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Parametric Cost Ranging in Economic Methodology

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PARAMETRIC COST RANGING IN ECONOMIC METHODOLOGY*

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Parametric cost ranging (PCR) is a mathematical tool presently being used in product evaluation by businessmen, researchers, teachers, and extension personnel. In those situations where linear programming is used to find optimum blends, PCR can be used for determining the value of products used as ingredients. In agriculture, for example, the optimum mix of ingredients for manufactured feeds is usually determined using feed blend linear programming.

The value of an ingredient used in blending is primarily based on four factors: (1) composition of the ingredient, (2) specifications of the blend, (3) availability, composition, and prices of competitive ingredients, and (4) external factors such as contractual arrangements between buyers and sellers. PCR is designed to determine value on the first three factors. One could say that PCR is an ideal tool for analyzing with mathematical precision the intrinsic value of ingredients used in blending.

PCR has been available to the animal production industry on an easy to use basis since the fall of 1968. At that time a company offering speciality computer time-sharing programs to the animal production industry made it a standard offering. Since the original introduction, the other major companies specializing in computer systems to agriculture have made it available as part of their linear programming programs. Prior to 1968, several computer manufacturers had parametrics available on their computer systems, however, usage was difficult, especially by those not computer orientated.

PCR has high appeal to physical scientists. They like its precision

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and application to practical problems. It is as precise as any technique or procedure they use in other aspects of their research. Nutritionists, chemists, and other physical scientists conducting research on feed ingredients have shown considerable enthusiasm in using PCR in evaluating and providing direction to their research. The first major publication using PCR in ingredient evaluation was co-authored by two economists and two physical scientists[1].

Subsequent publications have also been co-authored by economists and physical scientists. The economists accept responsibility for the analysis, and the physical scientists for the technical coefficients. I do not know of any other economic tool presently available to economists that has as much potential for interdisciplinary research as PCR.

PARAMETRIC COST RANGING

Parametric cost ranging is a mathematical technique whereby the value of an ingredient can be determined at various usage levels in a given competitive situation. It defines the price-quantity relationship. The ingredient to be analyzed is chosen and its price and if desired, the prices of other ingredients ranged through a broad spectrum to determine the effects of change. The prices of all competing ingredients not being ranged remain fixed. In fact, all parameters of the problem with the exception of price, remain constant.

Validity of results of PCR depend on how closely problem parameters approach reality. In the case of an individual blender using a linear programming data matrix as a decision tool, the results of PCR are completely valid. For the ingredient supplier or researcher simulating the reactions of an industry, the results will not be as valid as for the blenders. An industry such as animal production does not use common linear programming data matrices.

A solution often changes if a single matrix coefficient is altered. While this may appear as a weakness of the technique it must be remembered that difference and change is the reality of the market place.

A "purist" might object to using a linear tool in analyzing relationships that are not linear. However, as long as industry uses linear programming to determine least-cost or optimal ingredient blends, PCR remains an ideal tool in determining value. In fact, it can determine intrinsic value more precisely than any economic tool that has ever been used.

One of the most appealing features of PCR is the ease with which it can be implemented as a tool for economic evaluation. In the animal production industry, for example, PCR is offered by several companies as a subroutine of their feed-blend linear programming programs. The analyzer merely identifies the ingredient or ingredients he wishes to range and the range of prices to be considered. If desired, the parametric analysis will be printed out following the print-out of the least-cost or optimum feed mix. The analysis includes the value of the ingredient, its usage level, and the cost of the blend at each point on the price-quantity analysis where a new formulation would be profitable. In the case of one vender, a customer may obtain a complete feed formula with economic analysis for any one or all points on the PCR solution.

USERS

Blenders, ingredient suppliers, researchers, teachers, and cooperative extension personnel are presently using PCR on a routine basis. Each of these users will be discussed separately.

Blenders

The blender can and does use the technique in daily decision making. He generally uses linear programming data matrices specifically designed for his operation. Blenders throughout the United States, Canada, and Europe use it in making purchase decisions on ingredients and in determining optimal distribution of scarce ingredients among competing end-uses.

In purchasing, he is able to determine the maximum amount he can afford to pay for an ingredient at every usage level in a given blend based upon price and availability of competing ingredients. He possesses perfect knowledge for that decision at the time of decision.

In the distribution of limited ingredients he is able to reach decisions based on mathematical precision. He can distribute the limited ingredient among competing end-uses in such a manner that marginal values are equated as closely as possible considering the discontinous functions, thus maximizing value from that particular ingredient. Many blenders have been able to increase profits significantly simply by altering distribution of ingredients. Simple linear programming presents information on the best use of unlimited ingredients at given prices, it does not handle distribution of limited ingredients in an efficient manner.

Suppliers

The ingredient supplier must estimate the demand for his product among various customers in a changing competitive environment. Linear programming parameters are established in most cases by the customer and not the supplier. To use parametric cost ranging effectively, the supplier must simulate these parameters accurately. After obtaining results, he must choose the best possible pricing strategy.

At first glance, it might appear that parametric cost ranging is ineffective in this situation. It is, however, the best tool available to the supplier in making evaluations. Definite relationships are often established that remain valid over wide ranges in prices. In dehydrated alfalfa meal, for example, xanthophyll was established as the most important factor in making the product competitive in poultry rations at a value that would cover the costs of production [1]. Establishing these relationships can lead to effective decisions in a suppliers marketing strategy.

A technique used by some ingredient suppliers is to offer linear programming as a service to their customers. This gives them control over the coefficients in the data matrix. In this situation, their information is superior to that of the customers. This is a strategy that could be used very effectively by manufacturers doing custom blending.

Researchers

Parametric cost ranging presents the ingredient researcher with an economic research tool without equal in precision and validity of results. His results, of course, depend on the accuracy of his matrix coefficients. In the animal production industry these are quite valid. He has access to coefficients for ingredients and feed rations established by the National Research Council, Universities, and researchers in private industry. While these will not be the exact coefficients used by an individual blender, they are excellent for the industry in total.

The researcher, however, is not without challenge. He must often be concerned with the overall situation. He cannot take the price of all other ingredients as constant. The production level or the change in quality of one ingredient will affect the price and usage levels of other ingredients. It is possible, in fact, that the improvement of an ingredient could reduce its total usage level and perhaps the total revenue realized from its sale. The technique is effective in determining intrinsic value. It is not capable of ascertaining the complexities of supply and demand, especially at the macro level.

In spite of some limitations, parametric cost ranging is the most precise economic tool available for product evaluation. Relationships can be studied and analyzed in depth. The economic impact of research projects can be simulated in a multitude of competitive situations. Effects of end-product use and geographical locations can be determined. Economic impact of quality changes can be analyzed. Acceptance of the tool by physical scientists is high, thus improving communications and acceptance of results. Quality research can be conducted quickly and at low cost. The tool can be utilized in macro as well as micro research and evaluation.

Teachers

Parametric cost ranging offers the economics teacher a unique opportunity of demonstrating many basic economic principles with mathematical precision. The whole concept of price quantity relationships with its ramifications can be studied, analyzed, and presented. The parametric cost analysis presents a discontinous value curve for an ingredient in a given competitive environment. If the analysis is made, reducing the price of the ingredient being analyzed from a level where it is not competitive. The first point of solution is a point of indifference. At that point, the total value of the objective function--cost of the ration—is the same whether the ingredient is used at the price and quantity specified or whether it is not used at all.

Each subsequent point on the price-quantity relationship is a point of substitution. It is where a nutrient in the ingredient being analyzed becomes cheaper than the nutrient from some other source. The exact placement of the point in the relationship is determined by additional constraints on the problem. Careful study of the analysis at a point of solution will usually determine why the substitution took place.

Use of the procedure can enable the teacher to demonstrate at least the following economic principles with great precision.

1. Price-Quantity Relations
2. Factor-Factor Relationships
3. Product-Product Relationships
4. Factor-Product Relationships
5. Indifference Analysis
6. Substitution Analysis
7. End-Use Analysis
8. Product-Quality Comparisons
9. Interregional Competition
10. The Use of Mathematics in Practical Economic Evaluation

Since PCR is used as a sub-routine in linear programmin, all the advantages and disadvantages of linear programming can be taught as well. PCR being a sub-routine of linear programming inherits all of its advantages and disadvantages as well as those factors unique unto itself.

Extension Specialists

The technique can be used as effectively by extension personnel as by the feed formulator, ingredient supplier, researcher, or teacher. At The Ohio State University, for example, the technique is used by extension personnel in their educational efforts. Portable computer terminals are used that operate through the regular telephone network. The only requirements necessary for operation are a terminal, telephone, and electrical outlet. The system has been used in county offices, classrooms, motels, and on kitchen tables. It provides the extension economist with a precise and practical tool.

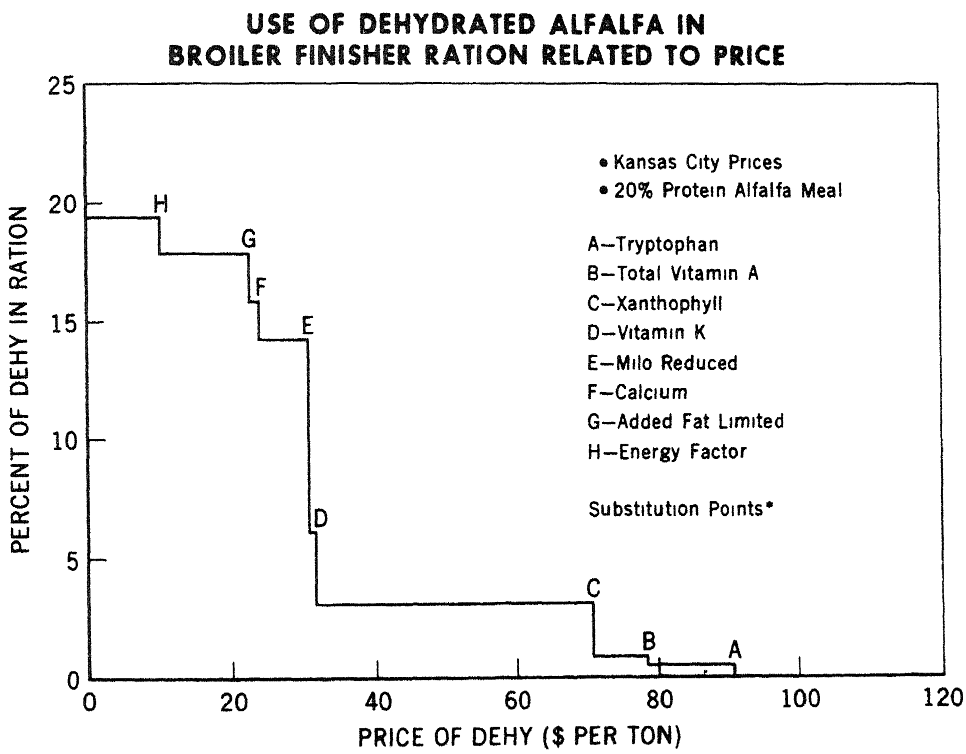
EXAMPLES OF RESEARCH RESULTS

Five examples of the use of PCR in evaluating alfalfa meal will be presented. While the examples are taken from the analysis of one feed ingredient in various competitive situations, the principles illustrated would have general application. The examples are taken from two previous publications by the author, and have withstood review and criticism over time by both economists and physical scientists. Each example illustrates different uses of the technique.

The Basic Principle [1, pp.5,6]

Dehy, 20 percent protein was evaluated in a broiler finisher ration. The points on the value curve are shown in Figure 1. The value of the meal varied inversely to the amount used. No alfalfa entered the solution until the price was reduced to $91 a ton. At this price, the ration included 0.5 percent dehy. This is the point of indifference. The amount included increased to 0.8 percent at a price of $78 a ton, and then to 3 percent when the price was $71 a ton. A drastic price reduction then occurred to $32 a ton before usage increased at which point 6.1 percent was included in the ration. Below $32 a ton small price decreases greatly increased usage. As the price dropped from $32 a ton to $31, the amount used climbed to almost 15 percent of the ration. The maximum used, at zero cost, was about 20 percent of the ration.

At each point on the value curve, a complete ration formulation can be obtained. In addition to the formulation, it gives shadow prices (the amount the ration cost would increase by using one unit of an ingredient not included in the solution) for the ingredients not used, and the opportunity cost (the amount the ration cost would be increased or decreased by changing a ration requirement or restriction one unit) of requirements in scarce supply. By examining formulations, shadow prices, and opportunity costs, the significance



*At each substitution point on the curve, a complete ration is obtainable.

Figure 1

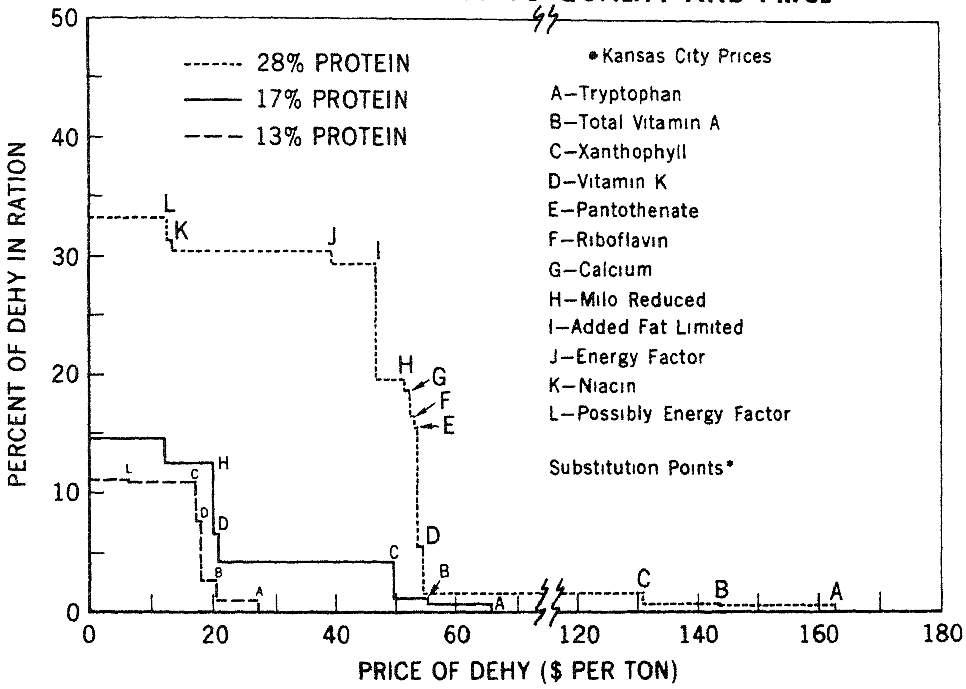
of each point can usually be determined. At point A on the curve in Figure 1, the tryptophan in dehy was substituted for tryptophan from some other source. At point B, dehy vitamin A was substituted for synthetic vitamin A. At point C, the substitution was dehy xanthophyll for corn gluten meal xanthophyll. The xanthophyll point was the most significant. At this point, 20 percent dehy was valued at $71 a ton and made up 3 percent of the ration. The greatest value of dehy in broiler finisher rations was in supplying xanthophyll, vitamin A, and tryptophan. These factors could change if other ingredients were considered or if prices varied.

Ingredient Quality Comparisons [1, pp.6,7]

Comparisons between value curves are of great interest. Figure 2 illustrates the value curves for 28, 17, and 13 percent protein dehydrated alfalfa meals in a broiler finisher ration. In comparing curves of different protein levels, the points of substitution are of significance. As an example, point C on each of the curves is where xanthophyll in dehy substitutes for xanthophyll in corn gluten meal. Dehy of 28 percent protein content constituted 1.5 percent of the ration at a value of $130 a ton; 20 percent dehy constituted 3.1 percent of the ration at $71 a ton; 17 percent dehy is 4.1 percent of the ration at $50 a ton; and 13 percent dehy is 10.9 percent of the ration at $17 a ton.

With only minor exceptions, the total cost of the ration was identical no matter which protein level of dehy was used. At point C, the xanthophyll substitution point, the cost of the ration for different protein levels of dehy was exactly $74.87. Also the cost of the dehy in the ration remained at approximately $2 regardless of the quality of dehy used. Thus, a feed formulator could alternatively use 1.5 percent of the 28 percent meal at a price of $130 a ton, 4.1 percent of the 17 percent meal at $50 a ton, or 10.9 percent of the 13 percent meal at a price of $17 a ton.

USE OF DEHYDRATED ALFALFA IN BROILER FINISHER RATION RELATED TO QUALITY AND PRICE



*At each substitution point on the curve, a complete ration formula was obtained

Figure 2

<u>End Use Comparisons</u> [1, pp.7,8]

Value is dependent on the ration being formulated. Since specifications change, the relationships between ingredients also differ. Figure 3 compares broiler finisher, broiler starter, and layer rations for 15 percent dehy. Any other quality dehy would have been as effective in demonstrating the principle, but dehy 15 allows a scale with reasonable limits. (Dehy 28, for example, would have entered the layer ration at $321 per ton and constituted less than 0.7 percent of the ration.)

Alfalfa meal had the highest value in the layer ration at almost all comparative points of substitution. In the layer ration, dehy came into the formula at $72 per ton as 2.3 percent of the ration. For the broiler finisher ration, the comparable figures were $50 and 0.75 percent, and for the broiler starter ration, $47 and 1.0 percent. At the xanthophyll point of substitution, dehy at $65 per ton made up 5.6 percent of the formula in the layer ration. The comparable figures for the broiler finisher ration were $33 and 6.4 percent, and for the broiler starter ration, $41 and 3.2 percent.

The energy factor was not as restricting in the broiler starter and layer rations as in the broiler finisher ration. At zero cost for dehy, the layer ration included 22 percent dehy, the broiler starter, 21.5 percent, but the broiler finisher only 13.5 percent. The layer and broiler starter rations each required 2,970 calories of metabolizable energy per kilo of feed, while the broiler finisher ration required 3,200. With a 10 percent limit on the amount of added fat (a nutritional parameter) that could be in the ration, energy became a critical factor in formulation.

<u>Interregional Analysis</u> [2, pp.88,91]

Location is an important factor in determining the value of an ingredient. This is due to the availability and prices of competitive ingredients.

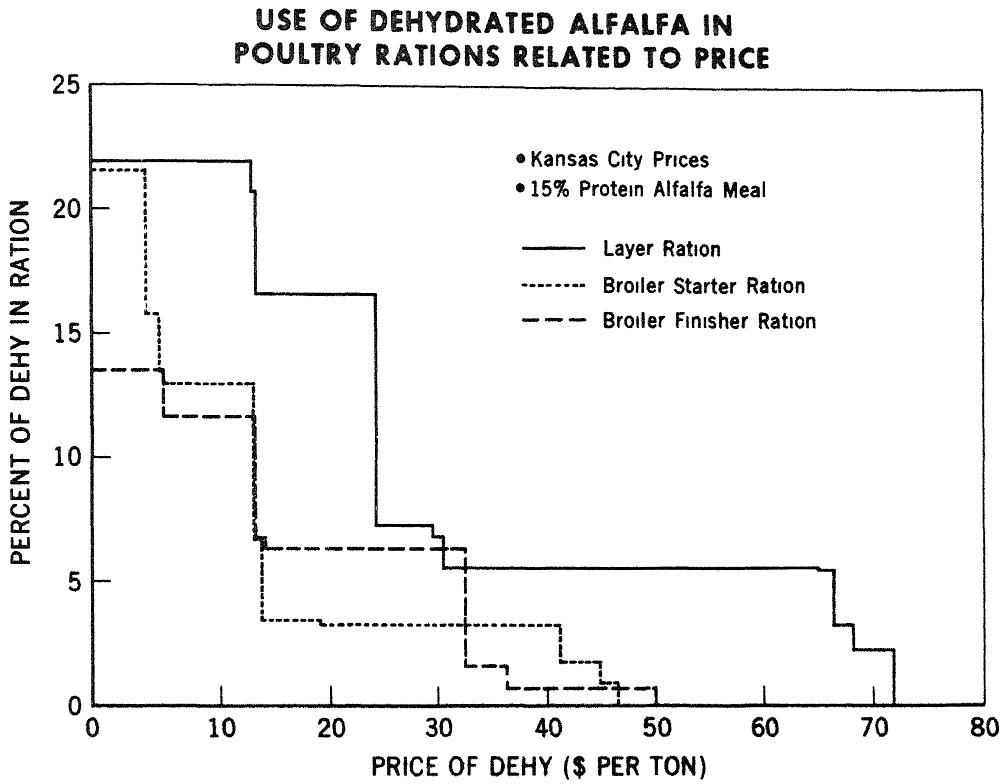

USE OF DEHYDRATED ALFALFA IN
POULTRY RATIONS RELATED TO PRICE
• Kansas City Prices
• 15% Protein Alfalfa Meal
Layer Ration
Broiler Starter Ration
Broiler Finisher Ration
PERCENT OF DEHY IN RATION
PRICE OF DEHY ($ PER TON)
0
5
10
15
20
25
0
10
20
30
40
50
60
70
80

Figure 3

To test this effect, dehy 20 in a broiler finisher ration was analyzed in Missouri, Massachusetts, and California. Figure 4 presents the value curves up to 6 percent of the rations. At greater dehy usage levels, the curves were fairly similar.

Up to the vitamin K point of substitution, approximately 6 percent of the ration in all three cases, dehy had by far the greatest value in California, a lesser value in Missouri, and the least value in Massachusetts. In California, dehy first entered the ration at $140 per ton and constituted 1.2 percent of the ration. For Missouri, the comparable figures were $80 and 0.6 percent, and for Massachusetts, $55 and 1.0 percent. At the xanthophyll point of substitution, dehy at $116 per ton made up 2.8 percent of the formula at California. The comparable figures for Missouri were $66 and 3.1 percent and for Massachusetts $44 and 1.5 percent. At the vitamin K point of substitution, the figures were similar with the price ranging from $28 to $32 a ton and dehy constituting 6.1 percent of the ration in all three cases.

These large differences in the high price low volume sectors of the value curves were primarily due to the availability and relative prices of milo, corn, and corn gluten meal.

Restriction Analysis [1, pp.8,9]

Blend restrictions on linear programming can be analyzed in depth by using PCR. Xanthophyll serves as a restriction in feed blending. Xanthophyll is the mixture of pigmenting substances found in dehy, corn gluten meal, corn, and other ingredients. Feed blenders require it in most poultry rations to give eggs and carcasses their characteristic yellow coloring. Xanthophyll content was very important in evaluating dehy. To further examine this factor, dehy 20 was analyzed in a broiler finisher ration.

Three analyses were made. In the first analysis, no xanthophyll was

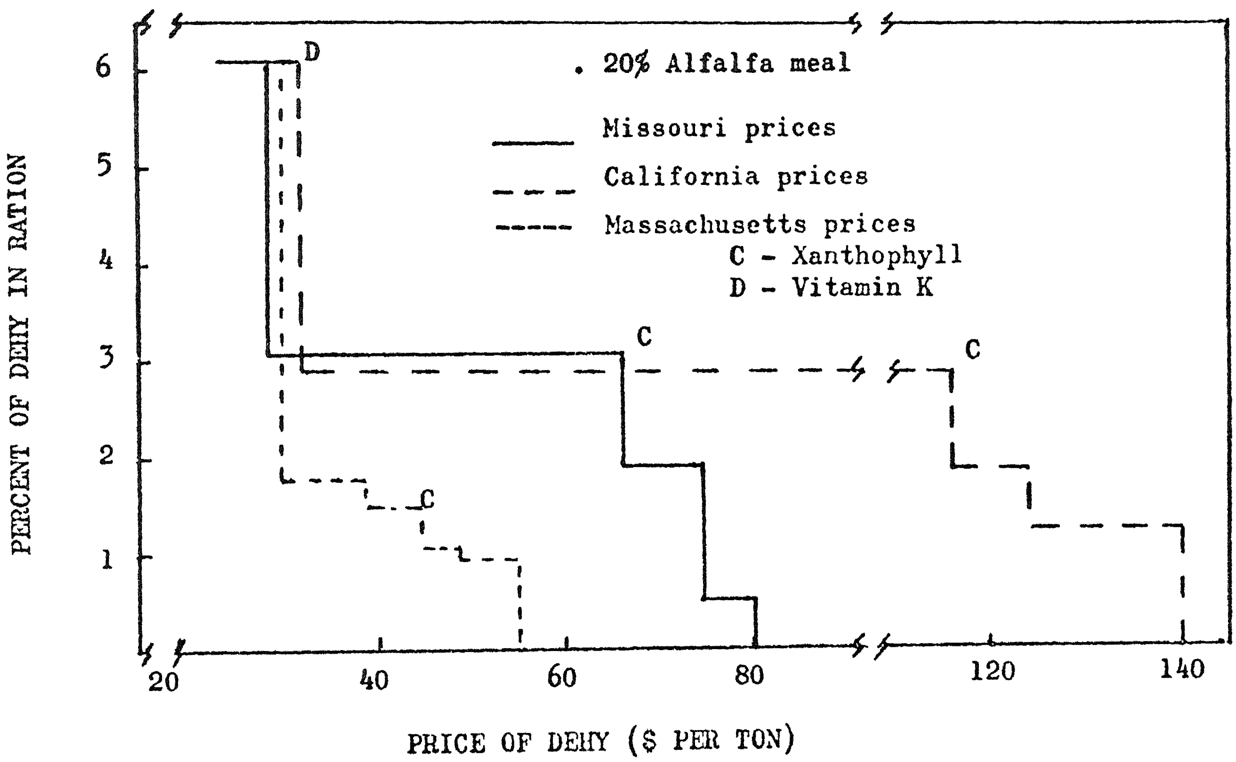

6
5
4
3
2
1
PERCENT OF DEHY IN RATION
D
. 20% Alfalfa meal
Missouri prices
California prices
Massachusetts prices
C - Xanthophyll
D - Vitamin K
C
C
C
20
40
60
80
120
140
PRICE OF DEHY ($ PER TON)

Figure 4

required in the ration; in the second, the requirement was set at 12 milligrams of xanthophyll per kilogram of ration, and in the third, the requirement was increased to 30 milligrams (Figure 5). These represented low, medium, and high ranges of actual commercial requirements for xanthophyll. In the case of no xanthophyll requirement, it was necessary to lower the price of dehy to $40 a ton before it came into the ration. At this price, the ration would contain 1 percent dehy. In the second situation (12 milligrams per kilogram), dehy entered the ration at $91 a ton and made up 0.5 percent of the formula. In the third situation (30 milligrams per kilogram), dehy entered the ration at $147 a ton, at which price it made up 0.25 percent of the formula. These were all points of indifference.

At the xanthophyll point of substitution, the big factor was in the usage level. In the formula requiring 12 milligrams of xanthophyll per kilogram, the ration would include 3 percent dehy and could cost up to $71 per ton. The ration requiring 30 milligrams of xanthophyll per kilogram would include 9.3 percent dehy at a price of $70 per ton. The price of dehy at the xanthophyll point of substitution was approximately the same in both rations, but the amount used varied with the amount of xanthophyll required. This resulted because the xanthophyll of dehy was substituting for the xanthophyll of high protein corn gluten meal. As dehy became cheaper than high protein corn gluten meal in supplying xanthophyll, substitution could occur as long as there was high protein corn gluten meal in the solution to be replaced.

SUMMARY AND CONCLUSIONS

Parametric cost ranging is a precise mathematical tool that can and is being used in the economic evaluation of products. It is effective in determining intrinsic values of ingredients where linear programming is used in blending least-cost or optimum combinations of ingredients. The total price-

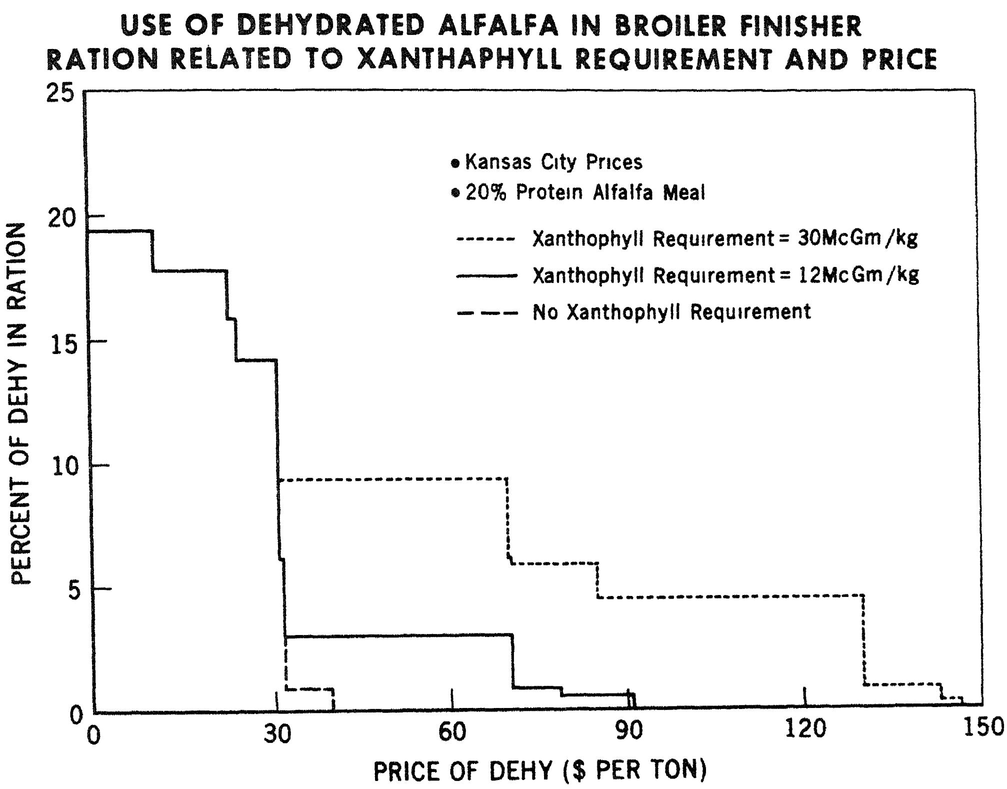

USE OF DEHYDRATED ALFALFA IN BROILER FINISHER
RATION RELATED TO XANTHAPHYLL REQUIREMENT AND PRICE
• Kansas City Prices
• 20% Protein Alfalfa Meal
Xanthophyll Requirement = 30McGm/kg
Xanthophyll Requirement = 12McGm/kg
No Xanthophyll Requirement
PERCENT OF DEHY IN RATION
25
20
15
10
5
0
0
30
60
90
120
150
PRICE OF DEHY ($ PER TON)

Figure 5

quantity relationship of an ingredient in a given competitive situation can be defined with mathematical precision.

Blenders, ingredient suppliers, researchers, teachers, and extension personnel are using the technique routinely. Blenders use it to determine ingredient purchase and distribution strategy. Ingredient suppliers find it effective in analyzing pricing. Researchers utilize it in determining market potential for new ingredients, and to provide evaluation and direction to research. Teachers find it effective in demonstrating basic economic principles in real life situations. It improves extension's ability to advise their clientele and is helpful in educational programs.

Several companies are offering speciality computer systems to agriculture. At least three of them include parametric cost ranging as a subroutine on their linear programming systems. In one system, for example, the computer and its programs can be accessed through the usual telephone system using portable computer terminals. This means that parametric cost ranging can be utilized almost anywhere.

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