Alternatives to formulate laying hen diets beyond the traditional least-cost model

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Primary Audience: Nutritionists, Poultry Producers

SUMMARY

Owing to the high cost of feed for poultry, there is continuous pressure to formulate 'least-cost' diets that meet nutritional requirements. However, the main aim of any commercial enterprise is usually to maximize profits with the resources or inputs available, and the conventional or historic tool of least-cost ration formulation has limitations in a more demanding economic environment. The layer industry may experience particularly volatile changes in egg price, principally owing to changes in supply rather than demand, and in the past, it has been reported to possess less production and financial data reporting than other industries. Thus, increased flexibility during these uncertain times may give the layer industry greater opportunity and capacity to cope with market fluctuations. A practical example of how a laying hen operation may benefit from these approaches demonstrates that the maximum-profit solution does not always match the least-cost solution and that stochastic feed formulation may be used to accurately assign safety margins and define the level of certainty this safety margin will provide. Finally, as producers better understand how their hens respond to different dietary specifications, the opportunity arises to choose the set of specifications that result in maximum profits for their unique situations, rather than relying on least-cost diets formulated to nutrient requirements alone.

Key words: diet, formulation, least-cost, maximum-profit, stochastic, laying hen

2021 J. Appl. Poult. Res. 30:100137
https://doi.org/10.1016/j.japr.2020.100137

DESCRIPTION OF PROBLEM

Feed constitutes more than 65% of live production costs in poultry production (Wilkinson, 2018); thus, there is vast pressure to formulate 'least-cost' diets that meet nutritional requirements. Least-cost linear programming formulates the cheapest possible diet while still fulfilling the specified nutrient requirements of the bird. Although the goals of companies or producers differ, generally, the main aim of a commercial enterprise is to produce maximum profits with the resources or inputs available. In this context, it is necessary to hold a firm understanding of the cost of inputs, value of outputs, and model of the relationship between the two to determine the maximum profit achievable. Unfortunately, least-cost diet formulation is limited as it does not take this relationship into

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account and does not necessarily generate the optimal solution to maximize profits (Cerrate and Waldroup, 2009). Nutrient requirements recommended for each commercial breed are determined to ensure the minimal amount of nutrient can be offered without significantly affecting the optimal biological or production performance. However, the biological optimum of a bird does not necessarily equal maximum profits. For example, it may be more profitable to feed a slightly lower protein diet than what is required to meet the breed recommendations as protein is an expensive dietary component. Or, if a particular market preferred larger eggs, for example, it may be profitable to feed laying hens amino acids such as methionine with inclusions higher than the recommendations to achieve the greater egg size and hence access a price premium. Care must be taken to consider the upper and lower bounds of nutrients as bird welfare must not be sacrificed in the process, and many of these subtle relationships are difficult to objectively define and monitor.

With big data and communication technology rapidly evolving, there is opportunity to capture and provide timely updates of production and market data to feed into poultry diet decision-making and formulation (Wilkinson, 2018). Thus, there is opportunity to shift the way diets are formulated to better reflect the end goals of producers in the poultry industry. The layer hen industry may experience particularly volatile changes in egg price, principally owing to changes in supply rather than demand, and in the past, it has been reported to possess less production and financial data reporting than other industries (O'Connor and Giles, 2001). Thus, it may be of particular interest for producers within the layer hen industry to enhance record keeping where possible, which would aid in future forecasting, help to steady egg supply, and allow layer hen diets to be formulated to optimize economic returns over the forecasted period.

The industry not only experiences insecurity owing to volatile egg prices but also ensures that formulated and mixed diets contain the intended amount of nutrient is another uncertainty facing many agricultural industries. Within the poultry industry, integrated nutritionists may have access to near-infrared (**NIR**) spectroscopy for diet formulation. However, they may experience sampling errors and delays in receiving this information. In addition, many consultant nutritionists may not have access to a timely NIR system. Thus, nutritionists may need to rely on a combination of NIR and historical or 'book' values. To combat the potential variation between the nutrient content of the actual feed ingredient and those in the book values, safety margins must be applied to formulations to ensure the minimum nutrient requirements of poultry are being met. However, increasing safety margins raises diet cost and thus compromises profitability. Furthermore, how can nutritionists decide the size of a safety margin to implement? In this instance, stochastic feed formulation may be of assistance as it uses nutrient variability data to allow nutritionists to decide the level of uncertainty they are comfortable with in their diet formulations (D'Alfonso et al., 1992).

Therefore, this article will review the considerations of formulating diets in a traditional least-cost vs. maximum-profit and stochastic approaches and simulate a practical example to demonstrate the differences between these feed formulation strategies. The aim is to demonstrate the importance of improving collection of ingredient, production, and market data and using these data to formulate diets in a more economically sustainable manner. As the layer hen industry faces particular challenges owing to uncertainty in its market and the requirements for protein and amino acids of laying hens are an expensive constituent of the diet and hold important implications for egg size, this article will hold focus on methionine levels in laying hen diets for the diet formulation examples.

Least-cost Feed Formulation Models

In traditional least-cost feed formulation, a series of nutrient requirements that maximize performance are set; however, profitability may be compromised when rigid nutrient requirements are imposed (Cerrate and Waldroup, 2009). Least-cost feed formulation considers fluctuations in feed ingredient price and uses the cheapest combination of ingredients that satisfy the given nutrient requirement and any other limitations set on the feed ingredient inclusion rates. However, the resulting final product or output returns are not considered in the calculation. In addition, least-cost linear programming models disregard variability in feed ingredients (D'Alfonso et al., 1992), which can also be problematic and probably reduce returns because of safety margins that are allocated into formulations to negate variability.

Maximum-Profit Model

A maximum-profit model of feed formulation considers fluctuations in feed ingredient price, as well as the variation in performance at various nutrient levels and the final value of the resulting product (Cerrate and Waldroup, 2009). Thus, as outputs are considered in formulation, diets may be formulated in a nonlinear fashion with 'nutrient responses' rather than 'nutrient requirements.' Equations or restrictions can also be entered to consider the impact of nutrients on the health and welfare of the bird, to ensure that the maximum-profit solution meets these requirements. Many maximum-profit models (e.g., Pesti et al., 1986; Cerrate and Waldroup, 2009) center around the law of diminishing returns; advantages gained from a slight improvement in input will only advance marginally per unit and may plateau, or decrease, after a given point (Brue, 1993). For example, as we increase the methionine level, the egg size may increase, but at a diminishing rate. While some studies only use one equation to define profit over a whole production cycle, Cerrate and Waldroup (2009) showed the importance of maintaining numerous diets by incorporating multiple stages into their model to define the performance over several stages of growth, leading to optimal end profits.

Stochastic Models

Stochastic models attempt to quantify the level of uncertainty of ingredient nutrient variability that exists in both linear and nonlinear feed formulation models. Owing to feed ingredient variability, feeds formulated on average values are expected to contain less than the minimum restriction (least-cost) or optimal content (maximum-profit) 50% of the time (Pesti and Seila, 1999). This inaccuracy or uncertainty means that many nutritionists implement safety margins into their formulations. However, the size of the safety margin is difficult to decide if we do not know the level of uncertainty that exists. Stochastic models essentially shift the diet's nutrient distribution (calculated as a sum of the ingredient's nutrient distributions) as the probability of failing to meet a nutrient requirement or chosen nutrient level will decease as the mean amount of nutrient in the diet is increased (D'Alfonso et al., 1992). Thus, this method allows a nutritionist to achieve a set level of probability that the diet will fall within the desired nutrient levels. Although this naturally increases diet cost, standard levels of variation within practical diets can induce substantial issues. For example, Pesti et al. (2020) reported that the variation found in a practical broiler diet is enough that 12.9% of diets are expected to have less than 0.40% nonphytate phosphorus and 12.8% of diets are expected to have more than 0.50% nonphytate phosphorus. Thus, the normal levels of variation within industry may be enough to induce leg issues such as phosphorus-dependent rickets or tibial dyschondroplasia. However, this approach does assume that the distributions of the ingredients are normal, which need not necessarily be the case (Kirby et al., 1993).

Practical Formulation Example: Methionine Level During Lay

A feed formulation exercise was completed using example data sourced from industry and those published within the literature. The result of the following exercise is not intended to be directly applied to industry systems; rather, the purpose is to demonstrate the benefits of formulating with maximum-profit or stochastic models rather than just the least-cost model. It is still imperative for producers to perform these calculations with their own data to identify the diet that specifically suits their circumstances.

MATERIALS AND METHODS

This feed formulation exercise consists of exploring maximum-profit and stochastic feed formulation techniques with a focus on the response of laying hens to methionine levels during lay. Within the maximum-profit model example, the response of feed intake, egg weight and percentage production, and egg mass of caged white egg-laying hens of 52–58 wk of age to 5 graded true digestible methionine levels has been illustrated by Bregendahl et al. (2008) via a broken-line model. These data were used to model the response of laying hens to the increasing methionine level over the 6-wk period (52–58 wk of age). Economic data were sourced from industry (fourth quarter of 2019, $USD; unpublished data). The principal of this exercise is to demonstrate the benefits of implementing a maximum-profit model over a least-cost model and is applicable to all housing types, and it is envisaged that producers will conduct this type of economic analysis using their current production and economic data. Barley–wheat–soybean–based diets were formulated in a least-cost manner to the 5 dietary methionine levels using EFG Software (2020) (EFG Software, KwaZulu-Natal, South Africa). The nutrient content of the ingredients used in formulations was sourced from Moss (2020). Apart from the dietary methionine level, diets were formulated to meet the minimum nutrient requirement as provided by the Hyline Management guide (2020). Data from the study by Bregendahl et al. (2008) were used to calculate profitability of each dietary methionine level in Microsoft Office Excel (2016) (Microsoft Office Excel, WA) as per the following equation: Profit = Egg sale + Spent hen sale–diet cost–packaging cost/dozen–pullet cost–other cost/dozen.

Within the stochastic model example, the Microsoft Office Excel–based spreadsheet ‘LSMFT’ developed by Professor Gene Pesti from the University of Georgia was used (Pesti and Seila, 1999) to stochastically formulate diets. The LSMFT spreadsheet was altered so that diets would solve to the variability of digestible methionine in the ingredients, rather than true protein. Standard deviations of digestible methionine in feed ingredients were sourced from the Australian feed ingredient database developed by Moss (2020). Simulated frequency distributions of the dietary methionine level were generated using Excel’s NORMDIST function.

RESULTS AND DISCUSSION

Example 1: Least-Cost vs. Maximum-Profit Model

Five barley–wheat–soybean meal–based diets, priced at the typical cost for the fourth quarter of 2019 ($USD), were constructed via a least-cost approach with the methionine levels reported in the study by Bregendahl et al. (2008) to determine the change in diet cost and production output as the methionine level changes (Table 1). All diets were barley–wheat–soybean meal–based ones, were isoenergetic, and were formulated to the same digestible lysine concentration (0.91%), keeping all other amino acids (but methionine) constant in a ratio to digestible lysine. The mean methionine requirement reported over several studies in the study by Bregendahl et al. (2008) is 47% (in relation to lysine requirement, set at 100%; the actual methionine concentration is therefore 0.44% digestible methionine). Thus, diet 3 from the aforementioned study containing 48% methionine as a proportion of the total digestible lysine content was chosen as the ‘standard industry diet’ to compare with as it is the closest diet to the recommendation and thus will give suitable hen performance data. The response of laying hens to the changing dietary methionine level was modeled from the data provided in the study by Bregendahl et al. (2008), and the price of egg sales was also estimated to represent a typical price that may be attained for cage eggs (Table 1).

Thus, the total profit over this 6-wk simulation may be calculated as detailed in the Materials and methods section from the data given in Table 2.

Therefore, as shown in Table 1, in this example, the standard industry diet had a methionine content of 0.48%, cost of $333.59 per ton, resulting in an estimated egg mass of 52 g per bird per day and an egg production of 83% between 52 and 58 wk of age. It is noteworthy that the 0.37% dietary methionine level increased intake compared with the other treatments, presumably to maintain production. We assume the variable and fixed costs as shown in Table 2: pullets ($6.87 each; as we are only focusing on a 6-wk period of production, say, a likely 74 wk of production, we will simply equate this to $0.09 per week per hen or $0.56 per hen for the sake of our profit calculation over this 6-wk period), packaging cost ($0.17 per dozen), other costs (labor, utilities, insurance, leasing, and transport; $0.36 per dozen). Therefore, a farm of 20,000 laying hens of 52–58 wk of age (42 d) may expect to produce

Table 1. Production and economic data to model the effect of methionine (Met) level on production and profitability.

Dietary true digestible Met level (%)	Synthetic methionine inclusion rate[1] (%)	Feed intake (g/bird/day)	Diet cost ($USD/ton)	Egg production[2] (%)	Egg weight[2] (g)	Egg grade	Egg grade sale price ($USD/dozen)
0.13	0	60.8	329.06	23	56	600	1.50
0.25	0	92.3	329.78	74	59	700	1.59
0.37	0.11	97.5	330.51	83	62	700	1.59
0.48	0.22	92.3	333.40	83	62	700	1.59
0.6	0.35	91.0	336.29	83	62	700	1.59

Production data were sourced from the study by Bregendahl et al. (2008; diets formulated via least cost), and economic data were estimated from present values (fourth quarter of 2019; $USD) provided by the layer hen industry to serve as a guide for this exercise.

[1]Synthetic methionine priced at $2639.70 per ton.

[2]Calculated from equations provided in the study by Bregendahl et al. (2008) as means were not tabulated.

approximately 35 eggs per hen for a total of 58,100 dozen eggs, at an average of 62 g per egg over this period, which falls into the 700-g egg grade with a sale price of $1.59 per dozen (Table 2). Spent hen sale price ($0.18/hen) may be equated to represent $0.01 over this 6-wk period (calculated as per-pullet price). With an intake of 92.3 g of feed per bird per day, this equates to approximately 77.5 tons of feed for all birds over the 6-wk period, at $333.40 per ton, with a total feed cost of $25,863. Profit margins were calculated for the remaining 4 dietary methionine levels, as given in Table 2. It is evident that the greatest profit of $25,189 over the 6-wk simulation may be achieved with the 0.6% dietary methionine level with a diet cost of $336.29 per ton, $3 per ton higher than that of the least-cost model, but generating a total of $134 more profit owing to the reduced feed intake compared with the 0.48% methionine diet.

To determine the maximal profit achievable, we need to calculate the point at which more methionine inclusion will not generate any extra profit. The marginal profit may be defined as the change in profit at each level of methionine content. The point at which the marginal profit equals zero, or marginal costs and marginal revenues are equal, is the point of maximal profit. The marginal profit is represented in Table 3, and it is apparent that as the marginal profit has not yet approached zero, higher levels of methionine would be required to reach the point at which profit maximization is attained. To estimate this point from the data available, the following equation was generated:

$$y = 2.0 \times 10^{6} e^{-15.17x}$$

where y is the marginal profit ($USD) and x is the dietary true digestible methionine level (%). Thus, the marginal cost approaches 0 at the 0.95% dietary methionine level, giving a marginal cost of 1.1 (Figure 1). Nevertheless, biological data were not available over this range, and thus, this projected point may not be accurate. However, it has been provided as an example; profits continued to increase well beyond the 'recommendation.'

What would happen if variables were to change? In the aforementioned example, feeding a higher methionine level marginally improved profitability, which is driven by the improvement of feed efficiency. However, if feeding a higher methionine level increased egg size to the point that the mean was higher than 67 g per egg, within the 800-g egg range, then, as egg prices rise from $1.59 to $1.68 per dozen, there would be a big impact on profitability. To explore this effect, another simulation was performed, this time simplifying the problem further and solely focusing on the relationship between egg size, grade, and sale price (Figure 2A), wherein we can see that egg prices go up in 'steps' as egg weight increases, and egg size, feed intake, and feed cost (Figure 2B), wherein it is calculated that with each increase in 1 g of egg size, intake increases by approximately 1.4 g, which increases the total feed cost. To simplify this example and purely demonstrate the aforementioned relationships, the

Table 2. Calculated income, variable and fixed costs, and profits for each dietary methionine level for a 20,000 bird flock over the 6-wk simulation period to determine the most profitable inclusion.

Dietary true digestible Met level (%)	Total diet consumed (tons)	Dozen eggs produced	Total egg sale income[1] ($USD)	Spent hen income[2] ($USD)	Total diet cost[3] ($USD)	Packaging cost total[4] ($USD)	Pullet cost total[5] ($USD)	Other costs total[6] ($USD)	Profit ($USD)
0.13	51.1	16,100	24,102.42	289.28	16,805.95	2,678.05	11,137.43	5,821.84	-12,051.57
0.25	77.5	51,800	82,417.01	289.28	25,550.29	8,616.32	11,137.43	18,731.14	18,671.11
0.37	81.9	58,100	92,440.70	289.28	27,094.34	9,664.26	11,137.43	21,009.25	23,824.71
0.48	77.5	58,100	92,440.70	289.28	25,863.44	9,664.26	11,137.43	21,009.25	25,055.61
0.6	76.4	58,100	92,440.70	289.28	25,729.64	9,664.26	11,137.43	21,009.25	25,189.40

[1]As per-egg sale prices reported in Table 1.

[2]Equated spent hen price for the 6-wk simulation period; each sale price = $0.18. Assuming an average of 74 wk of production: $\$0.18/74 \times 6 = \$0.01$. Thus, spent hen sales represented $0.01 per hen over the 6-wk period.

[3]Total diet cost over the 6-wk period.

[4]Packaging cost over the 6-wk period estimated at $0.17 per dozen eggs.

[5]Equated cost of pullets for the 6-wk simulation period; each pullet cost = $6.87. Assuming an average of 74 wk of production: $\$6.87/74 \times 6 = \$0.56$. Thus, pullet cost represented $0.56 per hen over the 6-wk period.

[6]Labor, utilities, insurance, leasing, and transport: $0.36 per dozen.

Table 3. Calculated change in marginal profit for each dietary methionine level as described in Table 2.

Dietary true digestible Met level (%)	Change in marginal profit ($USD)
0.13[1]	
0.25	29,209.00
0.37	5,154.00
0.48	1,231.00
0.6	135.00

[1]Baseline.

cost of the feed was fixed at $329 per ton (and thus, the increase in egg size is purely based on intake) and the number of dozen eggs laid was fixed at 58,100. Thus, for our 20,000 hen flock over 6 wk, the model now becomes: Profit = (egg grade price × number of eggs laid) – (diet cost/ton × intake).

Combining the relationship between egg size, grade and sale price, and feed intake and diet cost to determine profits over egg sizes, or essentially combining Figures 2A and 2B, demonstrates the effect of 'egg grades' on profits (Figure 2C). Owing to the grading system that essentially groups an egg weight range into a specific price class, we can see that it is most profitable when the average egg weight of a flock enters a specified egg grade, but profits are diminished as the egg size increases, and no extra income is generated, until the next grade is reached.

Example 2: Least-Cost vs. Stochastic Model

The 'standard' 0.48% methionine diet costing $461 per ton previously described was used for this exercise. The Excel-based spreadsheet 'LSMFT' (Pesti and Seila, 1999) was used as described in the methods. This spreadsheet clearly demonstrates that at a probability of $P = 0.5$, the stochastic solution matches the linear solution, that is, there is a 50% chance that nutrients within the diet will fall below or above the mean value. For example, for digestible methionine, the frequency distribution of the simulated dietary methionine level for $P = 0.5$, the 'standard' diet, is shown in Figure 3. The standard diet formulated at $P = 0.5$ (methionine level = 0.48) costs $333.40 but has approximately a 20% chance of a diet with <0.3% true digestible methionine, which could potentially be disastrous for profitability as previously shown. However, when formulated to $P = 0.8$ (methionine level = 1.26; Figure 4), the diet now costs $351.48, $18 more than the standard diet, but has <1% chance of a diet with <0.3% true digestible methionine. A more moderate increase in diet cost can be achieved at $P = 0.6$, for example, which costs $338, $5 more than the standard diet, but has a 9% chance of a diet <0.3 true digestible methionine. The mean dietary true digestible methionine (Figure 5A), price (Figure 5B), and approximate odds of a diet of <0.3% dietary true digestible methionine

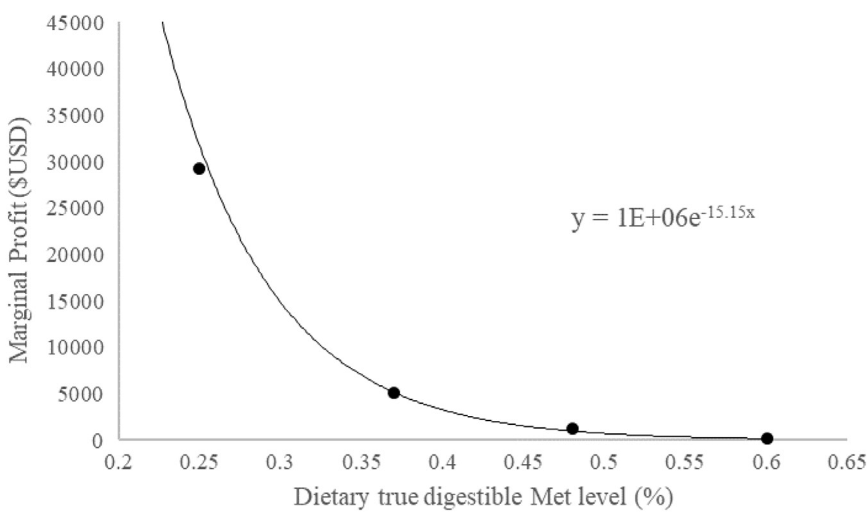

Figure 1. The exponential graph displaying the relationship between marginal profit ($USD) and the dietary true digestible methionine level (%).

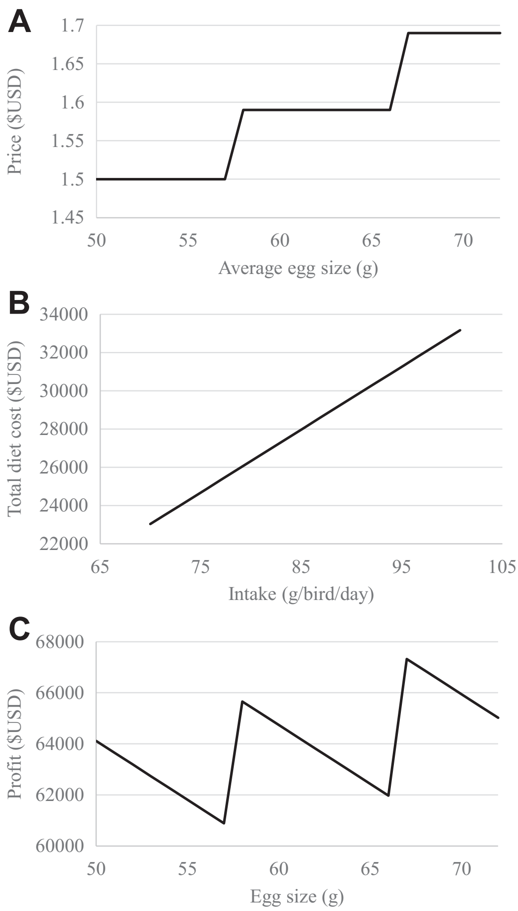

Figure 2. Graphs demonstrating (A) the relationships between the price ($USD) of eggs as they increase in the average egg size from '600 g' dozen eggs (weight range of 50–57 g/egg) to '700 g' dozen eggs (58–66 g/egg) to '800 g' dozen eggs (67–72 g/egg), (B) the relationship between feed intake and feed cost, and (C) profits over egg sizes, which essentially combines the relationships between egg size, grade and sale price, and feed intake and diet cost.

(Figure 5C) as the probability is shifted from $P = 0.5$ to $P = 0.9$ are shown in Figure 5. The odds of a diet falling below levels that may cause serious health, well-being, or production consequences may also be added to a maximum-profit model to determine the optimal safety margin to use.

PRACTICAL CONSIDERATIONS

Limitations

The layer hen industry faces particular market volatility, and thus, formulating to maximum-profit and the flexibility it provides may help the long-term sustainability of businesses and stochastic models may assist nutritionists in decision-making. Owing to the volatile egg prices, it may be beneficial for farms to stock smaller batches of feed that have frequent small changes to reflect the current market conditions and make any changes more gradually, allowing the hens to adapt to the new feed. However, this may be impractical as frequent diet transport is expensive. A median ground needs to be sought, and perhaps, multiple diet changes would be more practical if precision feeding technology is adopted, which allows dietary components to be blended on farm for frequent adjustments (Moss et al., 2020). The layer hen industry possesses less production and financial data reporting than other industries (O'Connor and Giles, 2001), and the array of business models from large integrated facilities through to smaller independent farms makes the broad implementation of stochastic and maximum-profit diet formulation difficult. However, if the industry makes a dedicated effort and focus is placed on improving data collection now, with time and further advances in technology, these concepts may become easily implemented and adopted, leading to more sustainable outcomes in the long term.

Advantages of Broader Economic Models

Of course, the optimal true digestible methionine to maximize profit needs to be determined on a case-by-case basis and updated with current economic data specific to each business; the formulation exercises within this article are presented for demonstration purposes of the method and concepts only and are not intended as a specific recommendation. For more precise estimations of nutrient response relationships on farm, trial facilities will be required, and significantly, more investment made in investigating nutrient variability will be undertaken. However, these exercises demonstrate the potential extra profits available if diets are formulated for maximum profit rather than for least cost. As the profit-maximizing model is dynamic, changing when the cost of inputs (e.g., feed) or outputs

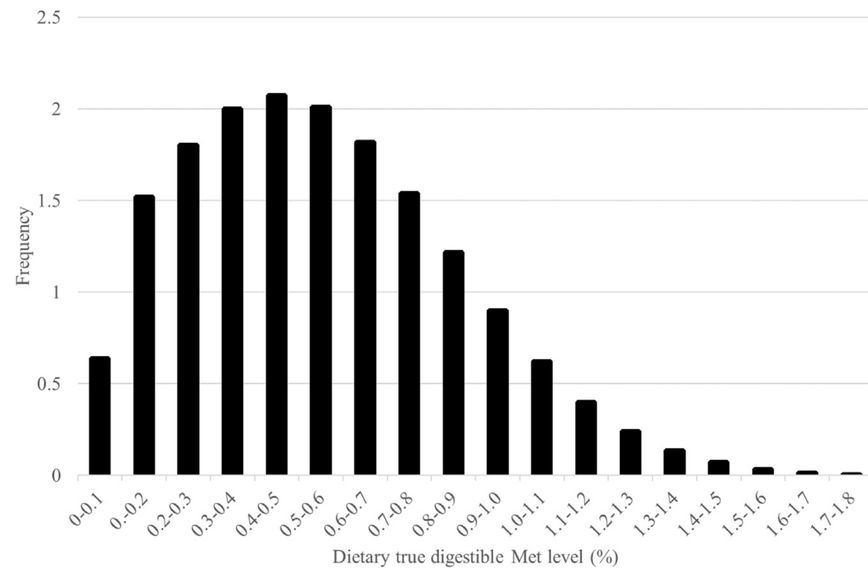

Figure 3. Frequency graph displaying the distribution of simulations of the dietary true digestible methionine level (%) formulated to 0.45% dietary true digestible methionine, with P = 0.5. (The mean is equal to 0.45% dietary true digestible methionine.)

(e.g., eggs) changes, it may also provide extra flexibility during periods of challenge, such as drought and increasing feed cost. In contrast, a ‘requirement’ is static and does not change to match the economic environment. For example, Kleyn (2013) posed the scenario that a pullet flock is underweight owing to a period of stress early in rearing. The scenario suggests that if only a least-cost model is considered, birds will be transitioned to a grower diet while still being underweight; having large ramifications for future production. However, under a

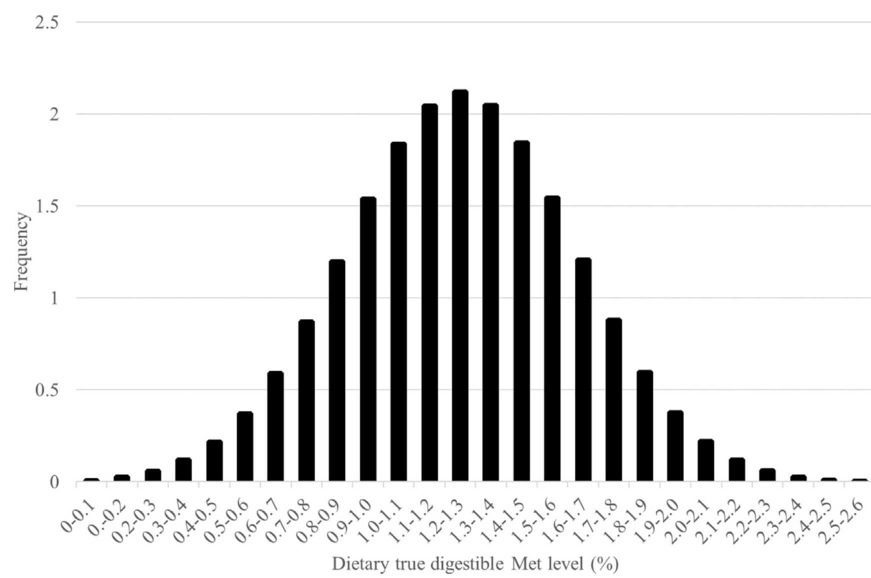

Figure 4. Frequency graph displaying the distribution of simulations of the dietary true digestible methionine level (%) formulated to 0.45% dietary true digestible methionine, with P = 0.8. (The mean is now equal to 1.26% dietary true digestible methionine.)

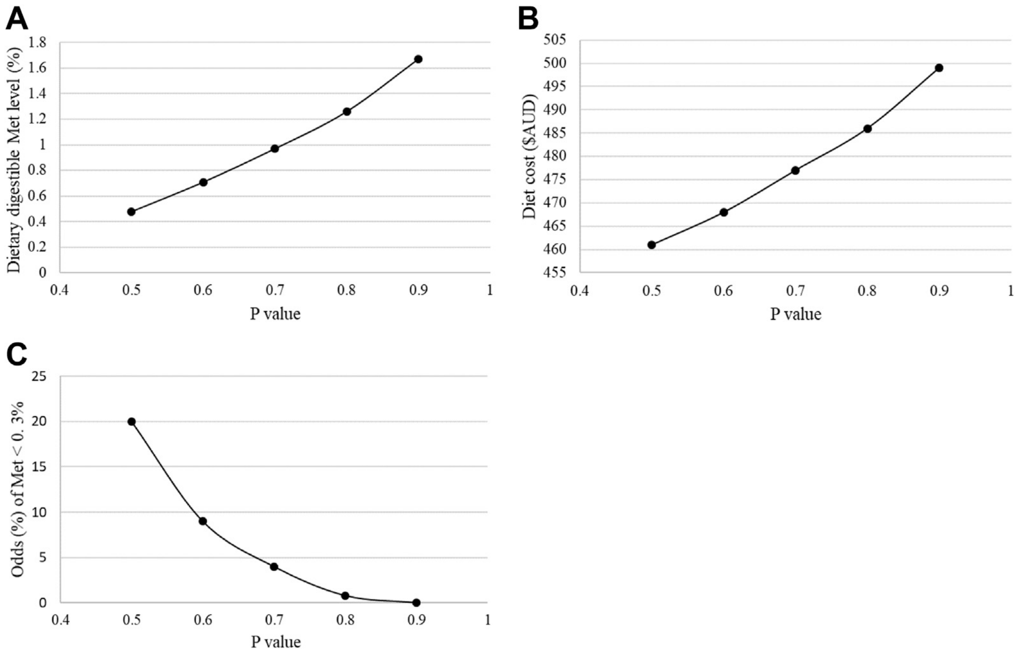

Figure 5. (A) Mean dietary true digestible methionine, (B) price, and (C) approximate odds of a diet of <0.3% dietary true digestible methionine as the probability is shifted from *P* = 0.5 to *P* = 0.9.

broader economic model, the advantages of keeping birds on the higher nutrient density starter diet for slightly longer time are made apparent. The trade-off for a greater feed cost to achieve an appropriate mature weight may be cost-effective if it prevents a post-peak dip in production. Pesti et al. (2009) summarized it well, stating, "The law of diminishing marginal productivity can be applied to poultry nutrition, and the 'most economic feed level' may replace the concept of 'requirements'". Adoption of this concept may particularly assist the layer hen industry owing to its volatility, and certainly other poultry industries globally, to produce the most economically sustainable outcomes.

CONCLUSION AND APPLICATIONS

1. Present least-cost feed formulation to requirements for optimal biological performance restricts the options that nutritionists and poultry managers have to navigate these difficult times. Maximum-profit and stochastic approaches use production and market data to formulate diets by more economically sustainable means, giving increased flexibility, opportunity, and capacity for the poultry industry to cope and thrive under market challenges.
2. With some improvement to production and market data collection, nutritionists may incorporate economic data into their nutritional models to determine which diet may generate maximum profits for each producer's unique situation.
3. Further research into economic modeling, including the development of more sophisticated approaches, is required to integrate biological performance with economic models.

ACKNOWLEDGMENTS

The authors would like to acknowledge and thank Australian Eggs for funding this project and for their guidance, encouragement, and support.

DISCLOSURES

The authors declare that they have no financial and personal relationships with other people or organizations that can inappropriately influence their work and there is no professional or other personal interest of any nature or kind in any product, service, and/or company that could be construed as influencing the content of this article.

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