Supplementary Material

**Table 1.** Experimental design

|  |  |  |  |
| --- | --- | --- | --- |
| Groups | Replicates | Hens in Subgroups | Experimental Diets |
| FRP-0 | 8 | 3 | Basal (control) diet |
| FRP-1 | 8 | 3 | Basal diet + 1 g FRP |
| FRP-2 | 8 | 3 | Basal diet + 2 g FRP |

FRP: Ferula root powder

**Table 2.** The composition and nutrient levels of basal feed

|  |  |
| --- | --- |
| **Items** | **kg/ton** |
| Maize | 475.00 |
| Soybean meal (46% CP) | 41.44 |
| Full fat soybean (34% CP) | 150.00 |
| Wheat | 143.86 |
| Sunflower seed meal (34% CP) | 86.29 |
| Sunflower oil | 5.10 |
| Limestone | 88.00 |
| Dicalcium phosphate | 3.79 |
| Salt | 2.50 |
| DL-Methionine | 0.87 |
| Lisin sulphate | 0.65 |
| Premix\* | 2.50 |
| Chemical composition (analyzed) % | |
| Dry matter | 89.08 |
| Crude protein | 16.88 |
| Ether extract | 5.49 |
| Crude ash | 11.92 |
| Calcium | 3.60 |
| Metabolizable energy (kcal/kg)\* 2725 | |

\*Supplied the following per 2.5 kg of diet: 10.000.000 IU vitamin A, 3.000.000 IU vitamin D3, 25.000 mg vitamin E, 4000 mg vitamin K3, 2.000 mg vitamin B1, 5000 mg vitamin B2, 40.000 mg niacin, 12.000 mg calcium D pantothenate, 4.000 mg vitamin B6, 20 mg vitamin B12, 1.000 mg folic acid, 60 mg biotin, 120.000 Mn, 40.000 mg Fe, 70.000 Zn, 7.000 mg Cu, 500 mg Se, 2.000 mg canthaxanthin, and 1.200.000 phytase

\*\*The metabolizable energy level was calculated as stated by Carpenter and Clegg (1956).

**Table 3.** Some nutrient composition of ferula (*F. elaeochytris*) root

|  |  |
| --- | --- |
| **Items** | **%** |
| Dry matter | 93.4 |
| Crude protein | 4.3 |
| Ether extract | 4.0 |
| Crude fiber | 16.0 |
| Crude ash | 9.0 |

**Table 4.** Volatile oil profile of ferula (*F. elaeochytris*) root

|  |  |  |  |
| --- | --- | --- | --- |
| **Volatile oils** | **g/100 g** | **Volatile oils** | **g/100g** |
| m-Tolualdehyde | 2.0 | Thujopsan-2-alpha-ol | 0.4 |
| p-Tolualdehyde | 0.8 | 1,4-Methanobenzocyclodecene | 1.0 |
| Ethanone, 1-(2-hydroxphenyl) | 0.4 | 1,4-Methanoazulen-7-ol,decahydro- | 0.7 |
| Carvone | 0.4 | Benzene | 2.1 |
| Phenol, 4-(1-methylethyl) | 0.5 | trans-beta-Guaine | 0.2 |
| Cyclohexanone | 0.4 | Neo-Intermedeol | 0.3 |
| p-Cymen-7-ol | 1.1 | Cyclohexane | 1.5 |
| Benzoic acid | 0.4 | Oplopenone | 3.5 |
| Carvacrol | 28.6 | Viridiflorol | 1.0 |
| 1-10-Decanediol | 1.5 | Cadalene | 9.0 |
| β-Citronellene | 0.5 | Helifolen-12-AL D | 1.1 |
| Geranylaceton (isomer 2) | 4.3 | 1,2-Dimethyl-3-ethylbenzene | 0.3 |
| R-Curcumene | 0.8 | R-Tumerol | 0.7 |
| alpha-trans-Bergamotene | 0.9 | Helifolen-12-AL B | 0.4 |
| Cuparene | 2.3 | E-Sesquilavandulol | 0.6 |
| β-Bisabolene | 1.8 | E-Nuciferol | 0.9 |
| Hexahydro-1-methyl-2H-azepine-2-thione | 2.3 | Himachalol | 0.2 |
| Nerolidoloxide | 1.2 | neo-allo-Ocimene | 2.0 |
| Hexanedioic acid,3-methyl-, bis (1-methyl propyl) ester | 1.3 | Furanmethanol | 3.6 |
| Bisabolol oxide A | 0.4 | Z-Lanceol | 1.0 |
| Bicylo (2.2.1.) heptane,2,2-dimethyl-3-methylene | 1.4 | Z-alpha-trans-Bergamotol | 2.6 |
| E-Nerolidol | 4.8 | alpha-Curcumen | 0.6 |
| 2,6-Octadien-1-ol,3,7-dimethyl-acetate | 0.5 | Diisobutyl phthalate | 0.8 |
| Benzene, 1-(1.5-dimethyl-4-hexenyl)-4-methyl- | 0.3 | β-Curcumene | 0.2 |
| 3,5,9-undecatrien-2-one, 6,10-dimethyl-,(E,E) | 0.6 | Z,E-Farnesol | 2.1 |
| Cyclohexene, 1,3,3-trimethyl-6-methylene | 2.5 | Ethanone | 1.2 |

**Table 5.** Effects of dietary supplementation of ferula (*F. elaeochytris*) root powder on performance parameters (1-28 days)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Items** | **Ferula root powder (g/kg)** | | | **SEM** | ***P*-values** | |
| **0** | **1** | **2** | **Combined** | **Linear** |
| Egg weight, g | 63.89 | 65.05 | 64.10 | 0.333 | 0.319 | 0.797 |
| Feed conversion ratio, kg feed/kg egg | 1.86 | 1.85 | 1.86 | 0.016 | 0.914 | 0.988 |
| Feed consumption, g | 118.93 | 120.10 | 119.40 | 0.804 | 0.841 | 0.816 |
| Egg production, % | 86.50 | 93.19 | 87.17 | 1.587 | 0.166 | 0.862 |
| Egg mass, g/hen/day | 55.37 | 60.63 | 55.85 | 1.106 | 0.098 | 0.854 |

n=16

SEM: Standard error of mean

**Table 6.** Effects of dietary supplementation of ferula (*F. elaeochytris*) root powder on performance parameters (28-56 days)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Items** | **Ferula root powder (g/kg)** | | | **SEM** | ***P*-values** | |
| **0** | **1** | **2** | **Combined** | **Linear** |
| Egg weight, g | 64.04 | 64.68 | 63.12 | 0.377 | 0.245 | 0.323 |
| Feed conversion ratio, kg feed/kg egg | 1.75 | 1.75 | 1.82 | 0.014 | 0.053 | 0.036 |
| Feed consumption, g | 111.95 | 113.14 | 114.99 | 0.772 | 0.274 | 0.112 |
| Egg production, % | 93.45 | 93.75 | 92.26 | 1.389 | 0.902 | 0.733 |
| Egg mass, g/hen/day | 59.93 | 60.77 | 58.24 | 1.039 | 0.609 | 0.514 |

n=16

SEM: Standard error of mean

**Table 7.** Effects of dietary supplementation of ferula (*F. elaeochytris*) root powder on performance parameters (1-56 days)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Items** | **Ferula root powder (g/kg)** | | | **SEM** | ***P*-values** | |
| **0** | **1** | **2** | **Combined** | **Linear** |
| Egg weight, g | 63.96 | 64.87 | 63.91 | 0.251 | 0.109 | 0.562 |
| Feed conversion ratio, kg feed/kg egg | 1.81 | 1.80 | 1.84 | 0.011 | 0.263 | 0.208 |
| Feed consumption, g | 115.44 | 116.62 | 117.20 | 0.637 | 0.523 | 0.265 |
| Egg production, % | 89.97 | 93.47 | 89.71 | 1.071 | 0.281 | 0.921 |
| Egg mass, g/hen/day | 57.65 | 60.70 | 57.05 | 0.765 | 0.112 | 0.745 |

n=32

SEM: Standard error of mean

**Table 8.** Effects of dietary supplementation of ferula (*F. elaeochytris*) root powder on egg quality parameters

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Items** | **Ferula root powder (g/kg)** | | | **SEM** | ***P*-values** | |
| **0** | **1** | **2** | **Combined** | **Linear** |
| Egg width, mm | 44.17 | 44.82 | 44.82 | 0.210 | 0.355 | 0.213 |
| Egg length, mm | 56.58 | 56.96 | 56.33 | 0.198 | 0.427 | 0.610 |
| Shape index, % | 78.08 | 78.73 | 79.58 | 0.372 | 0.260 | 0.103 |
| Yolk diameter, mm | 43.32 | 43.49 | 43.23 | 0.142 | 0.761 | 0.805 |
| Yolk height, mm | 18.29b | 18.84a | 18.82a | 0.072 | 0.001 | 0.001 |
| Albumen height, mm | 6.46 | 6.75 | 6.65 | 0.084 | 0.365 | 0.347 |
| Yolk index, % | 42.25b | 43.35a | 43.59a | 0.232 | 0.038 | 0.016 |
| Albumen index, % | 7.930 | 8.472 | 8.520 | 0.143 | 0.174 | 0.092 |
| Haugh unit, % | 79.19 | 80.66 | 80.57 | 0.612 | 0.556 | 0.366 |
| Yolk color L | 52.62 | 55.63 | 56.11 | 0.982 | 0.296 | 0.152 |
| Yolk color a | 20.70 | 20.56 | 20.49 | 0.166 | 0.875 | 0.613 |
| Yolk color b | 47.69 | 48.13 | 47.99 | 0.414 | 0.909 | 0.768 |
| Albumen pH | 7.883a | 7.892a | 7.818b | 0.041 | 0.042 | 0.126 |
| Shell weight, g | 6.24 | 6.39 | 6.37 | 0.075 | 0.668 | 0.468 |
| Shell thickness, µm | 0.353 | 0.361 | 0.361 | 0.003 | 0.523 | 0.316 |

n=20

SEM: Standard error of mean

L: lightness, a: redness, and b: yellowness

Different superscript letters (a, b) within the same row mean significant differences between groups (P<0.05).

**Table 9.** Effects of dietary supplementation of ferula (*F. elaeochytris*) root powder on oxidative stability of eggs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Items** | **Ferula root powder (g/kg)** | | | **SEM** | ***P*-values** | |
| **0** | **1** | **2** | **Combined** | **Linear** |
| TBARs (µmol MDA/kg egg) | 1.822a | 1.238b | 1.034b | 0.102 | 0.002 | 0.001 |
| DPPH (%) | 7.991b | 8.100b | 8.731a | 0.096 | 0.002 | 0.001 |

n=20

SEM: Standard error of mean

TBARs: Thiobarbituric reactive substances, MDA: Malondialdehyde, DPPH: 2,2-diphenyl-1-picrylhydrazyl

Different superscript letters (a, b) within the same row mean significant differences between groups (P<0.05).

**Table 10.** Effects of dietary supplementation of ferula (*F. elaeochytris*) root powder on some serum biochemical parameters

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Items** | **Ferula root powder (g/kg)** | | | **SEM** | ***P*-values** | |
| **0** | **1** | **2** | **Combined** | **Linear** |
| AST, U/L | 151.40 | 158.86 | 156.54 | 2.933 | 0.593 | 0.494 |
| ALT, U/L | 24.70 | 25.52 | 28.42 | 4.135 | 0.940 | 0.742 |
| ALP, U/L | 432.60 | 466.73 | 470.83 | 8.374 | 0.121 | 0.062 |
| Total protein, g/dL | 10.26 | 11.68 | 11.53 | 0.315 | 0.128 | 0.097 |
| Triglyceride, mg/dL | 1545.32a | 1136.99ab | 947.10b | 98.69 | 0.031 | 0.011 |
| Total cholesterol, mg/dL | 69.42a | 68.63a | 59.49b | 1.282 | 0.007 | 0.044 |

n=7

SEM: Standard error of mean

AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, ALP: Alkaline phosphatase

Different superscript letters (a, b) within the same row mean significant differences between groups (P<0.05).

**Table 11.** Effects of dietary supplementation of ferula (*F. elaeochytris*) root powder on some serum hormone parameters

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Items** | **Ferula root powder (g/kg)** | | | **SEM** | ***P*-values** | |
| **0** | **1** | **2** | **Combined** | **Linear** |
| Estradiol (E2), pg/mL | 257.86 | 273.81 | 279.73 | 12.564 | 0.781 | 0.503 |
| Progesterone, ng/mL | 0.224 | 0.171 | 0.287 | 0.024 | 0.138 | 0.269 |

n=7

SEM: Standard error of mean

**Table 12.** Effects of dietary supplementation of ferula (*F. elaeochytris*) root powder on some internal organ weight

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Items** | **Ferula root powder (g/kg)** | | | **SEM** | ***P*-values** | |
| **0** | **1** | **2** | **Combined** | **Linear** |
| Liver weight, g | 32.84 | 33.13 | 33.78 | 0.395 | 0.629 | 0.353 |
| Spleen weight, g | 1.52 | 1.37 | 1.47 | 0.054 | 0.555 | 0.700 |
| Gizzard weight, g | 26.87 | 26.10 | 27.38 | 0.303 | 0.229 | 0.492 |
| Heart weight, g | 6.25 | 5.91 | 6.09 | 0.132 | 0.607 | 0.643 |

n=7

SEM: Standard error of mean

**Table 13.** Effects of dietary supplementation of ferula (*F. elaeochytris*) root powder on follicles and some parts of oviduct

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Items** | **Ferula root powder (g/kg)** | | | **SEM** | ***P*-values** | |
| **0** | **1** | **2** | **Combined** | **Linear** |
| Total follicle weight, g | 36.86 | 41.62 | 41.41 | 1.276 | 0.235 | 0.151 |
| Graff follicle weight, g | 11.81 | 12.40 | 13.16 | 0.265 | 0.112 | 0.039 |
| Total oviduct weight, g | 60.66 | 64.49 | 62.48 | 1.160 | 0.441 | 0.541 |
| Uterus width, mm | 51.56 | 51.06 | 54.77 | 0.866 | 0.168 | 0.130 |
| Uterus length, mm | 81.41b | 93.47a | 92.15a | 1.715 | 0.002 | 0.003 |
| Graff follicle diameter, mm | 30.81 | 33.04 | 32.82 | 0.481 | 0.108 | 0.083 |

n=7

SEM: Standard error of mean

Different superscript letters (a, b) within the same row mean significant differences between groups (P<0.05).