An improved algorithm for solving profit-maximizing cattle diet problems

J. G. O. Marques 1, R. de O. Silva 1, L. G. Barioni 2, J. A. J. Hall 3, L. O. Tedeschi 4 and D. Moran 1

*1 Global Academy of Agriculture and Food Security, the University of Edinburgh, Edinburgh, UK.*

*2 Embrapa Agricultural Informatics, Campinas, Brazil.*

3 School of Mathematics, the University of Edinburgh, Edinburgh, UK.

*4 Department of Animal Science, Texas A&M University, College Station, Texas, USA.*

Supplementary Material

Table S1 - Ingredient Properties from (NASEM, 2016).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ID | Feed | Forage%DM | DM%AF | CP%DM | Fat%DM | NDF%DM | TDN%DM | MEMcal/kg | NEmaMcal/kg | NEgaMcal/kg | RUP%CP | peNDF%NDF |
| 34 | Citrus pulp, dry | 0 | 87.7 | 6.9 | 2.4 | 24.0 | 70.0 | 2.5 | 1.6 | 1.0 | 40.3 | 33.0 |
| 45 | Corn grain | 0 | 87.2 | 8.8 | 3.8 | 9.7 | 87.6 | 3.2 | 2.2 | 1.5 | 65.3 | 30.0 |
| 50 | Corn silage | 50.0 | 33.1 | 8.2 | 3.3 | 43.0 | 67.7 | 2.4 | 1.6 | 1.0 | 25.4 | 81.0 |
| 58 | Cottonseed meal | 0 | 88.6 | 45.0 | 3.9 | 33.6 | 69.6 | 2.5 | 1.6 | 1.0 | 42.7 | 36.0 |
| 59 | Cottonseed whole | 0 | 92.6 | 22.9 | 19.4 | 47.8 | 93.0 | 3.4 | 2.3 | 1.6 | 30.4 | 100.0 |
| 60 | Distillers grain plus soluble, dry | 0 | 90.0 | 30.8 | 10.7 | 33.7 | 89.0 | 3.2 | 2.2 | 1.5 | 67.9 | 4.0 |
| 79 | Grain sorghum grain | 0 | 88.7 | 11.6 | 3.5 | 7.2 | 86.0 | 3.1 | 2.1 | 1.4 | 71.1 | 34.0 |
| 133 | Soybean hulls | 0 | 90.0 | 12.4 | 2.3 | 64.8 | 62.6 | 2.3 | 1.4 | 0.8 | 53.1 | 2.0 |
| 134 | Soybean meal high CP | 0 | 89.2 | 52.9 | 1.9 | 11.3 | 79.5 | 2.9 | 1.9 | 1.3 | 29.5 | 36.0 |
| 148 | Sugarcane silage | 100.0 | 34.2 | 5.4 | 1.9 | 68.8 | 52.0 | 1.9 | 1.0 | 0.5 | 47.7 | 81.0 |
| 166 | Wheat middlings | 0 | 88.8 | 18.6 | 4.1 | 38.3 | 72.9 | 2.6 | 1.7 | 1.1 | 31.6 | 2.0 |
| 845 | Urea | 0 | 99.0 | 281.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 | 0 |

NASEM - National Academies of Sciences, Engineering, and Medicine 2016. Nutrient Requirements of Beef Cattle, 8th Revised Edition. National Academies Press, Washington, DC, USA.

Table S2 – Sensitivity analysis on shrunk body weight (SBW), animal’s sale price, and body condition score (BCS). Scenarios in bold are the default scenario with 300kg SBW, US$ 1.44 animal selling price, and BCS 5.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Scenario | CNEm[Mcal/kg] | MPm[kg per day] | DMI[kg per day] | Nem[Mcal] | SWG[kg per day] | Objective function (Profit)[US$ per day] | Cost[US$ per day] | Revenue[US$ per day] |
| Weight | 350 kg | 1.85 | 0.31 | 8.10 | 6.23 | 1.29 | 0.32 | 1.53 | 1.85 |
| 325 kg | 1.86 | 0.29 | 7.49 | 5.89 | 1.25 | 0.37 | 1.43 | 1.80 |
| **300 kg** | **1.88** | **0.27** | **6.86** | **5.55** | **1.21** | **0.41** | **1.33** | **1.74** |
| 275 kg | 1.90 | 0.26 | 6.25 | 5.20 | 1.16 | 0.44 | 1.23 | 1.67 |
| 250 kg | 1.91 | 0.24 | 5.66 | 4.84 | 1.11 | 0.47 | 1.12 | 1.59 |
| Sale's Price | Sale +15% | 1.92 | 0.27 | 6.76 | 5.55 | 1.22 | 0.67 | 1.35 | 2.02 |
| Sale +10% | 1.92 | 0.27 | 6.78 | 5.55 | 1.21 | 0.58 | 1.34 | 1.92 |
| Sale +5% | 1.90 | 0.27 | 6.82 | 5.55 | 1.21 | 0.49 | 1.34 | 1.83 |
| **Sale** | **1.88** | **0.27** | **6.86** | **5.55** | **1.21** | **0.41** | **1.33** | **1.74** |
| Sale -5% | 1.86 | 0.27 | 6.91 | 5.55 | 1.20 | 0.32 | 1.32 | 1.64 |
| Sale -10% | 1.85 | 0.27 | 6.95 | 5.55 | 1.19 | 0.23 | 1.31 | 1.54 |
| Sale -15% | 1.85 | 0.27 | 6.95 | 5.55 | 1.19 | 0.15 | 1.31 | 1.46 |
| BCS | BCS 3 | 1.88 | 0.27 | 6.86 | 5.00 | 1.30 | 0.54 | 1.33 | 1.87 |
| BCS 4 | 1.88 | 0.27 | 6.86 | 5.27 | 1.25 | 0.47 | 1.33 | 1.80 |
| **BCS 5** | **1.88** | **0.27** | **6.86** | **5.55** | **1.21** | **0.41** | **1.33** | **1.74** |
| BCS 6 | 1.88 | 0.27 | 6.86 | 5.83 | 1.16 | 0.34 | 1.33 | 1.67 |
| BCS 7 | 1.88 | 0.27 | 6.86 | 6.11 | 1.11 | 0.28 | 1.33 | 1.60 |
| Multi variated | 350, +15%, 3 | 1.89 | 0.31 | 7.99 | 5.61 | 1.39 | 0.76 | 1.55 | 2.31 |
| 350, +15%, 7 | 1.90 | 0.31 | 7.96 | 6.85 | 1.22 | 0.45 | 1.56 | 2.01 |
| 350, -15%, 3 | 1.85 | 0.31 | 8.10 | 5.61 | 1.38 | 0.16 | 1.53 | 1.69 |
| 350, -15%, 7 | 1.85 | 0.31 | 8.10 | 6.85 | 1.20 | -0.07 | 1.53 | 1.46 |
| 250, +15%, 3 | 1.94 | 0.24 | 5.60 | 4.36 | 1.20 | 0.86 | 1.13 | 1.99 |
| 250, +15%, 7 | 1.94 | 0.24 | 5.60 | 5.33 | 1.02 | 0.57 | 1.13 | 1.69 |
| 250, -15%, 3 | 1.86 | 0.24 | 5.76 | 4.36 | 1.18 | 0.35 | 1.10 | 1.44 |
| 250, -15%, 7 | 1.87 | 0.24 | 5.74 | 5.33 | 1.00 | 0.13 | 1.10 | 1.23 |

|  |  |  |
| --- | --- | --- |
|  |  | Diet Composition |
|  | Scenario | Cottonseed whole | Grain sorghum grain | Soybean meal high CP | Sugarcane silage | Urea |
| Weight | 350 kg | 18.74% | 58.67% | 0.00% | 16.29% | 6.29% |
| 325 kg | 19.36% | 50.69% | 9.34% | 15.43% | 5.19% |
| **300 kg** | **20.21%** | **39.61%** | **22.27%** | **14.24%** | **3.67%** |
| 275 kg | 20.79% | 32.09% | 31.06% | 13.42% | 2.63% |
| 250 kg | 21.24% | 26.34% | 37.77% | 12.80% | 1.85% |
| Sale's Price | Sale +15% | 21.74% | 19.92% | 45.27% | 12.11% | 0.96% |
| Sale +10% | 21.38% | 24.57% | 39.84% | 12.61% | 1.60% |
| Sale +5% | 20.79% | 32.09% | 31.06% | 13.42% | 2.63% |
| **Sale** | **20.21%** | **39.61%** | **22.27%** | **14.24%** | **3.67%** |
| Sale -5% | 19.36% | 50.69% | 9.34% | 15.43% | 5.19% |
| Sale -10% | 18.74% | 58.67% | 0.00% | 16.29% | 6.29% |
| Sale -15% | 18.74% | 58.67% | 0.00% | 16.29% | 6.29% |
| BCS | BCS 3 | 20.21% | 39.61% | 22.27% | 14.24% | 3.67% |
| BCS 4 | 20.21% | 39.61% | 22.27% | 14.24% | 3.67% |
| **BCS 5** | **20.21%** | **39.61%** | **22.27%** | **14.24%** | **3.67%** |
| BCS 6 | 20.21% | 39.61% | 22.27% | 14.24% | 3.67% |
| BCS 7 | 20.08% | 41.33% | 20.25% | 14.42% | 3.92% |
| Multi variated | 350, +15%, 3 | 20.30% | 38.52% | 23.55% | 14.12% | 3.52% |
| 350, +15%, 7 | 20.79% | 32.09% | 31.06% | 13.42% | 2.63% |
| 350, -15%, 3 | 18.74% | 58.67% | 0.00% | 16.29% | 6.29% |
| 350, -15%, 7 | 18.74% | 58.67% | 0.00% | 16.29% | 6.29% |
| 250, +15%, 3 | 22.28% | 12.88% | 53.49% | 11.35% | 0.00% |
| 250, +15%, 7 | 22.28% | 12.88% | 53.49% | 11.35% | 0.00% |
| 250, -15%, 3 | 19.36% | 50.69% | 9.34% | 15.43% | 5.19% |
| 250, -15%, 7 | 19.59% | 47.74% | 12.76% | 15.11% | 4.80% |