samples compared to the non-pastured samples.

Table 3: Omega 6:3 Ratios

	Omega 6 (g/100g)	**Omega 3 (g/100g)**	**Omega 6:3**
Pastured Samples*			
D-N22-NS	0.614	0.247	2.5:1
D-BSC-NS	0.712	0.269	2.7:1
D-CC-NS	0.378	0.159	2.4:1
D-N22-S	2.37	0.297	8.0:1
D-BSC-S	1.58	0.215	7.4:1
D-CC-S	1.35	0.187	7.2:1
Non-Pastured Samples			
Split Breast	1.48	0.109	13.6:1
Whole Chicken	1.30	0.055	23.6:1
Free Range, Organic	1.43	0.123	11.6:1
Free Range, Non-Organic	0.848	0.075	11.3:1
Comparisons			
Pastured, No-Soy Average	0.568	0.225	3:1
Pastured, Soy Average	1.767	0.233	8:1
USDA	1.74	0.12	15:1

*D=Dickinson, N22=Noll 22, BSC=Barred Silver Cross, D=Dickinson, NS=Non-Soy, S=Soy

Table 4: Fatty Acid Analysis				
	SFA (g/100g)*	**MFA (g/100g)***	**PFA (g/100g)***	**TFA (IU/100g)***
Pastured Samples**				
D-N22-NS	1.17	1.63	0.823	3.81
D-BSC-NS	1.76	2.60	0.94	5.57
D-CC-NS	0.888	1.31	0.513	2.85
D-N22-S	1.59	2.32	2.55	6.79
D-BSC-S	1.16	1.55	1.72	4.64
D-CC-S	1.11	1.28	1.47	4.06
Non-Pastured Samples				
Split Breast	2.54	3.64	1.52	8.10
Whole Chicken	1.92	2.78	1.30	6.31
Free Range, Organic	1.56	2.15	1.48	5.47
Free Range, Non-Organic	2.00	3.17	0.884	6.39
Comparisons				
Pastured, No-Soy Average	1.27	1.85	0.76	4.08
Pastured, Soy Average	1.29	1.72	1.91	5.16
USDA [6]	2.66	3.82	1.96	9.2
*SFA = Saturated Fatty Acids, MFA = Monounsaturated Fatty Acids, PFA = Polyunsaturated Fatty Acids, TFA = Total Fatty Acids				
**D=Dickinson, N22=Noll 22, BSC=Barred Silver Cross, D=Dickinson, NS=Non-Soy, S=Soy				

Vitamin Results

APPPA tested the carcasses for the following fat soluble vitamins: A, D, and E. Vitamin A was not above the minimum detectable amount of 200 IU/100g sample with one exception. The Barred Silver Cross no-soy broiler had a vitamin A level of 343 IU/100g. The 2000 Gorski study found vitamin A levels in the skinless breast sample to be zero, while it found the whole chickens to have vitamin A levels to be 210 IU/100g or 50% higher than the USDA National Nutrient Database for Standard Reference.

Vitamin D is a fat soluble vitamin that can be synthesized from exposure to sunlight, with a limited amount coming from the food we eat. It aids bone development and helps the body absorb calcium. A diet deficient in vitamin D is only able to absorb half the amount of dietary calcium than a diet with adequate vitamin D [2]. The laboratory testing measured the amounts of D2 and D3 in the broiler carcasses.

Vitamin D2 is typically obtained from green plants, while D3 is primarily obtained from exposure to sunlight.

Vitamin D2 levels for all samples were below the limits detectable by the test, which was 8 IU/100 g. Dr. Michael Holnick, author of the *Vitamin D Solution*, says, “Numerous epidemiologic studies suggest that exposure to sunlight, which enhances the production of vitamin D3 in the skin, is important in preventing many chronic diseases. Because very few foods naturally contain vitamin D, sunlight supplies most of our vitamin D requirement” [2]. APPPA’s results indicate that the pasture-raised broilers contained an average of 17.8 IU/100 g of vitamin D3, while the USDA’s National Nutrient Database for Standard Reference does not list a specific value for vitamin D3.The non-pastured test samples did not detect any vitamin D3 greater than the minimum test threshold of 0.500 IU/100g. The high presence of vitamin D3 in the pastured broiler carcasses indicates the influence the exposure to sunlight has on the chickens.

Vitamin E is generally recognized as an important part of the diet that is beneficial to many organs. It acts as an antioxidant. On average, the vitamin E results of the pasture-raised broilers were 408% higher than the USDA’s National Nutrient Database for Standard Reference value. The pasture-raised broilers had an average 1.86 IU/100g while the standard reference is 0.367 IU/100g.

Table 5 summarizes the Vitamin D3 and E results.

Cholesterol Results

On average, the pasture-raised broilers were 11% higher than the USDA’s National Nutrient Database for Standard Reference value of 64 IU/100g. Of the no-soy samples, the Cornish Cross had the highest cholesterol level compared to the other breeds. Of the soy-based samples, the Cornish Cross carcass had the lowest cholesterol levels compared to the other breeds. For the Barred Silver Cross and the Noll 22 broilers, the no-soy samples had lower cholesterol levels. All of the store samples had cholesterol levels higher than the pasture-raised samples.

The detailed cholesterol levels are summarized in Table 5.

Table 5: Vitamin D3, E & Cholesterol

Sample	Vitamin D3 (IU/100g)	Vitamin E (IU/100g)	Cholesterol (IU/100g)
Pastured Samples			
D-N22-NS	<2.00	2.13	66.6
D-N22-S	34.3	1.86	74.5
D-BSC-NS	19.0	1.41	68.2
D-BSC-S	15.7	1.84	73.5
D-CC-NS	24.0	2.43	75.4
D-CC-S	13.9	1.47	68.6

Pastured Average	**17.82**	**1.86**	***71.1***
Non-Pastured Samples			
Split Breast	<2.00	0.838	84.1
Whole Chicken	<2.00	0.652	93.2
Free Range, Organic	<2.00	0.732	77.1
Free Range, Non-Organic	<2.00	<0.500	97.7
USDA	n/a	0.367	64
*D=Dickinson, N22=Noll 22, BSC=Barred Silver Cross, D=Dickinson, NS=Non-Soy, S=Soy			

Conclusion

Where possible, the pasture-raised broiler results were compared primarily to the USDA's National Nutrient Database for Standard Reference values. The four purchased store samples were chosen primarily because they were non-pastured; however, they are neither from the same company nor from the same production practices. One sample was a certified organic free-range broiler. The other free-range sample is also known (by the author) to not be pasture-raised and not organic. The remaining two store samples were regular store-bought chickens that made no marketing claims.

Their inclusion was to compare a variety of CAFO-raised samples to provide some anecdotal comparisons as well as to help fill in gaps in the USDA's National Nutrient Database for Standard Reference values on meat analysis, notably vitamin D levels. The free-range samples provide a point of direct comparison to the pasture-raised samples.

Free-range and organic as regulated by the federal government only implies that the birds have access to the outdoors. Actually ensuring that the birds go outside or providing sufficient space for the birds to move around comfortably is not a requirement under these claims.

The test results indicate differences between a pasture-raised broiler and a chicken allowed to "free-range" inside a CAFO. Vitamins D3 and E are notably higher on the pasture-raised broilers. Likewise, the omega 6:3 ratios between the pasture-raised broilers and the conventionally raised broilers are in stark contrast. Further studies that compare pasture-raised broilers to a significant sample size of free-range and organic CAFO broilers would provide more confidence in these initial results.

The analysis indicates with confidence that pasture-raised broilers do have a favorable nutrition profile in terms of vitamins D3 and E. When compared to the USDA's National Nutrient Database for Standard Reference, the omega 6:3 ratio for pastured broilers eating feed that contained roasted soybeans is 47% lower. The pastured broilers that ate feed without soy, had on omega 6:3 ratio that is 80% lower than the standard reference. This analysis suggests that poultry that are allowed to supplement their formulated feed ration with forage will affect the omega 6:3 ratio of the finished broiler carcasses.

Feed inputs are also a factor in the omega analysis of the broiler carcass; however, it becomes less clear if the absence of soy is a primary explanation for less polyunsaturated fat content or if the inclusion of other feed ingredients are contributing to soy/no-soy feed differences. The laboratory analysis does indicate that lower omega 6 values are the primary reason for the lower 6:3 ratio between the soy and no-soy group.

In terms of omega 3, flaxseed oil, as well as green plants, are rich sources of omega 3 [3]; however, the results of this study indicate that the two feed groups had comparable omega 3 concentrations, as seen in Table 3. The flax seed in the no-soy feed does not appear to be affecting the omega 3 profile of the pasture-raised broilers. The results indicate that pasture is the primary cause of the elevated omega 3 values compared to the USDA's National Nutrient Database for Standard Reference. The purchased non-pastured samples have low omega 3 values comparable to USDA's cited values.

Breed did not appear to play a factor in the analysis, with the possible exception of the cholesterol results. Perhaps a larger sample size would provide additional insights into the nutritional qualities of various breeds. A study that compared heritage breeds to hybrid breeds would be an interesting, well needed follow-up project.

This study examined a select nutritional profile of broilers raised on pasture in a typical production environment and provides evidence that the feed input and a pasture-based production practice do have a quantifiable and beneficial effect on the finished carcass.

Test Methods

Covance Laboratories in Madison, Wisconsin, performed the laboratory analysis on the APPPA supplied broiler carcasses using the following tests.

Cholesterol (CHOK_S:11)

Official Methods of Analysis of AOAC INTERNATIONAL 18th Ed., AOAC INTERNATIONAL, Gaithersburg, MD, USA, (2005), Official Method 994.10. (Modified)

Fatty Acids Calculated as Triglycerides (FALT_S:21)

Official Method No. 996.06, Official Methods of Analysis of the AOAC INTERNATIONAL (modified), 19th Ed., AOAC INTERNATIONAL: Gaithersburg, Maryland (2012).

Official Methods and Recommended Practices of the AOCS, Official methods Ce 2b-11 (2011), Ce 1h-05 (2009), Ce 1j-07 (2013), Ce 2-66 (2009),The American Oil Chemists' Society, Champaign, IL (modified).

Vitamin A as Retinol (VALC_S:11)

Official Methods of Analysis, Methods 992.04, 992.06, and 2001.13, AOAC INTERNATIONAL (Modified).

Vitamin D by LCMS (VDMS_S:13)

Official Methods of Analysis of AOAC INTERNATIONAL, Current Ed., Method 2011.11, AOAC INTERNATIONAL, Gaithersburg, MD, USA.

Huang, M., Laluzerne, P., Winters, D., Sullivan, D., “Measurement of Vitamin D in Foods and Nutritional Supplements by Liquid

Chromatography/Tandem Mass Spectrometry,” Journal of AOAC International, Volume (92). No. 5:1327-1335 (2009).

Vitamin E (Natural) (LCE1_S:12)

Cort, W. M., Vincente, T. S., Waysek, E. H., and Williams, B. D., Journal of Agricultural Food Chemistry, 31:1330-1333 (1983). (Modified)

Speek, A. J., Schijver, J., and Schreurs, W. H. P., Journal of Food Science, 50:121-124 (1985). (Modified)

McMurray, C. H., Blanchflower, W. J., and Rice, D. A., Journal of the Association of Official Analytical Chemists, 63: 1258-1261 (1980). (Modified)

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[2] Holick MF. Vitamin D: importance in the prevention of cancers, type 1 diabetes, heart disease, and osteoporosis. Am J Clin Nutr. 2004 Mar;79(3):362-71.Review. Erratum in: Am J Clin Nutr. 2004 May;79(5):890. PubMed PMID: 14985208.

[3] Kris-Etherton PM, Taylor DS, Yu-Poth S, Huth P, Moriarty K, Fishell V,Hargrove RL, Zhao G, Etherton TD. Polyunsaturated fatty acids in the food chain in the United States. Am J Clin Nutr. 2000 Jan;71(1 Suppl):179S-88S. Review. PubMed PMID: 10617969.

[4] Nutrition Facts: Chicken, broilers or fryers, breast, meat and skin, raw. Self Nutrition Data. http://nutritiondata.self.com/facts/poultry-products/696/2

[5] Simopoulos AP. The importance of the ratio of omega-6/omega-3 essential fatty acids. Biomed Pharmacother. 2002 Oct;56(8):365-79. Review. PubMed PMID: 12442909.

[6] USDA National Nutrient Database for Standard Reference (Release 26). Full Report (All Nutrients): 0507, Chicken, broilers or fryers, breast, meat and skin, raw. http://ndb.nal.usda.gov/ndb/foods/show/850.