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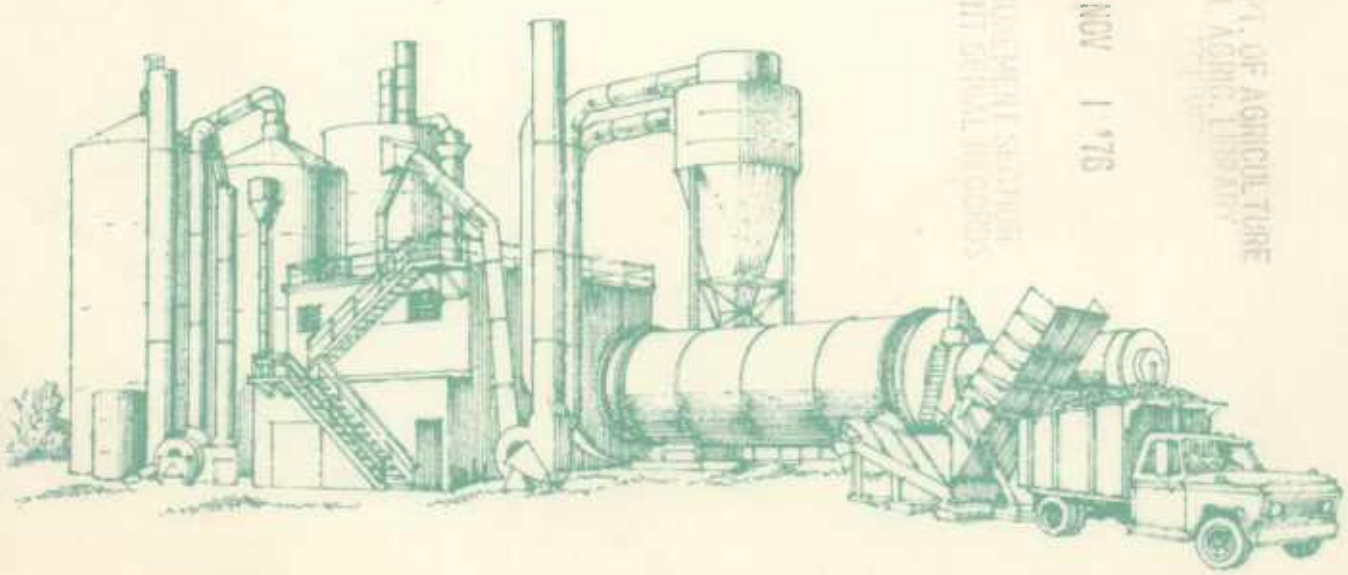
LEAF PROTEIN CONCENTRATE (PRO-XAN) FROM ALFALFA:

AN ECONOMIC EVALUATION



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LEAF PROTEIN CONCENTRATE (PRO-XAN) FROM ALFALFA: AN ECONOMIC EVALUATION. By Carl J. Vosloh, Jr., Richard H. Edwards, Robert V. Enochian, Donald D. Kuzmicky, and George O. Kohler. National Economic Analysis Division, Economic Research Service. Agricultural Economic Report No. 346.

ABSTRACT

Extraction of leaf protein concentrate (Pro-Xan) from alfalfa for use in various livestock feeds provides new investment opportunities under a wide variety of conditions. This report evaluates four systems for making this extraction and the effect of four variables on the annual rate of return on investment. The four systems differ in the method of expressing juice from the fresh alfalfa and the yield of Pro-Xan. The system in which the fresh alfalfa is ground prior to pressing, and which has a Pro-Xan yield of 12 percent, had the highest rate of return on investment.

The four variables evaluated were the method of utilizing the press cake remaining after the Pro-Xan containing juice is expressed, the method of disposition of alfalfa solubles remaining after the Pro-Xan is recovered from the juice, the length of operating season, and the size of the processing plant. The most profitable method of solubles disposition is dependent upon the feasibility of disposing of them in a nearby irrigation system, the price that can be obtained for them when concentrated for use as a feed ingredient, and the price of natural gas.

KEYWORDS: Alfalfa, dehy, leaf protein, Pro-Xan, feed ingredients, poultry feeds, feed prices, processing costs.

Washington, D.C. 20250 September 1976

PREFACE

The Economic Research Service (ERS) cooperates with the Agricultural Research Service (ARS) in evaluating the economics of improvements on a wide range of agricultural processes and products. Such evaluations provide knowledge for judging whether it is feasible to attempt to commercialize research findings and for planning and implementing research programs.

This report is the result of a cooperative effort by scientists trained in economics, engineering, animal nutrition, and chemistry. It presents a comprehensive economic evaluation of a process for separating a high protein-high xanthophyll, low fiber fraction from alfalfa for use as an ingredient in certain livestock rations. Data for this study were obtained from many individuals and firms too numerous to acknowledge individually. Special acknowledgement, however, is due to Joseph Chrisman, Western Regional Research Center Collaborator, William L. Arnold, Marketing Director, American Dehydrators Association (ADA), and many members of the ADA and equipment manufacturing firms.

The report is one of a series of cooperative ERS and ARS studies on livestock feed ingredients. Other reports in the series are: Alfalfa Meal in Poultry Feeds--An Economic Evaluation Using Parametric Linear Programming, Agr. Econ. Rpt. No. 130, January 1968; Alfalfa Dehydration, Separation, and Storage: Costs and Capital Requirements, Mkt. Res. Rpt. No. 881, May 1970; Wheat Millfeeds in Livestock Rations--An Economic Analysis, Agr. Econ. Rpt. No. 219, January 1972; and Air Separation of Alfalfa Into High and Low Protein Fractions-An Economic Evaluation, Agr. Econ. Rpt. No. 259, June 1974.

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SUMMARY

A number of processes have been developed for separating alfalfa into a fraction low in fiber and high in protein and xanthophyll for feeding monogastric animals, and a fraction high in fiber which is suitable for feeding cattle. This report presents the results of an economic evaluation of a process of wet separation of alfalfa into these two fractions, by what has been named the Pro-Xan process. Fresh alfalfa is pressed to obtain a green juice which contains the high protein-high xanthophyll fraction (Pro-Xan). The green juice is processed to recover a fraction which when dried yields Pro-Xan, a dark green granular product. Alfalfa solubles remaining in the juice after recovery of the Pro-Xan fraction also contain nutrients that can be utilized in various ways. The press cake remaining after the juice has been pressed from the fresh alfalfa can be fed to cattle as is, or dried and pelleted for use as a feed ingredient. Its protein content, though somewhat lower than that of fresh alfalfa, may be as high as some commercially available dehydrated alfalfa, depending upon the amount of juice removed.

The economics of four systems for producing Pro-Xan and the effects of several variables are evaluated. The basic difference among the four systems is the way in which the juice is expressed from the fresh alfalfa (green-chop), each of which results in a different yield of Pro-Xan (8 to 12 percent yield).

The variables studied, each of which have a significant effect on the relative economics of the process, are: 1) The method of disposition of the alfalfa solubles; 2) the method of handling the press cake; 3) the length of operating season; and 4) the plant capacity or size. Since the combinations of the four systems with these variables would yield many models for analysis, the economic analysis was carried out in four sequenced phases to select the most economic alternative in each phase without having to evaluate the effect of each variable on each system.

For each of the four phases of analysis, total investment costs were estimated. These estimates were based on synthesized model plants developed from engineering data obtained from pilot plant studies of the Pro-Xan process conducted at the Western Regional Research Center, ARS, and on equipment cost estimates provided by equipment manufacturers. Annual fixed and variable costs were calculated for the Pro-Xan model plants using these data. Raw material, harvesting, hauling, storage, marketing, transportation, and working capital costs were likewise included. Also, the annual production of Pro-Xan, press cake, and alfalfa solubles was determined and an annual sales value for each of these products computed using 1974 Kansas City prices of competing feed ingredients as a basis.

To evaluate the economics of the four systems and the four variables, annual rate of return on total investment before income taxes for model plants was calculated as follows: Annual earnings for each were calculated by deducting total annual costs from the annual sales value of all products. In turn, annual earnings were divided by total investment costs to arrive at an annual rate of return on investment.

In the first phase of the analysis, an economic evaluation was made for each of the four Pro-Xan systems assuming a 180 day operating season, an input capacity of 40 tons of green-chop per hour, return of the dilute alfalfa solubles to the wet press cake, and dehydration of the press cake. Total investment costs ranged from $2,396,134 for System I to $2,924,163 for System III. These figures include $341,000 for harvesting and hauling equipment. The annual rate of return on investment for each system was as follows: System I (8 percent Pro-Xan recovery), 43.1 percent; System II (9.5 percent Pro-Xan recovery), 44.6 percent; System III (12 percent Pro-Xan recovery), 40.0 percent; and System IV (12 percent Pro-Xan recovery), 48.5 percent. Because System IV yielded the superior return it was used throughout the remainder of the analysis to evaluate the effect of the four variables. A comparison shows annual rates of return on investment for comparable dehy plants to be somewhat lower than for the Pro-Xan Systems.

In the second phase of the analysis, the effects of alfalfa solubles and press cake disposition were evaluated. Using System IV with a 180 day operating season and an input rate of 40 tons of green-chop per hour, an evaluation was made for 6 alternatives as follows:

A. Dilute alfalfa solubles added to press cake and press cake dehydrated (System IV in Phase I).
B. Dilute alfalfa solubles pumped to the field and press cake left wet.
C. Dilute alfalfa solubles pumped to the field and press cake dehydrated.
D. Alfalfa solubles concentrated, added to press cake, and press cake left wet.
E. Alfalfa solubles concentrated, added to press cake, and press cake dehydrated.
F. Alfalfa solubles concentrated for use as a liquid feed supplement, and press cake dehydrated.

Total investment costs for model plants with these alternatives ranged from $1,668,809 for alternative B to $2,988,595 for alternatives E and F. The annual rates of return on investment for alternatives A, C, and F were nearly equivalent: 48.5, 48.0, and 50.0 percent, respectively. The returns for alternatives B, D, and E were 30.0, 21.5, and 43.6 percent. The quantity and sales values of Pro-Xan were the same for all alternatives.

Alternatives B and D had much lower rates of return than the other alternatives because of the assumption that wet press cake would be sold locally for the costs of green-chop plus hauling. With B and C the assumption was made that alfalfa solubles could be pumped into a nearby irrigation system, which may not be feasible in some situations. Alternative F assumed a value for concentrated alfalfa solubles equal to sugarcane molasses. Although this assumption has not been confirmed by feeding trials, the physical properties and nutritive values of both products are similar. Because of similarities in assumptions used for alternatives A and E, the rate of return for E approached that of A.

Although the investment costs were higher for alternative E than for A, the operating costs were lower because much less gas was required. This fact

becomes increasingly important with higher fuel costs. In areas with gas costs higher than the 66 cents per 1,000 cubic feet assumed in this analysis, alternative E might be the most feasible. This analysis showed that if gas costs were $1.32 per 1,000 cubic feet, the rate of return for alternative E would be equivalent to A, C, and F.

In the third phase, the effect of four different lengths of operating season for System IV alternative A were analyzed. In addition to a 180 day season which was used in the earlier phases, the effect of 130, 230, and 280 day seasons on annual rate of return was computed. The annual rate of return on investment for a plant processing 40 tons of green-chop per hour ranged from a low of 30.9 percent for a 130 day season to a high of 90.5 percent for a 280 day season.

The fourth and final phase of the analysis related rate of return to capacity or size of plant. In addition to a plant processing 40 tons of green-chop per hour, as in the earlier phases of the analysis, plants with capacities of 20 and 80 tons per hour were evaluated. The rates of return for plants operating for 180 days per season and processing 20, 40, and 80 tons per hour were 38.3, 48.5, and 64.7 percent, respectively.

The foregoing is based on a static analysis in that prices of all inputs and product outputs are assumed to be fixed. For a given processor in a given location, at a given time, these price relationships may not be valid; nor would they be over time. Since alternatives A, C, and F had nearly the same rates of return on investment, in cases where it is feasible to pump alfalfa solubles into a nearby irrigation system or if concentrated solubles can be sold at the price of molasses, the availability of gas may be the determining factor in selecting the most feasible alternative. Thus, each potential adopter of the Pro-Xan process must make his own evaluation by making necessary adjustments in the estimates based on his own situation.

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INTRODUCTION

Dehydrated alfalfa (dehy) is an important ingredient in many kinds of livestock feeds. In poultry feeds, xanthophyll and protein are generally considered to be the most important nutrients provided by dehy, but the indigestible fiber of the product limits usage to low levels. For ruminant feeding the fiber portion of the plant is largely utilized and dehy helps to increase urea utilization, improve palatability, and add natural protein to mixed feeds.

Dehydration results in better preservation of the valuable nutrients in alfalfa than sun drying, and alfalfa dehydration has developed into an important industry. But, the market for dehy at current prices is nearly saturated and new products from alfalfa, particularly for non-ruminants, would result in additional outlets for the alfalfa crop and increased returns to alfalfa producers and processors. Increasing costs and possible shortages of natural gas are other factors causing alfalfa processors to seek alternate ways of processing alfalfa.

For many years, researchers have attempted to develop products from alfalfa and other forage crops which would improve the utilization and increase the value of these crops. Initial work in this field was reported over 25 years ago and numerous approaches and techniques for obtaining leaf protein concentrate from alfalfa have been tried by many researchers (14)[2/] The Western Regional Research Center (WRRC), ARS, USDA, in Albany, Calif. has been active in this research. In the last 5 to 10 years, considerable progress has been made. A process for air separation of alfalfa into high and low protein fractions has been developed and an economic evaluation shows commercial possiblities (2, 17).

A process of wet fractionation of alfalfa, named the Pro-Xan process by WRRC researchers (3, 8, 9), is receiving considerable attention at present.

1/ Respectively: Agricultural Economist, National Economic Analysis Division, (NEAD), Economic Research Service (ERS), Washington, D.C.; Research Engineer, Western Regional Research Center (WRRC), Agricultural Research Service, (ARS), Albany, Calif.; Agricultural Economist, NEAD, ERS, Albany, Calif.; and Research Chemist, and Research Leader, WRRC, ARS, Albany, Calif.

2/ Underlined numbers in parentheses refer to items in Literature Cited.

This process results in a better separation of the fiber from the high protein-high xanthophyll fraction than does air separation of dehy. However, until now, pilot plant data on material balances and processing variables, on which to base an economic evaluation of the process, were not available.

In this study, economic aspects of wet fractionation of alfalfa and the market potential for the new product outputs are examined to aid potential adopters in deciding whether or not to commercialize the Pro-Xan technique.

The Pro-Xan Process

Although there are a number of possible variations to the Pro-Xan process, the basic process starts with fresh alfalfa (green-chop) being fed into a machine to mechanically dejuice or dewater the alfalfa. For enhancement of processing behavior, the expressed green juice is then ammoniated to a level of pH 8 to 8.5 which reduces proteolytic activity, stabilizes the carotene and xanthophyll during processing, preserves the green color of the product, and increases the firmness of the Pro-Xan curd. Ammoniation also adds non-protein nitrogen to the remaining alfalfa solubles which remain after the Pro-Xan curd is removed from the green juice.

So that the final Pro-Xan products will contain only 2 percent fiber, suspended fiber is removed by a stationary dewatering screen. The juice is then heated by direct steam injection to 85° to 95°C to precipitate most of the true protein present in the juice. The chlorophyll, carotene, and xanthophyll present in the original juice remain complexed with, or attached to, the heat precipitated protein.

The heat precipitated protein forms distinct curds (Pro-Xan), which are then separated from the alfalfa solubles by centrifugation. The curd is granulated or extruded and then dried in a hot air drying system. Other products from the process are the press cake fraction, containing most of the fiber, which can be fed directly to cattle or dehydrated for feeding purposes, and the alfalfa solubles which may be either concentrated for use as a liquid feed supplement, added dilute to the press cake prior to press cake dehydration, or added concentrated to the press cake which can be either used wet or dehydrated. A portion of the dilute alfalfa solubles also may be returned to the green-chop to facilitate juice recovery. A complete description of the Pro-Xan process is contained in several sources (3, 8, 9).

Study Procedure

In this study the costs of four systems of producing Pro-Xan under various processing alternatives were analyzed. Included were the costs of expressing green juice from alfalfa, of dehydrating the Pro-Xan, and of dehydrating the press cake. Also included were the costs of raw product (green-chop), costs of harvesting and hauling green-chop to the processing plant, and storage, marketing, and transportation expenses for the end products. These costs and expenses were deducted from the estimated sales value of the end products to calculate earnings, before income taxes, for each system and processing modification. Earnings were then related to total investment to arrive at an annual rate of return on investment, before income taxes, for alternative methods.

Flow charts for the four systems of processing alfalfa into Pro-Xan are depicted in figures 1 through 4 on pages 4 and 5. The basic differences among these systems are in the way juice is expressed from the alfalfa, each resulting in a different yield of Pro-Xan. These differences are summarized in the figure titles.

In addition to system effects, the effects of four important processing variables on plant costs and earnings were evaluated. These variables are: 1) Method of disposition of the alfalfa solubles; 2) method of handling the press cake; 3) length of operating season; and 4) plant capacity or size. Since combinations of the four systems with these four variables would result in more models than could be feasibly analyzed, evaluation was carried out in four sequenced phases to select the most economic alternative in each phase without having to evaluate the effect of each variable on each system. The following outline shows the variables that were analyzed in each phase to evaluate the four systems and the four variables:

Phase	Plant size[1]	System	Pro-Xan yield[2]	Season length[3]	Disposition of alfalfa solubles	Disposition of press cake
I	Effect of System					
	40 tons	I	8.0%	180	Returned dilute to press cake prior to drying.	Dehydrated
		II	9.5%			
		III	12.0%			
		IV	12.0%			
II	Effect of Soluble and Press Cake Disposition					
	40 tons	IV	12.0%	180	A. Dilute solubles added to press cake.	Dehydrated
					B. Dilute solubles pumped to the field.	Used wet
					C. Dilute solubles pumped to the field.	Dehydrated
					D. Solubles concentrated and added to press cake.	Used wet
					E. Solubles concentrated and added to press cake.	Dehydrated
					F. Solubles concentrated and used as liquid feed supplement.	Dehydrated
III	Effect of Season Length					
	40 tons	IV	12.0%	130	Returned dilute to press cake prior to drying.	Dehydrated
				180		
				230		
				280		
IV	Effect of Plant Size					
	20 tons	IV	12.0%	180	Returned dilute to press cake prior to drying.	Dehydrated
	40 tons					
	80 tons					

1/ Tons of green-chop processed per hour.
2/ Based on dry weights of fresh alfalfa (green-chop) and Pro-Xan.
3/ Number of operating days per year.

PRO-XAN SYSTEM I--SINGLE PRESSING OF CHOPPED ALFALFA (PRO-XAN YIELD, 8 PERCENT)

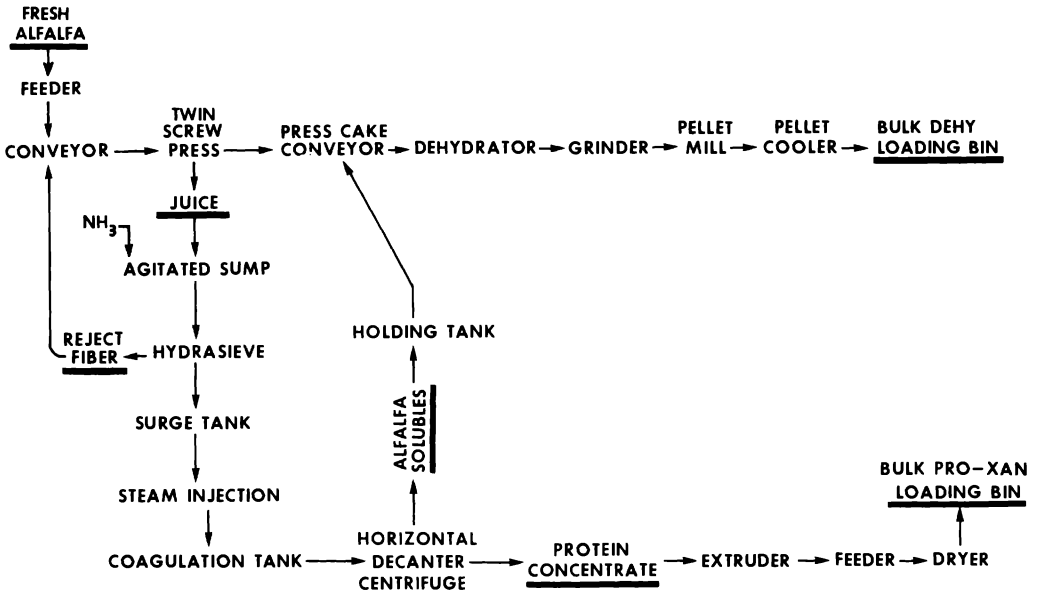

Figure 1

PRO-XAN SYSTEM II--ALFALFA SOLUBLES ADDED TO CHOPPED ALFALFA PRIOR TO SINGLE PRESSING (PRO-XAN YIELD, 9.5 PERCENT)

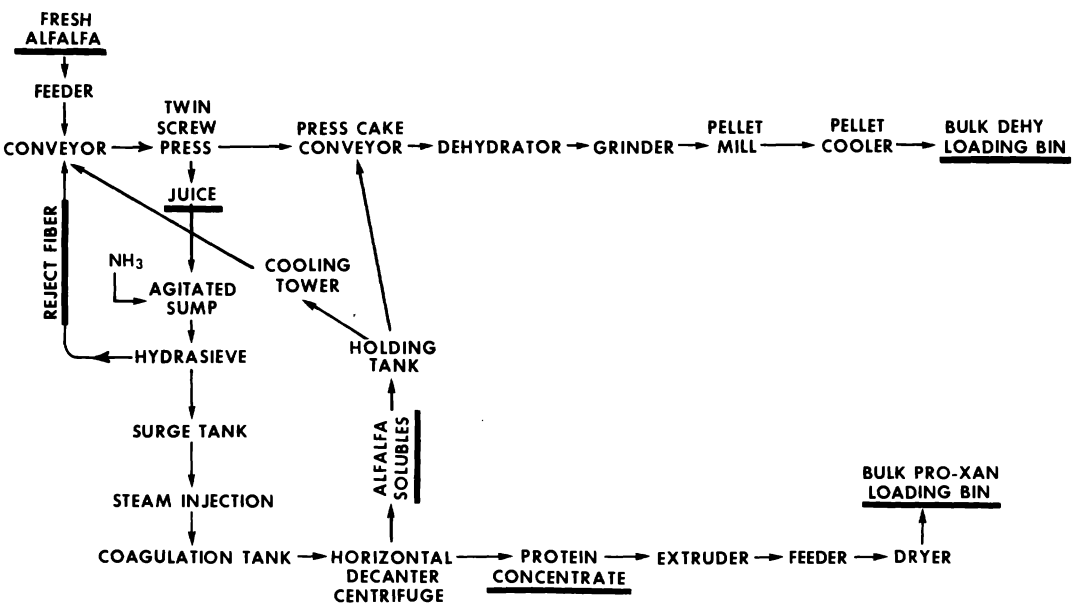

Figure 2

PRO-XAN SYSTEM III--DOUBLE PRESSING OF CHOPPED ALFALFA WITH SOLUBLES ADDED BETWEEN PRESSINGS (PRO-XAN YIELD, 12 PERCENT)

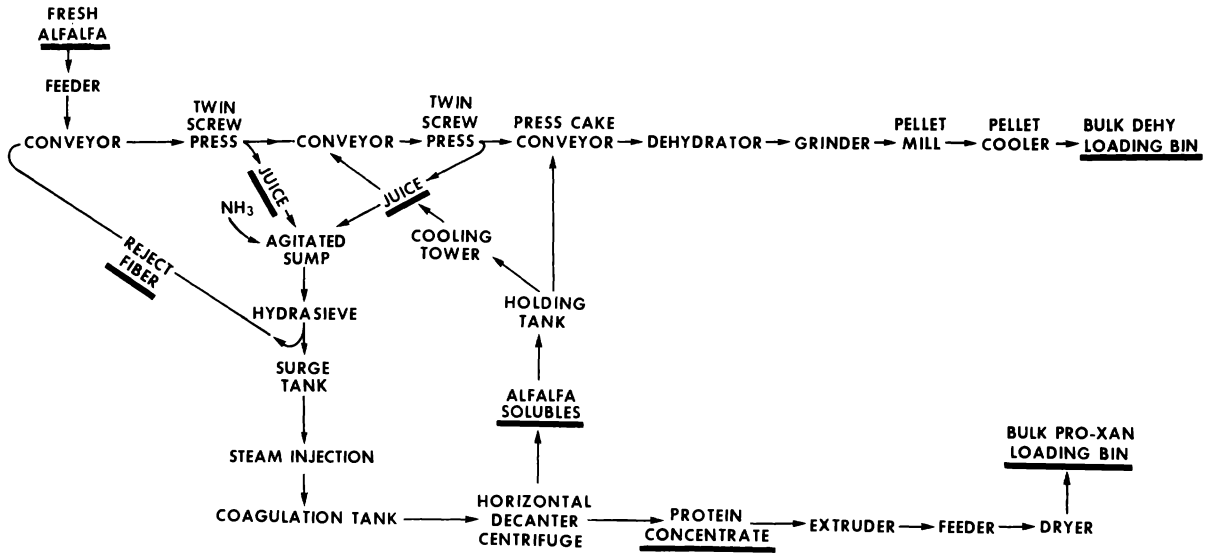

Figure 3

PRO-XAN SYSTEM IV--CHOPPED ALFALFA GROUND PRIOR TO SINGLE PRESSING (PRO-XAN YIELD, 12 PERCENT)

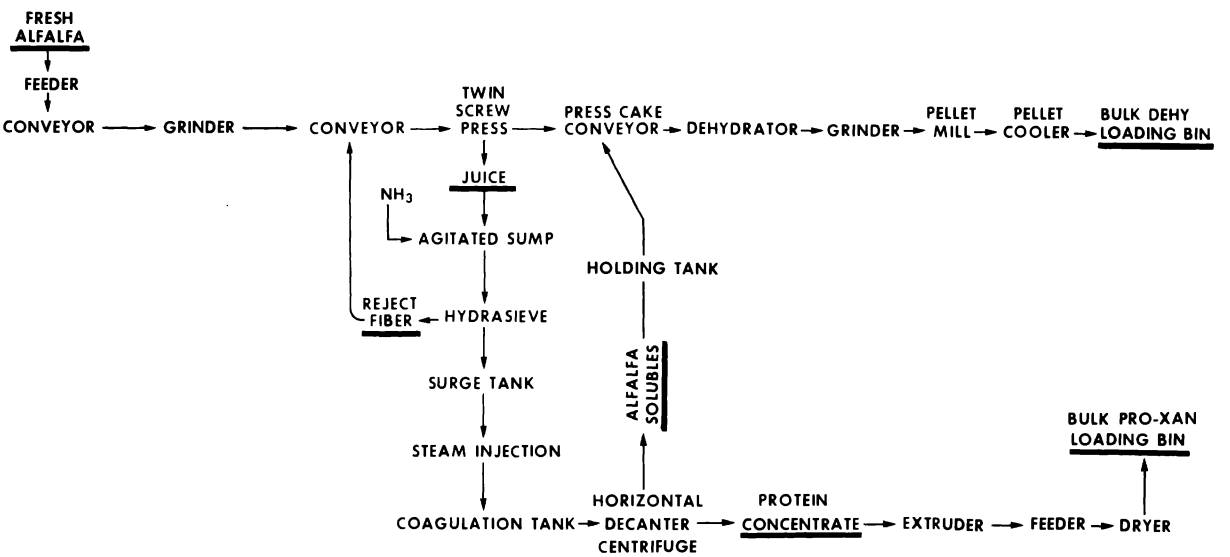

Figure 4

In phase I, the system with the greatest rate of return on investment for a given plant size, length of season, and soluble and press cake disposition was to be chosen as the basis for analyzing in subsequent phases the effect of different methods of soluble and press cake disposition, length of season, and plant size.

To carry out this analysis, cost estimates for each system with given variables, the sales value of the products, and the earnings had to be estimated sequentially, phase by phase. Discussed below is the basis for the cost and sales value estimates from which earnings were calculated.

COSTS OF FACILITIES AND OPERATIONS

Material balances for the four Pro-Xan systems were based on pilot scale experimental work done at the Western Regional Research Center (4). Green-chop input rates were determined by a least cost matching of the capacities of the screw presses, and the dehydration drums. From these input rates, harvesting, hauling, and processing equipment requirements were determined for a series of "model" Pro-Xan plants as specified above. Building space requirements for each model plant were based on the size of each required piece of equipment. Land requirements were based on building sizes and on area required for truck movement.

Labor required for Pro-Xan processing operations and plant maintenance were estimated as were space and other requirements for product storage, transportation, and marketing. Costs and expenses were then developed for all of these items.

The costs for all plant modifications were based on prices and wage rates prevailing in Kansas and Nebraska in 1975. Should such rates differ for other locations and for other time periods, all costs presented in this report would have to be adjusted accordingly.

Operational and Raw Material Specifications

All model plants were assumed to operate at capacity rates for 22 hours per day. The remaining 2 hours were allowed for slack or down time due to breakdowns, poor coordination of raw product delivery, and cleanup time. Each plant contains equipment, not shown in figures 1 through 4, to permit automatic conversion of the Pro-Xan operation to a straight dehydration operation in case of mechanical failure or other emergency.

Although alfalfa varies in moisture content and composition, depending upon such things as growing conditions, season of year, and location of production, all processed green-chop for purposes of this analysis was assumed to have a moisture content of 78 percent and a protein content of 20 percent of the dry matter (18.4 percent on an 8 percent moisture basis).

In Systems II and III, alfalfa solubles are added to the green-chop prior to final pressing. The amount of solubles added is 50 percent of the weight of green-chop. The yield of green juice pressed from the green-chop varies with each system. These yields and other material balance data for the four Pro-Xan systems are given in table 1.

Table 1--Material balance descriptions of model Pro-Xan plants with green-chop input of 40 tons per hour

Item	Systems[1/]			
	I Single pressing, Pro-Xan yield 8%	II Single pressing, alfalfa solubles added to green chop, Pro-Xan yield 9.5%	III Double pressing, alfalfa solubles added between pressings, Pro-Xan yield 12%	IV Single pressing of ground alfalfa, Pro-Xan yield 12%
	Pounds per hour			
Green-chop input	80,000	80,000	80,000	80,000
Green juice	38,400	78,400[2/]	84,000[2/]	44,000
Press cake	41,600	41,600	36,000	36,000
Heating steam used	5,300	8,240	9,000	6,072
Wet Pro-Xan cake	3,518	4,180	5,280	5,280
Dilute alfalfa solubles	40,182	42,460	47,720	44,792
Water evaporated from Pro-Xan	1,954	2,322	2,934	2,934
Water evaporated from press cake	64,182	66,747	66,886	63,958
Pro-Xan (10% water)	1,564	1,858	2,346	2,346
Dehy. press cake (8% water)	17,600	17,313	16,834	16,834

1/ See description of systems in figures 1-4. In all systems dilute alfalfa solubles added to press cake prior to dehydration.

2/ Includes 40,000 pounds of recycled alfalfa solubles.

Raw Material, Harvesting and Hauling

Alfalfa dehydrators produce their own alfalfa or purchase it from growers. In either case, they may harvest and haul the fresh alfalfa to their plants for processing using their own equipment or contract to have it done. For purposes of this study, it was assumed that raw material supplies would be purchased from alfalfa growers and that harvesting and hauling would be provided by the processing plant operators using their own equipment.

Prices paid for alfalfa during the 1974-75 season in Kansas and Nebraska, as quoted by alfalfa dehydration industry representatives, averaged $5.15 per green ton, standing in the field. This price is equivalent to $21.53 per ton on a dehy basis (8 percent moisture).

Estimates of equipment requirements for harvesting and hauling green-chop were based on alfalfa dehydration industry experience and on an earlier study of alfalfa harvesting costs (16). Estimates of useful life of equipment, depreciation rates, and operating requirements also were based on these sources. Investment costs for harvesting equipment and trucks were based on 1975 prices obtained from equipment manufacturers.

Fuel and oil requirements for harvesters and trucks were based on estimates of average usage by alfalfa dehydrators in Kansas and Nebraska in 1975. The average cost for fuel and oil was estimated to be about $0.75 per ton of green-chop (equivalent to $3.15 per ton on a dehy basis).

Harvesting and hauling equipment specifications and requirements for plants of different capacities are given in appendix table 1.

Pro-Xan System Equipment Specifications

The type, size, and number of equipment items required for each model plant were synthesized from product input-output relationships, manufacturers' equipment specifications, and practical experience from pilot-scale operations. In some models, all equipment is not fully utilized but the best balance of available equipment capacity was designed into the model plants. As indicated above, the least cost combinations of capacities of the green-chop press and the press cake dehydration drum were selected. In some models this resulted in the dehydration drum being utilized at less than rated capacity.

It was assumed that all model plants were equipped with pollution control devices that meet EPA specifications for the dehydrated press cake grinding operation. Drier emission controls were not included, but all driers had gas recycling systems. Recent experience suggests that EPA emission standards for the drying operation can be met by use of recycling systems and by careful control of the drying cycle by operators.

Plant equipment prices used in the estimates represent delivered costs of each piece of equipment using 1975 prices. Equipment installation and plant engineering costs were estimated to be 35 percent of the total delivered costs of equipment.

A plant equipment list for each of the four systems is given in appendix tables 2 through 5.

Buildings and Land

All model plants were assumed to be built on level sites with access to both a railroad and a highway. Soil conditions were assumed to be satisfactory for the building and storage facilities required. Land requirements for model plants, based upon land occupied by buildings and adequate space to facilitate truck movement, ranged from 3 to 5 acres, at an assumed cost of $4,000 per acre.

Buildings were a combination of masonry and steel sheeting having reinforced concrete roofs with structural beam supports and concrete floors and foundations. There were variations in construction within each building depending upon whether space was to be used for processing operations, office or maintenance needs, or for boiler equipment. Total space requirements for the model plants, however, ranged from 6,400 to 11,550 square feet. Estimated costs for space within eacn building ranged from $16.00 to $34.50 per square foot depending upon how space was to be utilized.

Labor

Crew size for both harvesting and hauling activities and processing plant operations varied depending upon plant size. For plants processing 40 tons of green-chop per hour, it was assumed that 4 harvesting equipment operators and 4 truck drivers were required for each of 2 shifts. For the processing plant, a total of 10 workers was required. These were assumed to be divided between 2 shifts as needed.

Processing plant labor was assumed to handle all operations from receiving green-chop through pelleting of press cake and to perform preventive maintenance and repair work as needed.

Wage rates were assumed to be $3.30 per hour, including fringe benefits, for harvesting equipment operators and truck drivers, and $3.75 per hour for processing plant workers except for performance of maintenance functions for which time they were assumed to receive $4.00 per hour.

Depreciation and Interest

Rates for estimating depreciation costs were developed from information provided by alfalfa dehydrators and equipment manufacturers and allowances authorized by Internal Revenue Service regulations.

A 10-year depreciation period was used for harvesters and a 6-year period for trucks. Although depreciation periods in the alfalfa dehydration industry vary widely, a 15-year depreciation period for processing equipment, using the straight-line method, was used for this study. A 25-year depreciation period was used for buildings.

Interest was considered to be a cost regardless of the source of invested capital. Annual interest cost was estimated to be 4.5 percent - or half the nominal interest rate of 9 percent - of the total capital investment in equipment and buildings. In addition, an annual rate of 9 percent was used for the interest cost on the non-depreciable land investment.

Taxes, License Fees, and Insurance

Property tax rates and assessed values vary considerably among States and even among communities within a State. In some States, taxes are levied on all property, while in others equipment is exempt from property taxes. In this study, an annual tax rate of 1 percent of assessed value, which is assumed to be 35 percent of the initial total investment, was used.

Fees for licenses to operate trucks on public roads were based on estimates received from alfalfa dehydrators.

Factors affecting the cost of insurance include building materials, types of electric motors, types of fire prevention equipment in the plant, and the location of the facility with regard to local fire protection. An annual rate of 1 percent for all equipment and 0.5 percent for buildings was used to estimate the average cost of insurance.

Utilities and Chemicals

Utilities include electricity, natural gas, and water. An operating electrical load of 80 percent of total connected horsepower was assumed except for power required to run the green-chop grinder and the screw presses. The energy requirement for the grinder was assumed to be 7.5 kilowatt-hours per ton of green-chop processed. Screw press energy consumption was assumed to be 7 kilowatt-hours per ton of unground green-chop and 4 kilowatt-hours per ton of ground green-chop (12). A rate of 2.1 cents per kilowatt-hour was applied for costing electricity regardless of the amount used.

Natural gas was regarded as the fuel source for the boiler, the press cake dehydration drum, and the hot air Pro-Xan dryer. Estimated requirements for the press cake dehydrator were 1,700 B.T.U.'s per pound of water evaporated for dehydrating press cake without solubles or press cake with concentrated solubles, and 1,600 B.T.U.'s for dehydrating press cake with dilute solubles added. Energy consumption by the Pro-Xan dryer was set at 2,000 B.T.U.'s per pound of water evaporated. Boiler efficiency was rated at 80 percent.

In those model plants concentrating dilute solubles, the steam used by the 2, 3, or 4 effect vacuum evaporators, corresponding to the 20, 40, and 80 ton-per-hour plant sizes, was 4, 5, and 6 pounds of water evaporated per pound of steam used. Additional steam for evaporator startup was also considered. A rate of 66 cents per 1,000 cubic feet was used to estimate basic gas costs for all model plants. This was the prevailing rate in Kansas-Nebraska in the spring of 1975. The effects of higher gas costs on relative earnings of different systems also were analyzed.

For all systems, anhydrous ammonia is added to the green juice at the rate of 2 pounds per ton of green-chop input. The price for anhydrous ammonia at the time of the study was $150 per ton.

The cost of water used in the Pro-Xan process was not considered in the cost analysis.

Maintenance and Repairs

Although building maintenance cost is usually quite small, compared with that of equipment, the average annual cost for maintenance and repairs for both plant equipment and buildings was estimated to be 7 percent of the total investment. This is the rate allowed by IRS and does not include in-plant maintenance labor, which was discussed above.

Maintenance and repair costs for harvesters and trucks were estimated by equipment manufacturers to be about $1.00 per ton of green-chop (equivalent to $4.20 per ton on a dehy basis).

Administrative Costs and Supervisor's Salary

Administrative costs included the manager's salary, office workers' wages, and miscellaneous office expenses. The total of all of these costs would vary with the model plant, the length of season and, in an actual operation, might involve other enterprises, such as farming. For purposes of this analysis, estimates based on alfalfa dehydrators' experiences were used to estimate annual administrative costs. The overall administrative costs for a plant processing 40 tons of green-chop per hour and operating 180 days per year were estimated to be $23,000. It was assumed that a third of this would be required to cover harvesting and hauling administration, 40 percent for processing plant operations, and the remainder for storage and marketing which were treated as custom charges.

The supervisor's salary was estimated to be $20,000 per year. It was assumed that 45 percent of this salary was charged to the harvesting and hauling operations and 55 percent to processing plant operations.

Storage, Marketing, Transportation, and Working Capital Expenses

After alfalfa has been processed into Pro-Xan, dehydrated press cake, and concentrated alfalfa solubles, these products must be transported to market and sold, although part of the production is stored for disposal throughout the year. Alfalfa dehydrators either perform these functions themselves or they are done cooperatively by a group of plants with each plant paying for its use of the service. In this analysis, it was assumed that these services would be purchased by the model plants.

Expenses for these services would vary depending upon distance to market, length of time the product is stored, and payment arrangements. Estimates by alfalfa dehydrators in Kansas and Nebraska, however, were used to arrive at figures that might be considered representative.

Expenses for inert gas storage of dehy in 1975 were estimated to be $1.50 per month per ton of product stored. In this analysis, it was assumed that for plants operating 130 and 180 days per season, one-half of each of the production of dehydrated press cake and Pro-Xan was stored for an average of 6 months. For plants operating 230 and 280 days, it was assumed that one-fourth of such production was stored for 6 months.

Press cake sold wet and concentrated alfalfa solubles were assumed to be sold f.o.b. processing plant without any storage, marketing, or transportation expenses.

Selling charges for dehydrated press cake and Pro-Xan were assumed to be $1.50 per ton which is commonly the commission for selling dehy. This charge was assumed to cover quality control costs.

Transportation charges to market would vary depending upon size of load and distance hauled. Alfalfa dehydration industry representatives indicated that the carlot charge per ton to ship dehy from Alfalfa Center, Nebr., to Kansas City, Mo.--the location used to estimate product values--was $10 per ton. Therefore, transportation charges of $10 per ton were used for both Pro-Xan and dehydrated press cake.

The amount of working capital required in any business depends upon the rate of inventory movement and credit arrangements between suppliers and customers. Working capital requirements for this study were based on the assumption that for plants operating 130 and 180 days per season an amount equal to one-fourth of all annual costs would be needed. For plants operating 230 and 280 days per season, one-eighth of all annual costs was judged to be the necessary sum. The annual cost to the processor for working capital was based on an interest charge of 9 percent for the entire year.

All of these expenses might vary for plants in different locations. However, for similar conditions and assumptions regarding length of storage, quantity of product stored, distance to market, etc., the differences among locations - and, therefore, among the model plants - would not be expected to be significantly different from these estimates.

PRO-XAN PRODUCTS AND THEIR SALES VALUE

As indicated above, the Pro-Xan process results in two or three end products - each in a different proportion and each with a different composition and sales value - depending upon the method of processing. The three products evaluated were press cake (dehydrated or wet), Pro-Xan, and concentrated alfalfa solubles (50 percent solids).

Pro-Xan and press cake are obtained with all systems. Alfalfa solubles, however, are obtained as a separate product only when they are not added to the press cake or treated as waste. Although the proportion of Pro-Xan recovered varies with each system, its nutrient composition and, therefore, its unit value is the same from all systems. The nutrient composition of Pro-Xan is given in table 2.

The amount and composition of press cake recovered from the Pro-Xan process depends upon the processing system as well as the disposition of the alfalfa solubles. The more Pro-Xan that is extracted from the green-chop, the lower will be the recovery and protein content of the press cake.

If alfalfa solubles are returned to the press cake, its protein content is increased. It can be used either as dehydrated or undried feed for

Table 2--Nutrient composition of Pro-Xan

Nutrient	Unit	Content in Pro-Xan
Dry matter	Pct.	90.0
Metabolizable energy	Kcal./lb.	1,175.0
Protein	Pct.	51.7
Arginine	do.	3.34
Glycine	do.	2.86
Isoleucine	do.	2.90
Lysine	do.	3.06
Methionine	do.	1.19
Methionine & cystine	do.	1.80
Threonine	do.	2.64
Tryptophan	do.	.77
Phosphorous	do.	.54
Calcium	do.	1.39
Fiber	do.	1.83
Fat	do.	8.47
Xanthophyll[1/]	Mg./lb.	350.0

1/ Pigmentation type xanthophyll as measured by a method developed by Livingston, et al. (11)
Source: (1)

livestock. Table 3 shows the protein content of dry press cake (8 percent moisture) for the different processing systems and Pro-Xan recoveries. If alfalfa solubles are not disposed of, or are not returned to the press cake, they can be recovered and concentrated to 50 percent solids for use as a liquid feed supplement. Composition of concentrated alfalfa solubles is given in table 4.

Pro-Xan, press cake, and alfalfa solubles are not currently being marketed. Therefore, estimates of their sales value were made so that possible earnings from the Pro-Xan model plants could be calculated. Estimates of sales value were based on the market prices of commercially available feed ingredients that would provide comparable nutrients.

Table 3--Protein content of press cake for model plant systems

System No.	Pro-Xan yield[1/]	Protein content of dehydrated press cake[2/]	
		Without solubles	With solubles
	Percent	Percent	Percent
I	8.0	15.3	16.0
II	9.5	14.5	15.4
III	12.0	13.2	14.4
IV	12.0	13.2	14.4

1/ Based on dry weights of fresh alfalfa (green-chop) and Pro-Xan.

2/ Assumes green-chop contains 18.4 percent protein on an 8 percent moisture basis. Press cake also contains 8 percent moisture.

Table 4--Nutrient composition of concentrated alfalfa solubles

Nutrient	Content in concentrated solubles
	Percent
Dry matter	50.00
Protein	13.8
Fat	.15
Fiber	0.0
Ash	10.0
Calcium	.29
Phosphorous	.75
Sugars	11.1
Pentosans	1.75
Nitrogen free extract	26.5
Total digestible nutrients	41.0

Source: (10)

Pro-Xan Value

The estimated sales value of Pro-Xan was determined through the use of computerized parametric linear programming. Three elements are needed to make this determination for a new feed ingredient. These are: 1) The nutritional specifications of the ration in which the ingredient is to be used; 2) the nutritional values of all ingredients that might be used to satisfy the nutritional specifications of the ration, including nutrient values for the new ingredient; and 3) market prices of all feed ingredients that might go into a least cost ration. These three inputs are programmed to determine the combination of ingredients that supplies all of the required nutrients in a ration at least cost. The initial least cost formulation contains none of the new ingredient, because it is arbitrarily priced too high to be economically acceptable for the ration. The computer then recomputes the ration composition at successively lower prices for the new ingredient until the price of the new ingredient is low enough for it to replace some of the other ingredients that supply the same nutrients. This procedure results in a series of prices at which use of the new ingredient will be feasible in successively larger quantities. For this analysis, the sales value selected for Pro-Xan was at the first level of use that was closest to 2.0 percent of the total composition of a broiler finisher ration. At this level, Pro-Xan would supply about one-half of the xanthophyll requirements. Requirements for this ration were considered to be the most appropriate for valuing a high energy, high protein, high xanthophyll ingredient such as Pro-Xan.

Prices used for other feed ingredients in making this computation were those recorded monthly for Kansas City during 1974. Using these, an estimated sales value for Pro-Xan in Kansas City was calculated for each month of 1974. These monthly values were then averaged to arrive at a sales value of $309.04 per ton which was the sales value assumed for Pro-Xan for all systems.

The nutritional requirements for the broiler finisher ration, the nutritional values of the ingredients used in poultry rations, the average monthly prices of feed ingredients in Kansas City during 1974, and the monthly sales values and quantities of Pro-Xan estimated for broiler finisher rations are given in appendix tables 6 through 9. A more complete description of the use of parametric linear programming for estimating sales values of new feed ingredients can be found in other reports (5, 6, 7, 15).

Press Cake Value

The basis for determining a sales value for dehydrated press cake was the average price received for 17 percent protein dehy in Kansas City during 1974. This price was discounted for the reduction in protein content due to the extraction of Pro-Xan. The dehy price used was $87.13 per ton. On the basis of observed price differentials of dehy of different qualities or protein levels, and discussions with dehy industry representatives, it was decided to discount the average market price of dehy by 10 cents per ton for each 0.1 percent reduction in protein content below 17 percent to arrive at estimated sales values for dehydrated press cake of different protein contents. Thus, using the

protein values in table 3, the average sales value of dried press cake used in this study ranged from $84.53 to $86.13 per ton.

The sales value of wet press cake was based on the costs of the harvested green-chop, delivered to the processing plant and whether or not alfalfa solids were added. The price used for green-chop was an average of prices received by farmers in Kansas and Nebraska during the 1974-75 season. The estimated costs of harvesting and hauling green-chop to alfalfa dehydration plants were added to this price to arrive at a value of $8.14 per ton, fresh basis, for green-chop delivered to the processing plant. This value was used as the basis for computing sales values for wet press cake which, therefore, contains none of the costs of processing, nor any profit, both of which are allocated to the Pro-Xan.

Two different sales values were computed for wet press cake. The difference is due to the method of disposition of the alfalfa solubles. Wet press cake without alfalfa solubles added contains 1.673 times the solids of the green-chop, and therefore was assumed to be worth $13.62 per ton. The solids content of the wet press cake with solids added is 1.739 times that of green-chop, and was assumed to be worth $14.16 per ton.

Concentrated Alfalfa Solubles Value

Alfalfa solubles were concentrated in one of the model plant variations to produce a liquid feed supplement. The physical characteristics of concentrated alfalfa solubles are similar to those of molasses. The composition of the solubles product (table 4) is somewhat similar to that of molasses although solid content is lower and crude protein content is higher. Research has shown that it has potential as an ingredient in liquid feed supplements (13). For purposes of this analysis, it was assumed that this product could be sold for the same price as sugarcane molasses which averaged $61.40 per ton in Kansas City during 1974.

COMPARATIVE COSTS AND RETURNS

Pro-Xan Recovery System (Phase I)

In the first phase of the cost analysis, estimates of costs, sales values, and earnings were made of the four different Pro-Xan recovery systems using medium sized plants (40 tons of green-chop per hour), operating for an average length of season (180 days per year), and returning the dilute alfalfa solubles to the press cake, which was subsequently dehydrated. The estimated investment costs, annual operating costs, sales values, and earnings are discussed below. These form the basis for computing an annual rate of return on investment, before income taxes, for each of the four systems.

Investment Costs--Investment in harvesting and hauling equipment for a plant processing 40 tons of green-chop per hour amounted to $341,000. This equipment consists of harvesters and trucks as shown in appendix table 1 and its cost is the same for all four model Pro-Xan systems (table 5).

Table 5--Investment costs for four Pro-Xan systems processing 40 tons of green-chop per hour and operating a 180 day season

Cost item	Systems[1/]			
	I Single pressing, Pro-Xan yield 8%	II Single pressing, alfalfa solubles added to green-chop, Pro-Xan yield 9.5%	III Double pressing, alfalfa solubles added between pressings, Pro-Xan yield 12%	IV Single pressing of ground alfalfa, Pro-Xan yield 12%
	Dollars			
Harvesting & hauling equipment	341,000	341,000	341,000	341,000
Processing plant equipment				
Receiving	111,150	111,150	111,150	111,150
Dehydration & pelleting	664,720	664,720	664,720	664,720
Pro-Xan processing	611,192	669,617	1,002,325	742,035
Subtotal	1,387,062	1,445,487	1,778,195	1,517,905
Installation[2/]	485,472	505,920	622,368	531,267
Total	1,872,534	1,951,407	2,400,563	2,049,172
Buildings[3/]				
Dehydration & pelleting	37,000	37,000	37,000	37,000
Pro-Xan processing	59,000	59,000	59,000	59,000
Office	36,000	36,000	36,000	36,000
Maintenance shop	21,700	21,700	21,700	21,700
Boiler room	12,900	12,900	12,900	12,900
Total	166,600	166,600	166,600	166,600
Land[4/]	16,000	16,000	16,000	16,000
Grand total	2,396,134	2,475,007	2,924,163	2,572,772

1/ See description of systems in figures 1-4. In all systems dilute alfalfa solubles added to press cake prior to dehydration.
2/ Based on estimate of 35 percent of list price of equipment and includes plant engineering.
3/ Buildings are the same for all systems and include space for all operations with the exception of storage.
4/ Land area is the same for all systems--4 acres at $4,000 per acre.

Total processing plant investment costs (equipment, buildings, and land) for the four systems ranged from $2,396,134 to $2,924,163 (table 5). Buildings and land accounted for only 7 and 9 percent of these total costs.

Annual Operating Cost--Annual cost for harvesting and hauling for all four systems was $473,801 (table 6). The major fixed cost items were depreciation and interest on investment. Variable costs accounted for over 80 percent of total annual costs because of the high costs of labor, fuel, and maintenance expenses for operating harvesters and trucks.

Table 6--Annual harvesting and hauling costs for all Pro-Xan systems processing 40 tons of green-chop per hour in a 180 day season

Cost item	Costs for all four systems
	Dollars
Fixed	
Depreciation	44,700
Administration	7,700
Taxes and licenses	1,194
Insurance	3,410
Interest	15,345
Supervisor	9,000
Subtotal	81,349
Variable	
Labor	114,048
Gasoline and oil	119,316
Maintenance and repairs	159,088
Subtotal	392,452
Total	473,801

Annual processing plant costs for the four systems ranged from a low of $965,563 for System I to a high of $1,116,743 for System III (table 7). Fixed costs were between 28 to 30 percent of the season's operating cost. Depreciation accounted for about 50 percent of the fixed costs for all four systems. Interest on investment was the second largest fixed cost item and accounted for about one-third of total fixed costs.

Variable costs accounted for around 70 percent of the total annual plant operating costs. Utility cost was the largest item and accounted for nearly two-thirds of the variable costs and over 45 percent of the total annual plant costs.

Table 7--Annual processing plant costs for each of four Pro-Xan systems processing 40 tons of green-chop per hour in a 180 day season

Cost item	Systems 1/			
	I Single pressing, Pro-Xan yield 8%	II Single pressing, alfalfa solubles added to green-chop, Pro-Xan yield 9.5%	III Double pressing, alfalfa solubles added between pressings, Pro-Xan yield 12%	IV Single pressing of ground alfalfa Pro-Xan yield 12%
	Dollars			
Fixed				
Depreciation	131,498	136,758	166,702	143,276
Administration	9,200	9,200	9,200	9,200
Taxes	7,193	7,469	9,041	7,811
Insurance	19,558	20,347	24,839	21,325
Interest	93,201	96,750	116,962	101,150
Supervisor	11,000	11,000	11,000	11,000
Subtotal	271,650	281,524	337,744	293,762
Variable				
Processing labor	57,348	57,348	57,348	57,348
Maintenance labor	26,136	26,136	26,136	26,136
Utilities	443,930	465,275	492,054	486,364
Maintenance and repairs	142,739	148,260	179,701	155,104
Ammonia	23,760	23,760	23,760	23,760
Subtotal	693,913	720,779	778,999	748,712
Total 2/	965,563	1,002,303	1,116,743	1,042,474

1/ See description of systems in figures 1-4. In all systems dilute alfalfa solubles added to press cake prior to dehydration.

2/ Does not include harvesting and hauling costs (see table 6).

After utilities, maintenance and repair were the next largest cost items and accounted for about 15 percent of the total annual plant operating costs.

Sales Value of Products and Earnings--With each of the four basic systems, the products produced are Pro-Xan and dehydrated press cake with alfalfa solubles included. Table 8 shows production per hour, total annual production, estimated price per ton, and total annual sales value for products produced by each of the four basic systems, as well as various total annual operating costs. Total annual sales value of dehydrated press cake and Pro-Xan ranged from $3,958,555 for System I to $4,252,960 for Systems III and IV.

Total annual costs deducted from these annual sales values showed an estimated annual earnings before payment of income taxes to be the lowest ($1,031,910) for System I and the highest ($1,247,167) for System IV.

Rate of Return on Investment--To make direct comparisons among the four systems, an annual rate of return on investment was calculated for each. This rate is the percentage that annual earnings are of the total investment prior to deduction of income taxes. The higher this rate, the more profitable the operation. The rate of return ranged from 40.0 percent for System III to 48.5 percent for System IV (table 8). The total sales value of Pro-Xan and dehydrated press cake was the same with Systems III and IV, both of which have Pro-Xan recoveries of 12 percent. The larger investment and processing costs for System III, however, resulted in lowering the rate of return by 8.5 percentage points. There would be significant economies of scale for each of these systems which is illustrated below by an analysis of the possible economies of scale for System IV.

System II, the second most profitable system, had a lower investment cost than either System III or IV, but had a lower annual sales value because of the lower yield of Pro-Xan.

As indicated above, the processing location and the time period might have significant effects on costs and therefore on rates of return. Similarly, different price levels for the end products in different time periods also would affect rates of return. In 1975, the U.S. Department of Agriculture index of feed prices averaged about 3 percent lower than in 1974, the year for which the values of Pro-Xan and dehydrated press cake were estimated.

The effect of a 3 percent lower price for Pro-Xan, dehydrated press cake, and green-chop, on the comparative rates of return on investment for different Pro-Xan systems is shown in table 9. Also shown in table 9 is the effect on rate of return of a hypothetical discount of 15 percent of the 1974 estimated values of Pro-Xan, press cake, and green-chop. These data illustrate the sensitivity of the rate of return on investment to a range in prices for Pro-Xan, dehydrated press cake, and green-chop which might prevail in future years. Even with 15 percent lower prices for Pro-Xan, press cake, and green-chop than would have been expected in 1974, the rate of return from investment in a Pro-Xan operation seems quite satisfactory using the same investment and operating costs as before.

Table 8--Evaluation of four Pro-Xan systems processing 40 tons of green-chop per hour in a 180 day season

Item	Unit	Systems[1/]			
		I Single pressing, Pro-Xan yield 8%	II Single pressing, alfalfa solubles added to green-chop, Pro-Xan yield 9.5%	III Double pressing, alfalfa solubles added between pressings, Pro-Xan yield 12%	IV Single pressing of ground alfalfa, Pro-Xan yield 12%
Dehydrated press cake					
Production per hour	Pounds	17,600	17,313	16,834	16,834
Annual production	Tons	34,848	34,280	33,331	33,331
Price per ton	Dollars	86.13	85.53	84.53	84.53
Annual sales value	do.	3,001,458	2,931,968	2,817,469	2,817,469
Pro-Xan					
Production per hour	Pounds	1,564	1,858	2,346	2,346
Annual production	Tons	3,097	3,679	4,645	4,645
Price per ton	Dollars	309.04	309.04	309.04	309.04
Annual sales value	do.	957,097	1,136,958	1,435,491	1,435,491
Annual sales value of all products	do.	3,958,555	4,068,926	4,252,960	4,252,960
Annual costs (fixed & variable)					
Green-chop	do.	815,760	815,760	815,760	815,760
Harvesting & hauling	do.	473,801	473,801	473,801	473,801
Processing	do.	965,563	1,002,309	1,116,743	1,042,474
Storage	do.	170,753	170,816	170,892	170,892
Marketing	do.	56,918	56,939	56,964	56,964
Transport to market	do.	379,450	379,590	379,760	379,760
Working capital	do.	64,600	65,232	67,813	66,142
Total costs	do.	2,926,645	2,964,447	3,081,733	3,005,793
Annual earnings[2/]	do.	1,031,910	1,104,479	1,171,227	1,247,167
Total investment[3/]	do.	2,396,134	2,475,007	2,924,163	2,572,772
Rate of return[4/]	Percent	43.1	44.6	40.0	48.5

1/ See description of systems in figures 1-4. In all systems dilute alfalfa solubles added to press cake prior to dehydration.

2/ Total annual sales value of all products less total annual costs.

3/ Includes investment for harvesting and hauling equipment as well as processing plant investment.

4/ Percent that annual earnings are of total investment prior to deduction of income taxes.

Table 9--Rate of return on investment for different Pro-Xan systems with different prices for Pro-Xan, dehydrated press cake, and green-chop

System	Rate of return--		
	With calculated values for Pro-Xan and press cake using 1974 feed prices[1/]	With 1974 values adjusted by 1975 USDA feed price index[2/]	With 1974 values discounted a hypothetical 15 percent
	Percent		
I	43.1	39.1	23.4
II	44.6	40.7	24.9
III	40.0	36.5	22.4
IV	48.5	44.5	28.4

1/ Average values per ton: Pro-Xan $309.04; dehydrated press cake $86.13 for System I, $85.53 for System II, and $84.53 for Systems III and IV. Value for green-chop $5.15 per ton standing in field.

2/ 1974 estimated values for Pro-Xan, press cake, and green-chop discounted 3 percent to adjust to 1975 values.

Costs of equipment, labor, and other inputs for the harvesting, hauling, and processing operation would be expected to remain stable over relatively short periods.

On the basis of these comparisons of estimated annual rates of return, System IV was considered to be the most profitable and was therefore the system used for evaluating the effects of the other variables in the phased analysis described above.

Comparative Returns on Investment from Pro-Xan and Dehy Plants--Alfalfa dehydrators may be among the first to give consideration to investment in a Pro-Xan processing operation. They might be expected to compare the potential returns from a Pro-Xan plant to one producing only dehy. The annual sales value, costs, and rate of return for a dehy plant processing 40 tons of green-chop per hour and operating for 180 days per season were computed. These computations showed that the annual rate of return on investment for such a plant would be 44.0 percent, less than the 48.5 percent computed for a Pro-Xan plant of the same capacity and length of season using the System IV process (table 8).

The alfalfa dehydration industry is concentrated largely in the Nebraska-Kansas area. The average length of season in that area is closer to 130 days

days than 180 days and a typical plant is more likely to have an input rate of green-chop of 20 tons per hour than 40 tons. Estimates of the annual costs, sales value of products, and rate of return on investment for both a dehy plant and Pro-Xan plant of this capacity and length of season are given in table 10. These data show that the rate of return for these plants would be roughly equivalent, with the Pro-Xan plant having a slight edge.

Solubles and Press Cake Disposition (Phase II)

A number of alternatives or modifications are possible for each of the Pro-Xan recovery systems. The modifications evaluated in this section relate to the way in which the alfalfa solubles and the press cake are utilized. In Phase I, it was assumed that dilute alfalfa solubles were added to the press cake and the press cake was dehydrated (Alternative A below). Several other possible alternatives are described and referred to by letters B through F.

A. Dilute alfalfa solubles added to press cake and press cake dehydrated (as in System IV Phase I).
B. Dilute alfalfa solubles pumped to the field and press cake left wet.
C. Dilute alfalfa solubles pumped to the field and press cake dehydrated.
D. Alfalfa solubles concentrated, added to press cake, and press cake left wet.
E. Alfalfa solubles concentrated, added to press cake, and press cake dehydrated.
F. Alfalfa solubles concentrated for use as a liquid feed supplement, and press cake dehydrated.

With each of these alternatives, a number of changes were required in both the processing equipment and buildings. For example, in processing plants where the press cake was left wet (B and D), the dehydration and pelleting equipment, as well as the building housing this equipment, was eliminated. For the alternatives in which the alfalfa solubles were concentrated (D, E, and F), an evaporator for concentration of the solubles was required. Harvesting and hauling requirements and costs for each of these alternatives were the same as in Phase I.

Total investment costs for each of these alternatives for System IV are given in table 11.

Investment Costs--Total costs for harvesting and hauling equipment, processing equipment, buildings, and land ranged from $1,668,809 for alternative B to $2,988,595 for alternatives E and F (table 11).

Processing plant equipment costs for these model plants, including installation, ranged from a low of $1,182,209 for alternative B to $2,464,995 for alternatives E and F (table 11), or between 71 to 82 percent of total investment costs. All model plants were assumed to require the same receiving equipment. Only alternatives B and D had equipment for loadout of the wet press cake. This consisted primarily of conveyors used to load the

Table 10--Comparison of Pro-Xan and dehy plants processing 20 tons of green-chop per hour in a 130 day season

Item	Unit	Dehy plant	Pro-Xan plant[1/]
Dehy or dehydrated press cake			
Production per hour	Pounds	9,565	8,417
Annual production	Tons	13,678	12,036
Price per ton	Dollars	87.13	84.53
Annual sales value	do.	1,191,764	1,017,403
Pro-Xan			
Production per hour	Pounds	-	1,173
Annual production	Tons	-	1,677
Price per ton	Dollars	-	309.04
Annual sales value	do.	-	518,260
Annual sales value of all products	do.	1,191,764	1,535,663
Annual costs (fixed and variable)			
Green-chop	do.	294,580	294,580
Harvesting and hauling	do.	192,834	192,834
Processing	do.	305,415	494,013
Storage	do.	61,551	61,708
Marketing	do.	20,517	20,570
Transport to market	do.	136,780	137,130
Working capital	do.	22,763	27,019
Total costs	do.	1,034,440	1,227,854
Annual earnings	do.	157,324	307,809
Total investment	do.	786,558	1,426,397
Rate of return	Percent	20.0	21.6

1/ System IV Pro-Xan plant (figure 4).

Table 11--Investment costs for six alternative methods of handling alfalfa solubles and press cake in Pro-Xan System IV processing 40 tons of green-chop per hour in a 180 day season

Investment cost item	Alternatives					
	Alfalfa solubles added to press cake	Alfalfa solubles pumped to field		Alfalfa solubles concentrated		
				Added to press cake		Used as liquid feed supplement
	Press cake dried	Press cake left wet	Press cake dried	Press cake left wet	Press cake dried	Press cake dried
	A	B	C	D	E	F
	Dollars					
Harvesting & hauling equipment	341,000	341,000	341,000	341,000	341,000	341,000
Processing plant equipment						
Receiving	111,150	111,150	111,150	111,150	111,150	111,150
Loadout wet press cake	--	22,525	--	22,525	--	--
Dehydration & pelleting	664,720	--	479,290	--	479,290	479,290
Pro-Xan processing	742,035	742,035	742,035	742,035	742,035	742,035
Solubles concentration	--	--	--	493,447	493,447	493,447
Subtotal	1,517,905	875,710	1,332,475	1,369,157	1,825,922	1,825,922
Installation[2/]	531,267	306,499	466,366	479,205	639,073	639,073
Total	2,049,172	1,182,209	1,798,841	1,848,362	2,464,995	2,464,995
Buildings						
Dehydration & pelleting	37,000	--	37,000	--	37,000	37,000
Pro-Xan processing	59,000	59,000	59,000	59,000	59,000	59,000
Office	36,000	36,000	36,000	36,000	36,000	36,000
Maintenance shop	21,700	21,700	21,700	21,700	21,700	21,700
Boiler room	12,900	12,900	12,900	12,900	12,900	12,900
Total	166,600	129,600	166,600	129,600	166,600	166,600
Land	16,000	16,000	16,000	16,000	16,000	16,000
Grand total	2,572,772	1,668,809	2,322,441	2,334,962	2,988,595	2,988,595

1/ See description of System IV in figure 4.
2/ Based on estimate of 35 percent of list price of equipment and includes plant engineering.

wet press cake into trucks for removal to feeding operations or temporary storage. These two plants required no dehydration and pelleting equipment. Alternatives A, B, and C required no equipment for solubles concentration.

As with equipment, there were some differences in investment requirements for buildings. Building costs ranged from $129,600 for alternatives B and D to $166,600 for the others (table 11). Alternatives B and D did not dehydrate or pellet the press cake; therefore, no building was required for these operations.

Processing Plant Operating Costs--Total annual plant operating costs for the six alternative methods of handling alfalfa solubles and press cake, excluding harvesting and hauling costs, ranged from a low of $500,903 for alternative B to $1,042,474 for alternative A (table 12). Operating costs varied considerably depending upon the method of disposition of products. Alternative A had annual operating costs more than double those of alternative B. However, to determine the most profitable alternative, these annual operating costs must be related to the annual production and sales value of products.

Fixed costs for these model plants accounted for 28 to 40 percent of the total annual costs. Alternative A with the highest total cost had fixed costs of only 28 percent of the total (table 12). Depreciation was the greatest single expense of fixed costs. It made up 46 to 49 percent of total fixed costs. Interest was the second largest item, and accounted for about a third of the fixed costs in all alternatives.

Variable costs for these plants illustrate the wide spread in requirements for utilities. Variable costs ranged from 60 to 72 percent of the total annual plant operating costs. Utilities accounted for 38 to 65 percent of the total variable costs. Alternative B, which did not dry press cake or concentrate alfalfa solubles, had the lowest utility cost, $120,042 (table 12). The greatest utility expense ($486,364) occurred in alternative A which added dilute alfalfa solubles to, and dried, the press cake. Total labor (processing and maintenance) made up from 11 to 26 percent of the variable costs.

Rate of Return on Investment--To derive rates of return, it was necessary to estimate sales values for wet press cake in alternatives B and D and for concentrated solubles in alternative F. The method used for estimating the sales values of these products was described under Phase I.

Alternative A, in this part of the analysis, is the same as System IV in the first phase. System IV provided the greatest return on investment and was used as a basis for comparing returns for alternative methods of handling press cake and alfalfa solubles. The annual rate of return on investment for alternative A was estimated to be 48.5 percent. Alternatives C and F in this phase had essentially the same rates of return: 48.0 and 50.0 percent, respectively (table 13). Although the annual sales values of the products from alternatives A and F were greater than for C, the costs for alternative C were lower.

Table 12--Annual processing plant costs for six alternative methods of handling alfalfa solubles and press cake in Pro-Xan System IV processing 40 tons of green-chop per hour in a 180 day season

Operating cost item	Alternatives					
	Alfalfa solubles added to press cake	Alfalfa solubles pumped to field		Alfalfa solubles concentrated		
				Added to press cake		Used as liquid feed supplement
	Press cake dried	Press cake left wet	Press cake dried	Press cake left wet	Press cake dried	Press cake dried
	A	B	C	D	E	F
	Dollars					
Fixed						
Depreciation	143,276	84,002	126,587	128,414	171,005	171,005
Administration	9,200	9,200	9,200	9,200	9,200	9,200
Taxes	7,811	4,647	6,935	6,469	9,267	9,267
Insurance	21,325	12,470	18,821	19,132	25,483	25,483
Interest	101,150	60,471	89,885	90,448	119,862	119,862
Supervisor	11,000	11,000	11,000	11,000	11,000	11,000
Subtotal	293,762	181,790	262,428	264,663	345,817	345,817
Variable						
Processing labor	57,348	57,348	57,348	57,348	57,348	57,348
Maintenance labor	26,136	26,136	26,136	26,136	26,136	26,136
Utilities	486,364	120,042	308,635	149,597	350,188	340,720
Maintenance & repairs	155,104	91,827	137,581	138,457	184,212	184,172
Ammonia	23,760	23,760	23,760	23,760	23,760	23,760
Subtotal	748,712	319,113	553,460	395,298	641,644	632,136
Total[1/]	1,042,474	500,903	815,888	659,961	987,461	977,953

1/ Does not include harvesting and hauling costs (see table 6).

Table 13--Evaluation of six alternative methods of handling alfalfa solubles and press cake in Pro-Xan System IV processing 40 tons of green-chop per hour in a 180 day season

Item	Unit	Alternatives					
		Alfalfa solubles added to press cake	Alfalfa solubles pumped to field		Alfalfa solubles concentrated		
					Added to press cake		Used as liquid feed supplement
		Press cake dried	Press cake left wet	Press cake dried	Press cake left wet	Press cake dried	Press cake dried
		A	B	C	D	E	F
Dehydrated press cake							
Production per hour	Pounds	16,834	--	14,399	--	16,834	14,399
Annual production	Tons	33,331	--	28,510	--	33,331	28,510
Price per ton	Dollars	84.53	--	83.33	--	84.53	83.33
Annual sales value	do.	2,817,469	--	2,375,740	--	2,817,469	2,375,740
Wet press cake							
Production per hour	Pounds	--	36,000	--	40,480	--	--
Annual production	Tons	--	71,280	--	80,150	--	--
Price per ton	Dollars	--	13.62	--	14.16	--	--
Annual sales value	do.	--	970,834	--	1,134,924	--	--
Concentrated alfalfa solubles							
Production per hour	Pounds	--	--	--	--	--	4,480
Annual production	Tons	--	--	--	--	--	8,870
Price per ton	Dollars	--	--	--	--	--	61.40
Annual sales value	do.	--	--	--	--	--	544,618
Pro-Xan							
Production per hour	Pounds	2,346	2,346	2,346	2,346	2,346	2,346
Annual production	Tons	4,645	4,645	4,645	4,645	4,645	4,645
Price per ton	Dollars	309.04	309.04	309.04	309.04	309.04	309.04
Annual sales value	do.	1,435,491	1,435,491	1,435,491	1,435,491	1,435,491	1,435,491
Annual sales value of all products	do.	4,252,960	2,406,325	3,811,231	2,570,415	4,252,960	4,355,849
Annual costs (fixed & variable)							
Green-chop	do.	815,760	815,760	815,760	815,760	815,760	815,760
Harvesting & hauling	do.	473,801	473,801	473,801	473,801	473,801	473,801
Processing	do.	1,042,474	500,903	815,888	659,961	987,461	977,953
Storage	do.	170,892	20,903	149,207	20,903	170,892	149,207
Marketing	do.	56,964	6,960	49,736	6,960	56,964	49,736
Transport to market	do.	379,760	46,450	331,570	46,450	379,760	331,570
Working capital	do.	66,142	41,957	59,309	45,536	64,904	62,956
Total costs	do.	3,005,793	1,906,734	2,695,271	2,069,371	2,949,542	2,860,983
Annual earnings	do.	1,247,167	499,591	1,115,960	501,044	1,303,418	1,494,865
Total investment	do.	2,572,772	1,668,809	2,322,441	2,334,962	2,988,595	2,988,595
Rate of return	Percent	48.5	30.0	48.0	21.5	43.6	50.0

In all alternatives, the quantity and total value of Pro-Xan was the same. Alternatives B and D had much lower rates of return than the other alternatives because, as explained above, wet press cake was assumed to be sold at cost. The costs of handling, storage, and utilization for wet press cake were not considered in this analysis, and neither were any possible profits.

With alternative F, similar problems exist for the concentrated alfalfa solubles as for the wet press cake for other alternatives. Handling would not pose any unique problems but storage and utilization might. Also, as indicated before, it was assumed that concentrated alfalfa solubles could be a replacement for molasses in cattle rations, but further testing and market development would be required.

In alternatives B and C, it was assumed that the alfalfa solubles could be pumped into a nearby irrigation system. This practice would be feasible for most plants, which presumably would be located in rural agricultural areas. The solubles contain nitrogen, a valuable crop fertilizer. On the basis of irrigation practices for alfalfa in the Kansas-Nebraska area, an estimated 120 acres of alfalfa would be required for disposing of alfalfa solubles from a Pro-Xan plant with 40 tons per hour input capacity operating 180 days per season.

Alternatives A and E mostly differ because the moisture in the dilute alfalfa solubles is evaporated in the press cake dehydrator in alternative A, while in E, the dilute alfalfa solubles are concentrated in an evaporator before being added to the press cake. Although total values of sales for both of these alternatives were estimated to be the same, costs were not (table 13). Investment costs were greater for alternative E which resulted in the fixed cost portion of the operating costs being greater (table 12). Alternative A had much higher utility costs, however, which resulted in higher annual variable and total costs.

Gas Prices and Availability--With higher prices for fuel--a situation facing all fuel users and already a fact in some locations--the relative costs of alternatives would change and affect annual rates of return.

In the above analysis, System IV alternatives A, C, and F were shown to have larger returns on investment. Alternative A, however, had the highest total requirement for gas (table 14). Since alternatives C and F have essentially the same rates of return as alternative A, in operations where it is feasible to pump the alfalfa solubles directly to the fields or the price of concentrated alfalfa solubles is equal to that of molasses, then these would be the most feasible alternatives in case of gas shortages. Since electricity consumption is about the same for all three of these alternatives, its availability would not enter into making a selection among them.

After alternatives A, C, and F, alternative E had the highest rate of return on investment (table 14). Electricity consumption for alternative E was about equal to A, C, and F, but gas consumption was only 53 percent as much as alternative A and only slightly higher than alternatives C and F. With alternative E, concentrated solubles are returned to the press cake,

Table 14--Comparison of utility requirements and rate of return on investment for six alternatives of System IV processing 40 tons of green-chop per hour and operating for a 180 day season

Alternatives 1/	Utility usage per season		Rate of return on investment
	Gas	Electricity	
	1,000 cubic feet	Kilowatt Hours	Percent
A	459,716	8,712,000	48.5
B	46,558	4,253,040	30.0
C	195,972	8,537,760	48.0
D	78,487	4,656,960	21.5
E	241,671	9,080,280	43.6
F	225,898	9,080,280	50.0

1/ See table 11 headings and page 23 for description of alternatives.

which is then dehydrated; thus, the product output and sales values were the same as for alternative A in which dilute solubles are returned to the press cake prior to dehydration. For gas prices higher than the assumed 66 cents per 1,000 cubic feet, at some point alternative E would provide a greater rate of return on investment than alternative A. In table 15, the effects of three different prices for gas on rate of return are compared for alternatives A and E. Doubling the price for gas ($1.32 per 1,000 cubic feet) places the rate of return on investment for E slightly higher than for A. At about triple the price for gas ($2.00 per 1,000 cubic feet) returns to alternative E are one-third higher, although returns to both decline with higher gas prices.

Table 15--Impact of gas costs on rate of return for Pro-Xan System IV, alternatives A and E, processing 40 tons of green-chop per hour and operating for a 180 day season

Alternative	Cost of gas per 1000 cubic feet--		
	$0.66	$1.32	$2.00
	Percent return on investment		
A	48.5	36.7	24.5
E	43.6	38.3	32.8

In 1975, natural gas prices at some locations had already reached these higher prices. One alfalfa dehydrator in Northern California reported that he had paid $1.50 per 1,000 cubic feet. For coming years, projected prices for gas are this high or higher in most locations where alfalfa can be processed into Pro-Xan. Thus, each potential adopter of the Pro-Xan process must keep this in mind when selecting from among the possible methods of processing Pro-Xan.

Length of Season (Phase III)

The production season for alfalfa varies in different areas of the United States and is greatly influenced by weather. In the previous phases of this analysis, an average 180 day season was used. In some areas the season is as long as 280 days, in others, only 130 days.

Length of operating season has a great bearing on unit costs in a given size plant. The reason is that total annual fixed costs for a given size plant remain essentially constant regardless of the length of season. Thus, the longer a given plant operates, the greater will be the annual output and the lower the fixed costs per unit of output.

To illustrate the influence of length of season, System IV (alternative A) was analyzed for four different lengths of season: 130, 180, 230, and 280 days. The basic plant remains the same regardless of the days of operation. Total investment costs for this plant, including harvesting and hauling equipment, was $2,572,772 (table 5).

Annual fixed and variable costs in the four different lengths of season are given for harvesting and hauling in table 16 and for processing in table 17. These costs are summarized in table 18.

Length of season has a definite effect on the rate of return on investment. The four lengths of season clearly illustrate the advantage of being able to operate as long a season as possible. The annual rate of return increased from 30.9 percent for a System IV Pro-Xan plant operating 130 days to 90.5 percent for the same plant operating 280 days.

Plant Capacity (Phase IV)

In this phase of the analysis, three sizes of plant were analyzed to illustrate the economies of size in Pro-Xan processing plants. Model plant sizes used were 20, 40, and 80 tons of green-chop input per hour.

Total investment increased from $1,426,397 for the 20 ton plant to $4,334,295 for the 80 ton plant (table 19). As plant capacity increased, the investment per ton of capacity decreased. Thus, an investment only three times larger was needed to achieve an output four times larger.

Table 16--Annual harvesting and hauling costs for Pro-Xan System IV (alternative A) processing 40 tons of green-chop per hour for four different lengths of season

Cost item	Length of season (days)			
	130	180	230	280
	Dollars			
Fixed				
Depreciation	44,700	44,700	44,700	44,700
Administration	7,700	7,700	8,900	10,000
Taxes & licenses	1,194	1,194	1,194	1,194
Insurance	3,410	3,410	3,410	3,410
Interest	15,345	15,345	15,345	15,345
Supervisor	9,000	9,000	9,800	10,600
Subtotal	81,349	81,349	83,349	85,249
Variable				
Labor	82,368	114,048	145,728	177,408
Gasoline & oil	86,171	119,316	152,460	185,600
Maintenance & repairs	114,895	159,088	203,280	247,468
Subtotal	283,434	392,452	501,468	610,476
Total	364,783	473,801	584,817	695,725

The annual operating costs for harvesting and hauling and for processing plant operations are given in tables 20 and 21. Fixed costs for harvesting and hauling made up only 15 to 20 percent of total harvesting and hauling costs (table 20). For the processing plant, these costs made up between 27 and 29 percent of total plant operating costs (table 21). The cost of utilities (gas and electricity) was the largest single cost item in all of the plants.

Because operating costs per unit of output decreased as plant capacity increased, the rate of return on investment increased. The rate of return was 38.3 percent for the 20 ton plant and increased to 64.7 percent for the 80 ton plant (table 22).

Table 17--Annual processing plant costs for Pro-Xan System IV (alternative A) processing 40 tons of green-chop per hour for four lengths of season

Cost item	Length of season (days)			
	130	180	230	280
	Dollars			
Fixed				
Depreciation	143,276	143,276	143,276	143,276
Administration	9,200	9,200	10,700	12,200
Taxes	7,811	7,811	7,811	7,811
Insurance	21,325	21,325	21,325	21,325
Interest	101,150	101,150	101,150	101,150
Supervisor	11,000	11,000	12,000	13,000
Subtotal	293,762	293,762	296,262	298,762
Variable				
Processing labor	41,418	57,348	73,278	89,208
Maintenance labor	18,876	26,136	33,396	40,656
Utilities	351,263	486,364	621,465	756,566
Maintenance & repairs	112,020	155,104	198,188	241,273
Ammonia	17,160	23,760	30,360	36,960
Subtotal	540,737	748,712	956,687	1,164,663
Total[1/]	834,499	1,042,474	1,252,949	1,463,425

1/ Does not include harvesting and hauling costs (see table 14).

EVALUATION OF FINDINGS

A number of factors other than the estimated costs and sales values of products must be considered and evaluated before a final decision is made on whether or not to invest in a Pro-Xan processing operation.

One of the most important of these is the alternative opportunities available to a potential investor. Other investments, including investment in an alfalfa dehydration plant, may yield average rates of return that are equivalent to those from the Pro-Xan process. However, as indicated above, the market for dehy, at current prices, may already be saturated, while there appears to be considerable opportunity for developing new outlets for alfalfa products such as Pro-Xan.

Table 18--Evaluation of Pro-Xan System IV (alternative A) processing 40 tons of green-chop per hour for four lengths of season

Item	Unit	Length of season (days)			
		130	180	230	280
Dehydrated press cake					
Production per hour	Pounds	16,834	16,834	16,834	16,834
Annual production	Tons	24,073	33,331	42,590	51,849
Price per ton	Dollars	84.53	84.53	84.53	84.53
Annual sales value	do.	2,034,891	2,817,469	3,600,133	4,382,796
Pro-Xan					
Production per hour	Pounds	2,346	2,346	2,346	2,346
Annual production	Tons	3,355	4,645	5,935	7,226
Price per ton	Dollars	309.04	309.04	309.04	309.04
Annual sales value	do.	1,036,829	1,435,491	1,834,152	2,233,123
Annual sales value of all products	do.	3,071,720	4,252,960	5,434,285	6,615,919
Annual costs (fixed & variable)					
Green-chop	do.	589,160	815,760	1,042,360	1,268,960
Harvesting & hauling	do.	364,783	473,801	584,817	695,725
Processing	do.	834,499	1,042,474	1,252,949	1,463,425
Storage	do.	123,426	170,892	109,181	132,919
Marketing	do.	41,142	56,964	72,788	88,613
Transport to market	do.	274,280	379,760	485,250	590,750
Working capital	do.	50,114	66,142	39,908	47,704
Total costs	do.	2,277,404	3,005,793	3,587,253	4,288,096
Annual earnings	do.	794,316	1,247,167	1,847,032	2,327,823
Total investment	do.	2,572,772	2,572,772	2,572,772	2,572,772
Rate of return	Percent	30.9	48.5	71.8	90.5

Table 19--Investment costs for Pro-Xan System IV (alternative A) operating a 180 day season and processing 20, 40, or 80 tons of green-chop per hour[1/]

Cost item	Plant capacity (tons per hour)		
	20	40	80
	Dollars		
Harvesting & hauling equipment	190,000	341,000	677,500
Processing plant equipment			
Receiving	63,650	111,150	188,650
Dehydration & pelleting	314,615	664,720	1,003,315
Pro-Xan	430,251	742,035	1,337,068
Subtotal	808,516	1,517,905	2,529,033
Installation[2/]	282,981	531,267	885,162
Total	1,091,497	2,049,172	3,414,195
Buildings			
Dehydration & pelleting	23,100	37,000	53,300
Pro-Xan	59,000	59,000	83,500
Office	25,000	36,000	40,300
Maintenance shop	12,900	21,700	28,500
Boiler room	12,900	12,900	17,000
Total	132,900	166,600	222,600
Land	12,000	16,000	20,000
Grand total	1,426,397	2,572,772	4,334,295

1/ See description of System IV in figure 4.
2/ Based on estimate of 35 percent of list price of equipment and includes plant engineering.

The potential market for Pro-Xan in the rations of broilers and laying chickens in the United States alone, for example, is estimated to be about 600,000 tons per year. This does not include quantities that might be fed to turkeys and swine nor quantities that might be exported. To produce 600,000 tons of Pro-Xan would require about 5 million tons (hay equivalent) of alfalfa, about 6 percent of the annual U.S. alfalfa crop. At the 1974 estimated average values for Pro-Xan and dehydrated press cake, this would add about $125 million to the value of the alfalfa crop over what this quantity of alfalfa sold as dehy alone would bring. The output of press cake for producing this quantity of Pro-Xan would be about 2-1/2 times the present

annual production of dehy (1.7 million tons). Therefore, the production and introduction of Pro-Xan would have to be accompanied by an increase in the demand for dehydrated press cake if prices for it are expected to be nearly equivalent to dehy rather than approaching those for alfalfa hay, which generally sells at lower prices. Continuing high prices for feed grains would tend to result in an increased demand for dehydrated press cake for cattle feeding. However, no estimates were made of the potential loss of sales of other agricultural crops that would be displaced by products of the Pro-Xan process.

Table 20--Annual harvesting and hauling costs for Pro-Xan System IV (alternative A) operating a 180 day season and processing 20, 40, or 80 tons of green-chop per hour

Cost item	Plant capacity (tons per hour)		
	20	40	80
		Dollars	
Fixed			
Depreciation	25,600	44,700	88,650
Administration	6,600	7,700	8,800
Taxes & licenses	665	1,194	2,371
Insurance	1,900	3,410	6,775
Interest	8,550	15,345	30,488
Supervisor	7,800	9,000	10,300
Subtotal	51,115	81,349	147,384
Variable			
Labor	57,024	114,048	242,352
Gasoline & oil	59,658	119,316	238,631
Maintenance & repairs	79,544	159,088	318,175
Subtotal	196,226	392,452	799,158
Total	247,341	473,801	946,542

Table 21--Annual processing plant costs for Pro-Xan System IV (alternative A) operating a 180 day season and processing 20, 40, or 80 tons of green-chop per hour

Cost item	Plant capacity (tons per hour)		
	20	40	80
	Dollars		
Fixed			
Depreciation	78,083	143,276	236,514
Administration	8,000	9,200	10,700
Taxes	4,327	7,811	12,799
Insurance	11,579	21,325	35,355
Interest	56,177	101,150	165,456
Supervisor	9,500	11,000	12,500
Subtotal	167,666	293,762	473,324
Variable			
Processing labor production	49,248	57,348	65,664
Maintenance labor	17,496	26,136	34,992
Utilities	255,070	486,364	904,941
Maintenance & repairs	85,345	155,104	254,574
Ammonia	11,800	23,760	47,520
Subtotal	419,039	748,712	1,307,691
Total[1/]	586,705	1,042,474	1,781,015

1/ Does not include harvesting and hauling costs (see table 18).

Another important consideration in deciding whether or not to invest in a Pro-Xan processing operation is the availability of a raw material supply. In some areas, particularly during some years, alfalfa supplies have not been adequate for a continuous operation of dehydration plants over the normal season. Prices of alternate crops competing for the same land have a great influence on whether a farmer will grow alfalfa or another crop which will provide a greater return on his investment. If the alfalfa processor is forced to acquire his supplies from longer distances because of such a situation, hauling costs for raw material will rise--not only for truck operating costs but also possibly investment in more trucks.

The type of plant selected for processing alfalfa products ultimately will depend upon the availability of natural gas or other limitations on energy requirements. If a plant is seriously restricted with respect to the use of energy, different processing systems may be more profitable than the ones identified in the foregoing analysis.

Table 22--Rates of return on investment for Pro-Xan System IV (alternative A) operating a 180 day season and processing 20, 40, or 80 tons of green-chop per hour

Item	Unit	Plant capacity (tons per hour)		
		20	40	80
Dehydrated press cake				
Production per hour	Pounds	8,417	16,834	33,668
Annual production	Tons	16,664	33,331	66,663
Price per ton	Dollars	84.53	84.53	84.53
Annual sales value	do.	1,408,608	2,817,469	5,635,023
Pro-Xan				
Production per hour	Pounds	1,173	2,346	4,692
Annual production	Tons	2,324	4,645	9,290
Price per ton	Dollars	309.04	309.04	309.04
Annual sales value	do.	718,209	1,435,491	2,870,982
Annual sales value of all products	do.	2,126,817	4,252,960	8,506,005
Annual costs (fixed & variable)				
Green-chop	do.	407,880	815,760	1,631,520
Harvesting & hauling	do.	247,341	473,801	946,542
Processing	do.	586,705	1,042,474	1,781,015
Storage	do.	85,446	170,892	341,784
Marketing	do.	28,482	56,964	113,928
Transport to market	do.	189,880	379,760	759,520
Working capital	do.	34,779	66,142	125,422
Total costs	do.	1,580,513	3,005,793	5,699,731
Annual earnings	do.	546,164	1,247,167	2,806,274
Total investment	do.	1,426,397	2,572,772	4,334,295
Rate of return	Percent	38.3	48.5	64.7

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Appendix table 1--Harvesting and hauling equipment requirements for all Pro-Xan plants with different capacities

Item	Specifications	Size of plant		
		Tons of green-chop per hour		
		20	40	80
		Number of units		
Harvester	Self-propelled, 14-foot header	2	4	8
Truck	15-ton, tandem axle, diesel powered, 24-foot bed	3	5	10
Truck	3/4-ton pickup	2	2	3

Appendix table 2--Equipment requirements for Pro-Xan System I with input capacity of 40 tons of green-chop per hour

Item	Number required	Size or capacity per unit	Total connected horsepower of motors
Hydraulic truck lift	2	35 feet long	20
Truck scale	1	60 tons	--
Feeder	2	20 tons/hr.	40
Screw press	2	20 tons/hr.	300
Hydrasieve	1	72 in. wide	--
Steam injector	2	2.5 in. diameter	--
Centrifuge	1	85 gal. feed/min.	165
Extruder (Pro-Xan)	1	5,400 lb. wet curd/hr.	7.5
Dryer (Pro-Xan)	1	1,954 lb. H_2O evap./hr.	75
Pneumatic conveyor (Pro-Xan)	1	5 tons/hr.	25
Dryer (press cake)	1	60,000 lb. H_2O evap./hr.	200
Pneumatic conveyor (press cake)	1	12 tons/hr.	50
Grinder (dry press cake)	2	6 tons/hr.	400
Pellet mill (dry press cake)	2	6 tons/hr.	420
Transfer system (hot press cake pellets)	2	6 tons/hr.	10
Pellet cooler	2	6 tons/hr.	80
Transfer system (cold pellets)	2	6 tons/hr.	100
Automatic bagger (100 lb. bags)	1	5 bags/min.	1
Boiler	1	300 boiler h.p.	30
Air compressor	1	36 SCFM	10
Pumps	6	16 to 100 gal./min.	17
Conveyors	5	1 to 40 tons/hr.	18
Tanks	5	200 to 10,000 gal.	--

Appendix table 3--Equipment requirements for Pro-Xan System II with input capacity of 40 tons of green-chop per hour

Item	Number required	Size or capacity per unit	Total connected horsepower of motors
Hydraulic truck lift	2	35 feet long	20
Truck scale	1	60 tons	--
Feeder	2	20 tons/hr.	40
Screw press	2	20 tons/hr.	300
Hydrasieve	1	72 in. wide	--
Steam injector	2	3 in. diameter	--
Centrifuge	1	160 gal. feed/min.	190
Extruder (Pro-Xan)	1	5,400 lb. wet curd/hr.	7.5
Dryer (Pro-Xan)	1	2,322 lb. H_2O evap./hr.	100
Pneumatic conveyor (Pro-Xan)	1	5 tons/hr.	25
Cooling tower	1	80 gal./min.	--
Dryer (press cake)	1	60,000 lb. H_2O evap./hr.	200
Pneumatic conveyor (press cake)	1	12 tons/hr.	50
Grinder (dry press cake)	2	6 tons/hr.	400
Pellet mill (dry press cake)	2	6 tons/hr.	420
Transfer system (hot press cake pellets)	2	6 tons/hr.	10
Pellet cooler	2	6 tons/hr.	80
Transfer system (cold pellets)	2	6 tons/hr.	100
Automatic bagger (100 lb. bags)	1	5 bags/min.	1
Boiler	1	400 boiler h.p.	40
Air compressor	1	36 SCFM	10
Pumps	8	16 to 160 gal./min.	33
Conveyors	5	1 to 40 tons/hr.	18
Tanks	5	400 to 10,000 gal.	--

Appendix table 4--Equipment requirements for Pro-Xan System III with input capacity of 40 tons of green-chop per hour

Item	Number required	Size or capacity per unit	Total connected horsepower of motors
Hydraulic truck lift	2	35 feet long	20
Truck scale	1	60 tons	--
Feeder	2	20 tons/hr.	40
Screw press	4	20 tons/hr.	600
Hydrasieve	1	72 in. wide	--
Steam injector	2	3 in. diameter	--
Centrifuge	1	160 gal. feed/min.	190
Extruder (Pro-Xan)	1	5,400 lb. wet curd/hr.	7.5
Dryer (Pro-Xan)	1	2,934 lb. H_2O evap./hr.	100
Pneumatic conveyor (Pro-Xan)	1	5 tons/hr.	25
Cooling tower	1	80 gal./min.	--
Dryer (dehy)	1	60,000 lb. H_2O evap./hr.	200
Pneumatic conveyor (dehy)	1	12 tons/hr.	50
Grinder (dehy)	2	6 tons/hr.	400
Pellet mill	2	6 tons/hr.	420
Transfer system (hot press cake pellets)	2	6 tons/hr.	10
Pellet cooler	2	6 tons/hr.	80
Transfer system (cold pellets)	2	6 tons/hr.	100
Automatic bagger (100 lb. bags)	1	5 bags/min.	1
Boiler	1	400 boiler h.p.	40
Air compressor	1	36 SCFM	10
Pumps	8	16 to 160 gal./min.	33
Conveyors	10	1 to 40 tons/hr.	36
Tanks	6	400 to 10,000 gal.	--

Appendix table 5--Equipment requirements for Pro-Xan System IV with capacity of 40 tons of green-chop per hour

Item	Number required	Size or capacity per unit	Total connected horsepower of motors
Hydraulic truck lift	2	35 feet long	20
Truck scale	1	60 tons	--
Feeder	2	20 tons/hr.	40
Grinder (green-chop)	4	10 tons/hr.	600
Screw press	2	20 tons/hr.	300
Hydrasieve	1	72 in. wide	--
Steam injector	2	2.5 in. diameter	--
Centrifuge	1	95 gal. feed/min.	165
Extruder (Pro-Xan)	1	5,400 lb. wet curd/hr.	7.5
Dryer (Pro-Xan)	1	2,934 lb. H_2O evap./hr.	100
Pneumatic conveyor (Pro-Xan)	1	5 tons/hr.	25
Dryer (press cake)	1	60,000 lb. H_2O evap./hr.	200
Pneumatic conveyor (press cake)	1	12 tons/hr.	50
Grinder (dry press cake)	2	6 tons/hr.	400
Pellet mill (dry press cake)	2	6 tons/hr.	420
Transfer system (hot press cake pellets)	2	6 tons/hr.	10
Pellet cooler	2	6 tons/hr.	80
Transfer system (cold pellets)	2	6 tons/hr.	10
Automatic bagger (100 lb. bags)	1	5 bags/min.	1
Boiler	1	400 boiler h.p.	40
Air compressor	1	36 SCFM	10
Pumps	6	16 to 100 gal./min.	17
Conveyors	8	1 to 40 tons/hr.	40
Tanks	5	200 to 10,000 gal.	--

Appendix table 6--Nutritional specifications for broiler finisher ration[1/]

Nutrient or ingredient name[2/]	Unit	Quantity or proportion of each requirement[3/]
Metabolizable energy	Kcal/lb.	1450
Arginine, min.	Percent	1.16
Glycine, min.	do.	0.87
Isoleucine, min.	do.	0.78
Lysine, min.	do.	1.11
Methionine, min.	do.	0.4
Meth. + cystine, min.	do.	0.77
Threonine, min.	do.	0.72
Tryptophan, min.	do.	0.21
Avail. phosphorus, min.	do.	0.45
Calcium, min.	do.	0.8
Added fat, max.	do.	10
Fiber, max.[4/]	do.	100
Xanthophyll, min.	Mg./lb.	13
Fishmeal, max.	Percent	10
Ethoxyquin, exact	do.	0.0125
Salt, exact	do.	0.25
Mineral-vitamin mix, exact	do.	0.5
Cottonseed meal (41%), max.	do.	7.5
Meat meal (55%), max.	do.	5
Meat-bone meal (50%), max.	do.	5
Feathermeal (85%), max.	do.	2.5
Poultry byproduct meal (55%), max.	do.	5
Alfalfa, dehy (20%), max.	do.	5
Rice bran, max.	do.	5

1/ Developed by Western Regional Research Center, ARS, Albany, Calif.

2/ Percentages in parentheses refer to protein content.

3/ Rations with lower energy levels can be computed by proportionately reducing requirements for energy, amino acids, calcium, xanthophyll, salt, and mineral-vitamin mix.

4/ Although the fiber specification is not limited, the quantity of fiber in the ration is restricted by the metabolizable energy requirement to a range of less than 5 percent for poultry rations.

Appendix table 7--Nutritional values of ingredients used in poultry rations[1/]

Nutrient	Unit	Alfalfa dehydrated (20% protein)	Barley	Calcium carbonate	Corn	Corn gluten meal (60% protein)	Cottonseed meal (41% protein)	Deflorinated phosphate	Dicalcium phosphate	Fat, animal
Metabolizable energy	Kcal/lb.	780.00	1,210.00	0.00	1,580.00	1,580.00	850.00	0.00	0.00	3,580.00
Protein	Percent	20.00	10.00	0.00	8.50	60.00	41.00	0.00	0.00	0.00
Arginine	do.	0.98	0.43	0.00	0.41	1.82	3.70	0.00	0.00	0.00
Glycine	do.	1.01	0.31	0.00	0.30	1.64	2.04	0.00	0.00	0.00
Isoleucine	do.	0.98	0.35	0.00	0.36	2.81	1.42	0.00	0.00	0.00
Lysine	do.	0.87	0.29	0.00	0.23	0.95	1.50	0.00	0.00	0.00
Methionine	do.	0.33	0.15	0.00	0.17	1.59	0.62	0.00	0.00	0.00
Methionine + cystine	do.	0.56	0.31	0.00	0.32	2.68	1.45	0.00	0.00	0.00
Threonine	do.	0.88	0.30	0.00	0.35	2.17	1.20	0.00	0.00	0.00
Tryptophan	do.	0.46	0.12	0.00	0.08	0.30	0.50	0.00	0.00	0.00
Available phosphorus	do.	0.27	0.16	0.00	0.08	0.19	0.37	16.50	18.50	0.00
Calcium	do.	1.47	0.06	38.00	0.02	0.15	0.15	32.00	22.50	0.00
Fat	do.	3.58	1.80	0.00	3.80	2.10	1.00	0.00	0.00	100.00
Fiber	do.	20.20	6.50	0.00	2.50	1.30	13.00	0.00	0.00	0.00
Xanthophyll	Mg./lb.	149.00	0.00	0.00	9.00	106.00	0.00	0.00	0.00	0.00
Choline	do.	730.00	430.00	0.00	240.00	150.00	1,300.00	0.00	0.00	0.00
Vitamin K	do.	6.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alphatocopherol	do.	67.00	2.80	0.00	10.00	0.00	6.80	0.00	0.00	0.00
Vitamin A	MIU./lb.	164.00	0.00	0.00	3.10	7.50	0.00	0.00	0.00	0.00
Riboflavin	mg./lb.	7.00	0.59	0.00	0.50	0.70	2.30	0.00	0.00	0.00
Folic acid	do.	1.20	0.23	0.00	0.09	0.10	1.00	0.00	0.00	0.00
Niacin	do.	25.00	20.00	0.00	10.00	25.00	18.00	0.00	0.00	0.00
Pantothenic acid	do.	15.00	3.30	0.00	2.30	3.80	6.40	0.00	0.00	0.00

Continued

Appendix table 7--Nutritional values of ingredients used in poultry rations--Continued

Nutrient	Unit	Fat, hydrolyzed vegetable + animal	Feather-meal (85% protein)	Fishmeal, herring (70% protein)	Fishmeal, menhaden (60% protein)	Fishmeal, Peruvian (65% protein)	Lysine (50%)	Methionine hydroxy analog	Meat meal (55% protein)	Meat & bone meal (50% protein
Metabolizable energy	Kcal/lb.	3,700.00	1,078.00	1,332.00	1,246.00	1,160.00	0.00	0.00	900.00	900.00
Protein	Percent	0.00	85.00	70.00	60.00	65.00	59.90	0.00	55.00	50.00
Arginine	do.	0.00	3.94	5.30	3.60	3.38	0.00	0.00	3.50	3.15
Glycine	do.	0.00	4.76	4.60	3.88	4.29	0.00	0.00	7.30	6.60
Isoleucine	do.	0.00	2.66	3.00	3.10	2.96	0.00	0.00	1.73	1.49
Lysine	do.	0.00	1.05	5.70	4.34	4.05	50.00	0.00	2.65	2.44
Methionine	do.	0.00	0.37	2.45	1.99	1.93	0.00	80.00	0.66	0.53
Methionine + cystine	do.	0.00	2.35	3.18	3.22	2.81	0.00	80.00	1.33	1.10
Threonine	do.	0.00	2.80	2.88	2.34	2.45	0.00	0.00	1.68	1.44
Tryptophan	do.	0.00	0.40	0.75	0.54	0.66	0.00	0.00	0.36	0.33
Available phosphorus	do.	0.00	0.75	2.00	3.00	2.80	0.00	0.00	4.00	5.00
Calcium	do.	0.00	0.20	3.00	5.00	4.20	0.00	0.00	8.00	10.00
Fat	do.	100.00	2.50	7.00	10.00	4.10	0.00	0.00	6.00	9.50
Fiber	do.	0.00	1.50	1.00	1.00	1.00	0.00	0.00	2.50	2.50
Xanthophyll	Mg./lb.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Choline	do.	0.00	400.00	1,820.00	1,400.00	1,680.00	0.00	0.00	890.00	990.00
Vitamin K	do.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alphatocopherol	do.	0.00	0.00	12.00	4.10	1.50	0.00	0.00	0.45	0.45
Vitamin A	MIU./lb.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Riboflavin	Mg./lb.	0.00	0.91	4.10	2.20	3.00	0.00	0.00	2.40	2.00
Folic acid	do.	0.00	0.10	1.10	0.09	0.09	0.00	0.00	0.02	0.02
Niacin	do.	0.00	9.40	40.00	25.00	29.00	0.00	0.00	26.00	22.00
Pantothenic acid	do.	0.00	4.00	5.20	4.00	4.00	0.00	0.00	2.20	1.70

Continued

Appendix table 7--Nutritional values of ingredients used in poultry rations--Continued

Nutrient	Unit	Milo (sorghum)	Poultry byproduct meal (55% protein)	Rice bran	Safflower meal (42% protein)	Soybean meal (44% protein)	Soybean meal (49% protein)	Wheat HRW	Wheat middlings	Wheat millrun, west coast
Metabolizable energy	Kcal/lb.	1,505.00	1,260.00	670.00	770.00	1,020.00	1,050.00	1,410.00	794.00	733.00
Protein	Percent	8.50	55.00	13.50	42.00	44.00	49.00	11.73	11.90	12.60
Arginine	do.	0.33	3.20	1.12	3.65	3.00	3.34	0.59	0.84	0.85
Glycine	do.	0.30	2.93	0.74	2.29	1.80	1.99	0.53	0.68	0.69
Isoleucine	do.	0.40	2.33	0.53	1.68	2.17	2.42	0.45	0.36	0.38
Lysine	do.	0.21	2.57	0.65	1.20	2.58	2.88	0.33	0.50	0.51
Methionine	do.	0.17	1.16	0.32	0.68	0.63	0.70	0.20	0.18	0.19
Methionine + cystine	do.	0.32	2.11	0.63	1.39	1.29	1.44	0.53	0.47	0.47
Threonine	do.	0.30	2.03	0.51	1.30	1.72	1.91	0.36	0.41	0.41
Tryptophan	do.	0.10	0.46	0.22	0.97	0.63	0.70	0.15	0.17	0.17
Available phosphorus	do.	0.10	1.70	0.46	1.19	0.20	0.21	0.11	0.33	0.30
Calcium	do.	0.03	3.60	0.12	0.34	0.25	0.20	0.04	0.08	0.08
Fat	do.	2.80	12.00	0.80	1.00	0.50	0.90	1.50	4.00	3.80
Fiber	do.	2.50	2.50	15.20	14.50	7.00	2.90	2.24	8.80	8.00
Xanthophyll	Mg./lb.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Choline	do.	310.00	2,700.00	570.00	1,600.00	1,240.00	1,250.00	440.00	685.00	697.00
Vitamin K	do.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alphatocopherol	do.	5.40	0.00	27.00	0.00	1.40	1.50	5.10	11.80	12.00
Vitamin A	MIU./lb.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Riboflavin	Mg./lb.	0.54	4.00	1.20	1.30	1.55	1.40	0.69	1.58	1.52
Folic acid	do.	0.11	0.23	1.00	0.87	0.32	1.60	0.15	0.42	0.39
Niacin	do.	19.00	40.00	140.00	11.00	12.00	9.80	23.60	77.10	69.00
Pantothenic acid	do.	5.20	4.00	11.00	22.00	6.60	6.60	3.90	9.90	9.50

1/ Developed by Western Regional Research Center, ARS, Albany, Calif.

Appendix table 8--Feed ingredient prices, Kansas City, 1974[1/]

Feed ingredient	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	Dollars per 100 pounds											
Alfalfa, dehydrated (20%)	5.75	5.64	5.20	4.68	3.95	3.50	4.25	5.22	4.80	4.90	4.90	4.75
Barley	--	--	--	--	--	--	--	--	--	--	--	--
Calcium carbonate	1.28	1.05	1.05	1.05	1.05	.90	.90	.95	1.00	1.00	1.00	1.00
Corn	5.20	5.50	5.38	4.60	4.66	4.85	5.75	6.36	6.04	6.76	5.93	6.08
Corn gluten meal (60%)	12.30	13.20	13.20	12.80	9.00	9.00	10.25	12.50	10.80	11.25	10.50	10.00
Cottonseed meal (41%)	9.01	6.42	6.30	5.05	5.42	4.80	7.10	7.48	7.56	7.85	6.70	8.10
Deflorinated phosphate	8.90	8.88	9.00	9.00	9.00	7.00	7.00	9.40	9.90	10.10	9.90	9.90
Dicalcium phosphate	8.25	7.75	9.50	9.50	9.50	7.25	8.50	9.90	10.40	10.40	10.40	10.40
Fat, animal	15.50	17.75	18.50	18.60	10.00	15.50	12.25	14.50	11.75	13.25	13.50	8.04
Feathermeal (85%)	18.85	10.95	8.45	8.50	9.00	5.50	6.00	8.62	6.88	9.62	9.38	10.63
Fishmeal, Menhaden (60%)	28.50	23.50	21.00	17.25	15.00	12.00	11.50	16.00	14.00	16.00	15.50	14.75
Fishmeal, Peruvian (65%)	28.50	23.50	21.00	17.25	15.25	12.50	11.50	16.00	14.00	16.00	15.50	14.75
Lysine (98%)	175.00	175.00	175.00	175.00	143.00	148.00	130.00	130.00	130.00	130.00	130.00	130.00
Meat and bone meal (50%)	16.75	10.00	8.00	6.62	7.12	6.25	7.50	8.25	6.25	10.00	7.10	8.25
Methionine hydroxy analog	145.00	145.00	145.00	145.00	145.00	145.00	175.00	175.00	138.00	123.00	123.00	123.00
Milo	4.85	5.00	4.85	4.00	4.00	4.00	4.92	6.00	5.65	6.42	5.60	5.65
Poultry byproducts (55%)	18.50	10.50	10.75	10.00	10.25	10.00	9.38	10.62	8.12	9.88	10.62	10.63
Soybean meal (44%)	9.00	7.81	7.58	6.08	5.75	5.15	7.00	6.48	6.48	9.00	6.88	7.68
Soybean meal (49%)	10.00	8.66	8.32	6.73	6.17	5.65	7.50	6.98	6.98	9.62	7.68	8.28
Wheat	9.72	10.22	8.15	6.97	5.80	6.75	7.00	7.12	7.18	8.28	7.92	7.64
Wheat middlings	4.65	3.98	4.80	4.00	3.65	3.50	4.28	5.75	3.80	6.00	4.50	5.75

1/ Based on Market News Reports, Agricultural Marketing Service, U.S. Dept. Agr.

Appendix table 9--Parametric values of Pro-Xan and quantities that would be used in a broiler finisher ration using feed ingredient prices in Kansas City, monthly for 1974[1/]

Month	Value	Quantity in ration
	Dollars/ton	Percent
January	348.29	2.02
February	402.84	1.90
March	404.99	1.90
April	410.16	2.14
May	219.48	2.39
June	275.72	2.39
July	375.29	1.71
August	265.64	2.17
September	267.35	1.71
October	256.50	1.71
November	243.48	2.30
December	238.77	1.71
Annual average	309.04	2.00

1/ Pro-Xan contains 350 mg. of xanthophyll per pound. Xanthophyll requirement in broiler finisher ration was 13 mg. per pound of ration (see appendix table 6).