



Supplementary Files: A Meta-Analysis of the Effects of Slow-Release Urea Supplementation on the Performance of Beef Cattle

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Table S1. Reference list of studies excluded from the meta-analysis.

Almora, E. A., Huntington, G. B., & Burns, J. C. (2012). Effects of supplemental urea sources and feeding frequency on ruminal fermentation, fiber digestion, and nitrogen balance in beef steers. Animal feed science and technology, 171(2-4), 136-145.
Benedeti, P. D. B., Paulino, P. V. R., Marcondes, M. I., Valadares Filho, S. D. C., Martins, T. S.,
Lisboa, E. F., & Duarte, M. S. (2014). Soybean meal replaced by slow release urea in finishing
diets for beef cattle. Livestock Science, 165, 51-60.
Bourg, B. M., Tedeschi, L. O., Wickersham, T. A., & Tricarico, J. M. (2012). Effects of a slow-
release urea product on performance, carcass characteristics, and nitrogen balance of steers fed steam-flaked corn. <i>Journal of Animal Science</i> , 90(11), 3914-3923.
Ceconi, I., Ruiz-Moreno, M. J., DiLorenzo, N., DiCostanzo, A., & Crawford, G. I. (2015). Effect of
slow-release urea inclusion in diets containing modified corn distillers grains on total tract
digestibility and ruminal fermentation in feedlot cattle. Journal of animal science, 93(8), 4058-
4069.
Fialho, M. P. F., Miranda, P. A. B., Saliba, E. O. S., De Oliveira, L. O. F., Lopes, V., Da Silva, J. J.,
Moraes, S. A. D. (2007). Ruminal fermentation characteristics and microbial protein synthesis of
cattle fed supplements with different combinations of carbohydrate and protein. Scientific poster
presented at the 23rd Alltech Symposium, 20-23 May 2007, Lexington, USA.
Garcia-Gonzalez, R., Tricarico, J. M., Harrison, G. A., Meyer, M. D., McLeod, K. R., Harmon, D.
L., & Dawson, K. A. (2007). Optigen (R) is a sustained release source of non-protein nitrogen in
the rumen. J. Anim. Sci., 85(Suppl. 1), 98.
Gonçalves, A. P., Nascimento, C. F. M. D., Ferreira, F. A., Gomes, R. D. C., Manella, M. D. Q.,
Marino, C. T., & Rodrigues, P. H. M. (2015). Slow-release urea in supplement fed to beef steers.
Brazilian Archives of Biology and technology, 58(1), 22-30.
Holder, V., Harmon, D., Jennings, J. (2013). The effects of basal diet and the supply of degradable
intake protein on growth of steers. Scientific poster presented at the 29th Alltech Symposium, 19-
22 May 2013, Lexington, USA.
Holder, V., Harmon, D., Jennings, J. (2013). Effects of replacing soybean meal N with NPN from
urea or Optigen on intake and performance of receiving cattle. Scientific poster presented at the
29th Alltech Symposium, 19-22 May 2013, Lexington, USA.
Holder, V. B., El-Kadi, S. W., Tricarico, J. M., Vanzant, E. S., McLeod, K. R., & Harmon, D. L.
(2013). The effects of crude protein concentration and slow release urea on nitrogen metabolism
in Holstein steers. Archives of animal nutrition, 67(2), 93-103.
Holder, V. B., Tricarico, J. M., Kim, D. H., Kristensen, N. B., & Harmon, D. L. (2015). The effects of
degradable nitrogen level and slow release urea on nitrogen balance and urea kinetics in Holstein
steers. Animal Feed Science and Technology, 200, 57-65.
López-Soto, M. A., Aguilar-Hernández, J. A., Dávila-Ramos, H., Estrada-Angulo, A., Ríos, F. G.,
Urías-Estrada, J. D., & Plascencia, A. (2015). Effects of a combining feed grade urea and a slow-
release product on performance, dietary energetics and carcass characteristics of steers fed
finishing diets. Journal of Applied Animal Research, 43(3), 303-308.
Manella, M. Q., Matsuda, E. Y., & Carvalho, F.A.N. (2007). Replacing vegetable protein in
supplements with Optigen II in beef steers fed sugar cane silage as the sole forage. Scientific
poster presented at the 23rd Alltech Symposium, 20-23 May 2007, Lexington, USA.

Marchesin, W. A., Herling, V. R., de Moraes, A. L., Luz, P. H. C., Sanchez, J. M. D., Pereira, T. Q. M., Manella, M. Q., Putrino, S. M., & Glossklaus, C. (2008). Rearing Nelore heifers using low and high intake supplements in winter. Scientific poster presented at the 24th Alltech Symposium, 20-23 April 2008, Lexington, USA.

Pazdiora, R. D., Resende, F. D. D., Faria, M. H. D., Siqueira, G. R., Almeida, G. B. D. S., Sampaio, R. L., ... & Prietto, M. S. R. (2013). Animal performance and carcass characteristics of Nellore young bulls fed coated or uncoated urea slaughtered at different weights. Revista Brasileira de Zootecnia, 42(4), 273-283.

Wahrmund, J., De Araujo, D. V., Hersom, M., & Arthington, J. (2007). Evaluation of Optigen® II as a source of rumen degradable protein for mature beef cows. 2007 Florida Beef Report, University of Florida, Gainesville, Florida, USA, 61-63.

Study name Statistics for each study Difference Difference Lower Upper in means 1.350 0.722 1.978 Cabrita 2011 -0.110 -0.805 0.585 Corte et al. 2018 -0.700 -2.271 0.871 Eweedah et al. 2016 (1) -0.300 -0.498 -0.102 Eweedah et al. 2016 (2) -0.300 -0.498 -0.102 Ferres et al. 2010 0.270 -0.016 0.556 Koncnoff et al. 2006 (1) 0.040 -0.704 0.784 Koncnoff et al. 2006 (2) -0.060 -0.804 0.684
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Kononoff et al. 2006 (2) -0.060 -0.804 0.684
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Muroetal. 2011 0.120 -0.348 0.588 -
Pinos-Rodriquez et al. 2010 -0.500 -3.559 2.559
Rossi et al. 2013 -1.260 -1.910 -0.610
Simeone et al. 2009 (1) 0.110 -0.777 0.997 -
Simeone et al. 2009 (2) 0.690 -0.197 1.577
Tedeschi et al. 2002 (1) 0.790 0.245 1.335
Tedeschi et al. 2002 (2) 1.150 0.605 1.695
Tedeschi et al. 2002 (3) 0.020 -1.823 1.863
Tedeschi et al. 2002 (4) 0.110 -1.733 1.953
Nahrmund and Hersom 2009 (1) 0.230 -0.911 1.371
Nahrmund and Hersom 2009 (2) 0.130 -1.011 1.271
Nahrmund and Hersom 2009 (3) -1.090 -2.231 0.051
-Idder et al. 2013b (1) -0.100 -0.722 0.522 -
-Idder et al. 2013b (2) -0.050 -0.672 0.572 -
-Idder et al. 2013b (3) -0.190 -0.812 0.432 -
-Idl and and Jennings 2011 (1) 0.200 -0.544 0.944 -
-Idland and Jennings 2011 (2) -0.130 -0.874 0.614
_opez-Soto et al. 2015 (1) -0.420 -1.275 0.435
Lopez-Soto et al. 2015 (2) -0.650 -1.505 0.205
Lopez-Soto et al. 2015 (3) -1.190 -2.045 -0.335
Taylor-Edwards et al. 2009 (1) 0.330 -0.265 0.925
Taylor-Edwards et al. 2009 (2) 0.660 0.065 1.255
Taylor-Edwards et al. 2009 (3) 0.730 0.135 1.325 -
Taylor-Edwards et al. 2009 (4) 0.620 0.025 1.215
0.074 -0.132 0.281
-4.00 -2.00 0.00

Figure S1. Forest plot of the effect of slow-release urea supplementation on dry matter intake (DMI, kg/d) of growing and finishing beef cattle. Study name refers to the reference of that study. Raw mean differences (difference in means) represent the effect size estimate. Each square represents the mean effect size for that study. Thus, the squares to the right of the zero mid-line represent an increase in DMI, squares to the left of the 0 mid-line indicate a decrease in DMI and squares at the 0 mid-line indicate no effect on DMI. The upper and lower limit of the line connected to the square represents the upper and lower 95% confidence interval (CI) for the effect size. The size of the square reflects the relative weighting of the study to the overall effect size estimate, with larger squares representing greater weight. The diamond at the bottom represents the overall effect size estimate.

Study name	Statistics	for each	study		ifference	in means	and 95% C		
	Difference in means	Lower limit	Upper limit	Ι	Ι				Relative weight
Agovino et al. 2013	0,130	0,049	0,211						3,32
Cabrita 2011	0,020	-0,098	0,138			-			3,05
Corte et al. 2018	-0,140	-0,320	0,040		-	-0-4			2,53
Eweedah et al. 2016 (1)	-0,080	-0,117	-0,043			- -			3,54
Eweedah et al. 2016 (2)	-0,110	-0,147	-0,073						3,54
Ferres et al. 2010	-0,050	-0,087	-0,013						3,54
Kononoff et al. 2006 (1)	-0,010	-0,128	0,108			-⊕-			3,05
Kononoff et al. 2006 (2)	0,000	-0,118	0,118			-①-			3,05
Muro et al. 2011	0,080	0,013	0,147			—			3,40
Pinos-Rodriquez et al. 2010	0,000	-0,386	0,386		<u> </u>	<u>ф</u>	-		1,22
Rossi et al. 2013	-0,400	-0,494	-0,306		- b				3,23
Simeone et al. 2009 (1)	0,010	-0,090	0,110			- ()-			3,18
Simeone et al. 2009 (2)	0,060	-0,026	0,146						3,28
Tedeschi et al. 2002 (1)	0,130	0,086	0,174			+			3,51
Tedeschi et al. 2002 (2)	0,280	0,225	0,335				⋺╋╼		3,47
Tedeschi et al. 2002 (3)	0,060	-0,104	0,224			-⊡			2,67
Tedeschi et al. 2002 (4)	0,180	0,006	0,354				-		2,58
Wahrmund and Hersom 2009 (1)	0,140	-0,008	0,288			⊢⊡−			2,80
Wahrmund and Hersom 2009 (2)	0,130	-0,003	0,263			- <u>-</u> -			2,92
Wahrmund and Hersom 2009 (3)	-0,170	-0,311	-0,029		-				2,86
Holder et al. 2013b (1)	-0,050	-0,129	0,029						3,33
Holder et al. 2013b (2)	-0,080	-0,159	-0,001						3,33
Holder et al. 2013b (3)	-0,140	-0,219	-0,061			\Box			3,33
Holland and Jennings 2011 (1)	0,030	-0,057	0,117			÷			3,28
Holland and Jennings 2011 (2)	-0,010	-0,097	0,077			_ ⊡			3,28
Lopez-Soto et al. 2015 (1)	0,130	0,006	0,254						3,00
Lopez-Soto et al. 2015 (2)	0,090	-0,034	0,214			h			3,00
Lopez-Soto et al. 2015 (3)	0,000	-0,124	0,124			-①-			3,00
Taylor-Edwards et al. 2009 (1)	0,080	0,018	0,142			-[]-			3,43
Taylor-Edwards et al. 2009 (2)	0,170	0,108	0,232			-+ D-	-1		3,43
Taylor-Edwards et al. 2009 (3)	0,240	0,178	0,302						3,43
Taylor-Edwards et al. 2009 (4)	0,280	0,218	0,342						3,43
	0,033	-0,020	0,085			•			
				-1,00	-0,50	0,00	0,50	1,00	

Figure S2. Forest plot of the effect of slow-release urea supplementation on dietary protein intake (DPI, kg/d) of growing and finishing beef cattle. Study name refers to the reference of that study. Raw mean differences (difference in means) represent the effect size estimate. Each square represents the mean effect size for that study. Thus, the squares to the right of the zero mid-line represent an increase in DPI, squares to the left of the 0 mid-line indicate a decrease in DPI and squares at the 0 mid-line indicate no effect on DPI. The upper and lower limit of the line connected to the square represents the upper and lower 95% confidence interval (CI) for the effect size. The size of the square reflects the relative weighting of the study to the overall effect size estimate, with larger squares representing greater weight. The diamond at the bottom represents the overall effect size estimate.

Studyname	Statistics	for each	study	Difference in means and 95% Cl	
	Difference in means	Lower limit	Upper limit		Relative weight
Agovino et al. 2013	0.230	0.088	0.372		3.86
Cabrita 2011	0.120	-0.037	0.277		3.15
Corte et al. 2018	-0.100	-0.411	0.211		0.80
Eweedah et al. 2016 (1)	0.040	-0.072	0.152		6.23
Eweedah et al. 2016 (2)	-0.100	-0.212	0.012		6.23
Ferres et al. 2010	0.210	0.145	0.275		18.62
Kononoff et al. 2006 (1)	0.000	-0.198	0.198		1.97
Kononoff et al. 2006 (2)	-0.070	-0.268	0.128		1.97
Muroetal. 2011	0.200	-0.118	0.518		0.77
Pinos-Rodriquez et al. 2010	-0.100	-0.687	0.487		0.22
Rossi et al. 2013	0.090	-0.057	0.237		3.60
Simeone et al. 2009 (1)	-0.080	-0.280	0.120		1.93
Simeone et al. 2009 (2)	0.080	-0.120	0.280		1.93
Tedeschi et al. 2002 (1)	0.280	0.106	0.454		2.55
Tedeschietal. 2002 (2)	0.590	0.416	0.764		2.55
Tedeschi et al. 2002 (3)	0.110	-0.239	0.459		0.64
Tedeschi et al. 2002 (4)	0.120	-0.229	0.469		0.64
Wahrmund and Hersom 2009 (1)	0.020	-0.143	0.183		2.92
Wahrmund and Hersom 2009 (2)	0.050	-0.113	0.213		2.92
Wahrmund and Hersom 2009 (3)	0.100	-0.063	0.263		2.92
Holder et al. 2013b (1)	-0.050	-0.288	0.188		1.37
Holder et al. 2013b (2)	0.020	-0.218	0.258		1.37
Holder et al. 2013b (3)	-0.040	-0.278	0.198		1.37
Holland and Jennings 2011 (1)	0.020	-0.104	0.144		5.05
Holland and Jennings 2011 (2)	-0.040	-0.164	0.084		5.05
Lopez-Soto et al. 2015 (1)	0.120	-0.078	0.318		1.97
Lopez-Soto et al. 2015 (2)	0.000	-0.198	0.198		1.97
Lopez-Soto et al. 2015 (3)	-0.160	-0.358	0.038		1.97
Taylor-Edwards et al. 2009 (1)	0.150	-0.011	0.311		2.99
Taylor-Edwards et al. 2009 (2)	0.330	0.169	0.491		2.99
Taylor-Edwards et al. 2009 (3)	0.350	0.189	0.511		2.99
Taylor-Edwards et al. 2009 (4)	0.180	0.019	0.341		2.99
Manella et al. 2007	0.070	-0.156	0.296		1.51
	0.107	0.080	0.135		
				-1.00 -0.50 0.00 0.50 1.00	l.

Figure S3. Forest plot of the effect of slow-release urea supplementation on liveweight gain (LWG, kg/d) of growing and finishing beef cattle. Study name refers to the reference of that study. Raw mean differences (difference in means) represent the effect size estimate. Each square represents the mean effect size for that study. Thus, the squares to the right of the zero mid-line represent an increase in LWG, squares to the left of the 0 mid-line indicate a decrease in LWG and squares at the 0 mid-line indicate no effect on LWG. The upper and lower limit of the line connected to the square represents the upper and lower 95% confidence interval (CI) for the effect size. The size of the square reflects the relative weighting of the study to the overall effect size estimate, with larger squares representing greater weight. The diamond at the bottom represents the overall effect size estimate.

Studyname	Statistics	for each s	study
	Difference	Lower	Upper
	in means	limit	limit
Agovino et al. 2013	0.010	0.005	0.015
Cabrita 2011	0.020	0.014	0.026
Corte et al. 2018	0.000	-0.001	0.001
Eweedah et al. 2016 (1)	0.010	0.004	0.016
Eweedah et al. 2016 (2)	-0.010	-0.016	-0.004
Ferres et al. 2010	0.020	0.018	0.022
Kononoff et al. 2006 (1)	0.000	-0.006	0.006
Kononoff et al. 2006 (2)	-0.010	-0.016	-0.004
Muroetal. 2011	0.030	0.016	0.044
Pinos-Rodriquez et al. 2010	0.000	-0.017	0.017
Rossi et al. 2013	0.020	0.015	0.025
Simeone et al. 2009 (1)	-0.020	-0.027	-0.013
Simeone et al. 2009 (2)	0.000	-0.007	0.007
Tedeschi et al. 2002 (1)	0.040	0.036	0.044
Tedeschi et al. 2002 (2)	0.080	0.075	0.085
Tedeschi et al. 2002 (3)	0.010	0.002	0.018
Tedeschi et al. 2002 (4)	0.010	0.002	0.018
Wahrmund and Hersom 2009 (1)	0.000	-0.012	0.012
Wahrmund and Hersom 2009 (2)	0.000	-0.012	0.012
Wahrmund and Hersom 2009 (3)	0.030	0.018	0.042
Holder et al. 2013b (1)	-0.010	-0.035	0.015
Holder et al. 2013b (2)	0.000	-0.025	0.025
Holder et al. 2013b (3)	0.000	-0.025	0.025
Holland and Jennings 2011 (1)	0.000	-0.007	0.007
Holland and Jennings 2011 (2)	0.000	-0.007	0.007
Lopez-Soto et al. 2015 (1)	0.020	0.009	0.031
Lopez-Soto et al. 2015 (2)	0.010	-0.001	0.021
Lopez-Soto et al. 2015 (3)	0.000	-0.011	0.011
Taylor-Edwards et al. 2009 (1)	0.020	0.005	0.035
Taylor-Edwards et al. 2009 (2)	0.040	0.025	0.055
Taylor-Edwards et al. 2009 (3)	0.040	0.025	0.055
Taylor-Edwards et al. 2009 (4)	0.040	0.025	0.035
i ayıcı - Luvvai us cı al. 2008 (4)	0.020	0.005	0.035
	0.012	0.005	0.019

Figure S4. Forest plot of the effect of slow-release urea supplementation on feed efficiency (FE, kg LWG/kg DMI) of growing and finishing beef cattle. Study name refers to the reference of that study. Raw mean differences (difference in means) represent the effect size estimate. Each square represents the mean effect size for that study. Thus, the squares to the right of the zero mid-line represent an increase in FE, squares to the left of the 0 mid-line indicate a decrease in FE and squares at the 0 mid-line indicate no effect on FE. The upper and lower limit of the line connected to the square represents the upper and lower 95% confidence interval (CI) for the effect size. The size of the square reflects the relative weighting of the study to the overall effect size estimate, with larger squares representing greater weight. The diamond at the bottom represents the overall effect size estimate.



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