Nutritional Benefits of Feeding Hempseed Meal to Laying Hens as a Sustainable Feed Protein Alternative

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Introduction

Industrial hemp (*Cannabis sativa* L.) is a versatile commercial crop with its materials being used in construction, clothing, and human consumption. Hempseed is produced after the oil extraction and hemp hearts processing from industrial hemp production (Kaur and Kander, 2023). With the recent passage of the 2018 Farm Bill, there has been increasing interest in incorporating industrial hemp production byproducts in animal agriculture, particularly in the New York State (NYS) for its sustainable agriculture initiative (Congressional Research Service, 2019; AAFCO, 2021). Hempseed is a nutritious ingredient with high levels of protein, dietary essential amino acids, and essential fatty acids, which can be a great substitute to soybean mean that is commonly used in the poultry industry (Bailoni et al., 2021; Montero et al., 2022; Rodriguez-Leyva and Pierce, 2010). Repurposing hempseed from landfill to animal agriculture as a valuable feed ingredient can reduce agricultural waste, decrease the food-feed competition, and ultimately promote environmental sustainability. However, despite the potential broad applications of hempseed in animal agriculture, its use in animal feed has not been approved by the Food and Drug Administration due to the lack of scientific evidence for the safety of animals and the food (Congressional Research Service, 2019). More recently in December 2023, NYS Senate Bill S6326 on authorizing the use of hempseed in commercial feed for pets, horses, and camelids was vetoed by Governor Hochul due to similar concerns on the safety of such uses (The New York State Senate, 2023). Trace amounts of total cannabidiol (CBD) and Δ-9 tetrahydrocannabinol (Δ-9 THC) were detected in the adipose tissue of beef heifers that were fed 20% hempseed cake for 111 days as well as in the plasma and urine of the animals (Smith et al., 2023). Therefore, further research is warranted to investigate the implications of feeding hempseed as an animal feed to animal health.

Materials and Methods

The objective of this study was to assess the impacts of supplementing hempseed meal (HSM) in laying hens' diets on animal health as well as egg production and egg nutrient profiles. The animal experiment protocol was approved by the Institutional Animal Care and Use Committee of Cornell University (Ithaca, NY). A total of 40 Dekalb White laying hens was fed a corn-soybean meal basal diet supplemented with HSM (IND HEMP, LLC, Fort Benton, MT) in a stepwise addition fashion at 5% increment (i.e., 0%, 5%, 10%, and 15%) for 6 weeks (n = 10 each for 4 groups). During the experiment, eggs were recorded and collected daily, feed was recorded and replenished weekly, and body weights of animals were measured biweekly. At weeks 0,

3, and 6, blood samples were drawn from the brachial wing veins from each animal. Egg yolk samples were freeze-dried, and the fatty acids were extracted according to the Folch method and quantified using a gas chromatography system (Agilent 6890N) with a flame ionization detector and a fused-silica capillary column (CP-Sil 88) as described previously (Ou et al., 2023). Data were analyzed by one-way ANOVA and followed by Duncan's multiple-ranged method as well as linear and quadratic regression models using R (version 4.1.3). Data were presented as means with standard error of the mean (SEM), and statistical significance was declared at $P < 0.05$.

Results

Supplementing HSM at up to 15% did not affect body weights or feed intake of the animals. Egg production and characteristics were also not impacted by the HSM supplementations. The HSM supplementations significantly enriched the eggs with the omega-3 polyunsaturated fatty acid (n-3 PUFA), docosahexaenoic acid (DHA; C22:6n-3), dose-dependently ($P < 0.001$, $R^2 = 0.93$) at week 6 (**Table 1**). Egg yolks from the 15% HSM treatment contained approximately 40 mg DHA per egg, which was 2-fold higher ($P < 0.001$) than the DHA content in the control egg yolks (18 mg DHA per egg). The other n-3 PUFA, α-linolenic acid (ALA; C18:3n-3), was also significantly increased ($P < 0.001$) in the egg yolks from the HSM treatments. The increases of n-3 PUFAs were associated with the decreases of some monounsaturated fatty acids, including the palmitoleic acid (C16:1n-7; $P < 0.001$). The n-6 PUFAs were not impacted by the HSM supplementations, including linoleic acid (LA; C18:2n-6) and arachidonic acid (ARA; C20:4n-6). Therefore, the overall n-6 to n-3 ratios of the eggs from the HSM treatments were improved ($P < 0.001$) compared with the control eggs. The supplementations of HSM also impacted the animals' metabolism and the greenhouse gases production from their manure. Hens from the 10% HSM group produced 14%-17% less ($P < 0.05$) respiratory carbon dioxide (CO_2) than the hens in the control and the 15% HSM treatment when placed in a respiratory chamber, but the difference was not significant ($P = 0.11$) after correcting for their metabolic body weights ($BW^{0.75}$). In the fecal samples, the HSM treatments decreased the methane (CH_4) production ($P < 0.01$, $R^2 = 0.35$), where fecal samples in the 15% HSM treatment had significantly lower ($P < 0.05$) methane production than those of the control.

Table 1. Effects of hempseed meal supplementations at incremental doses on selected fatty acid concentrations of egg yolk of hens at week 6.*

mg/g dried yolk	0%	5%	10%	15%	SEM	*P* value
Linoleic acid	28.2	28.8	29.6	27.6	0.56	0.67
α-linolenic acid	0.685^{c}	0.900^{b}	1.14^{a}	1.07^{ab}	0.046	< 0.001
Arachidonic acid	3.67	3.47	3.72	3.62	0.065	0.59
Docosahexaenoic acid	1.83^{d}	2.51^{c}	3.45^{b}	3.97^{a}	0.18	< 0.001
n-6/n-3 ratio	12.9^{a}	9.56^{b}	7.34^{c}	6.28^{d}	0.54	< 0.001

*Data are reported as means with standard error of the mean (SEM), $n = 6$. Values within the same row without a common letter are different, $P < 0.05$.

Summary and Conclusions

In conclusion, HSM supplementations at up to 15% in laying hens were safe and could enrich eggs with considerable amounts of health-promoting n-3 PUFAs. Further studies are warranted to explore the use of HSM in other livestock species as well as to confirm the potential CBD and Δ-9 THC residues in the animal products for both human and animal health. Additionally, HSM may be supplemented with other beneficial feed additives concurrently (such as microalgae) in diets to explore the full potentials of n-3 PUFAs and DHA enrichments.

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