Comparation of biodisponibility of Condensed Distillers Solubles Oil and others pigmentant sources in the enhancement of layer hens egg quality and yolk color.

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Introduction

Carotenoids are the major compounds with pigmentation properties [1], are deposited in the egg yolk [2], have antioxidant [3], immunomodulatory [4], and, for some carotenoids, pro-vitamin A activity [5]. As neither avian nor mammalian species can synthesize carotenoids they must be obtained from the diet [6]. Avian species, in particular, require carotenoids as pigmentation indicates a birds general health, birds with parasite loads or other immune challenges will appear much paler than healthy birds on the same diet [7]. Supplemental carotenoids, primarily lutein, are commonly added to commercial poultry feeds to increase pigmentation of skin and egg yolk to improve consumer acceptance [8]. Customer preference for brightly colored egg yolks is fairly consistent worldwide, the precise color desired varies by region and culture, with some preferences being for bright yellow to orange and some much darker and nearly red[2, 9].

As costs of commercially available carotenoid supplements can be prohibitive alternate sources must be considered. A different possible source of carotenoids is corn distillers solubles oil (CDS oil). CDS oil is a co- product of the dry grind method of ethanol production and is produced by extracting the oil from distiller dried grains following ethanol production. CDS oil can then be used for biodiesel production or as an ingredient in animal feeds. Moreau found that CDS oil contained all of the carotenoids present in corn at much higher concentration and that the carotenoids were chemically intact and not degraded by the process of ethanol production [10]. It follows that CDS oil could be used as a dietary carotenoid supplement in place of the currently utilized marigold derived and synthetic supplements to increase pigmentation in poultry.

Methods

An experiment was conducted determine the bioavailability of the carotenoids in CDS oil on laying hens and compare CDS oil to three other commercially available carotenoid sources. 48 60-week-old Hy-Line W36 laying hens were individually housed at in cages and were randomly assigned one of six dietary treatments. Birds were kept in thermal comfort conditions and light program.16L :8D. All birds had *ad libitum* access to feed and water. This experiment was approved by the North Carolina State University Institutional Animal Care and Use Committee (Protocol No. 15-061A).

All birds were feed a common basal diet with pigmentation additions by treatment (Table 1). The diets were formulated based on white corn and soybean meal to minimize the inclusion of carotenoids in the basal diet. The experimental diets were produced by supplementing the basal diet with 0, 50, or 100% CDS oil, Yellow Pixafil Liquid-LZ (Alcosa Biotec, S.A., Apaseo El Grande, Mexico), Oro Glo 15 (Kemin, Des Moines, IA), or Anatto Powder (*Bixa Orellana tree extract*) in place of 2% soybean oil. CDS oil was sourced from plant G, the same as the broiler trial, because of its good stability and average carotenoid content. The commercial additives were added to the 2% soy oil and then added to the diets at a level that would approximate the level of carotenoids in the 100% CDS oil diet.

Number of eggs produced was recorded for each individual hen daily and 3 eggs were collected each week for internal and external egg quality determination. Individual hen feed intake was recorded by week. The 3 sampled eggs were weighed and one was used to measure haugh units, albumen height and yolk color while another was used to measure shell strength, shell elasticity, and strength of the vitelline membrane. During the final week of the trial blood plasma was collected for plasma carotenoid concentration.

Table 1: Basal Diet Formulation

Ingredient	%
White corn	56.12
Soybean Meal Hi Pro 48% CP	28.98
Limestone	5.10
Limestone fine	4.36
Soyhulls	2.55
Treatment Oil	2.04
Di-Calcium Phosphate	1.70
Wheat Midds	0.37
Salt	0.26
Poultry Tm Premix (TM-90)	0.20
Choline	0.15
DL Methionine	0.10
Poultry Selenium Premix	0.05
Poultry VTM Premix Market	0.05

Table 2: Dietary Treatments

Treatment	mg carotenoid/kg diet
0% CDS oil – 100% Soy oil	0
Pixafil	9.3
Oro-Glo	9.2
Anatto	9.2
50% CDS oil – 50% Soy oil	4.87
100% CDS oil	9.73

Results and Discussion

Over the 8 week period no differences were found in plasma carotenoid level, egg membrane strength, or egg membrane elasticity. Shell strength and shell elasticity were significantly improved in the eggs laid by hens treated with annatto and significantly lower in the eggs from the hens fed the 50% CDS oil diet. No differences were found in feed intake or in the feed conversion ratio of grams feed consumed to grams egg produced.

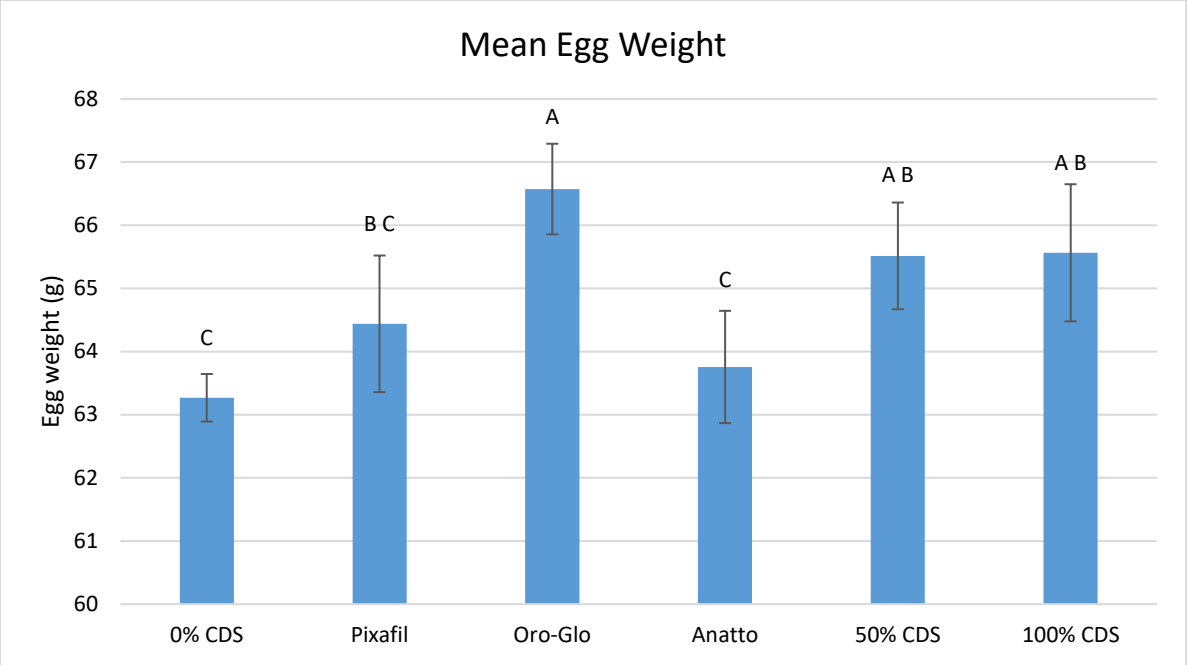

Figure 1: Mean egg weight over the 8 weeks of the study. Dietary CDS oil resulted in egg weights that were not different than Pixafil or Oro-Glo and were higher than unpigmented and Anatto dietary treatments.

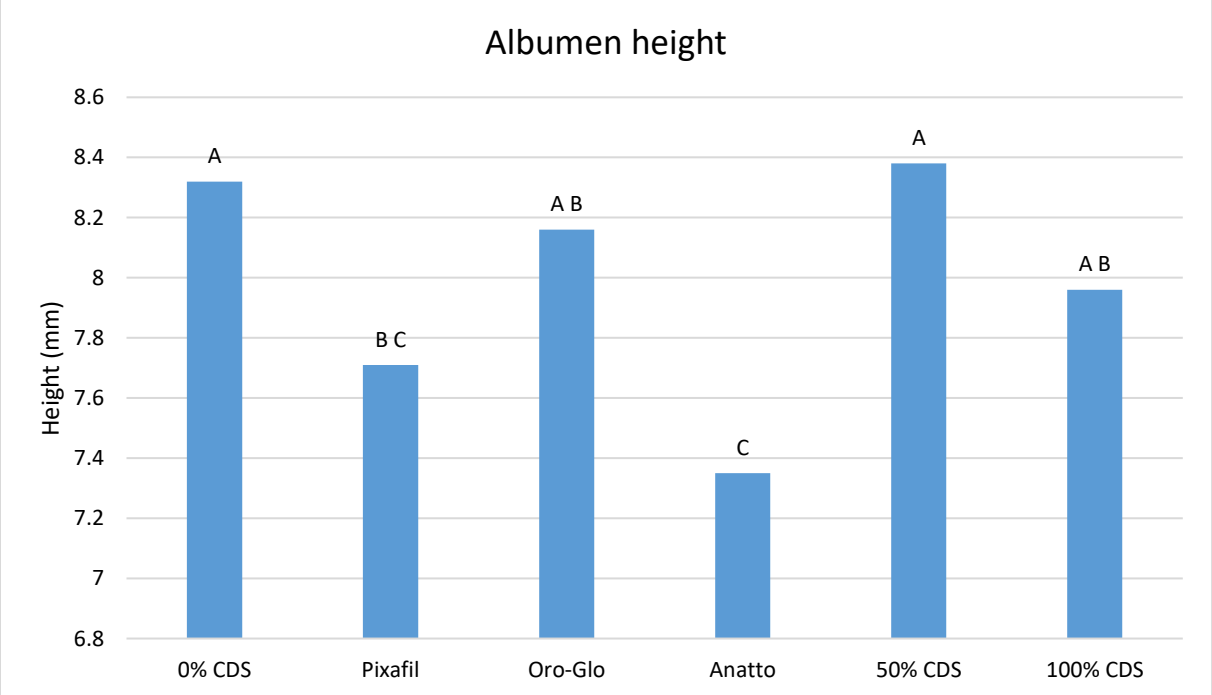

Figure 2: Albumen height of eggs was reduced in birds fed Anatto and Pixafil. Haugh units followed the same pattern.

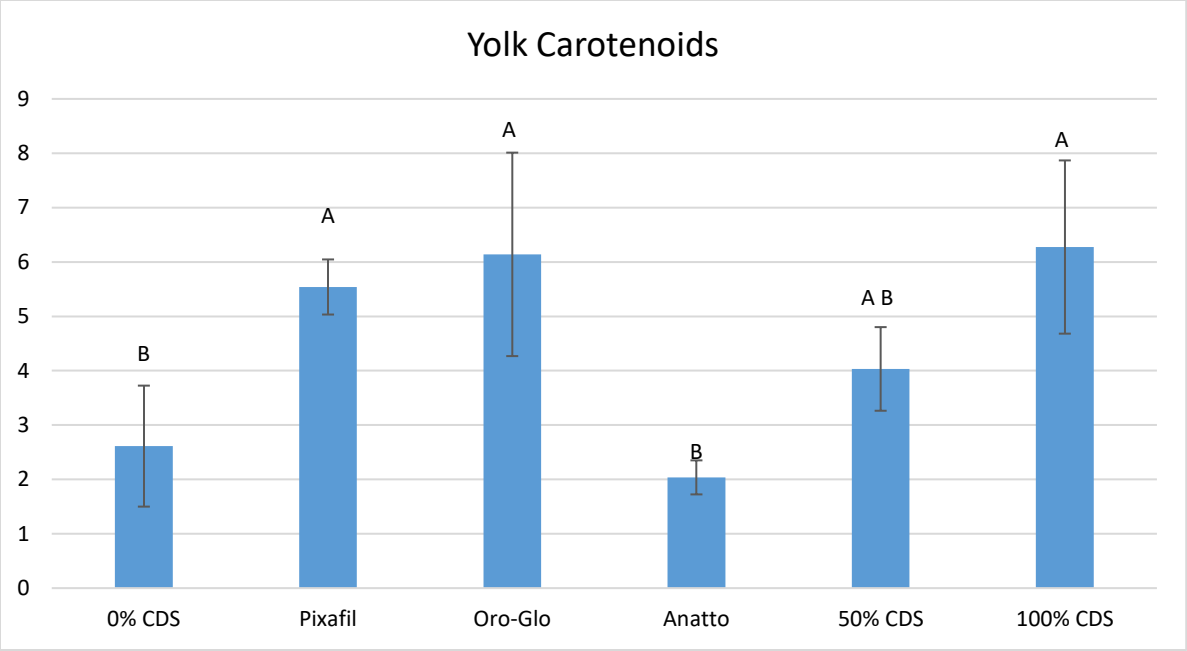

Figure 3: Yolk Carotenoids were lowest in birds fed diets containing no pigmentation and Anatto and was intermediate in the 50% CDS oil fed birds as compared to the 100% CDS oil, Pixafil and Oro-Glo treatments.

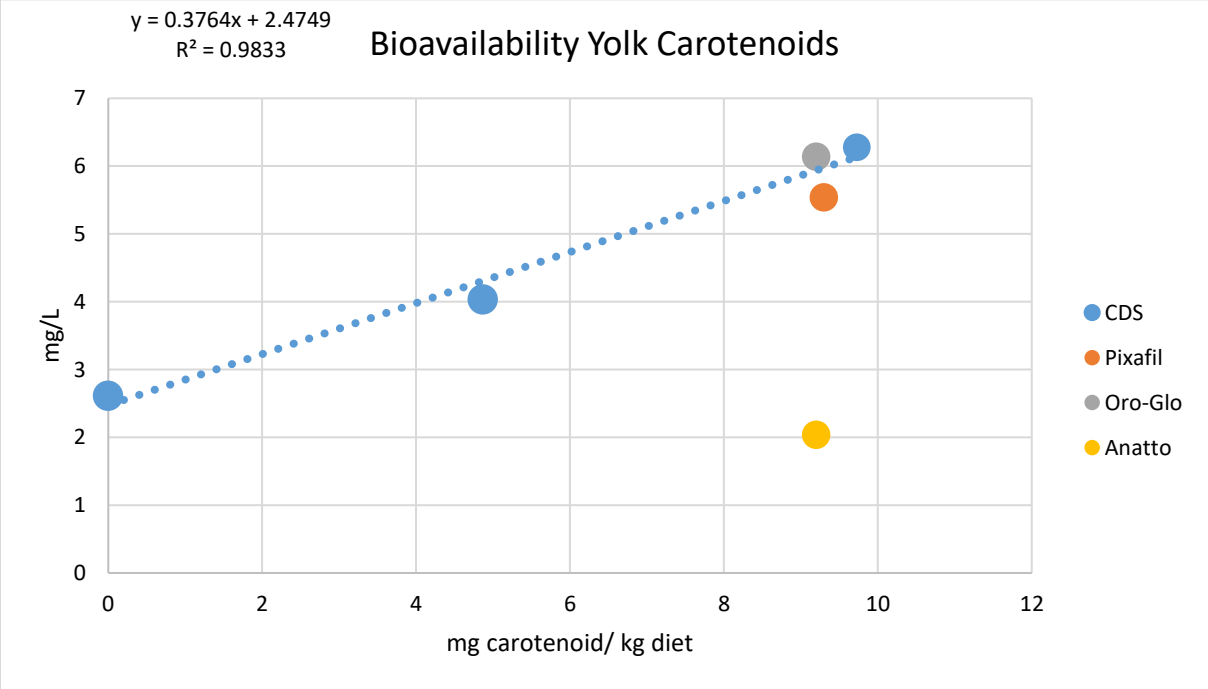

Figure 4: Carotenoid content of the egg yolk as measured by iCheck compared to the total carotenoid content of the diet. Bioavailability of CDS oil 107.9% Pixafil, 96.7% Oro-Glo, and 291.4% Anatto.

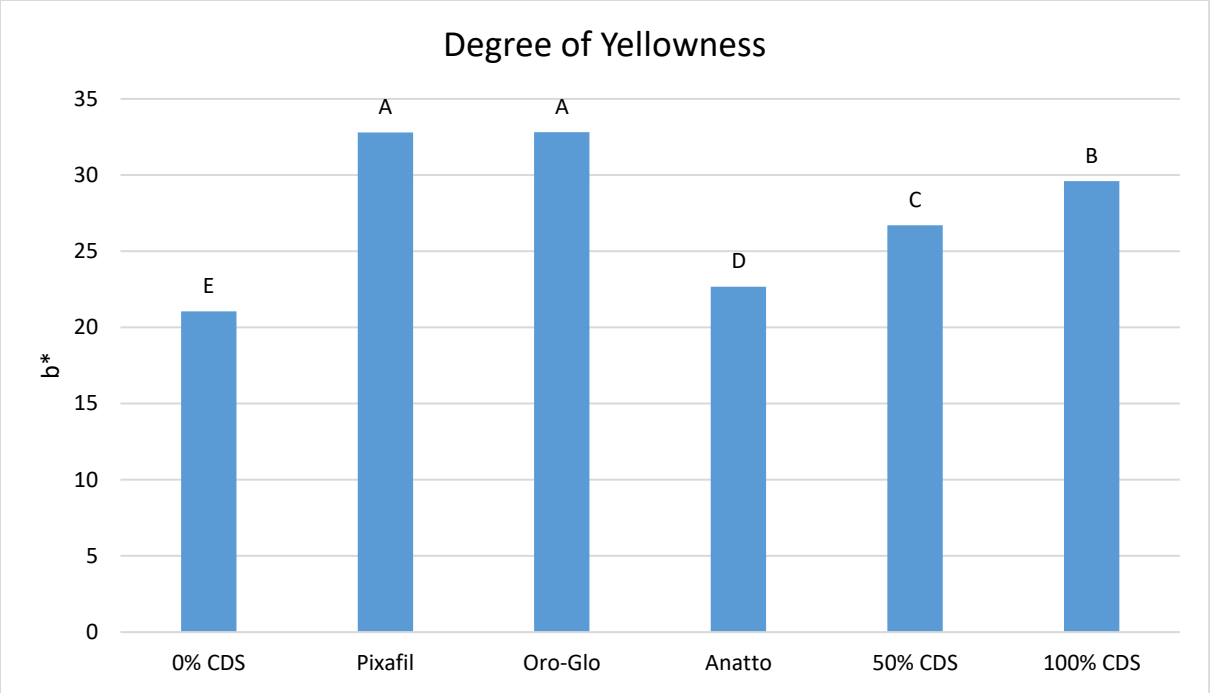

Figure 5: Degree of yellowness of the egg yolk as measured by a minolta colorimeter

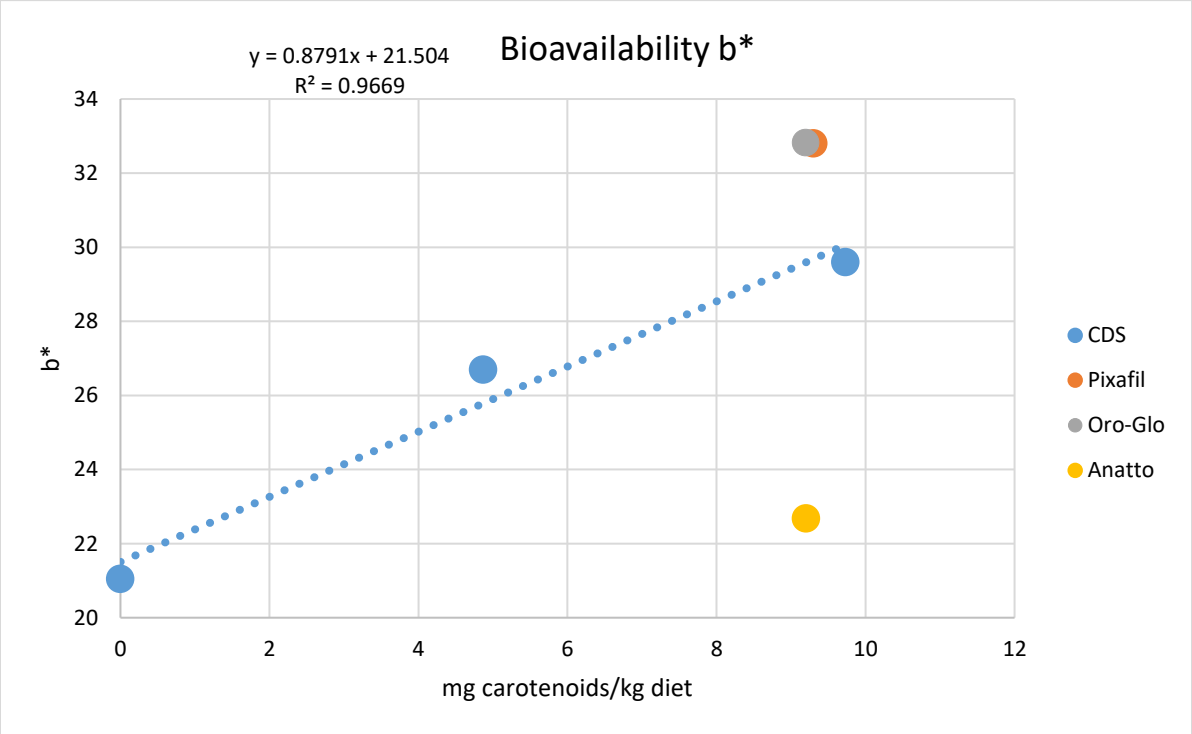

Figure 6: Yellowness of the egg yolk plotted against dietary carotenoid level. Bioavailability of CDS oil 90.5 % Pixafil, 90.2% Oro-Glo and 130.5% Anatto.

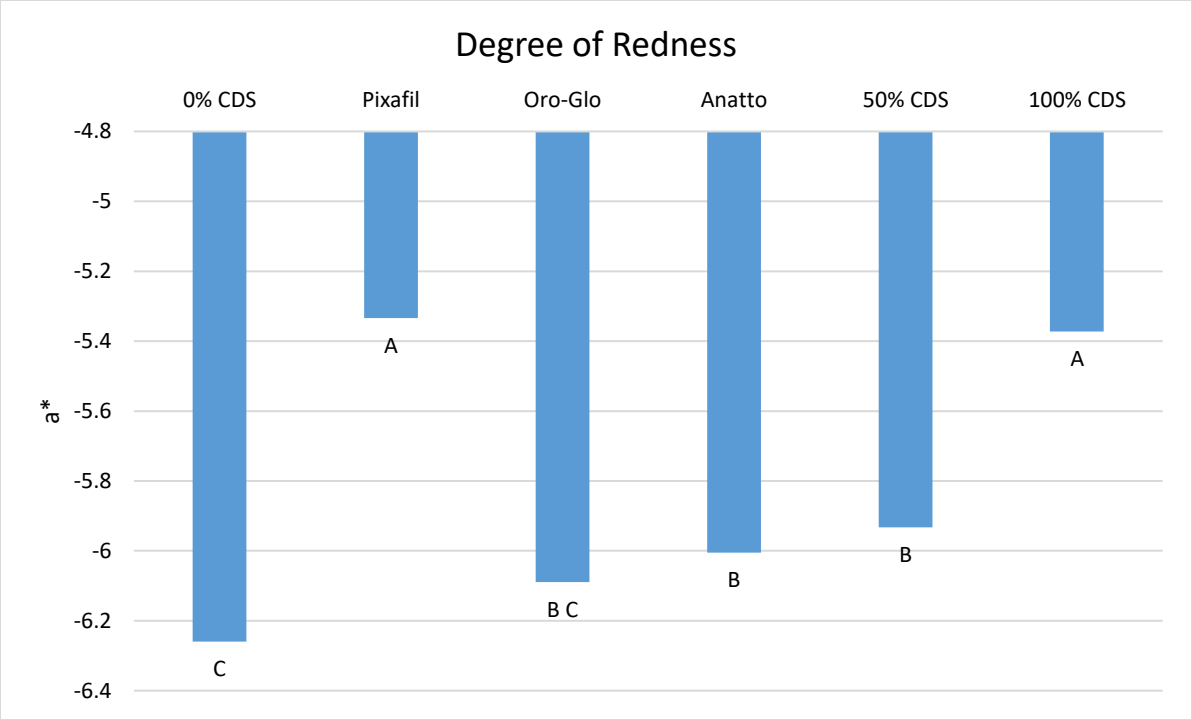

Figure 7: Degree of redness of the egg yolk as measured by Minolta colorimeter

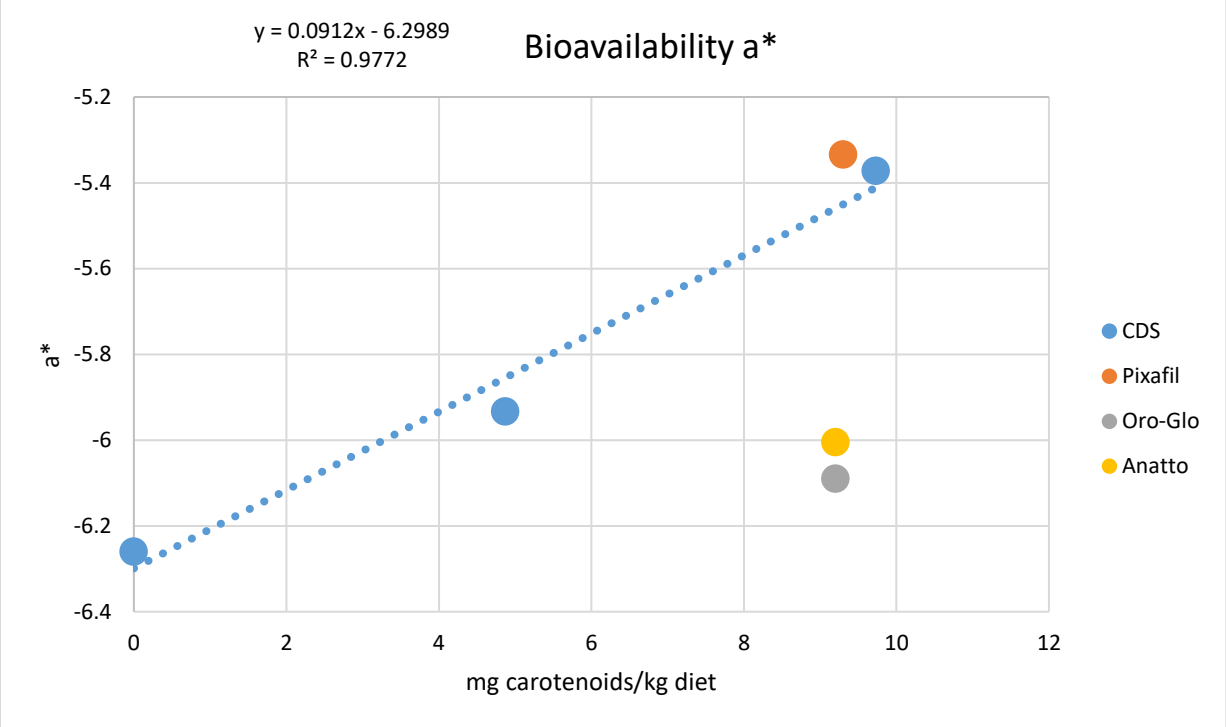

Figure 8: Redness of the egg yolk compared with the total carotenoid level in the diet. Bioavailability of CDS oil is 102.2% Pixafil, 89.7% Oro-Glo, and 90.9% Anatto.

Conclusions

CDS oil is a viable supplement for commercial laying hen diets to increase carotenoid inclusion and increase egg yolk pigmentation. Anatto supplementation improves egg shell quality but does not improve pigmentation or increase carotenoids deposited in the yolk. Laying hens maintained a similar plasma carotenoid concentration regardless of dietary carotenoid source or total carotenoid inclusion rate but the level of carotenoids in the yolk was significantly affected, suggesting that the hen first meets her needs and only when her needs are met does she deposit carotenoids into the egg yolk. CDS oil increases yellowness to levels approaching the commercial additives Pixafill and Oro-Glo and also increases redness similarly to Pixafil. Considering the high cost of commercial color enhancing additives the addition of CDS oil into the diet is an excellent choice to increase the deposition of carotenoids in the egg yolk thereby increasing both yellow and red pigmentation.

1. Blanch, A. and J. Hernandez, *Red carotenoids for optimal yolk pigmentation.* Feed Mix, 2000. **8**(6): p. 9-12.
2. Englmaierová, M., M. Skrivan, and I. Bubancova, *A comparison of lutein, spray-dried Chlorella, and synthetic carotenoids effects on yolk colour, oxidative stability, and reproductive performance of laying hens.* Czech Journal of Animal Science, 2013. **58**(9): p. 412-419.
3. Edge, R., D. McGarvey, and T. Truscott, *The carotenoids as anti-oxidants—a review.* Journal of Photochemistry and Photobiology B: Biology, 1997. **41**(3): p. 189-200.
4. Selvaraj, R.K., et al., *Dietary lutein and fat interact to modify macrophage properties in chicks hatched from carotenoid-deplete or replete eggs.* Journal of animal physiology and animal nutrition, 2006(90): p. 70-80.
5. Surai, P., B. Speake, and N. Sparks, *Carotenoids in Avian Nutrition and Embryonic Development. 2. Antioxident Properties and Discrimination in Embryonic Tissues.* The Journal of Poultry Science, 2001. **38**(2): p. 117-145.
6. Johnson, M. and D. Korver. *Carotenoids in poultry nutrition*. in *2010 Western Nutrition Conference, challenging conventional nutrition dogma, Saskatoon, Saskatchewan, Canada, 21-23 September 2010*. 2010. Western Nutrition Conference Planning Committee.
7. Olson, V.A. and I.P. Owens, *Costly sexual signals: are carotenoids rare, risky or required?* Trends in Ecology & Evolution, 1998. **13**(12): p. 510-514.
8. Hernandez, J., A. Blanch, and N. Bird, *Why consumers need carotenoids in poultry.* Int. Poult. Prod, 2001. **9**: p. 15-16.
9. Williams, W.D., *Origin and impact of color on consumer preference for food.* Poultry science, 1992. **71**(4): p. 744-746.
10. Moreau, R.A., et al., *The composition of crude corn oil recovered after fermentation via centrifugation from a commercial dry grind ethanol process.* Journal of the American Oil Chemists' Society, 2010. **87**(8): p. 895-902.