Programming a Virginia Packer's Processed Meats Operation

by

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INTRODUCTION

The Current Situation

Livestock products will, in the future, form an increasing proportion of cash receipts from farm marketings. 1/ This statement characterizes the feelings of research workers connected with the livestock industry. There are logical and basic reasons for such feelings. Real income per person has been increasing. As incomes have risen, the demand for and the price of meat and meat products have risen. These developments have occurred because consumers have considered meat a highly desirable good and have readily replaced other foods with meat when able to do so. The increase in prices along with increased crop production has, in the aggregate, made livestock production more rewarding relative to alternatives, and production has increased. A projection of these trends into the future suggests still further increases in livestock production.

Overhanging this rather optimistic outlook is Cochrane's conclusion that the income elasticity for farm foods in general, when based on quantity consumed, will decline over the next several decades. 2/ If his conclusion applies to meat and meat products, a one percent increase

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1/ Robert E. Branson, "Discussion: The Economic Impact of Technology on Meat Packing," Journal of Farm Economics, Volume 38, December 1956, pp. 1795-1796.

2/ Willard W. Cochrane, Farm Prices--Myth and Reality, (Minneapolis, University of Minnesota Press, 1958), p. 87.

in income will lead to a lower and lower fractional percent increase in quantity of meat consumed. The implication is that the rate at which producers have been increasing the use of resources (on a per capita basis) in the production of livestock will level off and perhaps decline. This, however, will not necessarily be true. Increasing incomes increase the willingness of consumers to pay the higher prices necessary to stimulate the production of higher quality meats. Such tendencies may well lead to a continued increase in the level of resources which can profitably be employed in livestock production. This supposition is supported by Cochrane's suggestion that at the present level of consumption, income elasticity calculated on the basis of expenditures approximates 1.0. He predicts that the coefficient will remain near this figure because food services will continue to be purchased as incomes rise. The producer will be called upon for more high quality livestock, and the packer and marketing agency will be expected to perform more services in the form of packaging and food preparation. The net effect will be a more acceptable product and thus a continued high demand for large quantities of livestock.

Many of Virginia's farmers are actively engaged in the production of livestock. Cattle and calf numbers were the highest they had ever been at 1,436,000 head in 1962. Since the number of dairy cows and calves kept for dairy purposes has declined, the increase was the direct result of an increase in the number of beef animals produced. Hog production throughout the 1950's was exceeded only during the World War II.

In addition, approximately 300,000 head of sheep and lambs were on hand on Virginia farms throughout the decade from 1952 to 1962. 1/

Virginia farmers, because of their location relative to surplus production areas and deficit consumption areas, would not be able to compete favorably with midwestern and other livestock producers if they had to do the bulk of their marketing out of state. A strong meat-packing and processing industry is therefore essential to the continued development of sound and economical livestock production in Virginia.

Generally, profits in food processing industries have been low in relation to those in manufacturing industries as a group, and meat packers' profits have been low compared with those of most other food processing companies. As a result, packers have continually made changes attempting to increase profits. They have not been successful. Between 1948 and 1961, net earnings of the meat packing industry decreased from $96 million to $89 million while net earnings as a percent of net worth remained fairly constant. 2/ This indicates in part the competitive nature of the packing industry.

Concurrent with constant returns, there have been significant changes in the meat economy as a whole. Retail stores and companies have become larger and fewer in number. Transportation and communication

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1/ Crops and Markets, Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D. C., 1952-1955, and Meat Animals, Agricultural Marketing Service, Crop Reporting Board, United States Department of Agriculture, Washington, D. C., 1956-1962.

2/ Financial Facts about the Meat Packing Industry, 1961, American Meat Institute, Department of Marketing, Chicago, July, 1962.

facilities have been improved. The retail concern has therefore become freer to draw upon packers from a wider area to fulfill its needs. As a result, retail buyers have become more influential in their dealings with meat suppliers and are likely to become even more so in the future.

Packers and retailers have both pushed for more direct sales to take advantage of possible savings. Handling has been reduced as has the time from packer to retailer. This has also eliminated the need for maintaining and staffing numerous packer branch houses.

Consumers have also induced changes as a result of increasing incomes and changing tastes and preferences. They have become more willing to pay for time and labor-saving conveniences such as table-ready meats, packaging, curing, and pre-cooking. This has provided a more attractive market for many raw materials and has offered an excellent opportunity for increased product differentiation.

Large packers have become more active in the importing of meats from foreign countries to help solve the problem of fluctuating livestock supplies and prices. They have contracted and, in many instances, financed feeding operations. This, too, has reduced the problem of seasonal supply fluctuation. Branch houses have been streamlined to meet the desires of a changing market. Systems of quality control and programming procedures have been set up and used to insure product quality, decrease costs of production, and make better use of available resources.

Such activities on the part of the national packers and processors have strong implications for the packing and processing industry in

Virginia. Commercial cattle and calf slaughter in Virginia was 52 percent of consumption and commercial hog slaughter was 74 percent of consumption in 1958. 1/ Thus a high percentage of meat consumed in Virginia came from out-of-state packers. This is an indication of how much competition Virginia firms faced in selling their products. They also faced strong competition in the live animal market from out-of-state packers who bought in Virginia and from packers in states where Virginia packers purchased livestock.

Current developments make the future look favorable for the southern packer who keeps abreast of technological innovations and market trends, and who takes advantage of any and all tools which will make for a more efficient operation. Increases in the consumption of meat have occurred primarily along with a shift from rural to urban living. The southern region has gained in urbanization relative to the United States each decade since 1900 with the largest gain between 1950 and 1960. As more people have moved to the cities and metropolitan areas, the average per capita income has risen. Since the income elasticity for meat and meat products has been positive, the consumption of meat has increased. Between 1939 and 1960, income payments to individuals in the South increased 404 percent as compared with a national increase of 300 percent. 2/

1/ R. G. Stout, J. C. Purcell, and W. L. Fishel, Marketing, Slaughter and Consumption of Livestock and Meats in the South, Bulletin No. 66, Southern Cooperative Series, August, 1961.

2/ The Economic Almanac, 1962, National Industrial Conference Board, New York 22, New York, pp. 136-137.

The increase in the South exceeded that of any other single section of the country. This suggests that the most rapidly developing market for meat products is to be found in the southern states. Packers in other areas are aware of these developments. The large, national packers have made and will continue to make efforts to expand sales in this fertile market area. Local packers will have to stay alert to maintain their relative position. If they do, local producers of livestock will benefit through a more readily available market.

The Problem

The increasing bargaining power of the retail segment of the market complex, unused plant capacity, and a high degree of competition in the market as a whole are among the causal factors of the low returns faced by packers. The trend in relative bargaining strength seems inevitable. Retailers are integrating so as to gain the advantage of the economies of large buying and selling operations. But high-cost operations, whether from unused capacity or an over-all lack of efficiency, are also important factors. This is an area where the packer and/or processor has an opportunity to help himself. The immediate effect of a decrease in operational costs will benefit the packer. Whether these savings will eventually be passed on to the consumer and/or producer will depend largely upon how many firms adopt the innovation and the subsequent pricing policies of the firms. If several competing firms decrease their costs at essentially the same time, their combined action will likely force rapid price adjustment and thus allow the consumer and/or producer

to reap a large part of the benefits. A single, large firm finding a cost-reducing technique might decrease its price in an effort to facilitate its competitive position. Clithero points out that many large packers will not keep the added profits they might reap but will pass such savings on for comparative advantage. 1/ This means decreased prices to wholesalers and retailers and/or increased payments to producers as the packer attempts to reap benefits through increased volume. A smaller firm would be more likely to retain the savings until the adoption of innovations moves other firms into analagous situations. Since the small firm has little opportunity to use the cost-reducing technique to increase its share of the market, the possibility of increased returns provides an incentive to develop the technology.

Virginia packers are small relative to packers on a national basis. The larger concerns have the facilities and financial backing necessary to conduct research and develop means of improving their operations. Such efforts, if successful, place a burden on the smaller Virginia packers who often lack the facilities, personnel, and financial backing needed to find means of improving their operations. The result has been a constant cost-price squeeze because of late adoption. Yet, as was mentioned in "The Current Situation", the economic health of Virginia packers is essential to the Virginia livestock industry.

1/ W. A. Clithero, "Mathematics in Meat Packing", Proceedings: Fourteenth Annual Reciprocal Meat Conference, National Livestock and Meat Board, Chicago, Illinois, June 1961, p. 153.

If the relatively small packer is to improve net returns, the greatest potential is probably in the processed meats phase of his operation. The processed meats operation is the most important sector of the entire business for many of the small firms. At least 50 percent of the cattle killed by most Virginia packers is for raw materials in processed meats.

The marketing situation for processed products is not as difficult in many ways as in the fresh meat operations. Due to the perishable and unstable nature of fresh meat cuts, packers can do little in the line of services which will enable them to differentiate their product. The meat is usually transported from the packer to the wholesale or retail outlet in the form of an entire carcass or large cuts such as quarters. The packaging, cutting, and other preparatory tasks are performed by the wholesaler or retailer near the point of final transfer to the consumer. The processed meats are usually packaged and prepared by the packer who produces them. Managers recognize this as an opportunity to differentiate their product and are quick to take advantage of it. For many Virginia packers the success of the processed meats sector will, therefore, largely determine the success of the business. Here is an area where managers can ill-afford to have high-cost operations and/or poorly organized patterns of production and sales.

This study is concerned with the processed meats operation of a specific firm which, as is true of many Virginia firms, can best be described as a price taker in both the finished product market and in the raw material or ingredient market. Due to the smallness of the firm's operation relative to other buying and selling firms in the market

area, managerial decisions are primarily quantitative in nature. The manager can affect only slightly the price of his firm's products and has no influence at all over the price he must pay for raw materials. Other buyers from Virginia, as well as buyers from adjoining states, bid for the livestock being offered for sale. Pennsylvania and Baltimore packers are especially influential in establishing Virginia livestock prices. A number of Virginia packers sell throughout Virginia, and regional and national packers are active particularly in the concentrated centers of population. The actions of these buyers and firms are the primary determinants of the prices which prevail in the respective markets at any moment in time. When operating under these competitive conditions and influences, the only alternative open to the small price-taking firm is to meet the prices largely determined by others and try to maintain profits by operating as efficiently as possible.

The packers large enough to affect the prices they receive or pay face a negatively sloping demand curve for their finished products and a positively sloping supply curve for raw materials. This particular firm and firms of similar size do not necessarily face either. The firm has, over time, established a share of the available products market and continues to supply it while operating within the environment determined primarily by larger firms. Though indeterminant, the demand curve for the small firm's products will likely be horizontal to the quantitative level for which a market has been established. The prices charged for finished products will not necessarily be equal for all firms, but they will be established using prices of larger packers as a major criterion.

After the price for any particular product has been set in this manner, the firm can sell an amount up to the level for which a market has been established. The price may change as the over-all market price is changed, but the quantitative level which can be sold will stay essentially the same, especially in the short run. Even with a portion of the demand curve horizontal, the firm has the possibility of receiving pure profits. Whether or not it will depends upon the relationship between the price established for any particular product and the firm's average cost curve for that commodity. If this relationship is favorable, pure profits in the amount of the margin of returns over costs multiplied by the number of units sold will be received. If the price is so low that the per unit costs exceed the price of the product, losses in the amount of the margin of loss multiplied by the units sold will be incurred. Production and sales of a product will usually be continued in the short run even if the price should fall below the variable costs per unit. Prices of processed meats fluctuate primarily on a seasonal basis, and it is not feasible to stop production of a product and allow the established market to dwindle away because of temporary losses. The most likely thing which will really help here is a decrease in costs.

Some products are more profitable than others. This provides an incentive to decrease production of the less profitable products and increase production and sales of the products which have proved to be most profitable. Such efforts are replete with problems. Subjective limits are placed on production to coincide with the established markets for the various products. The firm manager seldom knows what would

occur if attempts were made to expand sales to a significant extent for any particular product. There is a possibility that the horizontal average revenue curve could be extended slightly via improved services, quality of product, and improved customer relations. This would take time, probably increase per unit costs, and any increase in the market would almost certainly be small. Alternatively, attempts could be made to induce customers away from other packers by decreasing product prices. The hazards of such pricing policies would likely exceed any possible benefits. Beyond the arbitrary market limitation for each product, the demand curve for that product probably slopes downward to the right and thus takes on the form of the kinked demand curve which often prevails under oligopolistic conditions. Attempts to expand sales into this range of the demand function by lowering prices to a few marginal customers could well endanger the profit possibilities for outputs which fall in the horizontal portion of the function. Any retaliation from other producers could result in a lower price on all levels of output and more than offset gains from the increased number of customers. With no retaliation, the inability to segregate the market and thus practice price discrimination would cause discontent among the older customers who would demand a similar price cut or turn to other packers.

The manager of this particular firm, as well as many other Virginia firms, must turn to decreases in costs and/or improved patterns of production and sales as the most practicable means of improving returns. Decreases in costs could take the form of increased output per man hour, more efficient placement of machines, decreased distribution and transportation costs, or, very importantly, decreases in the cost of the

ingredient mix for the various processed products. A decrease in the cost of the product mix could arise as a result of an improved combination of ingredients--an improved combination being one which meets all legal and subjective restrictions affecting quality and still decreases the cost of the mix. Under optimal conditions, this would mean selling any ingredient from the firm's slaughter operation when it could be replaced by a cost-reducing ingredient either from within the firm or purchased from the raw material market. Such action depends upon the existence of an ingredient market. If such a market does not exist and cannot be developed, these raw materials can only be marketed through processed meat products. This places a serious restraint on the profit potential of the processed meats operation in particular and on the firm in general because it prohibits cost-reducing, ingredient substitution.

The structural changes in the livestock and related industries, the changes in consumer desires, the expanding population pressures, the increased demand for market services--all of these things have affected and will continue to affect the meat industry. For Virginia packers, these trends have meant the creation of new problems and the aggravation of existing ones. Increased competition among packers and a shift in bargaining power to the retailer are tendencies which have affected the outlook of Virginia packers. If they are to combat these problems and maintain or improve their competitive status relative to the rest of the nation's packers, they must take advantage of every managerial tool currently available and continually seek the development

and adaptation of new and improved ones. Improved knowledge and understanding of the implications of economic and marketing theory and more effective tools to assist in managerial decision making would seem to be the cornerstones upon which the successful packing and processing operation must be built.

Review of Literature

Little evidence was found of any research having been done in meat-packing firms in general and processed meat operations in particular. 1/ Much of the work in the livestock fields has revolved around attempts to improve the efficiency of production, live marketing, and live distribution.

R. T. Crowder 2/ conducted preliminary research among Virginia's meat-packing firms. Crowder was concerned with the variation in labor efficiency and other selected costs among the various firms. Considerable interfirm variation was revealed with the coefficient of variation exceeding 30 in most instances. High costs and variation in efficiency were the rule rather than the exception. Crowder's efforts served to reveal the need which Virginia packers have for management tools applicable to Virginia conditions.

1/ The Agricultural Index, The H. W. Wilson Company, Volumes 39-47, and Bibliography of Agriculture, U. S. Government Printing Office, Volumes 17-27.

2/ Richard T. Crowder, Variations in Labor Efficiency and Selected Costs Among Virginia Meat Packing Firms, (Unpublished M.S. Thesis, Virginia Polytechnic Institute, Blacksburg, Virginia, December, 1961).

J. H. Greene, et.al., 1/ applied the linear programming technique to provide models which would assist a packer in determining what weights of hogs to buy and which cuts of pork should prove most profitable. The models used denoted the optimum combination of various fresh and smoked cuts subject to plant and time restrictions. Processed products were not considered and the program was of the familiar type which serves to maximize profits subject to the costs, prices, and restrictions used for this sample problem. The costs used were the processing costs per pound with no attempt made to ascertain whether these costs were near or approaching a minimum. The procedure, however, is valid and should prove useful both in its direct applicability and as a guide for development of other and more expansive programs.

James E. Snyder 2/ has developed models similar to some of those to be used in this study. Models were developed for firms facing different degrees of competition under conditions typical of the market place in the midwest. The optimum formulas and combination of products were developed for three one-week periods. Conclusions were drawn as to how much profits would be increased if the optimum plan were followed instead of the plan then being used. An important and specific conclusion was that packers were often decreasing their returns by arbitrarily trying

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1/ J. H. Greene, K. Chatts, C. R. Hicks, and C. B. Cox, "Linear Programming in the Packing Industry", The Journal of Industrial Engineering, Volume 10, September - October, 1959.

2/ James E. Snyder, Management Models of Mathematical Programming, (Unpublished Ph.D. Dissertation, Purdue University, Lafayette, Indiana, 1962).

to use all of the edible by-products from their slaughter operations in the processed meats. This conclusion is valid if, and only if, the packer has a market for the by-product ingredients which he does not incorporate into his own salable finished products. Snyder, because of the expansive scope of his project, did not delve into the situation in an effort to determine how useful his results would be to any specific packer. This would require consideration of the packer's relative position in the market and whether a market for his by-products existed or could be developed. Snyder's work has made a contribution toward providing tools for a firm manager's use in his efforts to decrease the cost of his operation.

D. R. Frazeur, C. E. French, and L. M. Eisgruber of Purdue University have investigated the use of linear programming in the determination of least-cost mixes for ice cream. 1/ The procedure involved is similar to that used when minimizing the cost of processed meat products. Certain legal and subjective restraints were used to insure a high quality ice cream mix and the cost of the mix was minimized subject to those restraints. The authors indicate that the potential savings make the technique worthy of manufacturers' attention.

1/ D. R. Frazeur, C. E. French, and L. M. Eisgruber, "Electronic Brain Employed to Determine Ice Cream Mix Formula", Ice Cream Field, Baltimore, Maryland, November 1960.

Objectives

The foremost objective of this entire study is to provide the manager of the meat-packing firm with an additional tool which will enable him to function in a more learned manner. If the linear programming procedure proves to be useful to Virginia meat-packing firms, and especially the smaller ones, as it has already done in larger firms in other areas, it can take its place as a valuable addition to the manager's kit of tools. Toward these ends, the fulfillment of the following specific objectives was undertaken:

(1) To investigate the possibilities of decreasing the cost of the ingredient mix for selected processed meat products and to estimate the marginal value product of any restrictive resource.

(2) To determine the optimum combination of these products and thus provide guide lines for pricing and promotional policies.

(3) To estimate the possible effect of linear programming when applied under various conditional restrictions.

Hypotheses

It is postulated that the application of the linear programming procedure will enable the typical Virginia packer to reduce, subject to his restrictions, the costs of the ingredient mix for processed meat products. It is further postulated that the technique will be of assistance to the packer in developing a more nearly optimum pattern of production and sales and an improved array of product prices, and

create an increased awareness on the part of the packer of the justification and merit of certain facets of his operation.

Procedure

Data were collected from one packing firm selected for this analysis. The data included all variable non-ingredient costs such as labor, spice, and packaging costs. Ingredient costs equal to the market price of each ingredient were used in accordance with the cost allocation policies of the firm. The various operations which were performed in the preparation of the processed meat products were timed to get the labor costs per unit of output. All labor was charged at the average hourly wage for the entire plant. This wage rate included social security and unemployment compensation payments. The labor cost was combined with the spice cost, the cost of packaging materials, and the least-cost combination of ingredients to get the net returns to fixed resources for the various processed products.

In a few instances, actual data were not available from the firm. When such a situation arose, data representative of Virginia packers' operations were synthesized and used in the analysis. There is some variation from firm to firm in such things as variable operational costs. This variation among firms should not be of sufficient magnitude to destroy the significance of the results. Thus, the use of synthesized data when necessary did not damage the applicability of the procedure and results to the typical Virginia packer.

Since actual data were used where possible, the results are presented so as to protect the position of the cooperating packer. In many instances, this prevented the presentation of many of the important calculations in the process of analysis.

The least-cost ingredient mix for each product was ascertained and the results used in other programs to give the optimum combination of products under various conditional restraints. 1/ The first program was constructed to estimate the MVP's (marginal value products) of restrictive resources when the level of production was limited by the plant supply of ingredients. The second program permitted purchase of these restrictive ingredients but not the sale of unused ones. Such a program is most helpful in guiding the purchase of needed ingredients. A final program was established by which buying and selling of ingredients were permitted. Here, the primary intent was to estimate the economic incentive of developing a market for unused ingredients.

The possibility of developing an optimum array of product prices for an established operation was investigated. The results should prove useful in pricing policies where the prices could be adjusted in accordance with the optimum array of prices.

From appraisal of the results, conclusions were also drawn relative to the justification of slaughter operations for the purpose of providing ingredients for the processed products.

1/ The least-cost mixes were used consistently to allow comparison of situations where ingredients could not be purchased, could be purchased but not sold, and could be both purchased and sold. When unused raw materials cannot be sold, the least-cost mix will not necessarily be the optimum mix.

Due to their size of operation, all of the smaller firms in Virginia face essentially the same competitive situation. The usefulness of linear programming has already been established in larger firms where ready markets for buying and selling ingredients exist. These markets are usually available for Federally inspected firms which can take advantage of potential ingredient markets in other states. The smaller and non-Federally inspected plants have fewer such markets; they can buy from Federally inspected plants but cannot sell to them. Whether or not these small firms can develop an ingredient market will determine to a considerable extent how useful the programming technique will be. Thus, throughout the analysis, conclusions were drawn and comments made concerning the usefulness of such procedures to the Virginia packer.

ANALYSIS AND RESULTS

The initial step in the analysis was the portrayal of the least-cost ingredient mix for each of the various products. The programs were based upon and developed from the formulation restrictions for each of the products. Results from these programs were expected to (1) depict an ingredient combination which would be lower in cost than the combination being used and (2) provide coefficients for later programs to develop an optimum combination of products.

A program was then analyzed to ascertain the optimum combination of products subject to typical plant ingredient supplies. More specifically, the purposes of this program were to (1) estimate the MVP's of any restrictive resource and (2) compare the level of production allowed by such restrictive ingredients to the level permitted by noningredient restrictions such as plant capacity and sales potential.

Additional programs relative to the development of an optimum product combination were analyzed. One of these programs permitted the purchase of restrictive ingredients but required that unused ingredients be rendered. This is typical of the situation faced by the packer who has no market for unused ingredients. Another program permitted the purchase of restrictive ingredients and the sales of unused ingredients. A comparison between the functionals of the two programs gives a measure of the economic incentive to develop a market in which unused ingredients could be sold. The programs also provide valuable information relative to the MVP's of restrictive resources and the relative profitability of

the products being produced. Such revelations should prove useful to a firm manager in his efforts to improve his pattern of production and, overall, to develop a more efficient and profitable operation.

Least-Cost Ingredient Mixes

The cost minimization problem with which we are concerned here can be algebraically expressed as follows:

$$Z = \sum_{i=1}^{n} b_i X_i$$

Here, Z = the cost which we seek to minimize

X_i = the number of units of the i^{th} ingredient

b_i = the cost per unit of the i^{th} ingredient

n = the number of ingredients comprising the mix

In attempting to minimize Z, all ingredient levels must be either positive or zero since negative levels are unrealistic.

Linear programming was selected to minimize the above function. A linear programming problem must have three quantitative components: (1) an objective, (2) alternative methods or processes for attaining the objective, and (3) resource or other restrictions. Consideration reveals that the problem of minimizing the cost of an ingredient mix for processed meat products possesses these three necessary components. The objective, of course, is to minimize the cost of the mix. The formulation restrictions set forth all possible ingredients and the amount of each allowed in the final product. In so doing, they make

possible an infinite number of ingredient combinations which could comprise the mix. The specific combination which evolves will depend upon the composition of the potential ingredients, restrictions upon their use, and the prices of each which prevail at the time the analysis is made. The applicability of the linear programming procedure in minimizing the cost of an ingredient mix is not greatly affected by the competitive situation which the firm faces.

The bases for the development of a program to minimize the cost of the ingredient mix for a particular product are the formulation restrictions on the mix. These restrictions insure the quality of the product since they place restraints upon the ingredients used and upon the quantitative levels of the various ingredients. The ingredients in the formulas and their quantitative ranges vary from product to product. In general, the higher quality products contain more of the higher priced ingredients than the lower quality products. The lower quality products often contain milk powder and/or a flour from rice, rye, wheat, and oats. Both of these ingredients serve as a "binder" to help maintain the consistency of the product and are not permitted to vary.

Whatever the ingredient, the restrictions will take one of the following three forms:

$$X_i \geq Q$$

$$X_i \leq Q$$

$$X_i = Q$$

In each case, Q represents the quantitative level which dictates the limits within which the ingredient is permitted to vary or the exact

amount of the ingredient which must be included. The use of such restraints is illustrated below in the formulation restrictions for No. 1 franks.

Total fat	$\leq$ 36%
Cow meat plus bull meat	$\geq$ 40%
Cow meat plus bull meat	$\leq$ 52.5%
Lean beef trimmings	$\leq$ 15%
Fat beef trimmings	$\leq$ 12.5%
Beef cheeks	$\leq$ 10%
Pork cheeks	$\leq$ 15%
Beef cheeks plus pork cheeks	$\leq$ 22.5%
Skin emulsion	$\leq$ 10%

This was the basis for the matrix prepared as the first step in solving the problem. (See Table 1).

The only legal restriction on processed meat products concerns the water content. Legally, the amount of water in the mix cannot exceed four times the protein content plus ten percent of the finished product weight. Thus, water content is a variable which is dependent upon the protein content, another variable.

The derivation of the coefficients in the water row requires some explanation. If the mix contained no protein, water could be added up to ten percent of the finished product weight. This explains the ten percent in the activity column of the water row in the matrix. How much water can be added in addition to this minimum level depends upon the relationship between the moisture and protein content of the

Table 1. Matrix for Least-Cost Ingredient Mix--No. 1 Franks

Cs a/	Restrictions	Unit	Supply or activity level	Real Activities								Artificials
				Cow meat	Bull meat	Beef cheeks	Pork cheeks	Lean beef trimmings	Fat beef trimmings	Skin emulsion	Water	Bull meat and cow meat
0	Fat	%	≤ 36	12.6	11.7	9.7	16.	15.	31.9	46.5		
-9999.99	Bull meat and cow meat	%	≥ 40	100.	100.							-1.0
0	Bull meat and cow meat	%	≤ 52.5	100.	100.							
0	Lean beef trimmings	%	≤ 15					100.				
0	Fat beef trimmings	%	≤ 12.5						100.			
0	Beef cheeks	%	≤ 10			100.						
0	Pork cheeks	%	≤ 15				100.					
0	Beef cheeks and pork cheeks	%	≤ 22.5			100.	100.					
0	Skin emulsion	%	≤ 10							100.		
0	Water	%	≤ 10	-9.7	-9.7	-7.2	4.25	-13.	-5.9	-139.2	100.	
-9999.99	Bulk	Cwt.	= 1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
	Cj b/			-41.50	-43.50	-24.00	-24.00	-36.00	-31.50	-5.00	0	0

a/ The cost attached to disposal of a unit of the various restrictions.
b/ Cost per hundredweight of the various real activities and the cost attached to the artificial activity.

ingredients. By multiplying the protein content of any specific ingredient by four and subtracting the product from the moisture content, the coefficient for the water row and ingredient column can be ascertained. In Table 1, the coefficient for the water row and bull-meat column is -9.7. The protein content of bull meat is 19.4%; the moisture content is 67.9%; 67.9 - 4(19.4) = -9.7. The minus sign is necessary in this instance. So long as four times the protein content exceeds the moisture content, the inclusion of this particular ingredient will increase the amount of water which can be added.

The water row in the matrix is really in the form of an equation. The water to be added to the minimal ten percent plus the various ingredient levels multiplied by their respective coefficients form one side of the equality. The other side of the equality is zero. The negative coefficients in the matrix will thus contribute to the amount of water to be added when brought across the equal sign. From Table 1, we can see that the water to be added to the No. 1 franks will be determined by the following:

$$\text{Water supply} = 9.7X_1 + 9.7X_2 + 7.2X_3 - 4.25X_4 + 13.0X_5 + 5.9X_6 + 139.2X_7$$

As was done throughout the matrix, the real activities X_1 through X_7 are expressed in hundredweight. Pork cheeks, denoted by X_4 above, is the only ingredient whose entry reduced the water added because the moisture content exceeds four times the protein content.

The data used concerning the composition of the various ingredients were representative data. These data are available to packers from

various sources. In this analysis, the data used were verified through discussion with R. F. Kelly and material furnished by L. J. Bratzler. 1/

The moisture and protein contents of ingredients vary somewhat with such things as season and age and breed of livestock. The range of variation is small, but could result in a violation of the water restriction. To reduce the possibility of such an occurrence in the absence of an exact analysis, the lower figures in the range of protein content and the higher figures in the range of moisture content could be used. This would provide a slight margin of safety and still permit the desired exactness.

The least-cost mix which will evolve from solution of a matrix will be accurate within the bounds provided by the validity of the original data. Regardless of the restrictions imposed and the costs and prices assigned, the programming procedure will select from all possible combinations the one mix which will minimize costs. The results from the solution of the matrix were as follows:

1/ Dr. R. F. Kelly, Professor of Animal Husbandry at Virginia Polytechnic Institute, Blacksburg, Virginia and Mr. L. J. Bratzler, Professor of Food Science in the Animal Husbandry Department at Michigan State University, East Lansing, Michigan. Professor Bratzler provided a useful source of information in Publication No. 109, Moisture and Fat Content of Fresh Red Meat Materials, prepared by the Food and Standards Division, Michigan Department of Agriculture, Lansing 13, Michigan. This publication gives the water, fat, and protein content of virtually all ingredients which might go into processed meat products.

Ingredient	Cwt.	Cost per cwt.	Range (cost per cwt.)
Cow meat	.4	$41.50	$27.50 - $43.50
Beef cheeks	.1	24.00	0 - 26.87
Pork cheeks	.1198	24.00	21.44 - 28.48
Skin emulsion	.1	5.00	0 - 5.99
Water	.2801	-----	----------

Functional 1/ = $22.38 per cwt.

The range indicates that the cost of cow meat could vary from $27.50 to $43.50 per hundredweight before the amount of cow meat and thus the ingredient combination would change. The range for beef cheeks and skin emulsion begins at zero cost since these two ingredients have entered the mix at the maximum allowable level with a positive cost attached to their use.

The results also reveal the changes in costs which would be required before the omitted raw materials would become part of the mix. Such changes are always decreases in costs and were as follows:

Potential ingredient	Cost per cwt.	Required decrease per cwt.
Bull meat	$43.50	$2.00
Lean beef trimmings	36.00	7.68
Fat beef trimmings	31.50	4.96

1/ The functional is the programmed solution to the matrix and in this case, is the cost per hundredweight of the least-cost combination of ingredients.

So long as the cost of the ingredients comprising the mix stays within the depicted range and the price decrease required for the potential ingredients to become constituents does not occur, the least-cost mix will remain the same. If ingredient prices change so that either or both of these conditions are not fulfilled, a new analysis should be made to develop the least-cost mix subject to the new price situation.

The potential savings may or may not merit the use of programming for least-cost mixes alone. The cost of computer time and its availability must be weighed along with the usefulness of the procedure in other aspects of the manager's decision-making process before a decision can be made as to whether it is worthwhile to use programming. The results, however, indicate a possible reduction of $10,855 on an annual basis in the cost of the mix for the No. 1 franks. It seems likely that the use of the programming procedure to minimize the cost of the mix would be justified for the particular firm considered in this analysis. Omissions in the original data prevented a direct comparison between the least-cost mix for the other products and the cost of the mix actually being used. Actually, it is very probable that savings would be even greater per unit of the lower quality products because there are many more possible combinations of ingredients which will satisfy the packer's quality restrictions. Total weekly sales by this firm for all processed products were approximately four times the sales for the No. 1 franks, so the potential savings are obvious.

Optimum Product Combinations

Minimum-cost ingredient mixes have uses in addition to the direct reduction in costs. When combined with other variable costs, the net returns to the fixed resources can be estimated for each individual product. Such estimates are derived by subtracting total variable costs per unit from the sales price of that unit. These estimates can then be used in another program to ascertain the optimum combination of products subject to the available supply of ingredients and other restrictions on the level of production.

Other costs which vary with the level of production are labor, spice and package costs. These, when combined with the least-cost combination ingredient cost, constitute all important variable costs which may be attributed to the cost of producing the processed meat products. Utility costs were not included because they were thought to be too small per unit to be of importance in the programs.

The labor cost was attained for each product by timing the various operations to get the output per hour. The labor cost per pound varied somewhat because of the differences in packaging methods and the product. As expected, the labor involved in packaging bulk franks was less per pound than for franks prepared in a 12-ounce package, and the requirements for bologna were different than for franks. All labor was charged at the average hourly cost for the entire plant.

The spice and packaging costs also varied from product to product. Packaging costs were considerably higher on the 12-ounce and one-pound package franks than on the bulk packages of franks or the bologna products.

For the general problem, the variable costs are subtracted from the sales price to estimate net returns to the fixed resources for the various processed products.

After ascertaining the least-cost combinations and calculating the net returns, there remains the problem of obtaining the optimum combination of products. The objective is to maximize net returns to the fixed resources. An infinite combination of products would yield a return, but only one will be maximum. There are limits on the availability of ingredients, on plant capacity, and on sale possibilities. The linear programming technique is again adaptable since the three necessary components are present.

Algebraically, the problem can be expressed as follows:

$$Z = \sum_{i=1}^{n} b_i X_i$$

where

Z = net returns to fixed resources to be maximized

b_i = net returns from a unit of the i^{th} activity

X_i = number of units of the i^{th} activity

n = number of activities

The activities refer to the processed meats and any activity which sells unused ingredients.

The functional 1/ which will be obtained in this instance will be a positive returns figure and should be maximized subject to the various restrictions. It will be an indication of the contribution which the processed meat operation makes to the net returns to fixed resources for the plant as a whole.

Several possibilities will be analyzed with the objective always to maximize net returns. Different conditional restraints will be imposed so as to provide models for processors operating under different conditions. The models should provide the incentive and guide lines needed to stimulate change and tools to assist the manager in his attempts to improve his operation.

Optimum Combination of Products--Subject to Plant Supplies

The first program was based on the assumption that processed meats or rendering were the only outlets for the edible by-products of the plant's slaughter operation and that slaughter continued at a constant level. Many of the smaller firms feel they face such a situation where little or none of the potential ingredients can be marketed favorably unless they are converted and sold through the processed meat products. Buying of ingredients is possible but was not permitted in this program so as to estimate the MVP of any restrictive ingredient. Any unused

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1/ The functional in all programs pertaining to an optimum combination of products will be the net returns to the fixed resources.

ingredients were rendered at the nominal return of $4.50 per hundredweight. This constitutes a reduction in the losses which would result if they were simply disposed of without any returns at all.

The matrix for this program is shown in Table 2. The coefficients in the real activities sector of the matrix were taken from the least-cost combination of ingredients for each of the specific products. Supply levels were assigned which were thought to be representative of the supplies smaller firms have from their slaughter operations. The net returns to the fixed resources were ascertained as was discussed previously. The entries in the Cj row for the rendering activities represent the loss incurred when a hundredweight of the respective ingredient is rendered. This procedure was followed even though the costs of production were fixed costs at this point in the decision process. 1/ The entries were obtained by allocating the costs of production among the various ingredients and then subtracting $4.50 from the cost of producing a hundredweight of each of the respective ingredients. To make the allocation of costs as realistic as possible, the costs of

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1/ Such a procedure was necessary because the costs of ingredients were subtracted in estimating the net returns from production of the processed products even though the level of slaughter was not allowed to change and thus the supply of ingredients was fixed.

Table 2. Matrix for Optimum Combination of Products--Subject to Plant Supplies a/

Cs b/	Restrictions	Unit	Supply or activity level	No. 1 Franks			No. 2 Franks			No. 3 Franks			No. 1 bologna
				1 lb. pkg.	12 oz. pkg.	6 lb. pkg.	1 lb. pkg.	6 lb. pkg.	40 lb. pkg.	40 lb. pkg.	8-2 lb. pkg.	6 lb. pkg.	
-9999.99	Beef cheeks	Lb.	≤ 1200	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
-9999.99	Pork cheeks	Lb.	≤ 800	11.98	11.98	11.98							11.98
-9999.99	Snouts	Lb.	≤ 1200										
-9999.99	Hearts	Lb.	≤ 1800										
-9999.99	Melts	Lb.	≤ 317				10.	10.	10.	9.16	9.16	9.16	
0	Plant capacity per week	Cwt.	≤ 425	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
0	Sales potential per week	Cwt.	≤ 297.07	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Cj c/			13.88	15.61	16.05	14.19	14.41	11.17	11.22	8.51	10.41	10.64

a/ Nonrestrictive resources or ingredients are not included.
b/ The cost attached to disposal of a unit of the various restrictions.
c/ Net returns to the fixed resources per hundredweight of the processed products and rendering activities.

Table 2. (Continued)

Cs	Restrictions	No. 2 bologna	No. 3 bologna	No. 4 bologna	No. 5 bologna	Render beef cheeks	Render pork cheeks	Render snouts	Render hearts	Render melts
-9999.99	Beef cheeks					100.				
-9999.99	Pork cheeks						100.			
-9999.99	Snouts	20.	20.	20.	8.51			100.		
-9999.99	Hearts								100.	
-9999.99	Melts	10.	10.	10.	10.					100.
0	Plant capacity per week	1.0	1.0	1.0	1.0					
0	Sales potential per week	1.0	1.0	1.0	1.0					
	Cj	11.86	14.86	4.86	3.31	-18.88	-18.88	-14.98	-21.80	- 2.80

producing the cow meat was calculated 1/ and allocated to the other ingredients in proportion to their market value relative to the market value of cow meat. 2/ Since cow meat is the most important product and most of the other ingredients arise as by-products of the operation which produces the cow meat, this procedure was considered to result in an equitable allocation of costs.

Only the ingredients listed by the packer as having limited supplies were included in the matrix. The primary purpose of this program was to learn which of the ingredients was most restrictive. The MVP's of such restrictive resources were estimated. This provided guide lines as to which resources should have been purchased in an effort to improve returns and make better use of the entire supply of ingredients. There were, of course, quantitative limits on the supplies of the other

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1/ This calculation was based primarily upon cost data presented by Crowder for the typical Virginia packer and the market price of cows. The components of the production cost were as follows:

Cattle Kill	$1.10 per cwt.
Boning	2.01 per cwt.
Utilities	.35 per cwt.
Cattle Buy	36.96 per cwt.
Total	$40.42 per cwt.

2/ The procedure used in the allocation of costs to other ingredients was as follows:

Market price of cow meat = $41.50 per cwt.
Market price of beef cheeks = 24.00 per cwt.
Cost of producing cow meat = 40.42 per cwt.
Cost of producing beef cheeks = X

$$\frac{\$41.50}{\$40.42} = \frac{\$24.00}{X} \qquad X = \$23.38$$

Similar calculations were made to estimate the cost of producing other ingredients.

ingredients, but their supply was so high relative to such ingredients as melts and pork cheeks that they were omitted from the matrix by inspection. If they were to be included, most of their supply would have gone to rendering and added nothing to the development of the MVP's.

The most surprising result from the analysis was the amount of ingredients rendered. It was expected that a high percentage of the unlimited ingredients would be rendered, but portions of the beef cheeks, snouts, and hearts which the packer considered as limiting were also rendered. Melts and pork cheeks were the limiting factors. They became "bottlenecks" and limited the level of production. The results of this program are presented below. The nonrestrictive were included to facilitate comparison with later programs.

Activity	Level (cwt.)	Returns per cwt.
No. 1 Franks (six-pound package)	66.77	$16.05
No. 3 Bologna	31.70	14.86
Render beef cheeks	5.32	-18.88
Render snouts	5.66	-14.98
Render hearts	18.00	-21.80
Render cow meat	150.66	-35.92
Render bull meat	18.45	-35.92
Render lean trimmings	25.00	-30.56
Render fat trimmings	20.00	-26.18
Render skin emulsion	66.80	- .37
Render tripe	21.16	- 5.00

Functional = -$6,526.85

The MVP's of the melts and pork cheeks were $178.56 and $149.73 per hundredweight respectively. This was in contrast to a market price of $7.50 per hundredweight for melts and $24.00 per hundredweight for pork cheeks. The MVP's for these two ingredients were high relative to their costs because of the restrictions placed upon their supply. The MVP's for the two ingredients will remain at these figures until some other resource becomes restrictive. The incentive to go into the market and buy the melts and pork cheeks is obvious.

The restriction placed on the sales potential was representative of the actual weekly sales of processed meat products for the relatively small Virginia packer. The supplies of melts and pork cheeks proved so restrictive that 66.8 percent of this potential was unused.

There remains the problem of the rendered ingredients. In this particular program, the loss from the rendering activities was $577.63. This loss was entirely from the rendering of ingredients which the packer considered in limited supply, implying that they could become restrictive. When supplies of the omitted ingredients were included to facilitate comparison, the loss from rendering large portions of these nonrestrictive ingredients made the functional the large negative number presented above.

The loss from the rendering activities would have been decreased if ingredient combinations other than the least-cost mix had been used. For example, the full supply of hearts was rendered because hearts were never a component of the least-cost mixes for any of the products.

Hearts were included as a possible ingredient in the No. 3 Bologna, one of the components of the optimum product combination for this program. The least-cost ingredient mix for No. 3 Bologna was as follows:

Ingredient	Cwt.	Cost per cwt.	Range (cost per cwt.)
Cow meat	.2250	$41.50	$24.56 - $43.50
Skin emulsion	.0500	5.00	0 - 53.55
Snouts	.2000	20.00	0 - 23.77
Melts	.1000	7.50	0 - 20.48
Tripe	.2000	9.75	0 - 17.93
Beef cheeks	.0153	24.00	20.19 - 30.62
Powdered milk 1/	.0231	15.50	----------
Water	.1906	-----	----------

Functional = $17.01 per cwt.

The changes in cost which would be required before excluded raw materials would become ingredients were as follows:

Potential ingredient	Cost per cwt.	Required decrease per cwt.
Bull meat	$43.50	$2.00
Fat beef trimmings	31.50	7.79
Hearts	27.00	5.83

The price of hearts would have to decrease to $20.03 per hundredweight ($27.00 - 6.97) before hearts would become an ingredient. In a

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1/ No meaningful range can be presented for powdered milk since restrictions were imposed to keep the amount equal to the 2.31 pounds shown.

situation such as the one being considered where ingredients can neither be purchased nor sold, the relevant cost to use in deciding whether to use the hearts would be the returns from rendering or $4.50 per hundredweight. All costs of production have been incurred and are fixed. Since the $4.50 opportunity cost is less than the $20.03, another ingredient combination could have been used which would have permitted the use of all or part of the supply of hearts. The cost of the ingredient mix would be higher but such an increase in the cost of the mix would be more than offset by the savings accruing from the reduction in rendering activities. Such possibilities are definitely limited, however. Eventually, the cost of the mix would be increased to such an extent that the savings from the reduced level of rendering would be more than offset. Because such adjustments in the ingredient combination would differ from firm to firm, and because this program is but one in a series which were analyzed and compared, it was decided to use the least-cost mix in this and other programs throughout the analysis. Even though the results in this instance are extreme, the consistent use of the least-cost mixes permits valid comparisons.

There are other adjustments in addition to the adjustment of the ingredient combinations which might be enacted to offset the loss from rendering. One possibility would be to stop slaughter altogether and depend on the market for ingredient supplies. Another alternative, the one adopted by most packers, is to continue slaughtering and buy restrictive or "bottleneck" resources from the ingredient market since they consider the slaughter operation necessary because of their fresh meat

business. Many ingredients for the processed products are by-products from the fresh meat operation. If there is no market for such by-products, the only alternative is to try to market them through processed products or allow them to be rendered.

Under the rather extreme conditions presented here, an alert manager could easily recognize the ingredients restraining production so rigidly. Programming would but point out the obvious. The situation differs when there are many resources which become restrictive as would occur at higher levels of production. The manager is then faced with a more complex problem and consequently, a much more difficult decision. Care must be taken or the wrong resources will be purchased and returns decreased instead of increased. Programming becomes a valuable aid when this situation arises.

The applicability of programming in the above case is independent of the competitive situation confronting the particular firm. All firms have occasion to buy from the ingredient market and they all have one thing in common--the desire to buy the ingredients which are really restrictive and buy them in the right quantities. To do so without a managerial tool such as programming is extremely difficult.

Optimum Combination of Products--Buying Restrictive Ingredients

Buying restrictive ingredients is not a complete answer to the firm's problem of maximizing net income, but it does permit more complete usage of the ingredients for which there is an abundant supply within the plant and is beneficial in this sense.

The matrix for the second program is presented in Table 3. Activities were included which permitted the purchase of any ingredient which might become restrictive. The supplies of all ingredients were included and a large negative cost attached to their disposal to insure that they were either used in the processed products or rendered. The results were as follows:

Activity	Level (cwt.)	Returns per cwt.	Range 1/ (returns per cwt.)
No. 1 Franks (six-pound package)	237.07	$16.05	$15.61 - 17.08
No. 3 Bologna	60.00	14.86	13.83 - 20.82
Render hearts	18.00	-21.80	----------
Render cow meat	76.17	-35.92	----------
Render bull meat	18.45	-35.92	----------
Render lean beef trimmings	25.00	-30.56	----------
Render fat beef trimmings	20.00	-26.18	----------
Render skin emulsion	48.29	- .37	----------
Render tripe	15.50	- 5.00	----------
		Cost per cwt.	Range (cost per cwt.)
Buy pork cheeks	20.40	24.00	15.43 - 60.19
Buy melts	2.83	7.50	0 - 17.77
Buy beef cheeks	11.70	24.00	13.73 - 83.69

Functional = -$1269.17

1/ Due to the nature of the problem and the restrictions imposed, meaningful ranges cannot be presented for the render activities.

Table 3. Matrix for Optimum Combination of Products--Buy Ingredients

Cs a/	Restrictions	Unit	Supply or activity level	No. 1 Franks			No. 2 Franks			No. 3 Franks			No. 1 bologna	No. 2 bologna	No. 3 bologna	No. 4 bologna	No. 5 bologna
				1 lb. pkg.	12 oz. pkg.	6 lb. pkg.	1 lb. pkg.	6 lb. pkg.	40 lb. pkg.	40 lb. pkg.	8-2 lb. pkg.	6 lb. pkg.					
-9999.99	Beef cheeks	Lb.	≤ 1200	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.				
-9999.99	Pork cheeks	Lb.	≤ 800	11.98	11.98	11.98							11.98				
-9999.99	Snouts	Lb.	≤ 1200											20.	20.	20.	8.51
-9999.99	Hearts	Lb.	≤ 1800														
-9999.99	Melts	Lb.	≤ 317				10.	10.	10.	9.16	9.16	9.16		10.	10.	10.	10.
-9999.99	Cow meat	Lb.	≤18450	40.	40.	40.	20.	20.	20.	20.	20.	20.	40.	22.5	22.5	22.5	22.5
-9999.99	Bull meat	Lb.	≤ 1845														
-9999.99	Lean beef trimmings	Lb.	≤ 2500				5.	5.	5.	5.	5.	5.					
-9999.99	Fat beef trimmings	Lb.	≤ 2000														
-9999.99	Skin emulsion	Lb.	≤ 7500	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	5.	5.	5.	5.
-9999.99	Tripe	Lb.	≤ 2750				16.71	16.71	16.71					20.	20.	20.	20.
0	Plant capacity per week	Cwt.	≤ 425	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
0	Sales potential per week	Cwt.	≤ 297.07	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Cj b/			13.88	15.61	16.05	14.19	14.41	11.17	11.22	8.51	10.41	10.64	11.86	14.86	4.86	3.31

a/ The cost attached to disposal of a unit of the various restrictions.

b/ Net returns to fixed resources per hundredweight of the processed products and rendering activities and cost per hundredweight of the buying activities.

Table 3. (Continued)

Cs	Restrictions	Buy beef cheeks	Buy pork cheeks	Buy snouts	Buy melts	Render beef cheeks	Render pork cheeks	Render snouts	Render hearts	Render melts	Render cow meat	Render bull meat	Render lean trimmings	Render fat trimmings	Render skin emulsion	Render tripe
-9999.99	Beef cheeks	-100.				100.										
-9999.99	Pork cheeks		-100.				100.									
-9999.99	Snouts			-100.				100.								
-9999.99	Hearts								100.							
-9999.99	Melts				-100.					100.						
-9999.99	Cow meat										100.					
-9999.99	Bull meat											100.				
-9999.99	Lean beef trimmings												100.			
-9999.99	Fat beef trimmings													100.		
-9999.99	Skin emulsion														100.	
-9999.99	Tripe															100.
0	Plant capacity per week															
0	Sales potential per week															
	Cj	-24.00	-24.00	-20.00	-7.50	-18.88	-18.88	-14.98	-21.80	-2.80	-35.92	-35.92	-30.56	-26.18	-.37	-5.00

The range indicates the changes which could occur in the returns to the two processed products and the costs of the purchased ingredients before the optimum combination would change. The changes which would be necessary before the excluded products would become components of the optimum combination will be considered later in an analysis dealing with optimum product prices for an established operation.

As expected, the level of production increased as the melts and pork cheeks which restricted the first program were purchased. Beef cheeks then became restrictive and were also purchased. In every case, the limiting ingredient was purchased until its MVP was equal to its market price or cost. This is consistent with the established theory that returns will be maximized if inputs are used until their MVP equals their MFC (marginal factor cost). The factor which eventually restrained the level of production was the sales potential restriction. The MVP of another hundredweight of sales potential was $25.18. If sales could be expanded by another hundredweight at a cost of less than $25.18, it would be profitable to do so. This would hold true until some other resource became restrictive. None of the ingredients had MVP's which exceeded their market price.

A somewhat surprising result was the high proportion of the ingredients which were rendered. Buying the restrictive ingredients was expected to allow more complete utilization of the ingredients. This did occur but only to a limited extent. All of the hearts, lean and fat trimmings, and bull meat, as well as high percentages of the tripe, cow meat, and skin emulsion were rendered. The sales potential

restriction kept the level of production too low to enable more of the ingredients to be used. The result was a negative functional.

Again, the use of only the least-cost mix was a factor in preventing more of the ingredients from being used. Adjustments of the ingredient mixes in accordance with criteria such as those presented on page 42 would decrease the amount of ingredients which are rendered. The range of possibilities differs in this instance since purchase of restrictive ingredients was permitted. The total amount of ingredients used could be increased only by using an ingredient combination which would allow less water to be added. Adjustments of the mix for this purpose would never be practical since the $4.50 opportunity cost per hundredweight of the ingredients would exceed the cost of the water which is essentially free. The most practical adjustment would be one which permitted nonrestrictive ingredients to replace part of the restrictive ingredients which were purchased, thus using more of the plant supply of raw materials. Caution must be exercised in the making of such an adjustment since the increase in the cost of the mixes will eventually become prohibitive.

Other adjustments could be enacted to help alleviate the loss from rendering. One solution would be to stop slaughter and purchase all ingredients used. The ingredients could then be procured up to the level where their MVP equals their MFC and the loss from rendering unused ingredients avoided. To do this would give rise to unused plant facilities and the diversion of all fixed costs to the other phases of the business.

A second and perhaps more realistic solution would be a reduction in the volume of slaughter. The relationship between ingredient supplies and the level of production permitted by other restrictions was the primary problem in this particular program. So long as the ingredient supplies are high relative to a restraint such as sales potential, the losses from rendering will be inevitable. Changing the formulation restrictions to permit more complete usage of by-products which are abundant in supply would help, but slaughter, especially cow slaughter, should be decreased to bring the ingredient supplies down to levels more nearly comparable with the sales possibilities. Problems will still exist because certain of the ingredients such as cheeks, hearts, and melts accrue automatically as by-products of the slaughter operation, and their supplies will not necessarily be in the needed proportions. Reduced slaughter will likely mean a deficit in the supply of some of these ingredients, but they can be purchased without sacrificing as much in the way of returns as would be sacrificed if the slaughter were increased to insure adequate supplies of these by-products and force the rendering of cow meat.

A program could be written which would permit a reduced level of slaughter. The functional would then be more favorable. Even so, the problems which are sure to arise in attempting to adjust the level of slaughter in accordance with needs cast doubt upon the justification of a slaughter operation for the purpose of supplying ingredients for processed meat products.

There is at least one factor which prompts packers to keep their slaughter relatively high. Though many charge the ingredients at the market price, they can usually be acquired through slaughter at a lower cost. This tends to encourage higher levels of slaughter so that fewer ingredients must be bought. If pushed too far as has been done in the particular situation depicted, any savings from the slaughter operation will be more than eliminated by higher cost mixes and/or the necessity of rendering parts of the ingredient supplies.

Optimum Combination of Products--Buying and Selling Ingredients

Due to the conditional restraints imposed on the previous programs, the programming technique has not yet been used to its full potentiality in the portrayal of an optimum product combination. Evident in both programs has been the problem of what to do with unused resources. The problem was not as serious in the program where buying of restrictive resources was permitted, but even here, it was obvious that difficulty would be experienced in estimating the level of slaughter and keeping it consistent with the supplies of needed ingredients.

The answer to this problem is readily apparent. If the unused ingredients could be sold, the packer could take full advantage of his own slaughter while still minimizing the cost of his mixes. The programming procedure will portray the optimum combination of products, estimate the MVP's of restrictive resources, and denote which ingredients should be bought or sold and the level of each.

Though the answer is apparent, the means of attaining it are not. Most packers realize the benefits of being able to sell unused ingredients. Still, many are not active in this market. The small, non-Federally inspected packer often feels he does not have such a market and cannot develop one. In a few instances, this is likely true--primarily because he cannot sell to Federally inspected plants. In other instances, the markets have never been developed because the packers have not really applied themselves in an effort to develop them. Their conception of the benefits they would receive has been too hazy and subjective to provide the needed incentive.

Another program was constructed to provide an estimate of the increase in returns when selling of unused ingredients was permitted. The same restrictions were used as were used in the preceding program. The matrix for this program is presented in Table 4. The entries in the Cj row were attained by allocating the costs of production among the various ingredients and subtracting these costs from the market price of the respective ingredient. The costs of producing cow meat were calculated as carefully as possible and the costs of other ingredients were expressed on a basis proportional to their value and the value of cow meat. 1/ This prevented the unrealistic situation of an ingredient such as cow meat having a positive margin of returns over costs and a by-product such as tripe from the same operation having a negative margin.

1/ This procedure was explained in the footnotes on page 39.

Table 4. Matrix for Optimum Combination of Products--Buy and Sell Ingredients

Cs a/	Restrictions	Unit	Supply or activity level	No. 1 Franks			No. 2 Franks			No. 3 Franks			No. 1 bologna	No. 2 bologna	No. 3 bologna	No. 4 bologna	No. 5 bologna	Buy beef cheeks
				1 lb. pkg.	12 oz. pkg.	6 lb. pkg.	1 lb. pkg.	6 lb. pkg.	40 lb. pkg.	40 lb. pkg.	8-2 lb. pkg.	6 lb. pkg.						
0	Beef cheeks	Lb.	≤ 1200	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.					-100.
0	Pork cheeks	Lb.	≤ 800	11.98	11.98	11.98							11.98					
0	Snouts	Lb.	≤ 1200											20.	20.	20.	8.51	
0	Hearts	Lb.	≤ 1800															
0	Melts	Lb.	≤ 317				10.	10.	10.	9.16	9.16	9.16		10.	10.	10.	10.	
0	Cow meat	Lb.	≤ 18450	40.	40.	40.	20.	20.	20.	20.	20.	20.	40.	22.5	22.5	22.5	22.5	
0	Bull meat	Lb.	≤ 1845															
0	Lean beef trimmings	Lb.	≤ 2500				5.	5.	5.	5.	5.	5.						
0	Fat beef trimmings	Lb.	≤ 2000															
0	Skin emulsion	Lb.	≤ 7500	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	5.	5.	5.	5.	
0	Tripe	Lb.	≤ 2750				16.71	16.71	16.71					20.	20.	20.	20.	
0	Plant capacity per week	Cwt.	≤ 425	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
0	Sales potential per week	Cwt.	≤ 297.07	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
	Cj b/			13.88	15.61	16.05	14.19	14.41	11.17	11.22	8.51	10.41	10.64	11.86	14.86	4.86	3.31	-24.00

a/ The cost attached to disposal of a unit of the various restrictions.

b/ Net returns to the fixed resources per hundredweight of the processed products and selling activities and costs per hundredweight of the buying activities.

Table 4. (Continued)

Cs	Restrictions	Buy pork cheeks	Buy snouts	Buy hearts	Buy melts	Sell beef cheeks	Sell pork cheeks	Sell snouts	Sell hearts	Sell melts	Sell cow meat	Sell bull meat	Sell lean trimmings	Sell fat trimmings	Sell skin emulsion	Sell tripe
0	Beef cheeks					100.										
0	Pork cheeks	-100.					100.									
0	Snouts		-100.					100.								
0	Hearts			-100.					100.							
0	Melts				-100.					100.						
0	Cow meat										100.					
0	Bull meat											100.				
0	Lean beef trimmings												100.			
0	Fat beef trimmings													100.		
0	Skin emulsion														100.	
0	Tripe															100.
0	Plant capacity per week															
0	Sales potential per week															
	Cj	-24.00	-20.00	-27.00	-7.50	.62	.62	.52	.70	.20	1.08	3.08	.94	.82	.13	.25

The optimum combination of products and other results from this program were as follows:

Activity	Level (cwt.)	Returns per cwt.	Range (returns per cwt.)
No. 1 Franks (six-pound pkg.)	144.31	$16.05	$15.61 - 16.66
No. 2 Franks (six-pound pkg.)	92.75	14.41	14.19 - 16.62
No. 3 Bologna	60.00	14.86	12.22 - 16.11
Sell hearts	18.00	.70	0 - 27.00
Sell cow meat	94.73	1.08	0 - 13.44
Sell bull meat	18.45	3.08	0 - 43.50
Sell lean beef trimmings	20.36	.94	0 - 13.19
Sell fat beef trimmings	20.00	.82	0 - 31.50
Sell skin emulsion	48.29	.13	0 - 25.17
		Cost per cwt.	Range (cost per cwt.)
Buy pork cheeks	9.28	24.00	18.89 - 44.64
Buy melts	12.10	7.50	.20 - 13.62
Buy beef cheeks	11.70	24.00	.62 - 36.52

Functional = $4,163.60

The ranges for the processed products are expressions of the changes in returns per hundredweight before the optimum combination of products would change. All of the sales activities begin at zero since the only alternative is rendering which constitutes a loss. The hearts, bull meat, and the fat beef trimmings were not used in any processed product and thus the amount sold would not change so long as the returns do not exceed

their market price. For the ingredients such as cow meat which are used in the processed products, the upper limit of the range has a somewhat different meaning. If the returns per hundredweight of the sell cow meat activity were to exceed $13.44, more cow meat would be sold and the optimum combination of products would change. The range in the buying activities is that range over which the costs of the respective ingredients could vary before their level of purchase and thus the optimum combination of products would change.

The changes in returns per hundredweight which would be required for other processed products to become components of the optimum combination were also revealed. These changes were always increases in the returns per hundredweight and were as follows:

Product	Present returns per cwt.	Required increase in returns per cwt.
No. 1 Franks (one-pound pkg.)	$13.88	$2.17
No. 1 Franks (12-ounce pkg.)	15.61	.44
No. 2 Franks (one-pound pkg.)	14.19	.22
No. 2 Franks (40-pound pkg.)	11.17	3.24
No. 3 Franks (40-pound pkg.)	11.22	2.48
No. 3 Franks (two-pound pkg.)	8.51	5.18
No. 3 Franks (six-pound pkg.)	10.41	3.28
No. 1 Bologna	10.64	5.41
No. 2 Bologna	11.86	3.00
No. 4 Bologna	4.86	10.00
No. 5 Bologna	3.31	9.97

The MVP of an additional hundredweight of sales potential is only $10.33. This is in contrast to the $25.18 when selling of ingredients was not allowed. Snouts and tripe also had positive MVP's. The MVP for snouts is meaningless since the supply was exactly used and was neither purchased nor sold. Consequently, the MVP could range from zero to the purchase price of snouts. The MVP for tripe was $3.91 per hundredweight, considerably less than its $9.75 market price.

As shown, the MVP for sales potential was lower in this program where the sale of unused raw materials was permitted. The incentive to expand sales of the processed products is therefore much less when unused ingredients can be sold. Since the small packer is likely to encounter considerable difficulty in any attempt to expand finished product sales, the incentive to develop a market for unused raw materials becomes even stronger.

The functional represents an increase over the program in which the unused ingredients were rendered instead of sold of $4,163.60 - (-1269.17) or $5,432.77. This increase would not have been so large if something other than the least-cost ingredient mix had been used in the program where ingredients were rendered instead of sold since the losses from rendering would have been decreased from such an adjustment. But as has been explained previously, such adjustments would differ from firm to firm making it very difficult to develop a "typical" mix. Though the use of the least-cost mix has increased the margin of savings, it is felt that these savings would still be sufficient to encourage the development of a market for unused raw materials. The $5,432.77 is for

a period of one week. Over a period of a year, this means $282,504.40. Even if the margin of increase were cut in half, the potential savings are still of considerable magnitude.

An analysis of this type supplies still another measure of the practicability of a slaughter operation to supply ingredients for processed meat products. The variable cost charged to the production of cow meat was $40.42 per hundredweight. The market price at the time these data were collected was $41.50 per hundredweight. This leaves a margin of $1.08 per hundredweight between the variable cost of production and the market or selling price. If the fixed costs which must be charged to the production of cow meat do not exceed this $1.08, it will be profitable to continue the slaughter operation. Under these conditions, increased slaughter might prove to be profitable. The manager of any particular firm could make such calculations and comparisons to see if he can justify his slaughter operation. Caution should be exercised in the making of such a decision because the variable costs of production and the market price will vary, primarily on a seasonal basis. The situation which prevails over time should be used as a criterion rather than the situation at any one moment in time.

Patterns of Production

The programs in the preceding sections portrayed optimum product combinations composed of either two or three products. Obviously, this is not consistent with the sales policies of an actual firm. Most packers have, over time, established a market for a variety of processed

products. Many would hesitate to change such an established pattern of production and sales. It would not be practical for the manager to attempt an abrupt shift to the combination(s) portrayed by these programs, nor could he expect to stay in business over time with such a limited offering.

Since the optimum combination of products cannot be considered feasible in light of established production and sales patterns, the objective must become an improved pattern of production and sales. The results of the programs portray the range over which the prices of the products which comprise the optimum combination may vary before the combination would change. For the products not included in the optimum combination, they show the changes in net returns per unit which would be required before the respective products would become equally profitable and be included in the optimum combination of products. Such required changes are an indication of the expenditures which could be put into such things as improved services and advertising and still have a level of returns as high as would be possible if products not included in the optimum combination were being produced. If the No. 2 Franks in the one-pound package were being produced instead of the No. 2 Franks in the six-pound package (a component of the optimum combination), up to $.22 could be expended on the promotion and sales of a hundredweight of the six-pound package before net returns would decrease. If sales of the six-pound package could be established with an expenditure less than $.22 per hundredweight, then returns would be increased.

The methods by which the packer attempts to increase production and sales of the more profitable products will vary from product to product

since the type of competition which the individual product faces will also vary. The large package of franks will likely be sold to an institution such as a restaurant or hotel. Increased sales in this particular market will come largely as a result of increased effort by sales representatives or possibly as a result of the establishing of contractual relations. The smaller package of franks will go to the retail outlet. Increased sales to the individual consumer might come as a result of a change in the appearance of the package, point-of-sales display, or similar devices to increase product differentiation.

The portrayal of an optimum combination of products and the changes required to make all products equally profitable will be most useful to the firm active in bargaining for the prices it receives. In any bargaining process, some criterion must be used as a basis for the policies which are suggested and supported. Programming provides this criterion. The packer's task becomes one of moving in the direction the program suggests. The incentive to continue the production and sale of a wide range of products is still present since a market has already been established and all the products have played a part in any product or brand differentiation which has been attained. If the packer is to continue the sale of a variety of products, he naturally wishes the combination to be as profitable as possible. The programming results will not only show what adjustments should be made but will also furnish concrete support for bargaining efforts which attempt to enact such adjustments.

For the small packer, the adjustment becomes a long-run problem. Changes in the pattern of production must be made gradually and after the proper foundation has been laid through such things as improved customer relations and increased product differentiation. Any price changes must be small and should not be undertaken at all until consideration is given to possible repercussions.

Regardless of the size of the firm and the competitive situation it faces, production cannot be adjusted in direct accordance with the optimum combination nor can product prices be changed abruptly. Therefore, efforts to improve the pattern of production and sales will consist of both types of adjustment. Resources should be diverted to the more profitable products so long as the increased production can be marketed favorably. Prices of the less profitable products should be increased so long as such increases do not cause a decrease in the volume of sales which would offset the gains from higher prices. The combined effect of both types of adjustments should increase returns to the firm which exercises care in making such changes.

Optimum Product Prices for an Established Operation

Attempts to improve the pattern of production and sales usually take the form of changes in production and/or changes in product prices. Emphasis is placed on the production of the more profitable products and price changes are enacted insofar as is feasible to increase the profitability of other less profitable products.

Programming can also be used to portray the prices which make an established operation optimal. The manager can use this information to adjust his prices insofar as possible and increase the returns from his established operation. The extent of price adjustment and thus the increase in returns will be affected by the competitive position which the firm faces. The large price-making firm could anticipate benefits of a considerable magnitude. The smaller price-taking firm will be unable to adjust prices completely and the benefits will be smaller. Even so, this is an area worthy of close attention. Over time, efforts to differentiate specific products could be oriented so as to make needed price changes more nearly possible.

Toward this end, the operation of a firm was investigated. Here it was assumed that the manager decided he should not change his pattern of production and sales. This assumption was based on the supposition that the small firm has the most to fear from changing production and sales. It was also assumed that no market could be developed for unused ingredients because the small firm would probably experience the most difficulty in developing an ingredient market. Consequently, the results which evolved from the program depicted in Table 3 were used for this investigation. A similar investigation could have been made from the program of Table 4 for a packer who could sell unused ingredients and who chose not to change his operation.

The operation for this firm for the one-week period under appraisal yielded a net return to fixed resources of $3,138.40. The firm under

consideration does not sell unused raw materials. Consequently, the ingredient combinations have been adjusted to offset much of the loss from rendering. Since this is the situation, the best comparison will be between this figure and the positive $4,696.57 which would be received from the sale of the 237.07 hundredweight of No. 1 franks in the six-pound package and the 60 hundredweight of No. 3 bologna which was portrayed as the optimum combination of products in the program shown in Table 3.

In any attempt to develop an "optimum" array of product prices, restraints must be imposed and logic used to insure that the prices stay within realistic bounds. The optimum price for any particular product is that price which will yield the highest margin of returns while staying within feasible limits. The net returns to the fixed resources for the two products which made up the optimum combination of products in Table 3 were used as criteria by which an optimum array of prices for all products was developed.

The results of the program denote the change in or addition to the net returns per hundredweight which would be required before the remaining products would return as much to fixed resources as the two which comprise the optimum product combination. It was assumed that the variable costs of production remained constant for each product. Hence, the addition to net returns must take the form of an increase in price. By increasing the price and thus the net returns in this manner, a comparison between the total returns of the two different situations was made. The price increase which proved necessary for each of the products excluded from the optimum combination is shown in Table 5.

Table 5. Price Changes for Established Operation

Product	Price change necessary per cwt.	Net returns per cwt. after price change
No. 1 frank (12-ounce pkg.)	$ .44	$16.05
No. 1 frank (one-pound pkg.)	2.17	16.05
No. 1 frank (six-pound pkg.)	0	16.05
No. 2 frank (one-pound pkg.)	4.56	18.75
No. 2 frank (six-pound pkg.)	4.34	18.75
No. 2 frank (40-pound pkg.)	7.58	18.75
No. 3 frank (two-pound pkg.)	11.01	19.52
No. 3 frank (six-pound pkg.)	9.11	19.52
No. 3 frank (40-pound pkg.)	8.30	19.52
No. 1 bologna	5.41	16.05
No. 2 bologna	3.00	14.86
No. 3 bologna	0	14.86
No. 4 bologna	10.00	14.86
No. 5 bologna	12.68	15.99
Total net returns to fixed resources		$4,696.57

The adjustment in the net returns per hundredweight and, therefore, the necessary adjustment in price is the important factor in Table 5. Though all the products are equally profitable after such an adjustment, the net returns to the fixed resources are not the same for all products.

This points out the importance of the relationship between the price of a product and the resources which the product uses. The returns are maximized subject to these restrictive resources. A product which is low in price can yield returns greater than a higher priced product because of resource requirements.

After making the required price changes, the total returns to the operation were $4,696.57. 1/ All of the price changes used, however, are not fully possible. This is the optimal situation and would be very difficult to attain. Therefore, the full increase of $4,696.57 - 3,138.40 or $1,558.17 resulting from the adjusted prices is not possible to attain. Due to the relationship between costs and the market price, the net return on many of the products before adjustment was low. For example, the net return for No. 5 bologna was $3.31 per hundredweight, necessitating an increase in the sales price of $12.68 per hundredweight to make it as profitable as the No. 1 frank and No.3 bologna which were in the original optimum combination of products. Such an increase is certainly outside the bounds of feasibility.

While some of the price changes suggested above are not practical, many of them are within the realm of possibility. The No. 1 franks in the 12-ounce package would require an increase of only $.44 per

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1/ This returns figure was calculated by multiplying the level of production of each product by the net returns per hundredweight for that product after the price change and summing over-all products.

hundredweight, less than one half of one cent per pound. Certainly, such an adjustment as this is possible. The other needed increases are somewhat higher. For the No. 1 frank in the one-pound package, an increase of $2.17 per hundredweight would be needed; for No. 2 bologna, an increase of $3.00 per hundredweight. Over time and with the proper orientation of promotional policies, such increases as these might be attainable.

Some of the products are making a much lower contribution to total returns than are others. Unless these products are providing the exclusive market for ingredients which would otherwise be wasted, they should not receive the emphasis placed on the production and sale of the more profitable products.

For this particular firm, the optimal array of product prices is apparently out of reach. This does not prevent the partial attainment of this optimal situation nor does it prevent the use of programming as an aid to the manager in his decisions concerning price policies.

SUMMARY AND CONCLUSIONS

The production and sale of processed meats is a complex operation. Raw materials and edible by-products from slaughter operations must be converted to a finished product acceptable to the discriminating consumer. A multitude of decisions must be made during this conversion process. Many of the decisions are quantitative and of an objective nature; others are largely subjective and often take the form of value judgments. Decisions as to which ingredients to use and the level of each, which products to produce and the level of each, which price changes to attempt, and which products to emphasize in promotional efforts are made so often they appear to be commonplace. Here lies one of the differences between the successful operation and the one which is less successful. The decisions are far from commonplace and can be made correctly only if the firm manager has accepted the responsibility of staying abreast of market trends, innovations, changes in ingredient costs, and changing tastes and preferences in the demand for processed meat products.

Decisions such as the above are crucial largely because of the intense competition in the production and marketing of processed meat products. Competition has narrowed the operating margin to a level which leaves little hope for the inefficient operation. The difference in efficiency between one operation and another may be slight but could well mean the difference between a profitable operation and an unprofitable one.

Larger firms have adopted such tools as programming to help cope with the complexities of the packing business and problems from narrow margins. Quite often, this has led to the establishment of a staff with the ability and know-how to apply the tools in a profitable manner. Costs have been reduced as a result, giving the firms more latitude in their pricing policies. Large firms have tended to pass on such savings to the consumer and/or producer in an effort to facilitate their competitive position. If such efforts prove successful, the firm which has not taken advantage of the cost-reducing technology will be subjected to even more pressure from the cost-price squeeze and encounter more problems in its efforts to maintain a share of the market.

In general, the small firms lag behind in the adoption of such technology. They lack the facilities and financial backing possessed by the larger firms and often feel that they are unable to justify the expense of personnel who are adept in the application of this cost-reducing technique. Empirical evidence supporting the applicability of programming to the smaller firms is largely missing. The analyses which have been carried out have been cursory in nature and have not provided concrete estimates of the returns to be expected from the adoption of the technique. The combined effect of these deficiencies has been a "wait and see" attitude on the part of the small firm managers, resulting in a sacrifice in returns before adoption.

The reluctance on the part of the manager of the smaller firm is partially justified. Programming has proved to be useful to the large packer primarily because of the ability to bargain for prices and

because a market for unused raw materials usually exists. Price changes suggested by programming can be enacted to a greater degree than is possible for the small firm. Raw materials which the program excludes from the least-cost combination or which are not completely used in the optimum or improved pattern of production can be sold. Many of the smaller firms feel that they have to dispose of such raw materials through rendering. These limitations are known to the managers of many of the small firms and have discouraged the adoption and use of programming.

The tendency to wait before adopting an innovation such as programming, though partially justified, is costing the small packer through decreased returns. The first group of firms which adopts a cost-reducing technology reaps benefits in the form of increased returns and/or an improvement in competitive status. Firms which are later in adopting will not receive a net increase in returns, but the proceeds will approximately cover the costs incurred in the adoption of the technology. The last group to avail themselves of the new technology will do so largely for the sake of survival. By this time, the cost-price squeeze will have become more pronounced. Other firms will have infringed upon the markets being supplied by the group of late adopters. The need to maintain at least a slight margin of returns or perhaps to minimize losses will necessitate the adoption and use of the technology. This latter group of firms is comprised primarily of the smaller operations.

Some of the uses of programming are independent of the market conditions faced by the packer--others are not. Since no two firms operate

under the same market conditions or face identical competitive situations, the applicability of programming will vary somewhat from firm to firm.

As an aid in reducing the cost of an ingredient mix, linear programming is applicable to all firms. It may prove more profitable to the large packer, but this is partly a result of the formulation restrictions imposed by the packer who knows he can sell unused raw materials. The small packer tends to develop formulation restrictions which are conditioned by the lack of a market for unused raw materials. In this analysis, annual savings of $10,855 appeared possible on a product accounting for approximately one-fourth of processed meats production. The firm analyzed was small and not selling unused raw materials. If this affected the establishment of formulation restrictions as has been supposed, programming can still improve returns or reduce losses via lower-cost mixes.

A program which portrays the optimum combination of products subject to plant supplies is also applicable regardless of the market situation faced by the packer. A program of this type estimates the MVP's of restrictive resources and provides guidelines in the purchasing of needed ingredients. Since buying activities were not included in the program, however, no conclusion was drawn as to how much this type of program would increase returns. Returns would be expected to increase so long as ingredients are not purchased above the level where their cost exceeds the MVP of the restrictive resources.

A program which includes buying activities for any restrictive ingredient reveals the quantitative levels to which purchases should be made. In the analysis, three different ingredients became restrictive and were purchased, permitting more complete usage of the available supply of raw materials. In each case, the ingredient was purchased up to the level where its MVP equaled its MFC. This provided an increase in returns of $5,257.68 over the program which did not include buying activities. This type of program will be especially valuable to the manager who cannot develop a market for unused ingredients.

Returns are further improved when a market for unused raw materials exists or can be developed. Selling raw materials eliminates or reduces the loss incurred when they have to be rendered. Using the same restrictions and supply or activity levels, returns to the firm were increased by $5,432.77 when unused raw materials were sold instead of rendered. Perhaps this margin of increase will provide an incentive for packers to make a conscious effort to develop a market in which the unused resources can be sold. In the past, packers' conceptions of the returns they could expect from the development of such a market have been too hazy and subjective to stimulate action. In addition, noningredient restrictions such as sales potential are less crucial when the unused raw materials can be sold. The MVP of another hundredweight of sales potential was $10.33 when raw materials were permitted to be sold as compared to $25.18 when they were rendered.

The optimum product combinations which evolved from the analyses were not the same as the patterns of production and sales which actually

exist among Virginia firms. This was true even though programs were analyzed under various conditional restraints so as to provide programs which would be applicable under different situations. The results placed emphasis on the production of a small number of products to the complete exclusion of many other products which were actually being produced and sold. Such apparent discrepancies are not short-comings of programming but are reflections of the variation in the relationships between net returns and resource requirements from product to product. These results should not dampen the manager's enthusiasm. Programmed results cannot be accepted per se unless restrictions which are free of any margin of error have been included to cover every possible situation or occurrence. Therefore, the manager should recognize programming for what it is--an additional tool which will assist him in his efforts to function in a more learned manner. So long as this qualification is kept in mind, the manager can use the procedure to delineate the needed changes and then make those changes which appear feasible.

Even after appraising an application of programming, some of the Virginia packers would likely refuse to change their pattern of production. Attempts to make changes in the direction suggested by programmed results might cause discontent among customers, resulting in a decline in total sales and/or returns. Such convictions do not limit programming to the assistance it can render in developing least-cost mixes. The program which is most applicable to any particular firm can be used to suggest price changes which would maximize the returns to an established pattern of production. The results of the program chosen for this purpose

in the analysis revealed the price changes needed. Again, the manager should be cognizant of the hazards of attempting to adjust into complete accordance with the program results. The changes required for some of the products to make them equally profitable were feasible. For other products, the required changes were beyond the bounds of practicability. Logic and reason must be applied and changes enacted only when returns can be increased without offsetting repercussions.

If actual data could have been used in further analysis, more specific conclusions could have been drawn relative to the applicability of programming for this particular Virginia packer.

By making those changes in the pattern of production and/or prices of finished products which appear feasible to the manager, an estimate of the increase in returns from the revised operation could have been obtained. The opinions of the manager as to which changes he feels he could safely make would have been revealed.

The justification of the slaughter operation for the processed products could have been investigated more thoroughly. The exact supply of each of the raw materials and the proportion of the total fixed costs allocated to this portion of slaughter would have been needed. By using these data, a decision could have been reached as to whether the slaughter for the purpose of supplying raw materials for the processed products should be continued or whether such slaughter should be stopped and all raw materials purchased from the ingredient market.

Representative formulas were used in the analysis and some of the potential ingredients were never included in the least-cost mixes. The

least-cost program for each product portrayed the change in costs which would have been required before the excluded raw materials would have become ingredients.

At present, the combined effect of a lack of understanding on the part of the manager and the lack of empirical estimates of the economic incentive involved has proved sufficient to retard the adoption of programming by Virginia packers. Yet, the linear programming technique is applicable to the typical Virginia firm insofar as the processed meats operation is concerned. The extent of applicability will vary from firm to firm, the degree of variation depending upon the presence or absence of a market for raw materials as unused ingredients and the competitive situation faced by the packer. Since they have been slow to adopt the technique, another, and perhaps stronger, incentive will soon be forthcoming. The incentive referred to is the incentive to survive. As more and more firms adopt programming and similar cost-reducing innovations, the position of remaining firms which lag behind is threatened. If the remaining firms are to justify their existence, they must make a worthwhile contribution to the consumer, producer, and the industry as a whole. They fail to take advantage of the possibilities of making such a contribution when they fail to adopt technology which would improve their operation.

The Virginia packer who realizes the merits of such innovations as linear programming and adopts willingly in the search of increased returns will be in a superior position to the packer who hesitates and is eventually forced into adoption.

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Programming a Virginia Packer's Processed Meats Operation

by

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Blacksburg, Virginia

ABSTRACT

The processed meats operation of a typical Virginia meat-packing firm was analyzed to investigate the possibilities of improving the operation. Linear programming was chosen as the analytical tool. Large firms in competing areas have adopted programming and found it profitable. Little information has been available relative to the usefulness of programming to the size of operations typical in Virginia.

Least-cost ingredient mixes were developed for the various processed products. Optimum product combinations were ascertained under various conditional restraints. The marginal value products of restrictive resources were estimated. The possibility of improving the pattern of production was investigated and an optimum array of prices portrayed for an established operation.

Regardless of the competitive situation faced by the firm, linear programming will be useful in decreasing the cost of the ingredient mixes and in directing the purchase of restrictive ingredients. The feasibility of adjusting an operation in accordance with an optimum product combination and/or an optimum array of prices will be determined largely by the competitive situation faced by a particular firm. Since no two firms operate under the same conditions or face the same competitive situation, the applicability of programming will therefore vary from firm to firm.

The results suggest that programming can be an extremely valuable management tool for Virginia packers when used to suggest ways of

decreasing operating costs and to provide guide lines for the many decisions involved in the production and sale of processed meats.