Novel techniques in poultry feed formulation
A revolution in the poultry enterprise

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Poultry Innovation Showcase

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UNIVERSITY OF ALBERTA

POULTRY INNOVATION PARTNERSHIP

visionary change collaboration opportunity

poultryinnovationpartnership.ca

Outline

Feed formulation steps

Feed formulation targets from a novel perspective

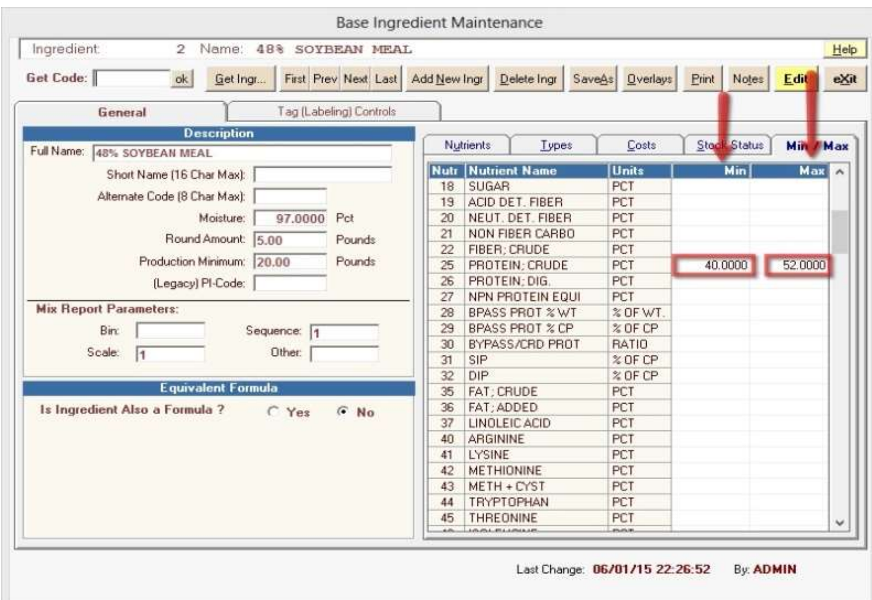
- Least Cost
- Maximum Profit
- Account for variability in nutrient composition of ingredients
- Account for variability in market and ingredients simultaneously

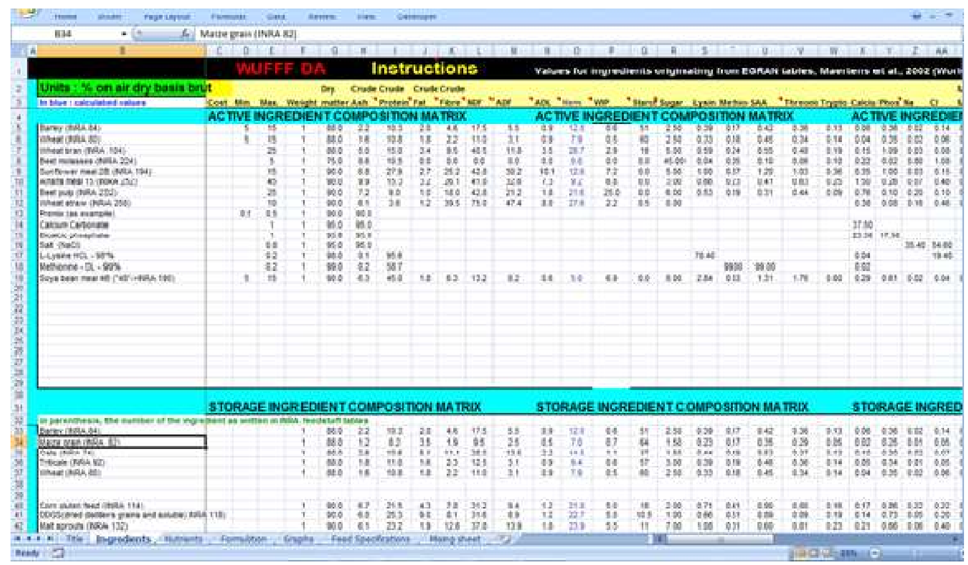
Walk through some feed formulation practices in Excel

Future direction

Feed formulation main steps

1. Nutrient requirements of the animal
2. Nutrient composition of feed ingredients
3. Using a precise feed formulation method to match nutrient supply with nutrient requirements





Nutrient requirements

- Age-specific

Table 7: Recommendations for Nutrient Levels for LOHMANN BROWN-LITE Pullets

Diet type*		Starter**	Grower	Developer	Pre-Layer
Nutrient		1.–3. Week	4.–8. Week	9.–16. Week	17. Week – 5 % Production
Metabol. Energy	kcal/kg	2800	2800	2800	2800
	kcal/lbs	1275	1275	1275	1275
Minimum	MJ/kg	12.00	11.70	11.70	11.70
Crude Protein	%	20.00	18.50	15.00	17.00
Methionine	%	0.48	0.40	0.34	0.36
Dig. Methionine	%	0.39	0.33	0.28	0.29
Methionine/Cystine	%	0.83	0.70	0.60	0.68
Digestible M./C.	%	0.68	0.57	0.50	0.56
Lysine	%	1.20	1.00	0.70	0.85
Digestible Lysine	%	0.98	0.82	0.57	0.70
Valine	%	0.89	0.75	0.53	0.64
Dig. Valine	%	0.76	0.64	0.46	0.55
Tryptophan	%	0.23	0.21	0.16	0.20
Dig. Tryptophan	%	0.19	0.17	0.13	0.16
Threonine	%	0.80	0.70	0.50	0.60
Dig. Threonine	%	0.65	0.57	0.40	0.49
Isoleucine	%	0.83	0.75	0.60	0.74
Dig. Isoleucine	%	0.68	0.62	0.50	0.61
Calcium	%	1.05	1.00	0.90	2.50
Phosphorus total	%	0.75	0.70	0.58	0.65
Phosphorus available	%	0.48	0.45	0.37	0.45
Sodium	%	0.18	0.17	0.16	0.16
Chlorine	%	0.20	0.19	0.16	0.16
Linoleic Acid	%	2.00	1.40	1.00	1.00

LOHMANN TIERZUCHT

Nutrient requirements

- Performance-specific

HY-LINE BROWN COMMERCIAL LAYERS

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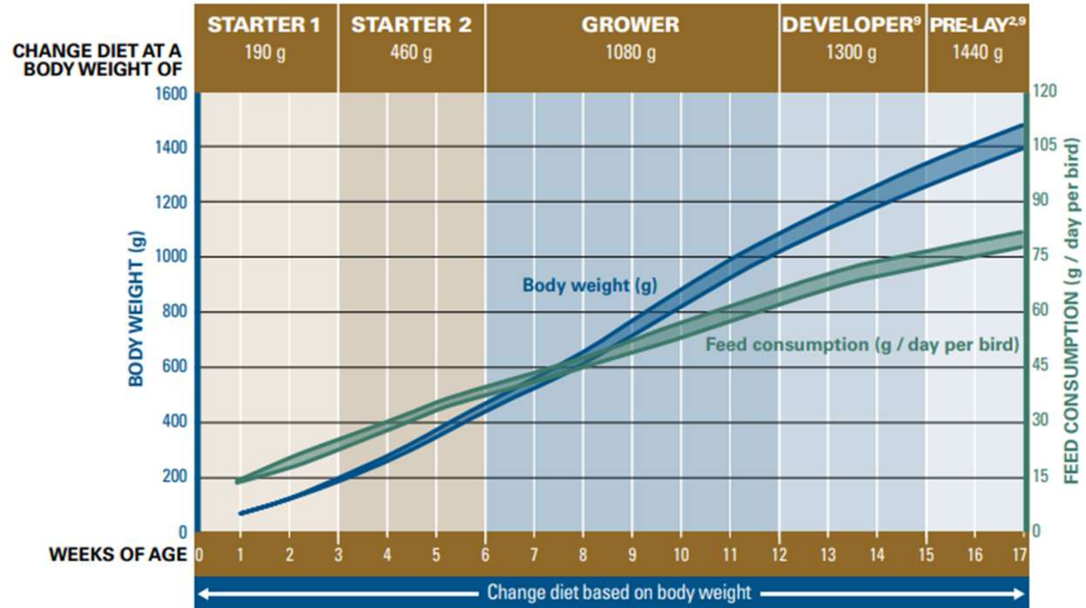
Rearing Period Nutritional Recommendations[1]



NUTRITION	STARTER 1	STARTER 2	GROWER	DEVELOPER	PRE-LAY
	RECOMMENDED NUTRIENT CONCENTRATION				
Metabolizable energy[3], kcal/kg	2867–3043	2867–3043	2800–3021	2734–3021	2778–2999
Metabolizable energy[3], MJ/kg	12.00–12.73	12.00–12.73	11.72–12.64	11.44–12.64	11.62–12.55
	Standardized Ileal Digestible Amino Acids / Total Amino Acids[4]				
Lysine, %	**1.01** / 1.11	**0.92** / 1.00	**0.82** / 0.89	**0.60** / 0.66	**0.72** / 0.78
Methionine, %	**0.45** / 0.49	**0.42** / 0.45	**0.39** / 0.43	**0.28** / 0.29	**0.35** / 0.38
Methionine+Cystine,%	**0.77** / 0.86	**0.72** / 0.81	**0.66** / 0.74	**0.50** / 0.57	**0.62** / 0.70
Threonine, %	**0.65** / 0.77	**0.60** / 0.70	**0.55** / 0.64	**0.41** / 0.49	**0.50** / 0.58
Tryptophan, %	**0.18** / 0.21	**0.17** / 0.20	**0.17** / 0.20	**0.13** / 0.16	**0.16** / 0.20
Arginine, %	**1.05** / 1.13	**0.96** / 1.03	**0.85** / 0.91	**0.63** / 0.67	**0.75** / 0.81
Isoleucine, %	**0.71** / 0.76	**0.66** / 0.71	**0.61** / 0.66	**0.45** / 0.48	**0.56** / 0.61
Valine, %	**0.73** / 0.80	**0.68** / 0.75	**0.64** / 0.70	**0.48** / 0.53	**0.61** / 0.67
Crude protein[5], %	20.00	18.25	17.50	15.00	16.50
Calcium[6], %	1.05	1.00	0.95	0.90	2.50

Hy-Line® BROWN

Robust growth models & accurate nutrient requirements

$$BW = Wm \times exp^{-exp^{-b\left(t-t_{inf}\right)}}$$

$$BW = (Wm + Wm_u) \times exp^{-exp^{-(b+b_u)\left(t-t_{inf}\right)}}$$

Prediction of age-specific BW to

- better match nutrient supply to nutrient requirements
- evaluate the economic impact of management decisions on designing target growth curves
- breeding programs
- nutritional management decisions

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Poultry Science
Volume 100, Issue 5, May 2021, 101059

Metabolism and Nutrition

Improving a nonlinear Gompertz growth model using bird-specific random coefficients in two heritage chicken lines

Mohammad Afrouziyeh *, René P. Kwakkel *, †, Martin J. Zuidhof *

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Abstract

Growth models describe body weight (**BW**) changes over time, allowing information from longitudinal measurements to be combined into a few parameters with biological interpretation. Nonlinear mixed models (**NLMM**)

How nutrient requirements are determined?
Nutritional Response Models

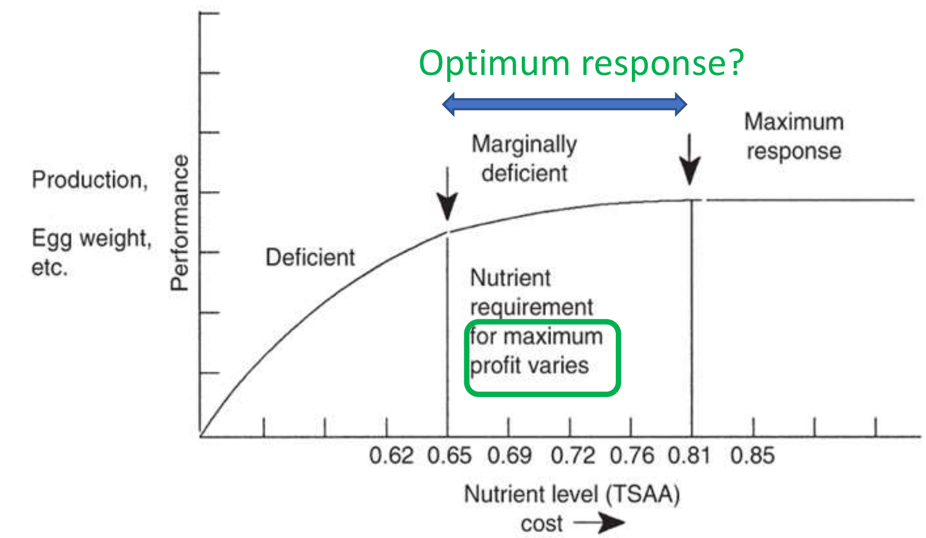


Fig. 37.1. How nutrient requirements are determined. In many instances, maximum response gives maximum profits. In many instances it does not. If price of feed and product income were constant, we could select one diet that always gives maximum return.

Source: Roland et al., 2000

Nutrient requirements vary

- Metabolizable Energy requirement
  - Laying hens: 2,684 - 2,992 kcal/kg
  - Broilers: 2,750 – 3,200 kcal/kg

- Total Sulfur Amino Acid (TSAA) levels (Ahmad and Roland, 2003)
  - 562 - 859 mg/day/hen depending upon energy and protein cost and market situation

- The requirement depends on the response criteria being evaluated

- We need mathematical models to select the most economical choice under the light of ingredients cost and product price

Take-home messages so far…

- Try to use performance-specific nutrient requirements as opposed to the age-specific ones
- Use robust models to determine nutrient requirements
- Let the energy and protein cost and product price dictate the dietary energy and nutrients levels
- Nutrient requirements vary and you need to choose the most relevant value regarding your target!

Define your feed formulation target

- 1920: Growth rate
- 1940: Feed efficiency and meat yield
- 1990: Least cost
- 2004: Maximum Profit (Guevara, 2004)
- 2010: Sustainable production (Economy, Environment, Social concerns)
- 2020: Flock OR Individual animal level (Zuidhof, 2020)
- 2020: Slower growth and meat quality

Feed formulation models and methods

1. Deal with market variation
    - Least Cost Feed Formulation (LCFF)
        - Linear programming models
    - Maximum Profit Feed Formulation (MPFF)
        - Nonlinear programming models
2. Deal with variation in feed ingredients composition
    - Margin of Safety (MOS) and Stochastic feed formulation
3. Deal with both!
    - Multiple Objective Programming (MOP)

Least Cost Feed Formulation (LCFF)

- Setting of nutrient restrictions intended to minimize the diet cost and maximize bird performance

- Meet nutrient requirements

You may want to create your own LCFF spreadsheet using the following tutorial video: https://youtu.be/tEAarcwd300

Source: Afolayan et al. (2008)

Sensitivity analysis of a formulated diet

/ariable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B21	CornLevel	0.572773059	0	0.234	0.002854194	0.031518277
C21	% Inclusion Wheat	0	0.072056157	0.275	1E+30	0.072056157
D21	% Inclusion Wheat Midd	0	0.198508256	0.25	1E+30	0.198508256
E21	% Inclusion Soybean oil	0.02653865	0	1.2	0.110556589	0.008769507
F21	% Inclusion Canola	0.3	-0.017694272	0.39	0.017694272	1E+30
G21	% Inclusion SoybeanMeal	0.022419528	0	0.51	0.134569752	0.001987795
H21	% Inclusion	0.055190135	0	1.2	0.003073896	0.090198866
I21	% Inclusion Oyster	0.003823225	0	0.04	0.010804942	0.631447725
J21	% Inclusion Limestone	0	0.010805037	0.05	1E+30	0.010805037
K21	% Inclusion D.phosphate	0.006540102	0	1	0.59932083	0.02152778
L21	% Inclusion Lys	0.003331506	0	3.8	2.475292586	0.365802161
M21	% Inclusion	0.001629453	0	9.5	6.414388506	0.495188174
N21	% Inclusion SodiumBicarbonate	0	0.213208931	0.06	1E+30	0.213208931
O21	% Inclusion Dried whey	0	0.717214926	0.8	1E+30	0.717214926
P21	% Inclusion Treonine	0.000848068	0	9.5	6.413142378	2.59480446
Q21	% Inclusion Vit premix	0.0025	2.187929024	1.6	1E+30	2.187929024
R21	% Inclusion Salt	0.001906274	0	0.04	0.307621647	0.17151071
S21	% Inclusion Mineral premix	0.0025	2.187929024	1.6	1E+30	2.187929024

If corn price increases by 0.0028$/kg or decreases by 0.0315$/kg, the inclusion level (57%) will remain same.

:onstraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
V4	Weight, kg Diet specification	1	-0.587929024	1	0.042176597	0.037285991
V6	Diet specification	2.95	0.210344591	2.95	0.122402515	0.138457402
V7	Protein,% Diet specification	20	0.003307618	20	0.91213385	1.505037054
V8	Calcium,% Diet specification	0.87	0.016503263	0.87	1.384195493	0.146284224
V9	Av.phosph.,% Diet specification	0.43	0.058879145	0.43	0.081615807	0.118483242
V10	Sodium, % Diet specification	0.16	0.016100744	0.16	1.454153664	0.011396238
V11	Chloride, % Diet specification	0.177522399	0	0.16	0.017522399	1E+30
V12	Lysine,% Diet specification	1.29	0.054536579	1.29	1.381203339	0.22519065
V13	Methionine,% Diet specification	0.579645584	0	0.51	0.069645584	1E+30
V14	Met-Cys% Diet specification	0.99	0.100996682	0.99	2.2080537	0.069295518

For each unit increase in dietary protein level, the dietary cost will increase by 3.3$/ton

For each unit decrease in dietary protein level, the dietary cost will decrease by 3.3$/ton

- In a range of 18.5% to 20.91%

Disadvantages of Least Cost Feed Formulation

- Reducing feed costs?
  - The cost side of the equation looks attractive **but not necessary optimizes profitability**

Margin = Revenue - Cost

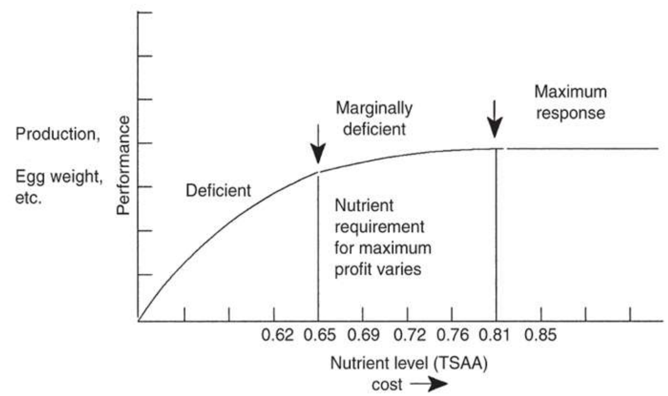


Fig. 37.1. How nutrient requirements are determined. In many instances, maximum response gives maximum profits. In many instances it does not. If price of feed and product income were constant, we could select one diet that always gives maximum return.

Sources: Cerrate and Waldroup (2009); Vieira and Angel (2012); Dadalt et al. (2015)

Moving to dynamic feed formulation method

- The response of birds to dietary energy diminishes with increasing nutrient density.
- Law of diminishing return
  - As nutrient intake increases, the performance (BW or Egg mass) also increases, but in a decreasing rate.

Maximum profit feed formulation in broilers

Margin = Revenue - Cost

Margin = (Product price × Product amount) – (feed cost × FI)

Margin = (Broiler price × $(-2.2571 \times E^2 + 14.69 \times E - 21.696)$) – (Feed cost × $(0.9925 \times E^2 - 6.9489 \times E + 15.581)$)

E: Energy density (Mcal/kg)

FI: Feed intake

Sources: Adopted from Guevara (2004)

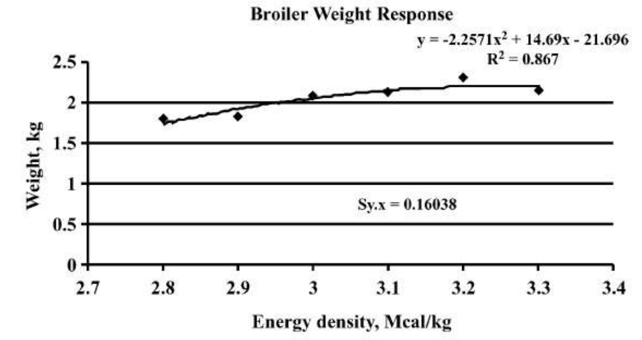


FIGURE 1. Broiler weight response to energy density at 42 d of age.

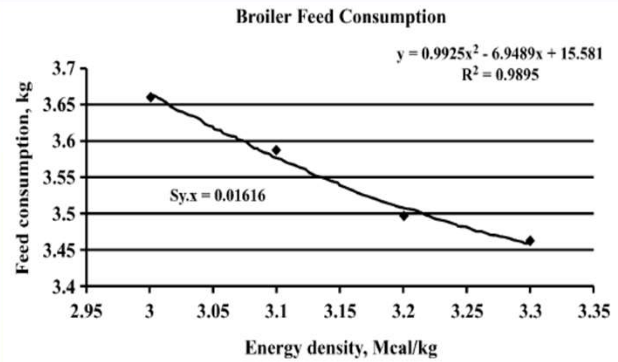


FIGURE 2. Broiler feed consumption response to energy density at 42 d of age.

Maximum profit feed formulation in layers

Margin = Revenue - Cost

Margin = (Product price × Product amount) – (Feed cost × FI)

Margin= (Egg price × $(0.25 \times E^2 - 0.5754 \times E + 4.1427)$) –
(Feed cost × $(-0.6786 \times E^2 + 1.2368 \times E + 10.542)$)

E: Energy density (Mcal/kg)

FI: Feed intake

Sources: Adopted from Afrouziyeh et al (2011)

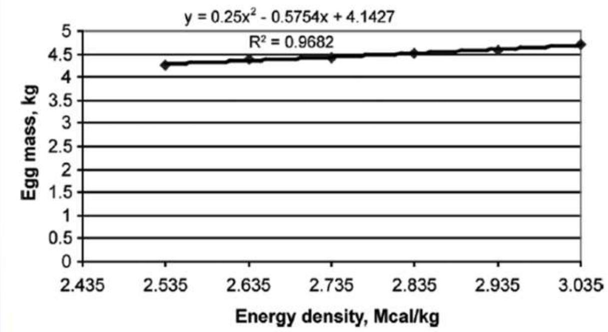


Figure 1. Egg mass response to energy density from 32 to 44 wk of age.

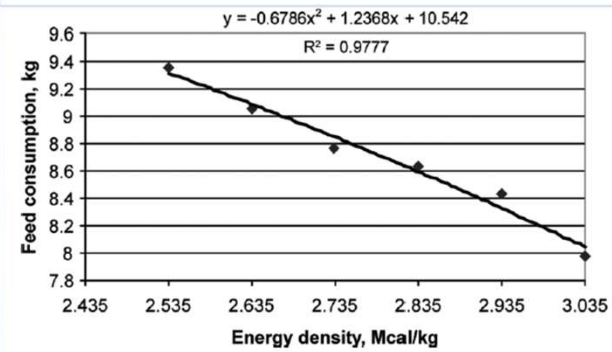


Figure 2. Laying hen feed consumption response to energy density from 32 to 44 wk of age.

Effects of changing prices of egg and ingredients on optimum dietary ME

Prices	ME (Mcal/kg)	Egg mass (g/day)	Feed consumption (g/day)	FCR	Margin (US $/hen)
LP[1]					2.51
NLP[2]					
Normal	2.730	52.79	105.48	2	2.70
Corn					
+25%	2.730	52.79	105.48	2	2.31
-25%	2.740	52.89	105.17	1.99	3.15
Soybean meal					
+25%	2.786	53.33	103.82	1.95	2.53
-25%	2.748	52.96	104.96	1.98	2.91
Egg[3]					
+25%	2.896	54.44	100.38	1.84	4.12
-25%	2.730	52.79	105.48	2	1.26

[1] Linear programming
[2] Non linear programming
[3] Egg price assumed: US $ 1.3/kg

Sources: Afrouziyeh et al (2011)

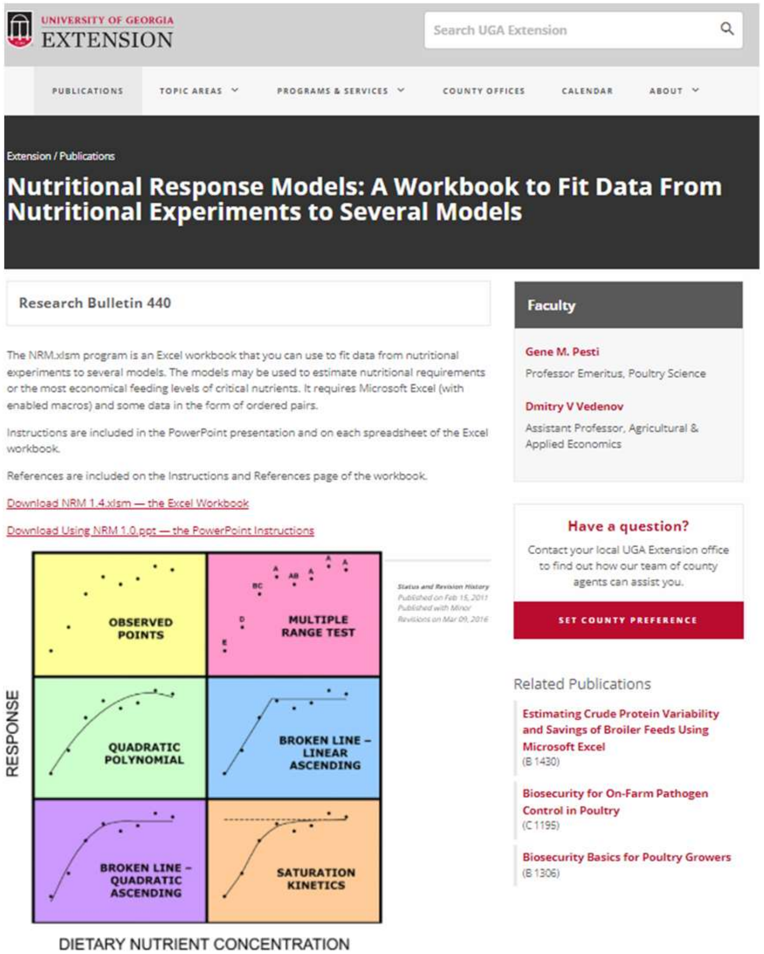
Effects of changing prices on diet formulation

Item	Price, US $/kg	Normal		Corn+		Corn−		SBM+		SBM−		Eggs+		Eggs−	
		NLP	LP	NLP	LP	NLP	LP	NLP	LP	NLP	LP	NLP	LP	NLP	LP
Ingredient															
Corn	0.3	59.96	60.37	59.96	60.25	68.87	60.37	61.57	60.37	69.21	60.37	61.16	60.37	59.96	60.37
Wheat	0.275	10	0	10	0.13	0	0	10	0	0	0	0.09	0	10	0
SBM[1]	0.51	16.56	19.93	16.56	20	17.63	19.93	11.6	19.93	19.24	20	22.61	19.93	16.56	19.93
Fish meal	1.2	0	4	0	4	0	4	4	4	0	3.99	0	4	0	4
Canola meal	0.39	2	0.77	2	0.68	2	0.77	2	0.77	0	0.71	0	0.77	2	0.77
Soybean oil	1.2	0	4	0	4	0	4	0	4	0	4	4	4	0	4
Limestone	0.04	4	4	4	4	4	4	4	4	4	4	4	4	4	4
OSM[2]	0.04	4.77	4.95	4.77	4.95	4.80	4.95	4.77	4.95	4.84	4.95	5.3	4.95	4.77	4.95
DCP[3]	1	1.7	1.27	1.7	1.27	1.69	1.27	1.17	1.27	1.71	1.27	1.83	1.27	1.7	1.27
DL-Met	9.5	0.13	0.13	0.13	0.13	0.13	0.13	0.10	0.13	0.13	0.13	0.15	0.13	0.13	0.13
Lys-HCl	3.8	0.12	0	0.12	0	0.10	0	0.07	0	0.09	0	0.05	0	0.12	0
NaCl	0.04	0.27	0.08	0.27	0.08	0.27	0.08	0.21	0.08	0.28	0.08	0.31	0.08	0.27	0.08
Mineral premix	1.6	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin premix	1.6	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Cost, US $/kg		0.3455	0.4184	0.3455	0.4637	0.2971	0.3732	0.3780	0.4439	0.3259	0.3929	0.3932	0.4184	0.3455	0.4184
Margin, US $/hen		2.70	2.51	2.31	2.13	3.15	2.88	2.53	2.29	2.91	2.72	4.12	4	1.26	1.01
Calculated analysis															
ME, Mcal/kg		2.730	2.935	2.730	2.935	2.740	2.935	2.786	2.935	2.748	2.935	2.896	2.935	2.730	2.935
Protein, %		14.41	16.64	14.41	16.64	14.47	16.64	14.71	16.64	14.51	16.64	15.29	16.64	14.41	16.64
Lys, %		0.76	0.88	0.76	0.88	0.76	0.88	0.78	0.88	0.77	0.88	0.81	0.88	0.76	0.88
Met, %		0.37	0.43	0.37	0.43	0.37	0.43	0.38	0.43	0.37	0.43	0.39	0.43	0.37	0.43
Met + Cys, %		0.63	0.70	0.63	0.70	0.63	0.70	0.63	0.70	0.63	0.70	0.65	0.70	0.63	0.70
Ca, %		3.79	4.10	3.79	4.10	3.81	4.10	3.87	4.10	3.82	4.10	4.03	4.10	3.79	4.10
Available P, %		0.43	0.46	0.43	0.46	0.43	0.46	0.43	0.46	0.43	0.46	0.45	0.46	0.43	0.46
Na, %		0.16	0.17	0.16	0.17	0.16	0.17	0.16	0.17	0.16	0.17	0.17	0.17	0.16	0.17

[1]SBM = soybean meal.
[2]OSM = oyster shell meal.
[3]DCP = dicalcium phosphate.

Profit was always higher for NLP method than the LP one

Sources: Afrouziyeh et al (2011)



Model Fit Comparisons				
Model	**Sum of Residuals**	R^2	Q^m	**Critical** Xi^2
Linear Regression Model	3056.143	94.96%	9.052	7.815
Quadratic Regression Model	426.383	99.30%	1.065	5.991
Broken-Line (Linear Ascending)	258.300	99.57%	1.031	5.991
Broken-Line (Quadratic Ascending)	426.381	99.30%	1.066	5.991
Saturation Kinetics	472.903	99.22%	1.228	3.841
Logistics, 3 Parameters	434.371	99.28%	1.113	5.991
Logistics, 4 Parameters	432.822	99.29%	1.113	3.841
RNB, Model 1	432.822	99.29%	1.134	3.841
RNB, Model 2	622.650	98.97%	1.525	5.991

Regression models with Q^m>critical Xi^2, indicating inadequate fits, are highlighted in red

What about predictive performance of models?

https://extension.uga.edu/publications/detail.html?number=RB440

Energy requirements models

Some potential implications

- valid estimated coefficients for maintenance, growth, and egg production
- Increase predictive performance of energy intake models
- match nutrient supply with nutrient requirements

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Poultry Science
Volume 101, Issue 1, January 2022, 101518

Architecture of broiler breeder energy partitioning models

Mohammad Afrouziyeh *, Nicole M. Zukiwsky *, Jihao You *, René P. Kwakkel *, †, Douglas R. Korver *, Martin J. Zuidhof *

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ABSTRACT

A robust model that estimates the ME intake over broiler breeder lifetime is essential for formulating diets with optimum nutrient levels. The experiment was conducted as a randomized controlled trial with 40 Ross 708 broiler breeder

Functional specifications of the evaluated ME intake models

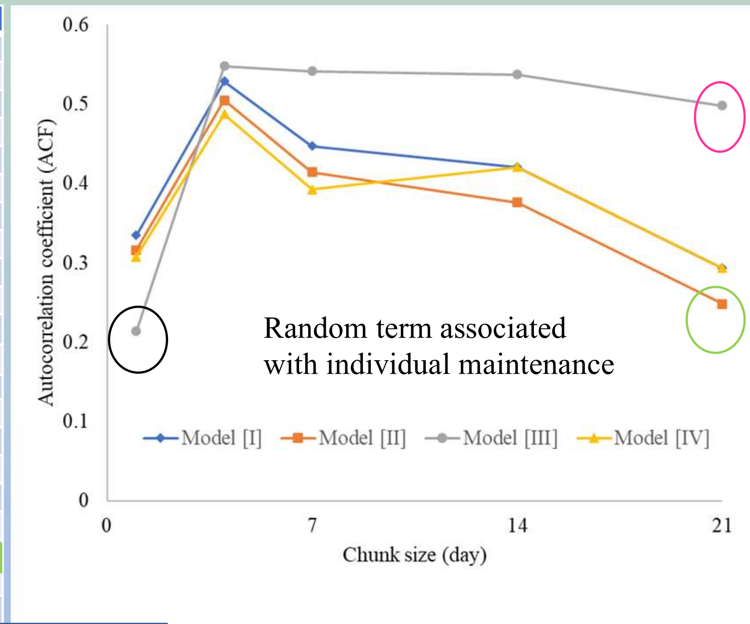
Model	Function specification
I	$MEI_d = a \times BW^b + c \times ADG_p + d \times ADG_n + e \times EM + \varepsilon$
II	$MEI_d = (a + u) \times BW^b + c \times ADG_p + d \times ADG_n + e \times EM + \varepsilon$
III	$MEI_d = (a + uu) \times BW^b + c \times ADG_p + d \times ADG_n + e \times EM + \varepsilon$
IV	$MEI_d = a \times BW^b + (c + v) \times ADG_p + d \times ADG_n + e \times EM + \varepsilon$

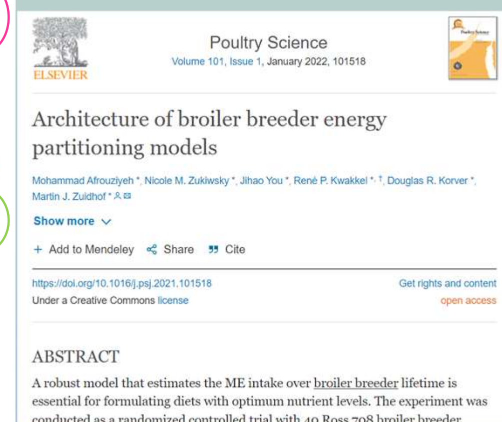
Estimated coefficients are lowercase letters.
MEI_d = daily ME intake (kcal/d);
BW = BW (kg)
ADGp = positive ADG (g/d)
ADG_n = negative ADG (g/d)
EM = egg mass (g/d)
u = bird-specific random term associated with individual maintenance
uu = age related random term
v = bird-specific random term associated with individual ADG
ε = residual error

Source: Afrouziyeh et al., 2021

Selection of the model of choice

	Model fitting statistics		Cross validation statistics			
Model	MSE	R^2	MAE	MSE	RMSE	R^2
[I] – daily	3616	0.730	42.8	3689	60.7	0.725
[II] – daily	3510	0.738	42.0	3573	59.7	0.734
[III] – daily	2762	0.794	37.8	2774	52.8	0.791
[IV] – daily	3501	0.739	42.2	3563	59.6	0.734
[I] – 4d	1739	0.845	28.4	1726	41.5	0.847
[II] – 4d	1649	0.853	27.7	1635	40.3	0.855
[III] – 4d	1190	0.894	23.0	1161	34.2	0.895
[IV] – 4d	1592	0.859	27.7	1566	39.4	0.862
[I] – 1wk	1412	0.872	25.2	1382	37.1	0.875
[II] – 1wk	1327	0.880	24.6	1305	36.1	0.882
[III] – 1wk	954	0.914	20.4	937	30.7	0.915
[IV] – 1wk	1273	0.885	24.6	1259	35.5	0.886
[I] – 2wk	978	0.908	21.5	1047	32.3	0.903
[II] – 2wk	900	0.915	20.7	974	31.0	0.911
[III] – 2wk	737	0.931	18.4	776	27.8	0.928
[IV] – 2wk	978	0.908	20.7	919	30.1	0.916
[I] – 3wk	832	0.918	20.4	875	29.6	0.914
[II] – 3wk	778	0.923	19.0	797	27.9	0.923
[III] – 3wk	601	0.941	16.6	612	24.7	0.939
[IV] – 3wk	832	0.918	19.8	786	27.8	0.924




Poultry Science
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Architecture of broiler breeder energy partitioning models

Mohammad Afrouziyeh, Nicole M. Zukiwsky, Jihao You, René P. Kwakkel, Douglas R. Korver, Martin J. Zuidhof

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ABSTRACT

A robust model that estimates the ME intake over broiler breeder lifetime is essential for formulating diets with optimum nutrient levels. The experiment was conducted as a randomized controlled trial with 40 Ross 708 broiler breeder

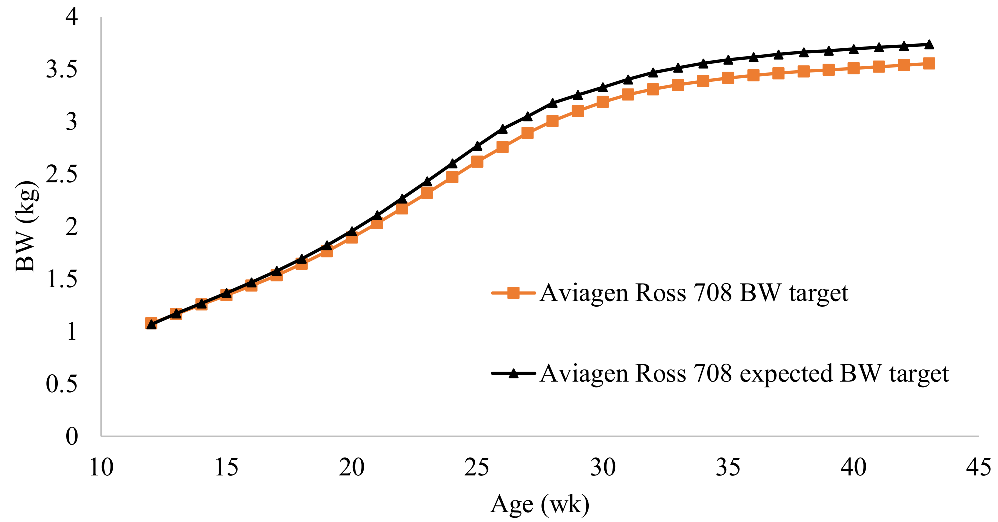
Best fitting performance but with autocorrelation bias

Lowest autocorrelation bias but does not have a reliable fitting and predictive performance

Model of choice

Afrouziyeh et al (2021)

Ross 708 broiler breeder expected BW based on the recommended ME intake



$$MEI_d = (100.47 \times BW^{0.56}) + (3.49 \times ADG_p) + (3.16 \times ADG_n) + (2.96 \times EM)$$

- MEI_d = daily Metabolizable Energy intake (kcal/d)
- BW = Body Weight (kg)
- ADG_p = positive Average Daily Gain (g/d)
- ADG_n = negative Average daily Gain (g/d)
- EM = egg mass (g/d)

Take-home messages so far…

- Maximum response (e.g. BW) is not always equal to maximum profit!
- Minimizing cost is just part of the story! Try to think out of the box!
- Profit is the final goal in economy.
- Try to evaluate mathematical programming models thoroughly, not just from the fitting-performance perspective.

Interested in creating a Maximum Profit Feed Formulation spreadsheet?

https://youtu.be/33sjsiy_6ck

Variation in nutrient composition of feed ingredients

NIR device

Image: https://www.spectroscopyeurope.com/product/portable-nir-raw-material-and-feed-analyses

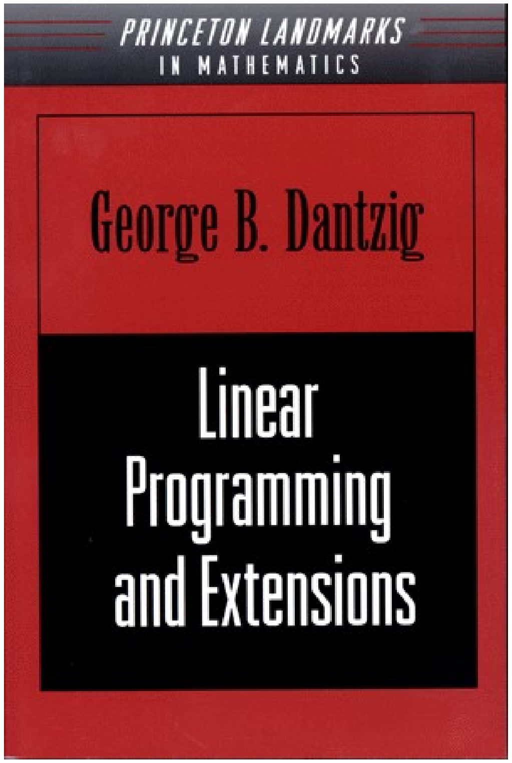
Uncertainty and risk are inherent in biological variability

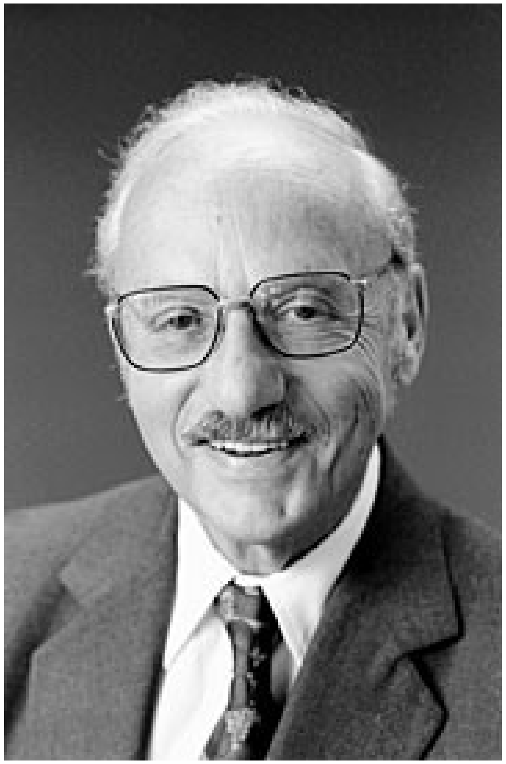
- “. . . I work on planning under uncertainty.

That’s the big field as far as I’m concerned; that’s the future. Maybe I’m the only one who says that.”

George Dantzig, Father of mathematical programming

(Roush et al., 2007)





Margin of safety and Stochastic Programming

- A simple way to adjust the nutrient matrix to compensate for **nutrient variability**
- Subtracting one-half of a SD from the mean value of nutrients
- Increase the probability of meeting an animal's requirement from 50% for a linear program to greater than or equal to 69% for a linear program adjusted for an MOS

Table 1. Crude protein statistics for corn and soybean meal samples — expressed on an as-fed basis

	Feed ingredient	
CP statistics	Corn	Soybean meal
No. of samples	132	114
Mean (%)	6.90	47.51
Minimum (%)	5.34	44.10
Maximum (%)	8.30	51.50
Variance (%)	0.35	2.01
SD (%)	0.59	1.41
CV (%)	8.60	2.99

Source: Alhotan et al. (2014)

Interested in creating a Stochastic Feed Formulation spreadsheet?

https://youtu.be/xG-kyjd4wCQ

MOP
(Multiple Objective Programming)

combination of Maximum Profit (NLP) and Stochastic feed formulation

Account for market and nutrient variability simultaneously

MOP (Multiple Objective Programming)

https://youtu.be/FeDnXUWp7RA

Take-home messages so far…

- Examine each batch of ingredients before formulating your diet
- Remember to take account for the variation in nutrient composition of feed ingredients
- Keeping track of ingredients’ composition is a useful tool to enlighten the future management decisions.

Future direction

- Develop a user-friendly multi-objective feed formulation software
- Develop feed library
- Investigate nutritional value of local feed ingredients
- Use mechanistic models to predict animal performance as opposed to empirical models

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