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ECONOMIC, NUTRITIONAL AND PHYSIOLOGICAL EVALUATION OF FEEDING FOOD PROCESSING WASTE PRODUCTS TO FARM LIVESTOCK*

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ABSTRACT

The report contains an analysis and evaluation of the nutritional, toxicological, operational, environmental, and regulatory aspects of feeding tomato pomace, string bean and carrot waste from vegetable processing plants to beef and dairy cattle. The economic evaluation includes detailed cost/benefit analyses of feeding waste vs. the dispoal of it. The results, based on research experiments, field visits with food processing companies, feedlot operators and farmers in parts of Canada and the United States, and computerized least cost waste ration formulas, show that the feeding of the selected wastes is generally safe, operationally feasible, and economically viable. Good gains have been achieved with proper attention to nutritional requirements, metabolic limitations, feeding methods, physiological aspects, and proper preservation. Benefits to the agribusiness and the processing industry have been identified.

PREFACE

This report represents an analysis and evaluation of the combined nutritional, physiological, operational and economic feasibility of utilizing selected food processing waste products to feed farm livestock. This analysis and evaluation is part of the Food Processing, Distribution and Retailing (PDR) Program administered by the Approval Board for the Interdepartmental PDR Research and Development Program of Agriculture Canada. The research, fieldwork and analysis of this project was procured by Agriculture Canada through a contract awarded to INMARINT International Marketing and Investment Ltd. of Ottawa. The contract was supervised by Dr. Robert W. Anderson, Commodity Markets Analysis of the Marketing and Economics Branch, assisted by Dr. Naveen Patni, of the Waste Utilization Program of the Animal Centre, Agriculture Canada.

The principal objectives of this report were to analyse and evaluate all aspects of the utilization of tomato pomace, green beans and carrot wastes for cattle feed including quantitative, nutritional, toxicological, regulatory and other pertinent details. The economic aspects included cost/benefit evaluations of feeding waste vs. its disposal, transportation, treatment, storage and other relevant costs and benefits.

Information and results were discussed with members of research stations, centres and expertise, food processing companies, and farmers and feedlot operators in Ontario, Quebec, Ohio, California and Oregon. Data and information were also obtained from other sources in Canada and the United States.

This project was completed in September 1982. With interest in this topic area increasing, the results of this study are being published in a working paper for use by all interested parties.

Any views expressed are not necessarily those of the Government of Canada nor will any recommendations necessarily be adopted. Questions related to the contents of this report and enquiries concerning copies should be directed to:

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I. OBJECTIVES, PARAMETERS, SUMMARY AND CONCLUSIONS

A. OBJECTIVE OF PROJECT

The objective of this project is to provide a nutritional, physiological, operational, and economic feasibility evaluation of utilizing selected food processing waste products as feed for farm livestock.

The project is to provide details on the characteristics of waste products and special nutritional and physiological requirements of livestock being fed food processing waste.

The project is to include analyses of preservation and storage methods of waste products for feeding purposes, special requirements and methods of waste feeding, and technical feeding requirements.

The feasibility evaluation is to include cost-benefit computations and evaluation of other pertinent economic factors.

The project is also to provide practical and operational answers, and economically viable solutions which can be utilized in agriculture thus yielding major benefits to both, the food processing and agricultural industries.

B. TERMS OF REFERENCE

The terms of reference of the project include the following:

- Identification and ranking, on the basis of economic returns, of selected solid processing wastes with potentials in terms of usage based on overall quantitative, nutritional, toxicological, treatment, storage, seasonality and other relevant aspects.
- Review and identification of environmental regulations affecting the disposal of food processing waste products.
- Comparison, on a cost basis, of methods of selected treatment processes for waste disposal versus treatment processes for the preparation as utilization for cattle feed.
- Identification of specific geographical locations of selected food processing plants with the volume of waste available and the livestock population within an economic radius.
- Identification of food processing waste by-products that can be used as animal feed supplements for ruminent livestock based on the relative feed values and other benefits.
- Analysis of transportation and related cost factors, logistics and economic radius of hauling waste by-products to farms or feedlots for direct feeding or storage and, where necessary, additional treatment for preservation. Provision of an analysis of transportation and related factors as well as logistics of transportation.
- Collection and review of research, experimental and scientific information, discussion of results in the course of field visits to selected food processors, farmers and feedlot operators, and procurement of practical experiences of feeding selected food processing waste to farm livestock.

- Provision of economic cost/benefit analyses and evaluations, conclusions and recommendations, as well as potential savings to the food processing industry in eliminating waste disposal and treatment expenditures through the utilization of waste products as feed for farm livestock.

C. GLOSSARY

DM - Dry Matter
TDN - Total Digestible Nutrients
CP - Crude Protein
DCP - Digestible Crude Protein
EE - Ether Extract
CF - Crude Fiber
Ca - Calcium
P - Phosphorus
K - Potassium
Se - Selenium
Mg - Magnesium
Cu - Copper
DE - Digestible Energy
NE - Net Energy
NE_L - Net Energy for Lactation
NE_M - Net Energy for Maintenance
NE_G - Net Energy for Gain
K Cal - Kilocalories
M Cal - Megacalories
FU - Feed Units
LW - Live Weight
LCR - Least Cost Rations
HRB - High Roughage Basis Ration
KJ - Kilo Joules
MJ - Mega Joules

D. SUMMARY AND CONCLUSIONS

The fruit and vegetable processing industry represents an important component in Canada's food processing activity. In 1979, there were 236 plants with 13,263 employees and shipments of $1.4 Billion.

Regulatory and environmental requirements place limitations on the disposal of processing waste resulting in difficulties in finding acceptable methods of disposal and increasing processing costs considerably. The estimated cost of disposing solid waste ranges from $5-7 per ton excluding supplemental internal plant costs.

Relatively limited work has been undertaken in Canada to find efficient methods of feeding tomato pomace, bean and carrot waste to livestock. With the exception of waste feeding on a few large feedlots and on some medium-sized farms, a considerable portion of the waste is still dumped. The limited use of waste for livestock feed, possibly due to inherent characteristics such as a very short season requiring fresh feeding or ensiling, transportation logistics, uncertainties on pesticide residuals, lack of solid feeding experimentation data, and absence of economic feasibility data, may result in a lack of risk-taking and commitment on the part of feedlot operators.

Results from a literature research, though rather limited, and discussions of these results with feedlot operators in Ontario, Quebec, California and Oregon, show that the feeding of tomato pomace, bean and carrot waste is generally safe, operationally feasible, and economically viable. With proper attention to nutritional requirements, metabolic limitations, feeding methods, physiological aspects, and preservation to improve the palatability, good gains have been achieved. Respective sections on the three products contain detailed and conclusive positive results.

Discussions with regulatory authorities, processors and feedlot operators showed that the various wastes are well within the stipulated pesticide residue levels; confidential information received from one source actually showed that the residue levels tested for 67 pesticides were considerably below permissible levels.

Waste feeding practices and methods, in most feedlot operations visited, were well organized. With proper care for nutritional requirements, breaking-in period, and a meticulous attention to all factors of cost/benefit aspects, the results were generally positive.

The transportation logistics did not present a problem in most cases. Where a regular pickup of waste by farmers or feedlot operators was not apparent, the processors either hauled the waste or had it transported by custom haulers. The costs appeared to be reasonable as long as the equipment could be gainfully used in the long off-season. Based on the value of waste compared with corn silage and hauling costs, an economic radius of approximately 17 miles for tomato pomace, 13 miles for bean waste and 19 miles for carrot waste was computed. Compared with alfalfa, the radius' would be 45, 35 and 50 miles respectively.

While there were some charges for the waste products to feedlot operators in California and Oregon (possibly due to the larger quantities, consistent supply over a 8-12 month growing and processing period, and better quality with respect to a higher dry matter content), few of the Canadian processors charged for the waste. A "material value" of waste mostly consisting of the transportation charges was established at $3.00 for the tomato pomace, $1.50 for the bean waste and $2.00 for the carrot waste. Supplementary costs include charges due to the pitting of the concrete in storage structures, shorter equipment life due to the acidity, extra costs in handling high moisture feeds (compared with conventional "dry" rations), and the loss of animals due to hardware disease. The total of these supplementary costs have been computed at about $3.50/ton of waste regardless of product. An additional transportation charge for the larger quantities of high moisture waste (in relation to home-grown feedstuffs) of $1.50/ton has been established for tomato pomace and carrot waste, and $1.00 for bean waste.

Through the courtesy of the staff of the Extension Department of the University of California, the benefits of waste vs. conventional rations were examined in 59 least cost rations run on its computer. We established a matrix of conventional and waste rations at different levels, specified constraints for each of the three products and for straight feedlot (growing and finishing steers), feeder/feedlot (growing and finishing steers), and dairy operations (heifers and lactating cows). Most of the rations were applicable in practice while some were rather impractical.

The nutritional evaluation of the least cost rations showed that all three products represent highly useful feeds for growing steers and dairy heifers, and, to a lesser degree, for finishing steers due to the higher energy needs. The utilization of waste for dairy cows is more limited in scope since most changes in the quality of the feed can have major effects on milk production.

The economic evaluation of the least cost rations shows most encouraging results with savings per feeding phase of waste rations vs. conventional rations, ranging from $10-$55 for straight feedlot growing steers, $40-$72 for feeder-feedlot growing steers and $20-$87 for dairy heifers depending on the percent of waste feed in the rations. The savings for finishing steers of straight feedlots and feeder-feedlots show a wider variation as the specified rates of gain and energy requirements did not always match the nutritional levels. The savings were highest for lactating dairy cows, ranging from about $80 to $200.

From the information contained in the least cost rations, the gross savings per ton of waste feed on an "as fed" basis were computed. For growing steers in a straight feedlot, they were about $10-$13 for tomato pomace,

$8-$9 for bean waste, and $10-$13 for carrot waste. For the feeder-feedlot and dairy heifer operations, they were higher for tomato pomace but lower for bean and carrot waste. The highest savings were achieved for all three wastes for lactating cows.

The total gross savings, based on the estimated available waste tonnages, would range between $373,000 to $727,000 per year (at constant dollars).

The returns per ton of waste feed, representing the difference between the gross savings and supplemental transportation and additional costs, were computed. They represent the returns to the feedlot operator and farmer for the risk-taking, commitment and related management efforts. Since the results were highly divergent, statistical averaging was unrealistic and a most probable range for the major uses established. The returns ranged from $10.50-$12.50 per ton for the tomato pomace, $7.50-$8.50 for bean waste, and $10.00-$11.00 for carrot waste.

The total savings to the processing industry from the elimination of disposal costs, would range between $193,000-$448,000 per year. The returns to the agricultural industry would range between $195,000-$444,000; the similarity between the two estimates, based on entirely different computations, is coincidental. The combined benefits ranging between $389,000 and $892,000 per year and at an assumed inflationary rate of 10%, would add to a cumulative $2.6-$6.0 million in 5 years,and $6.0-$14.0 in 10 years. These substantial results should provide sufficient incentives for the processing and agricultural industries to actively pursue further research and development in this field.

The extent of the recommendations, due to the facts that some feedlots are successfully feeding waste products, and that the major nutritional, physiological, pesticide residue, transportation and contractual facets are reasonably well solved, is relatively limited. We nevertheless recommend that more experiments on waste feeding, researching various aspects such as the digestibility of protein in fresh, ensiled and dried tomato pomace for instance, should be undertaken in Canada. Preservation research should quantify nutrient losses and protein changes in fermentation losses. More emphasis should also be given to pesticide research. And finally more local publicity should be given to the availability of waste products.

Concerted and coordinated efforts between the processing and agricultural industries, federal and provincial research branches and centres of expertise are anticipated to generate substantial benefits for the Canadian economy.

II. FOOD PROCESSING IN CANADA

A. INDUSTRY

The fruit and vegetable processing industries are an important component of Canadian food processing activity. There were 236 establishments in 1979, and the value of shipments was more than $1.4 billion. The distribution of these establishments across the country is shown below in Table 1 .

Table 1 Fruit and Vegetable Processing Industries in Canada

Provinces	No. of Est.	No. of Employees
Newfoundland	-	-
Prince Edward Island	3	X
Nova Scotia	12	537
New Brunswick	5	X
Quebec	59	1,965
Ontario	110	6,671
Manitoba	6	601
Saskatchewan	2	X
Alberta	6	X
British Columbia	33	1,398
Yukon and Northwest Territories	-	-
CANADA	236	13,263

Source: Statistics Canada, 32-218 Annual.

X Confidential to meet secrecy requirements of the Statistics Act.

About 72% of the firms are in Quebec and Ontario, and more than 65% of the 13,263 employed are in these two provinces.

B. PRODUCTION

The Canadian acreage of tomatoes, beans and carrots harvested for contract by/for processors in 1981 was 44,235 acres, with a farm value of $60 million (see Table 2). Tomatoes were the most important crop, respresenting 60% of the contracted acreage and 83% of the total value of the three crops.

Table 2 Area, Production and Value of Selected Processing Vegetables, Contracted and Harvested by or for Canadian Processors, 1981

	Area	Production	Value
	acres	tons	$'000
TOMATOES:			
CANADA	23,399	505,575	50,087
Maritimes	X	X	X
Quebec	378	3,756	384
Ontario	25,988	501,625	49,685
British Columbia	X	X	X
BEANS:			
CANADA	15,853	38,599	7,610
Maritimes	X	X	X
Quebec	7,218	18,008	3,205
Ontario	2,961	5,972	1,242
British Columbia	1,492	4,459	1,048
Prairies	X	X	X
CARROTS:			
CANADA	1,983	30,794	2,375

Source: Statistics Canada, 22-003 Seasonal
X Confidential to meet secrecy requirement of the Statistics Act.

Ontario produced 99% of the tomatoes grown for processing and the remainder were grown in Quebec. On the other hand Quebec produced about 47% of the beans, Ontario produced 15% and British Columbia produced about 12% of bean tonnage.

1. Quantity of Raw Product Acquired in Ontario and Quebec

Processing plants in Ontario acquired an average of 460,667 tons of produce annually over the 1977-1981 period (see Table 3). The tonnage ranged from a high of 505,381 tons of domestic tomatoes in 1981 to a low of 423,578 tons in 1980.

Domestic acquirements of tomatoes for processing in Quebec averaged 2,061 tons per year over the same period. The quantity ranged from a low of 1,162 tons in 1979 to a high of 3,756 tons in 1981.

The volume of domestic beans acquired for processing in Quebec averaged 22,847 tons per year between 1977-1981 and 10,035 tons in Ontario (see Table 3). The high and low ranges for Quebec were 24,804 tons in 1978 and 1980, and 18,008 tons in 1981. The high range in Ontario was 11,767 in 1979 and 5,972 tons in 1981.

Similar figures are not available for carrots and beets. Information compiled from plant visits in both provinces provide the following general estimates for annual acquisitions:

Carrots (3 plants reporting)	2,375 tons
Beets (1 plant reporting)	2,500 tons

2. Distribution of Vegetable Processing in Ontario and Quebec

The distribution of vegetable production and processing in Ontario and Quebec is shown by the locations of processing plants (see Figures 1 and 2). In Ontario there are areas of concentration. They are Kent and Essex counties, the Niagara Peninsula, and Prince Edward county area. The majority of the plants in Quebec are located in a relatively small area south and east of Montreal.

Table 3 Domestic Acquirements of Tomatoes and Beans for Processing in Quebec and Ontario, 1977-1981

	1977	1978	1979	1980	1981	Average
			(tons)			
TOMATOES						
Quebec	1,583	1,676	1,162	2,129	3,756	2,061
Ontario	462,607	464,555	453,099	421,449	501,625	460,667
Total	464,190	466,231	454,261	423,578	505,381	
BEANS						
Quebec	23,049	24,804	23,572	24,804	18,008	22,847
Ontario	10,522	10,904	11,767	11,008	5,972	10,035
Total	33,571	35,708	35,339	35,812	23,980	

Source: Special Compilation, Statistics Canada, August, 1981, Cat. No. 22-003 Seasonal

Figure 1

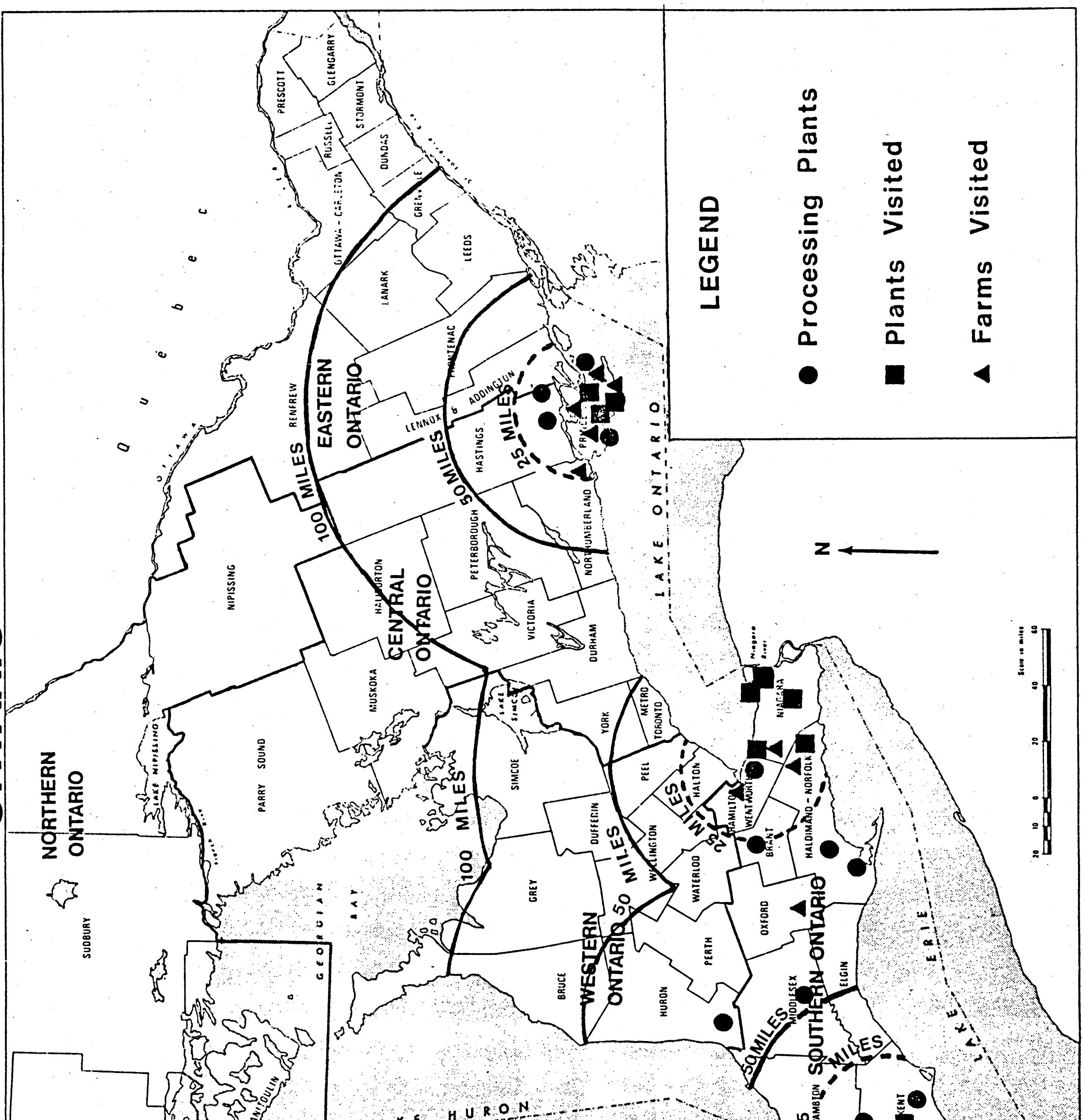
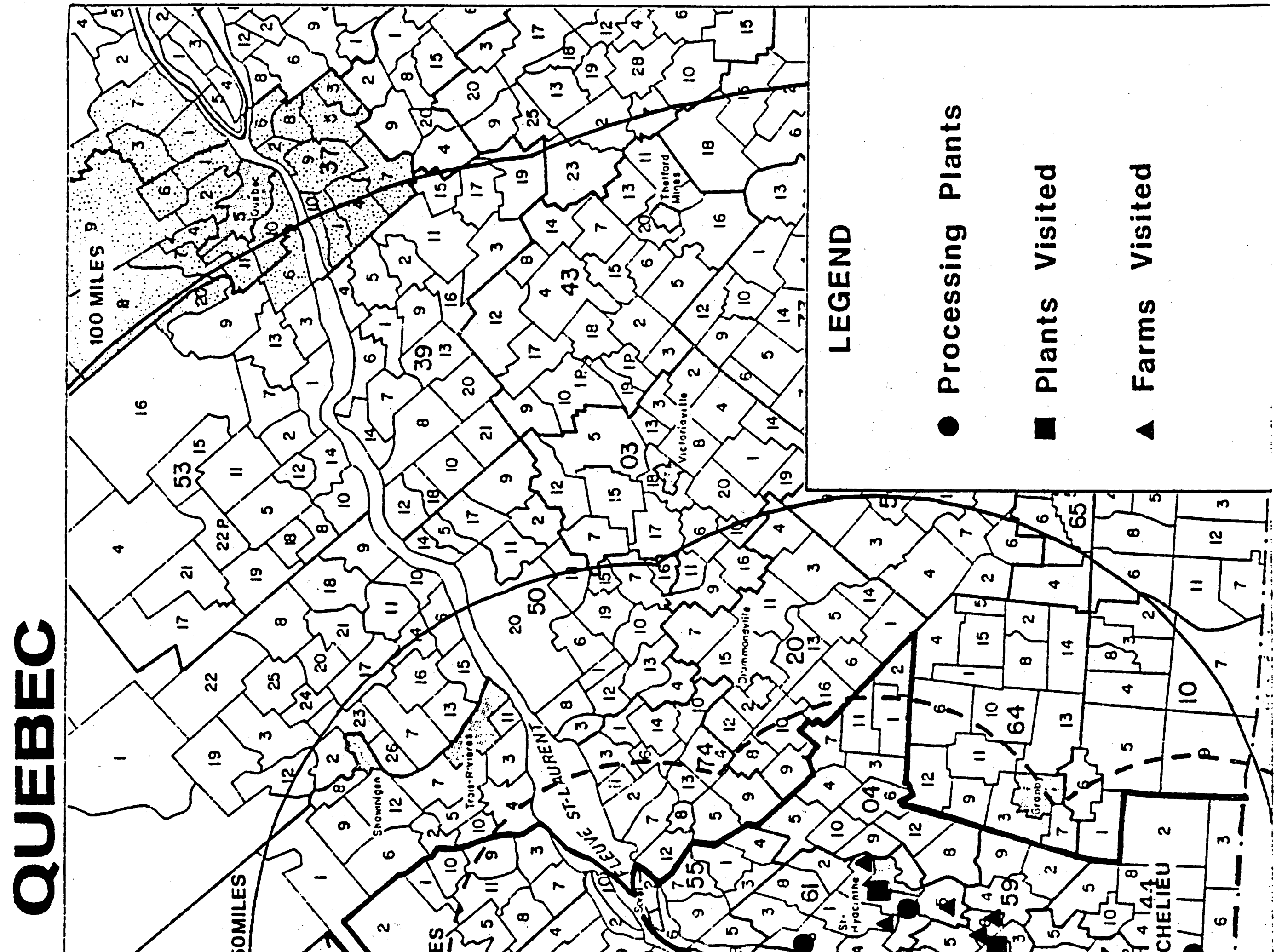

ONTARIO
NORTHERN ONTARIO
CENTRAL ONTARIO
EASTERN ONTARIO
WESTERN ONTARIO
SOUTHERN ONTARIO
100 MILES
50 MILES
25 MILES
LEGEND
● Processing Plants
■ Plants Visited
▲ Farms Visited
N
Scale in miles
20 10 0 20 40 60
Q u é b e c
United States
LAKE HURON
LAKE ONTARIO
LAKE ERIE
GEORGIAN BAY
LAKE NIPISSING
LAKE SIMCOE
LAKE ST. CLAIR
NORTH CHANNEL
OTTAWA
ALGOMA
SUDBURY
MANITOULIN
NIPISSING
PARRY SOUND
MUSKOKA
HALIBURTON
RENFREW
OTTAWA-CARLETON
PRESCOTT
RUSSELL
GLENGARRY
STORMONT
DUNDAS
GRENVILLE
LEEDS
LANARK
FRONTENAC
LENNOX & ADDINGTON
HASTINGS
PRINCE EDWARD
NORTHUMBERLAND
PETERBOROUGH
VICTORIA
DURHAM
YORK
METRO TORONTO
PEEL
HALTON
HAMILTON
WENTWORTH
NIAGARA
Niagara River
HALDIMAND-NORFOLK
BRANT
SIMCOE
DUFFERIN
WELLINGTON
WATERLOO
GREY
BRUCE
HURON
PERTH
OXFORD
MIDDLESEX
ELGIN
LAMBTON
KENT
ESSEX
St. Clair River
Detroit River

Figure 2


QUEBEC
LEGEND
● Processing Plants
■ Plants Visited
▲ Farms Visited
100 MILES
50 MILES
25 MILES
FLEUVE ST-LAURENT
NORD-DE-MONTRÉAL
SUD-OUEST-DE-MONTRÉAL
RICHELIEU
Québec
Thetford Mines
Victoriaville
Drummondville
Trois-Rivières
Shawinigan
Sorel
St-Hyacinthe
Granby
Joliette
Montréal
St-Jérôme
St-Jean
Valleyfield

C. ESTIMATED WASTE FROM SELECTED PRODUCTS

Estimates of solid waste residuals from processing vegetables vary considerably for each vegetable, depending on harvesting method, product processing, and type of processing equipment. In a review of data generated during the 1960s, U.S. researchers prepared some industry estimates for different vegetables.(1) These estimates are shown for four processing crops in Table 4 below.

Table 4 Wastes Generated from Selected Processing Crops

	Solid Residuals lbs/ton of Produce		Suspended Solids lbs/ton of Produce
Tomato	200	(10%)	4
Beans	420	(21%)	4
Beets	820	(41%)	50
Carrots	960	(48%)	40

According to Geisman, tomato waste in the form of pomace represents about 7% of the raw fruit by weight (2). Other researchers have carried out sample measurements of the discrete waste from processing beets and carrots (3). The discrete wastes are those retained in 7/64 inch square sieve. Samples were from a single plant. They are shown in Table 5 below.

Table 5 Discrete Waste Samples

	Raw Product Input tons/hour	Discrete Wastes lbs/hour	Waste Output lbs/ton	Percent
Beets	4.3	588.9	137	6.9%
Carrots	3.4	1689	497	24.9%

The figures are substantially lower than those cited by Rose et al, at the industry level. This could reflect any of several factors such as the type of equipment and/or the peeling process used. A comparison of waste output by conventional peeling versus dry caustic peeling of beets was made by Lee et al in 1972 (4). A plant with a conventional peeling line was compared with one equipped with a commercial scale "Magnuscrubber". The results are shown in Table 6 below.

Table 6 Comparison of Waste Output from Two Methods of Peeling Beets

Measurement*	Conventional Peeling	Dry Caustic Peeling
Raw beet input, ton/day	80	80
Water flow rate on peeling line gal/day	48,000	12,000
Total solids, lb/day	10,200	1,050
Suspended solids lb/day	340	40

*Average on 4 composite samples

The output of total solids per ton was 127.5 lbs with conventional peeling and 13 lbs with dry caustic peeling. No reference was made to any trimmed portion of the top and bottom of the beets. It is assumed therefore that the total solids listed represent only the beet skins.

The above discussion of U.S. data on fruit and vegetable processing wastes provides a useful background framework for interpreting estimates of wastes generated in Ontario and Quebec plants. Of the eight tomato processing plants visited, six provided estimates of solid tomato wastes. The estimates ranged from 1% to 12% of the raw fruit. Factors affecting the yield of waste included the type of product being processed, processing method, and method of harvesting the fruit. For example, dry wastes (skins and seeds) from hand-picked tomatoes generated the lowest percentage of wastes, while mixed dry and wet wastes from whole tomato processing or juice operations were in the 10-12% range. Other estimates of the proportion of wet waste generated appeared to fall in the 3-5% range.

Generally, mechanically harvested fruit, even though field sorted on conveyor belts, generated a higher proportion of waste because of vines, broken tomatoes and green tomatoes, which are not present in hand picked fruit.

Estimates of tomato wastes generated in Quebec and Ontario in 1980 were made by arbitrarily selecting two levels - 5% and 10%. The results are shown in Table 7 below.

Table 7 Estimates of Tomato Wastes Generated in Ontario and Quebec, 1980

In Tons

	Quantity of Tomatoes	Quantity of Waste	
		5% level	10% level
Quebec	2,129	196	212
Ontario	421,449	21,570	42,140

Based on the production contracted for processing in 1981 in Canada (see Table 2), the volume of tomato waste was 25,279 tons at the 5% level and 50,558 tons at the 10% level.

Estimates of bean wastes for different plants were identical at 15%. The waste contains leaves, stems, oversize and undersize beans. The total amount of beans processed by the two plants was in the order of 2500 tons, which would generate some 375 tons of bean wastes. This would have generated some 5,700 tons of waste in Canada at the 1981 level of harvesting.

Three plants that processed carrots estimated the level of solid waste from clippings and skins to range from 20-28% of the raw product weight. The three plants used about 2400 tons of raw carrots which, at a level of 25%, would generate some 600 tons of solid waste. Nationally, this is equivalent to about 7,700 tons of waste from 30,794 tons harvested for processing.

One plant handling beets reported estimates of raw products and wastes. The plant utilized 2500 tons of beet and generated 1000 tons of waste in total at a 40% rate. Half of the waste was in the form of solids and the other half was effluent. No estimates of beets for processing were available at the national level.

D. GEOGRAPHIC CORRELATION OF PROCESSING PLANT LOCATIONS AND LIVESTOCK POPULATION IN ONTARIO AND QUEBEC

There are 32 processing plants in Ontario and 12 in Quebec that process tomatoes, beans, carrots or beets.

The Ontario plants are concentrated in Essex and Kent Counties, with a second group in Prince Edward County (see Fig. 1). The remaining plants are distributed throughout the London-Niagara area. The largest processing plants are in the Essex-Kent and Niagara areas.

The 12 processing plants in Quebec are all located in the southern part of the province near Montreal (see Fig. 2). Three of the plants are located on the north shore of the St. Lawrence River between Ste Therése and Berthierville. The remaining 9 plants are located south and east of Montreal, mainly between Ormstown and St-Hyacinthe.

The number of cattle on farms and in feedlots within reasonable access distance to fruit and vegetable processing plants were estimated for Ontario and Quebec. A 50 mile radius was selected as being a reasonable distance to expect waste to be trucked for livestock feed. On this basis the cattle populations were tabulated by county in Ontario and by provincial statistical regions in Quebec (see Tables 8 and 9). Because of the size and shape of different counties in relation to plant location some cattle will obviously be considerably beyond the selected 50 mile radius. Further refinement of this approach would require detailed analysis of census data using census subdivisions and enumeration areas.

The cattle were classified into six groups that could be identified according to different feed ration criteria. The six groups were milking (dairy cows), non-milking (dairy heifers), cow/calf (beef cows and heifers), feedlot (slaughter heifers and steers), calves under one year, and bulls.

Ontario was divided into three areas for this analysis. Area 1 includes the 10 counties of southern Ontario. Area 2 includes Huron, Perth and Waterloo because of one processing plant in Huron county and Waterloo county is within access of a plant in Brant county. Wellington county was not included because only a small portion was within any reasonable access to processing plants. Area 3 includes the counties adjacent to processing plants in Hastings and Prince Edward counties.

Data from Quebec were available only for statistical regions which are groups of counties. The three agricultural statistic regions surrounding the processing plants were Richelieu, Sud-Ouest-de-Montreal, and Nord-de-Montreal.

There were more than 1.2 million head of cattle within reasonable access of the 30 fruit and vegetable processing plants in Ontario as of July 1, 1980 (see Fig. 1 and Table 8). In Quebec, there were some 269,000 cattle within access to the 12 processing plants there (see Fig. 2 and Table 9).

Table 8 Number of Cattle in Selected Ontario Counties, within Access to Processing Plants, July 1, 1980.

	Milking	Non-Milking	Cow/Calf			Feedlot			
				Beef Heifers					
Counties & Districts	Dairy Cows	Dairy Heifers One Year & Over	Beef Cows	Breeding One Year & Over	Slaughter One Year & Over	Steers One Year & Over	Calves Under One Year	Bulls One Year & Over	Total Cattle
AREA 1									
Brant	6,200	4,000	2,000	800	1,500	8,000	3,300	200	26,000
Elgin	7,600	2,500	5,500	1,100	6,600	17,000	8,600	300	49,200
Essex	4,400	1,500	900	500	2,200	2,400	1,800	200	13,900
Haldmand-Norfolk	14,000	5,900	6,100	1,700	2,000	17,000	12,000	700	59,400
Hamilton-Wentworth	6,200	2,900	3,500	900	4,100	6,600	4,900	300	29,400
Kent	1,000	300	3,200	900	5,500	27,000	4,800	200	42,900
Lambton	7,600	3,200	13,000	2,900	10,000	39,000	8,000	900	84,600
Middlesex	22,000	8,800	16,000	3,600	29,000	46,000	21,000	1,600	148,000
Niagara	10,000	3,900	3,400	1,500	1,100	2,000	9,600	500	32,000
Oxford	34,000	14,000	6,400	2,100	10,000	45,000	18,000	2,100	131,600
Area 1 Total	113,000	47,000	60,000	16,000	72,000	210,000	92,000	7,000	617,000
			76,000		282,000				
AREA 2									
Huron	26,000	8,000	19,000	5,400	44,000	60,000	28,000	1,900	192,300
Perth	36,000	17,000	13,000	6,500	21,000	30,000	27,000	1,000	151,500
Waterloo	14,000	8,600	7,500	2,100	7,000	36,000	19,000	1,000	95,200
Area 2 Total	76,000	33,600	39,500	14,000	72,000	126,000	74,000	3,900	439,000
			53,500		198,000				
AREA 3									
Frontenac	7,900	3,200	7,600	2,200	600	2,100	9,000	500	33,100
Hastings	14,000	8,300	10,000	2,300	600	3,100	14,000	1,100	53,400
Lennox & Addington	7,400	4,000	6,800	2,800	300	4,000	8,900	600	34,800
Northumberland	14,000	6,100	8,900	2,200	4,500	8,500	18,000	800	63,000
Prince Edward	8,700	4,000	3,000	700	300	1,000	6,100	200	24,000

Cont'd

Table 8 Cont'd

Area 3 Total	52,000	25,600	36,300	10,200	6,300	18,700	56,000	3,200	208,300
			46,500		25,000				
Total, Ontario Region	241,000	106,200	135,800	40,200	150,300	354,700	222,000	14,100	1,264,300
			176,000		505,000				

* within approximately 50 miles

Source: OMAF Pub. 20, 1980.

Table 9 Number of Cattle in Selected Agricultural Regions of Québec, July 1, 1980,* where Food Processing Plants are Located

	Milking	Non-Milking	Cow/Calf		Feedlot				
Agricultural Regions**	Dairy Cows	Dairy Heifers	Beef Cows	Beef Heifers	Beef Heifers Slaughter	Steers	Calves	Bulls	Total
Richelieu	68,900	47,900	14,500	3,800	1,800	3,600	23,700	4,400	168,600
			18,300		5,400				
Sud-Ouest-de-Montréal	45,800	31,800	16,100	4,300	2,000	6,300	17,800	2,500	126,600
			20,400		8,300				
Nord-de-Montréal	26,800	18,700	8,200	2,200	1,000	1,000	14,000	2,300	74,200
			10,400		2,000				
Total, Québec Region	141,500	98,400	38,800	10,300	4,800	10,900	55,500	9,200	269,400
			49,100		15,700				

* Separation of cows and heifers by region is based on ratios at the provincial level for beef and using the Ontario provincial ratio for dairy cows/heifers

** Richelieu

Bagot
Chambly
Iberville
Missisquoi
Richelieu
Rouville
St-Hyacinthe
Verchéres

Sud-Ouest-de-Montréal

Beauharnois
Chateauguay
Huntingdon
Laprairie
Napierville
Soulanges
St-Jean
Vaudreuil

Nord-de-Montréal

Berthier
Deux-Montagnes
Iles de Montréal & Jésus
Joliette
L'Assomption
Montcalm
Terrebonne

Source: Québec Department of Agriculture, preliminary estimates.

References:

(1) Rose et al, "Production and Disposal Practices for Liquid Wastes From Canning and Freezing Fruits and Vegetables" Proceedings, National Symposium on Food Processing Wastes, pp. 109-127.

(2) J.R. Geisman, "Tomato Seed: A Valuable Wasted Resource", Journal Article No. 56-81 of the Ohio Agricultural Research and Development Center, Wooster, OH 44691.

(3) K.G. Weckel, R.S. Rambo, R. Veloso, "Vegetable Canning - Process Wastes", Proceedings SOS/70 Third International Congress Food Science and Technology, Washington, D.C., August 1970, pp. 895-903.

(4) C.Y. Lee, D.L. Downing, Y.D. Hang, P.H. Russell, "Waste Reduction in Table Beet Proceedings Fourth National Symposium on Food Processing Wastes, Environmental Protection Series EPA-660/2-73-031, December 1973, pp. 66-70.

III. DISPOSAL OF SELECTED WASTE IN CANADA

A. INTRODUCTION

A description of the various categories of food processing waste is necessary prior to the review of the different methods of disposal. This section contains only a summarized description of waste while specific characteristics, dry matter, acidity, etc. are described in more detail in Section V dealing with the feeding of waste to livestock.

The characteristics of waste change from product to product. Depending on the harvesting, processing and plant waste operations, there are differences between the four principal waste products from tomatoes as follows:

- In some plants, a pre-wash cycle eliminates sand, earth, stones, rocks, foreign matter and, in some cases, broken green and over ripe tomatoes. In many instances this waste is used directly as landfill.
- The "wet" waste, principally consisting of the skin, seeds and core, originates from the processing cycle in some plants where the pressing of the tomatoes for catsup, paste, juice etc., is not as efficient as in other plants, or where the "dry" waste is mixed with "wet" waste, or transported in flumes to the loading dock. The dry matter (DM) of "Wet" waste can vary from 10 to 16%.
- The "dry" waste originates from the processing and cooking of the tomatoes using high pressure water extraction methods and thus leaving a relatively "dry" waste product with a DM ranging between 18 and 40%.
- The effluent contains particles, most of which are suspended in water. The Biochemical Oxygen Demand (BOD) of the effluent is relatively high.

The carrot waste contains the peelings, bottom, and in some cases, depending on the harvesting methods, a portion of the top. No distinction was made between "wet" and "dry" waste; the same principal differences as for tomato pomace would also apply for carrot waste.

The composition of the waste from string beans varies greatly depending on the variety, the time of harvesting and the care given to the mechanical harvesting process by the grower. In some cases, a considerable portion of the waste consists of stems and leaves, in other cases, it is very small. The waste also includes the ends, and pieces which are too short and too long.

A considerable portion of food processing waste is still disposed of in various ways instead of being utilized. Most of the processing plants visited in Ontario and Quebec however, are arranging for the utilization of the tomato pomace, bean and carrot waste by either shipping it or having it hauled to farms and feedlot operations.

Since the waste for disposal is hauled practically on a continuing basis during the processing season, the discussions with processors revealed that none was using any form of concentration, preservation additives, or chemical or biological treatment. Nor were they required in the various areas to treat the waste prior to the disposal. We learned that new regulations in one community required the compaction of all waste products and garbage. While in the past, "solid waste" was at times dumped into sewer systems or onto dumps with effluents, in other communities, it has now to be segregated.

B. REGULATORY ASPECTS

Regulations governing solid waste disposal from food processing plants are primarily a provincial responsibility. The main legislative framework is provincial, with local municipalities also having the authority to make regulations in this area. Federal involvement in solid waste disposal regulation is at a secondary level - for example where effluent from the waste is moving into interprovincial or international waters. Each province has different legislative and regulatory means to deal with solid wastes.

Ontario has at least three Acts that may have application for solid waste disposal. They are:

1. Environmental Protection Act, 1971
   Its objective is the protection and conservation of the natural environment. The Act contains detailed regulatory procedures and standards for solid waste treatment and disposal. It is the major regulatory mechanism for solid waste in Ontario and is administered by the Ministry of the Environment.
2. Ontario Water Resources Act
3. Pollution Abatement Incentives Act.

Local municipalities also impose regulations on handling and disposal of solid wastes under the following:

1. The Planning Act
2. Ontario Municipal Act
3. Public Health Act.

According to one official of the Ontario Ministry of the Environment, solid waste from a food processing plant is most likely to be handled under Regulation 229/74 (Sewage Systems) of the Environmental Protection Act. It would be treated as the operation of a Class 7 sewage system. The plant would be required to:

- Contract with an approved hauler
- Complete suitable weigh bills

- Have wastes taken to an approved waste disposal site.

This can be a very complex, time-consuming and expensive process, depending on the:

- Location of the plant
- Type of solid waste
- Volume of solid waste
- Frequency of disposal
- Location and type of disposal site
- Ownership of disposal site
- Municipality in which the disposal site is located.

An example of what is involved in this regard is the "Application for a Certificate of Approval and Permit for the Operation of a Class 7 Sewage System"; together with the requirements for supporting information (see attached details). Even with this detailed careful approach, there is no certainty that the plant operator will be able to have the waste moved to the disposal site without extensive liaison and coordination with other provincial and municipal agencies that have their own specific regulatory concerns under some of the other Acts cited above. Also, problems can arise at disposal sites that processors are already using - such as higher than expected volumes of waste or seepage of effluent into the ground water as indicated where the cause of a reportedly unbearable stench was largely the type of soil plus the excess waste coming from a processing plant during tomato processing season. When the wet sludge is dumped on the sandy soil, it becomes oozing, rolling mud. The City Council requested better treatment of the town's sludge and suggested prohibiting more sludge from the town being dumped there for the time being. But such action would play havoc with the processor and the tomato growers who supply it.

The Ontario Ministry of the Environment had asked the site operators to cover the waste properly. A hydro-geological study of the underground movement of waste is being done through the ministry.

Ministry of the Environment
Ontario

Application For a Certificate of Approval and Permit For the Operation of a Class 7 Sewage System

III-5

Application No. ____________

Date Received ____________

Fee Receipt No. ____________

(Please Print Clearly)

1. Name of Licence Holder	Telephone Number	Address (No. Street, ... City, Town, etc) ....
Class 2 Licence No.	Date Licence Issued/Renewed	2. Check Service to be Performed Emptying ☐ Hauling ☐ Storing ☐ Disposing ☐

3. Area of Operations: State Region(s), District(s) and Municipality(s) in which operation intended. If a licenced hauler proposes to haul sewage from areas under more than one authority or to a disposal site in an area controlled by another authority, then a Certificate of Approval and Use Permit are required from each authority. If barge operation, list lake(s) served and docks to be used. (attach additional sheets if required)

____

____

____

____

____

4. Attach following supporting information as applicable and check X if attached.

(a) Details or any major equipment to be used in connection with the work covered in this application, (make, year and model, licence number P.C.V. licence, colour, hose length, type and horsepower of pumps, barge dimensions and draft, carrying capacity, etc., as applicable) .... ☐

(b) Describe disposal site (Location, Lot No., Con. No., Municipality and owner's name). Attach copies of letters of agreement with owner(s) of the disposal site or person in charge of a treatment plant .... ☐

(c) Sketch showing details of the land disposal site .... ☐

(d) Plans and design details of any works related to the proposal that must be undertaken and completed before operations commence, (e.g. works at disposal sites, temporary storage facilities, barges, docks.) .... ☐

(e) Tabulate the source(s) of hauled sewage (e.g. holding tank, septic tank, aerobic tank) and the estimated annual quantity from each source to be dumped at each disposal site .... ☐

(f) Other attachments (specify) ____________

____________ ☐

5. The above application and attachments as indicated are submitted for approval

this ________ day of ____________ 19___ by ____________
(Signature of Holder)

6. For Office Use Only

(a) Application reviewed including necessary inspections of equipment, installations and disposal sites by ____________

(b) Recommended for:

(i) Issue of Certificate of Approval with Permit to follow successful completion of requirements noted thereon .... ☐

(ii) Issue of Certificate of Approval and Permit to Operate .... ☐

____
Date

____
(Inspector or Supervisor)

MOE 1061 (4/73)

APPLICANT'S COPY

CLASS 7 SEWAGE DISPOSAL SYSTEM

Supporting Information to an Application for a Certificate of Approval for a Class 7 Disposal Site System

1. Applicant - name, address
2. Site Owner - name, address
3. Operator/s - name, address
4. Site Location
   - a) location, map showing location and its relationship to villages, roadways, residences, wells, bodies of water, etc.
   - b) map showing municipality, lot, concession, highway and streets.
   - c) total area of site, total usable area for waste disposal.
5. Existing and Proposed Land Use
   - for site and adjacent properties.
   - conformity with official plans.
6. Planned Travel Routes to Site
7. Waste Characteristics
   - a) estimation of annual quantity of septage from each source; septic tanks, holding tanks, aerobic tanks, other; to be disposed of at site.
   - b) outline any unfamiliar wastes that may be disposed of at site or within site boundaries.
8. Site Plan
   - a) general details related to the hydrogeological, geographical and topographical conditions of site.
   - b) slope of land, water table, contours, soil type, etc.
   - c) effect of proposal on surrounding area.
   - d) description on development of site, e.g. gates, fencing, grubbing.
   - e) application rate of disposal.
   - f) control of pollution related problems.
9. Site Operation
   - a) method of operation.
   - b) control operations within site.
   - c) site and insect control measures.
10. Equipment
    - details on major equipment requirements.

11. Alternate Operations
    a) winter operations - if lagoon to be used, hearing may be required;
    b) list alternate sites being used by applicant.

12. Approval
    - Municipality's approval (if applicable)
    - Regional Municipality's approval (if applicable)
    - Medical Officer of Health's approval

13. Supporting Documents
    - plans, maps, legal documents, if necessary, for land ownership;
    - data related to previous operation.

Until a few years ago, environmental regulations for the dumping of food processing waste into sewers or on municipal dumps and landfill sites were either non-existent or rather light. Lately, some municipalities have instituted regulations with regard to the monitoring of waste for dumping.

The new landfill stipulations in some areas of Ontario require that any waste will have to be compacted. Wet tomato pomace therefore, may no longer be allowed to be dumped in landfill sites in the future. In past years, the waste was not segregated. It is being done now between solid waste and effluents. It was also indicated that a permit from the Ontario Ministry of the Environment was required to haul tomato waste to private dump sites. Some companies find it uneconomical to haul to municipal dump sites. Companies have been assessed surcharges of up to $10,000 per year. As a result, some of them were dumping their vegetable wastes in undisclosed locations which, until recently, did not require a permit. Their waste shipments are continually monitored.

Processors in another area reported that environmental requirements did not present problems either for the lagoon, spraying, landfill or fertilization disposal. Regular inspections were being undertaken, and the environmental inspectors seemed to be satisfied with the disposal methods.

Waste disposal in Quebec is governed primarily by two provincial statutes. They are:

1. Qualité de l'Environment (1972)
   This Act establishes the conditions and criteria for waste treatment plants in Quebec, as well as type of treatment. Section 7 of the Act deals specifically with solid wastes. Liquid waste management regulations are promulgated under this Act as well. Licensing and inspection of municipal treatment facilities are carried out by the Province.

2. Gestion des Déchets Solides (1978)
   The Solid Waste Management Act established standards for the kinds of wastes that are to be accepted at municipal and private sanitary landfill or waste disposal sites. These sites are licensed and inspected by the Province. The Act has recently been amended to deal with water quality problems around landfill and disposal sites on the basis of soil type and rate of water movement in the soil. One of the major problems of selecting suitable new solid waste disposal sites in Quebec stems from provincial zoning of agricultural land, which preserves agricultural land for food production.

Food processing wastes can be disposed of through existing municipal treatment facilities and disposal sites. They do not appear to be considered as a problem at this time.

C. METHODS OF DISPOSAL

1. Disposal on Municipal or Private Land Sites or Dumps

Food processing companies, who either disposed of all or a portion of the generally "wet" or "non-feedable" waste, supplied details on the disposal of their wastes and related costs. They included transportation costs and fees imposed by communities for landfill sites, dumps, and other municipal land uses. Details could not be obtained for the solid tomato, carrot or bean waste disposal, because the costs either included all vegetable and fruit wastes, or were combined for solid waste and effluents. The costs for the latter appear to overshadow the solid waste disposal costs, due to much larger quantities, BOD and other waste treatment requirements.

One processor stated that its tomato waste was transported onto a land site some 20 miles away from the plant. The total cost to the company was $60,000 per year for disposing of its solid waste. Since the average cost per ton exceeded customary costs, we assume that the total cost includes all vegetable and fruit waste.

Another company disposes of its "dry" tomato waste by having it picked up by a drying company. The wet waste is shipped to landfill sites by a hauling company.

The disposal of solid beet waste by another processor has to be carefully monitored, so that the juice won't run from the plant into the creek adjoining it; or from the hauling trucks onto the roads, leading away from the plant. An independent trucking company hauls the solid waste to an undisclosed dumpsite.

2. Spreading of, or Fertilization with Processing Waste

Some processors are spreading the tomato pomace on their own farm land or have it hauled away for fertilizing neighbouring farms. One farmer visited has been spreading tomato pomace for twenty-five years with good results on two farms comprising of 300 acres. He hauls about 600 tons of tomato waste per year, at approximately three loads of 6-7 tons per day during the canning season. The tomato waste is put on corn, beans or tomatoes and plowed under prior to the next year's crops. An estimated 50 tons are spread per acre on a rotation of every 3-5 years. The tomato pomace is dumped in piles and levelled with a bulldozer. On the hilly farm extra heavy amounts are spread on the sandy hills. This farmer considers the practice of making piles and later levelling them not very efficient due to the uneven spreading. The use of a manure spreader is not practical at all because the tomato pomace is too wet to be spread evenly over the fields.

The fertilizer value of tomato waste is not considered to be very high by this farmer, but he claims that some benefits have been obtained on the sandy hills. He also found that several years after the application, the tomato seeds break down slowly, providing nitrogen to the soil.

When other farmers were asked if they would spread tomato waste on their land, some indicated that they were not interested, providing no particular reasons. Others stated that in their area (the Province of Quebec), it was forbidden to spread carrot and tomato waste on fields and plow it under.

A processor disposes of his bean waste by hauling it to five or six farms, located 1-4 miles from the plant. This waste is spread on different fields, depending on the crop rotation practice. Due to the rapid breakdown of the leaves and pods, the hauling and spreading has to be done several times per day.

One of several farmers in a cash crop area has been spreading solid bean waste on his fields for fifteen years. His cash crop farm lies within one mile of the processing plant, resulting in minimal transportation costs. The Company arranged with a number of client cash crop farmers in that area to spread bean waste on a "mutual favour" basis. This enabled the plant to operate at no additional cost to the company in return for the disposal of the bean waste. The bean waste is spread very thinly (almost "tissue paper" thickness) onto the fields. The waste is rather wet. About 15 tons per acre or approximately 2 tons of solid matter per acre are spread on the land for cultivation in the following year but not on grass or pasture. No visible fertilizing benefits have been claimed by this farmer. He has his soil tested each year for fertilizer needs. The results show the identical fertilizer needs for waste-covered land, as well as for "non-waste-fertilized" fields. The farmer feels that this absence of benefits on the bean waste-covered land is probably due to a low coverage rate. On the other hand, he is not interested in spreading large quantities of bean waste on his land, the savings in fertilizer could be offset by his land being infested with weed seeds from fields where the beans were harvested.

Another farmer in the same area, within two miles of the food processing company, also spreads solid bean waste as a fertilizer. This particular cash crop farmer has been practicing this procedure for the last three to four years. The waste is spread on clay loam land for crops such as wheat, tomatoes and beans in the following year.

Much like the previously mentioned farmer, he also does not see any savings in fertilizer requirements, after testing his soil every year. He does feel, however, that the benefits of bean waste fertilization helps to put organic matter into the soil which is of benefit to him since he does not have a supply of manure for his fields. Another farmer, although not in a position to provide figures of increased yield, definitely noticed a higher growth of grass on the pasture, as well as increased yields after the spreading of bean waste.

3. Disposal of Effluents

The disposal of effluents is quite a different process from the disposal of solid wastes and has been covered extensively in the three reports issued by the Water Pollution Control Directorate of Environment Canada entitled: "Evaluation of Physical and Chemical Technologies for Water Re-Use, Byproduct Recovery and Waste Water Treatment in the Food Processing Industry" (Report EPS3-WP-79-3, April 1979); "Biological Treatment of Food Processing Waste Water: Design and Operations Manual" (Report EPS3-WP-79-7, October 1979); and "Design and Selection of Small Waste Water Treatment Systems" (Report EPS3-WP-80-3, March 1980).

One company disposing of tomato plant effluents pumps the waste into an aerobic lagoon or sludge pond of some 25,000 square feet, located next to the plant. Some effluent is spread onto farmland adjoining the company's premises with an ordinary spray nozzle irrigation system, covering about 5 acres. There is no particular spray pattern. After careful inspections of the field it was reported that the effluent produces an excellent forage and grazing crop, to be cut as often as every two weeks.

Another company pumps the effluent from tomato processing into an oxidation ditch to lower the BOD, to a clarifier and a clear water facility, and finally into an open ditch system. The settled solids are pumped back into the oxidation ditch system. This system has to be cleaned out once a year, with the sludge spread on land and dried. There is not much feed value because of sand and other solid particles contained in the waste.

The effluents from beet processing have to be carefully checked and treated prior to the discharge into the sewage system. It requires a thorough pretreatment and screening especially for pH neutralization.

D. DISPOSAL COSTS

The costs of disposing solid waste, including transportation, dump charges on municipal or private sites, and permits vary from plant to plant and region to region.

Some processors are hauling solid waste onto company-owned farms. One company indicated that a temporary permit was required, but no questions asked as to where it was being hauled and dumped. Another company visited incurs very little out-of-pocket costs since it hauls the waste in company-owned trucks and water tight dump boxes. The waste is dumped onto non-productive land, with no cost incurred for the use of the land.

One processor pays a hauler $204 for a load of 12 cu. yds. of waste carted away. This is made up of a $120.00 haulage charge, and $7.00 per cu. yd. dump fee. The waste is hauled about 25 miles to a private landfill site. The capacity of the container was given at about 7-8 tons. The costs are thus about $1.00 per ton mile which appear to be unusually high. Another company pays to a custom hauler $27.00 per load of 6-8 tons (or $4-4.50/ton) of waste removed. Purchase orders are issued with the condition that he has to take all waste and provide reliable hauling service whenever needed.

Some waste is hauled to municipal landfill sites. One company hauls 3,200 tons of flume waste, containing 30% screening waste. The screening waste is hauled by a trucking contractor, at a cost of $3.00 per ton, onto a municipal landfill site 3 miles from the plant. For another company, the cost of dumping tomato and apple waste was approximately $30-40,000, with a surcharge by the city to use the local dump. The waste dumped included 20,000 tons of tomato waste and 10-15,000 tons of apple waste. The hauling and dumping charge was thus about $1.00 per ton of waste. At an earlier date this company was quite willing to provide the apple and tomato pomace free of charge for the hauling. They found that farmers in the vicinity were not equipped to haul all the waste to be fed or ensiled. One company has the advantage of dumping solid waste in a municipal dump for which there are no extra municipal charges over and above the regular municipal taxes.

One processor provided detailed costs. The disposal costs of the tomato waste (solid and effluent as such) including labour, was $1.26/ton. The total costs of disposing of the waste of all products was $1.54/ton.

Since waste is neither compressed, preserved, nor chemically or biologically treated, additional costs are eliminated.

IV. DISPOSAL OF SELECTED WASTE IN THE U.S., SPECIFICALLY IN CALIFORNIA AND OREGON

A. INTRODUCTION

Details on the disposal of food processing waste are not available for recent years. In the 1979 report entitled "A Guide for Waste Management in the Food Processing Industry" by the Food Processors Institute and edited by A. Katsuyama of the Western Regional Research Laboratory of the National Food Processors Association, the following statistics have been provided for 1968, Table 10.

Table 10
Disposal Methods and Utilization of
Selected Food Processing Waste in the U.S., 1968

in 000 tons

	Tomato Pomace	Snap Bean Waste	Carrot Waste
Disposal, solid			
Landfill	250	35	6
Spreading	130	32	30
Disposal, liquid			
Water, sewer, etc.	30	3	2
DISPOSAL, TOTAL	410	70	38
Feed	120	64	100
TOTAL WASTE*	520	130	140

* Not additive due to rounding

The disposal of 410,000 tons of tomato pomace or 79% of the total waste, would appear to be unusually high for current conditions and based on visits to some food processors in California and Oregon. Even the proportion of 54% for snap bean waste and particularly of 27% for carrot waste, a sought-after waste product, would appear to be high for today's conditions.

Examples to this effect were provided by some processors. One company provided the following breakdown of solid waste utilization/disposal for two plants, Table 11:

Table 11 Utilization/Disposal of Solid Waste by a Processing Company

	Plant A	Plant B
Pre-Clean waste incl. Mud and Rocks for Landfill	4,270 cu.yd.	1,770 tons
Processing Waste for Feed	44,700 tons	12,700 tons
Processing Waste for Spreading	500 tons	-
Plant and Packaging Waste incl. cans, paper, fibre, pallets, etc.	6,570 cu.yd.	1,140 tons

Other processors, while not providing detailed statistics, also indicated that practically all waste products suitable for feeding were supplied for that purpose.

B. REGULATORY ASPECTS

Environmental laws and regulations governing waste management and disposal by food processors have been enacted at the federal, state and local levels. Protection of water quality was initiated at the federal level under the (U.S.) Federal Water Pollution Control Act (FWPCA) of 1956 and subsequently amended several times. The various States have also established water quality standards as mandated by the FWPCA, and established additional specific criteria or standards.

The (U.S.) Federal Safe Drinking Water Act was enacted in 1974. Regulations promulgated under this Act set certain standards for specific constituents. Maximum contaminant levels were set at that time for selected contaminants of concern. They are listed in Table 12 below:

Table 12

Contaminants Listed in the National Primary Drinking Water Regulations

Inorganic Chemicals	Organic Chemicals	Other
Arsenic	Chlorinated Hydrocarbons:	Coliform Bacteria
Barium		Turbidity
Cadmium	Endrin	Radioactive material:
Chromium	Lindane	radium-226
Lead	Methoxychlor	radium-228
Mercury	Toxaphene	gross alpha particles
Nitrate	Chlorophenoxys:	Man-made radionuclides:
Selenium	2, 4-D	beta particles
Silver	2, 4, 5-TP Silvex	photon radioactivity

Source: "A Guide for Waste Management in Food Process Industry," National Food Processors Association (U.S.).

Of note in this regard are the chlorinated hydrocarbons, such as, toxaphene and lindane, that are still in use as agricultural chemicals in the United States.

The U.S. Congress enacted the Resource Conservation and Recovery Act in 1976 to deal with plans and programs for solid waste management, however the laws and regulations promulgated by state and local agencies in accordance with the mandates of this Act are said to be of greater and more direct significance to the food processors - especially those conducting their own solid waste disposal operations.

Discussions with food processors, waste haulers, farmers and rangers in California and Oregon reflected this situation. In California,regulations of solid waste management and disposal rest at the county level where licenses and permits are issued and regulations are enforced. The responsibility appears to lie with the processors to ensure that the waste generated is managed according to specific criteria outlined in their permits, and that they pay the related costs, including any waste treatment. If the wastes are removed to some other location or for another use, they are the responsibility of the processors, unless they are covered by another permit, (eg. another company that dries food wastes for feed), or are picked up by a farmer for feed.

Pesticide residues do not appear to be considered as a problem in the disposal of food processing wastes in either Oregon or California. This applies to both solid wastes and plant effluents.

The regulatory agency for waste programs in California is the State Water Resources Control Board, Sacremento. In Oregon it is the Department of Environmental Quality in Portland.

Similarly with solid wastes, the programs in California are under the Solid Waste Management Board, Sacremento, and in Oregon under the Solid Waste Division of the Dept. of Environmental Quality, Portland.

C. METHODS OF DISPOSAL

1. Landfill and Fertilization

Food processors dispose of solid wastes in three ways, dumping on landfill sites, spreading on agricultural or waste land, and burning.

According to the previously-mentioned survey, more than half the landfill sites used by the industry are publicly owned and operated. Most of the land spreading sites are owned either by the processors or private farmers and ranchers. Burning sites were largely either on the processor's property or on publicly-owned land. It should be noted that these data are based on information received in 1968 and it has not been established if the burning of waste is still allowed under the current EPA regulations.

Most of the landfill and land spreading sites were within a 10 mile radius from the plants. A variety of land was used for landfill such as pits, quarries, marshes, tidelands. A high proportion of land spreading sites was on agricultural land or less productive fields.

Three processors visited used sanitary landfill sites for most of their plant waste. One company hired a garbage collecting firm to haul the waste to landfills. Problems were encountered only with bean waste, whose fibre in the stems and vines does not decompose as quickly as other wastes. Another processor sent mud from the washing operation to landfills. The peeler-scrubber waste of carrots had to be treated with CO_2 to neutralize the alkali peels to dispose of in landfills. If this were not done, the waste would have to be classified by type and checked by county officials. The cost per ton of CO_2 was given at $2.00. The CO_2 treatment appears to be cheaper than separating and classifying the waste and observing the county regulations.

In the course of the field work, we did not encounter processors or farmers who were spreading solid waste on land for fertilization and/or soil improvement. Reasons could include our primary objective of visiting plants and farmers who were utilizing rather than disposing the waste, and intensive land cultivation with irrigation yielding several crops per year with few opportunities of spreading waste on less productive land.

2. Effluent Disposal

Waste effluents are either disposed of in sewer systems or sprayed on land. One city has two waste purification plants: one for the city sewage, and another for industrial waste. The costs of waste disposal to one processor for example are considerably lower (approximately $100,000-$150,000 for two plants for the waste water) compared to the disposal in the city's purification plant. The effluents of both plants are disposed of in the industrial waste treatment plant. The sludge from steam-peeled potatoes is also put into that stream.

One company dumped carrot peelings directly into the city sewer system. The city checks daily the BOD, suspended solids, and total flow of effluents into the system. This company is also exploring the transporting of slurry by tank truck to farmland for fertilizer. Carrot peelings or waste, which do not go through a 40 mesh screen, are added to the waste feed stream.

Effluents from the bean, carrot and beet processing are sprayed by a processor on irrigation land. A problem of nitrogen buildup in the soil may occur after spraying for a number of years. Nitrogen in the soil combined with "wash" water can also result in the growth of canary grass and broad leaf weeds.

D. COSTS OF DISPOSAL

Capital costs for the in-plant handling of solid residuals are incurred for special equipment such as conveyors, containers, hoppers, trucks and other directly related items. In 1968, a conservative average industry estimate was provided at $1.20 per ton of fresh produce acquired or at an annual depreciation charge of $0.12/ton on 10 years. Internal operating and maintenance costs, including labour, were estimated at about $0.17/ton, totalling $0.29 per ton of produce acquired.

Costs associated with the handling, dumping, spreading etc. were estimated at $0.40 per ton of fresh produce. The internal and external operating costs thus added to $0.69 per ton.

Assuming a cumulative annual inflationary rate of, say, 10%, this would amount to $2.62 per ton of fresh produce or $9.36 per ton of waste products (computed at the average of 28% waste for each ton of all produce taken from the above mentioned survey (including tomato pomace, carrots, beans, corn, potatoes, asparagus, beets, cabbage, cauliflower, and other vegetables, regular and citrus fruit and others).
This would thus amount to $3.94 per ton for internal costs and $5.42 per ton for external costs.

The computed external hauling costs are very close to current charges for the hauling, dump charges, and fees for public or private landfill sites. A cost of $5.50 per ton to haul waste to a landfill site 50 miles away was paid by one cannery visited.

A hauler, who transports waste for disposal for at least five processors, charges the following amounts per ton:

- $2.50 for "dry" tomato pomace
- $5.00 for trash waste
- $5.00/ton for peeler waste.

Another processor uses a municipal dump. The company pays $2.00 per ton for a 6 mile drive, including municipal dump fees which is considered very reasonable. Costs will increase considerably when this landfill is full, and the waste will have to be carted to sites at much greater distances from the plant.

Three other companies dispose of vegetable waste in municipal landfills and city sewage systems. One cannery pays $400,000 per year to put effluents with suspended solids into the sewage system; the other $200,000 per year.

V. UTILIZATION OF SELECTED WASTE PRODUCTS FOR CATTLE FEED IN CANADA

A. INTRODUCTION

Introductory Note: While the results from the field work in Canada and the U.S. are reported in separate Sections it was felt advisable to combine the findings of the physical and nutritional characteristics and include them in the Canadian Section.

In the course of the field research work, twelve farms were visited in Ontario and seven farms in Quebec on which either selected food processing waste was being fed at the time or was fed in the past. Since the visits created interest in some areas, farmers were also encountered who expressed a willingness to feed waste and asked for details and information. The information presented consists of data from a literature search and from the field research. The following summary presents an overall view of waste feeding in the respective areas visited.

In the Essex, Kent and Lambton Counties, there are some conflicting trends concerning the opportunities of feeding waste on farms and feedlots. There are two large, efficient operators, feeding waste successfully to beef cattle. However, other cattle farms had discontinued feeding vegetable processing wastes. Reasons given were: the exchange of farms with feedlots for farms without feedlots to concentrate on cash crops; the closing of cattle operations, possibly because of low beef prices;

the use of corn silage instead of waste for beef cattle; and the risk involved in the feeding of waste since a loss of several head of cattle by a beeflot operation in the area reportedly became known. The Prince Edward County is a mixture of rich market garden areas (for tomatoes, peas, pumpkins, etc., corn and grain), and almost barren areas with little or no topsoil. There are several dozen rather large dairy and beef farms, as evidenced by the size of herds and the number and size of silos on those farms. These livestock farms could form a basis for potential utilization of food processing waste. In some areas, they are within an economic radius to food processing plants.

Some farmers indicated positive interest in feeding waste, in order to reduce high feed costs. The fact that waste feeds are available only on a seasonal basis did not affect their interest. The range of questions included the feasibility of feeding processing waste, ecological aspects, feeding practices, rations, nutritional values, hauling details and costs. Some requested addresses of farmers to gain more practical knowledge.

It was felt that the visit to some processing plants and farmers in this county had planted the seed for future potential usage of food processing waste for livestock. The suggestion was made that the waste from pumpkin be researched. Pumpkin is approximately 40% waste, consisting of seed, tissue from the inside of the pumpkin, skins and other parts. In the Niagara Peninsula, there do not appear to exist many dairy or beef farms as the belt between Lake Ontario and the Escarpment is mostly used for cash crop and fruit growing farms. On the Escarpment, there is a large number of chicken farms, and only a few dairy or beef farms. Not many of them were known to feed vegetable waste products. One farmer fed tomato pomace and bean waste; another fed whole carrots, which he subsequently discontinued. A factor relating to the difficulty of finding farmers feeding processing waste in this area could be the limited availability of substantial tonnages in this area to make feeding economically feasible. One company is drying their own tomato pomace as well as that from other processors in the area. Another factor could consist of the relative absence of medium size or large beef or cattle farms. Even though silos were seen in the course of the fieldwork, few herds were detected. The feeding of waste not only requires a commitment on the part of the farmer to accept all waste from a plant, but also facilities to store waste for a period of several months. Only medium or large operations would be in a position to make these capital investments.

In the Eastern Townships of Quebec, the four selected waste products are being fed to cattle in considerable amounts. There exists a large number of dairy and beef, and mixed cattle farms in the area, representing a good base for feeding food processing waste. It was in this area where the only dairy farmer was found to successfully feed bean and other waste products.

There are also a number of operators of medium and large feedlots, who are even canvassing the processors to obtain additional waste products. Several farmers had gone to the canneries to obtain more waste. However, satisfactory arrangements by the canneries with farmers in the vicinity had already been in existence for several years. The majority of the farmers and feedlot operators wished to obtain more waste. They are feeding waste corn silage, the products previously mentioned, as well as apple pomace, field-collected pea vines, etc.

B. DEFINITION OF SOLID VEGETABLE PROCESSING WASTE

This is defined as the waste produced in the processing plant after the raw products (tomatoes, carrots, beans) have been delivered to the plant. It does not include "field waste", eg. vines, stems and leaves, except as "contaminants" in the product as delivered. These contaminants vary according to the product from a very minor proportion of the total, eg. hand picked tomatoes, to a fairly major proportion, eg. green beans.

This solid waste is usually separated from the effluents in the plant by rotating or vibrating screens. It has generally been subjected to one or more washing processes, so that with certain minor exceptions, it arrives at the disposal site in a very wet condition. Here it is usually dropped into containers or trucks off a conveyor belt and hauled away on a daily basis to maintain a clean environment at the plant. There was neither provision for storage, nor any additives or preservatives added to the processing wastes at any of the plants visited.

C. SEASONALITY

The seasonal supply of waste feed is a distinct drawback to feeding. This is especially true when the supplies are sufficient to be fed on a daily basis, or are slightly higher, so as to make storage or silaging necessary. The supply from larger processors makes it viable to use storage facilities, trench silos or upright silos for a feeding program for most of the year.

The tomato season in the Kent and Essex Counties is about 6-7 weeks, starting from the first week in August to the end of September. In the Niagara Peninsula and Prince Edward County, the season starts and ends about 1-2 weeks later. The variation of supplies within the season represents another factor. One processor supplied the following supply/ processing pattern:

1st week	6%	5th week	21%
2nd week	12%	6th week	16%
3rd week	17%	7th week	6%
4th week	27%		

In the Prince Edward County, the season for beans is about 4 weeks, from the end of July to the end of August and in the Eastern Township region from July to beginning September. Beets are harvested and processed in about 4-5 weeks from mid-July to mid-August.

Carrots are harvested from early October to early November. The processing season, however, is considerably longer, using carrots from cold storage.

D. PRESERVATION

The scientific literature does not contain much information on the preservation of food processing waste. According to Canning (1976), tomato pomace of 70% moisture content was successfully ensiled in California in 30 ft. high packed stacks, similar to the manner in which corn silage can be conserved. Estimated losses from these stacks was 45%. The ensiled product was a very satisfactory feedstuff, but very acidic and corroded the concrete rapidly. Strict fly control methods are essential for concrete tanks and stacks of pomace.

It would appear then, that if dry enough, tomato pomace can be ensiled in much the same way as common feedstuffs such as forage. However, if the dry matter content is low, as for most of the waste supplied by Ontario canning plants, then concrete tanks or similar containers are essential. Since the pomace is produced in large quantities over a short period of time, (about 60 days) and cannot all be fed fresh, it is important that it be preserved and stored if its full feed potential is to be realized.

It seems clear that conservation losses are very high (up to about 45%), as compared with those expected (about 20%) from good ensiling techniques with field crops. A method of reducing these losses would obviously be of value to animal producers. Nevertheless, the product, as currently conserved, is a good source of valuable feed nutrients and it seems probable that the high organic acid content of the waste would greatly assist in the preservation process.

Considerable portions of waste are being fed fresh on a daily basis to beef cattle. Some waste, however, especially bean waste, starts rotting after the first day and

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Canning, W., 1976. Practical Considerations in Feeding High Moisture By-Products to Beef Cattle, Paper presented for Ag Recycle Corporation to CBCIA Beef "chew"-ference Oct. 6-7, Fresno, Calif.

has to be either ensiled or spread on land. However, as many farmers receive large quantities of waste during the processing season, they have to store it temporarily or preserve the portion which cannot be fed fresh for year round feeding.

Two of the most common waste products stored are sweet corn from canneries and tomato pomace. Other waste products such as carrots, green peppers, beans, onions, celery, broccoli and other vegetables have been mixed with sweet corn silage by a large feedlot operator with good results thus effectively preserving them.

With the exception of one feedlot operator, none of the Canadian farmers used preservatives for the ensiling of food processing waste. This feedlot operator adds ground limestone to the sweet corn silage to keep the acidity level down. No preservatives are added to the tomato pomace in the fermentation tanks.

Most farmers use various types and sizes of silos for storing their waste products, mainly sweet corn from canneries. Most farmers use trench silos, either above ground, or in ground.

On the larger feedlot operations, the storage generally had a capacity of several thousand tons. On one feedlot, the corn bunker silo had a capacity of 7-9,000 tons. It had a concrete floor, inclined entries, and concrete sides with 4 caged drains for the excess liquid. On another farm, the trench silo was 125'x50'x9' high, also with a concrete floor and sides. Another trench silo measured 135'x67'x8'. The trench silo on one farm consisted of a cement floor, and earth banks about 5-6 feet high.

The tomato silos were in-ground concrete pits with 3 vertical walls, and one side with an inclined concrete ramp for the hauling of the fermented pomace for feeding. They had a capacity of 2-3,000 tons.

Since the moisture content of the tomato waste, as received, varied from 80-86%, the drainage of the fluid from trench silos is an important factor for ensiling with little spoilage. Most silos had caged drains and catchment compartments from which the fluid can be pumped out. If this is not done, the spoilage rate can be extensive up to several feet of the entire lower portion of the trench silo. One farmer indicated moisture and dry matter losses of about 45% during the ensilage and storage period. On one farm visited, the fluid from the tomato and corn silos is pumped into a sludge pond for settling. From there the effluent is pumped onto corn land (irrigated) nearby. The feedlot operator does not see any benefits. On the contrary, he feels that there is a negative effect on the soil because the soil structure is reduced and becomes more vulnerable to wind and water erosion. The possibility, however, could exist that he may be pumping the sludge onto a limited acreage close to the pond in order to reduce costs and therefore applying excessive rates.

Some farmers experienced problems with moisture content of the waste materials. Quebec farmers had considerable difficulties with their corn silage during the excessively cold 1980/81 winter. Three to four feet of the corn silage froze on top during that December and January. They had to "saw" the top layer with a chain saw, in blocks, to be thawed and used. In addition to the extreme cold spell, too much moisture and too much compacting were additional reasons for freezing.

Most farmers mix their waste with corn silage. One smaller feedlot operator does not mix vegetable wastes with his own silage corn, because of different harvesting times. He can use practically all vegetable waste on a daily basis, except in the peak harvesting season. In the summer and fall, the cows are in pasture, where he feeds them the waste.

Most of the farm operators use front-end loaders to haul corn silage from the silos directly to the feeding troughs. Some farmers load corn and tomato waste and other feeds and supplements into a mixing truck, for distribution to troughs in open feeding stalls.

Many feedlot operators in the United States add preservatives such as lime to ensiled waste products, or mix the waste with other crops, such as corn silage or hay. Four farm operators fed waste products fresh, particularly beans and carrots. Fresh waste products were felt to be more palatable to the cattle. One rancher dumps the fresh waste directly into the manger. He plans the buying and selling of cattle around the peak of the carrot season which, due to the combined fresh packaging and canning, lasts for several months. With extensive pastures, he is also able to successively move the cattle from the pasture to the feedlot for finishing.

Another rancher put his tomato pomace into a trench silo. He also had good success with feeding mixed vegetable waste.

Two other feedlot operators, ensiled their waste products, basically with grain. One farmer ensiled culled carrots with hay, dried beet pulp (90% DM), and almond hulls. He indicated that the moisture content is most important for the proper preservation of waste in silos. The other farmer ensiled beans with oats, barley straw or rye straw (one part straw to 4 parts bean waste) in pits, holding approximately 15,000 tons, pressed down with a track loader. Both achieved excellent results without preservatives. Another feedlot operator ensiled vegetable waste in two large trench silos (35'x950'x60' on top, 30' at the bottom) with a concrete floor and earth sides, sloped at each end on the top and vertical on the bottom.

A feedlot operator, who also ensiles peach and other waste products with straw, felt that ensiled tomato pomace had a nutrient loss of about 40%. He covered his tomato pomace with plastic sheets and tires to seal out oxygen and to prevent cracking. Thin layers of tomato pomace will form a tight seal over corn silage in California. Water must be drained off the tomato pomace to ensure better quality of the ensiled waste especially at the lower port of a trench silo.

One processing company, that owns a farm with 100 head of cattle, feeds fresh bean waste. The portion not fed directly in the fields, is ensiled with dry rye grass. The ensilage of bean waste alone was not recommended because of the odour and lack of preservation qualities. The proportions of bean waste and dry rye grass, however, must be exact to ensure the proper moisture level for compaction. Cattle, it was indicated, also liked beet waste, since it contained more sugar and dry matter.

Tomato pomace and cantelope waste were ensiled separately by another feedlot operator. The tomato pomace examined appeared quite dry and smelled fresh; it had the same consistency as haylage. The dry matter of this ensiled tomato pomace was estimated at 45%.

In the course of the field visits, details were provided of another low cost, sealed storage system, a plastic bag called Silopress developed by the Eberhardt Company in Germany. It is used for hay, corn silage and other relatively dry waste feed. The absence of oxygen in this storage promotes a fermentation process which preserves the feed through the production of lactic acid. With a diameter of 8 feet and length of 80 feet, the bag's capacity is reportedly up to 100 tons. The cut material is unloaded from the forage wagon into the Silopress feed intake and, with a special mechanism, pushed into the bag with a mesh-covered frame at the end held by a cable on each side to ensure adequate pressure. The initial cost of this storage (in 1977) was indicated at U.S. $2.04 per ton of storage, compared with $1.09 for a bunker silo, and $6.95 for the oxygen-limiting silo.

E. DETAILS OF WASTE UTILIZATION FOR CATTLE FEED

1. Tomato Pomace

(a) Physical Characteristics

Tomatoes are normally processed in Canada and the U.S. in one of the following two ways:

Firstly, for tomato juice or a paste for production of catsup, chutney, etc., the tomatoes are washed as they enter the processing plant to be cleaned and to remove extraneous matter such as pieces of stem, after which they are inspected and culled to remove unsuitable fruit. They are chopped and cooked with spices and salt. The juice and pulp are then pressed out of the cooked mass through screens and the residue consisting of the seeds, skins, cores and some pulp is the tomato pomace. Having been cooked at 212°F or higher, it is essentially sterile and generally contains some spices and salt. Since about 80% of the tomato crop is processed in this way, this type of pomace is the most important waste product.

Secondly, for the production of canned tomatoes, the tomatoes are washed and culled as indicated before and then peeled, cored and canned. The peeling process may be either a steam or an alkali process. The resulting pomace differs from the by-product of paste and juice production as it contains fewer seeds and proportionately more skin and may also contain alkali. However, it is understood that the processors are changing from alkali to mainly steam peeling. Most of the alkali is disposed of in the effluent stream. The alkali portion remaining in the peel would not likely be a major problem to the livestock producer if he is feeding alkali waste mixed with considerable quantities of other feeds.

The waste in the form of cull tomatoes and field residues, which originates at the beginning of the production line is generally very wet. It is an inferior product, sometimes called "trash" waste, and may either be kept separate, and dumped for land fill, or combined with the pomace, depending on the agreement between the processor and livestock producer.

Otherwise the contract may specify that only the "dry" clean pomace without any trash waste is to be used. At one processor's plant visited, the pomace is kept as a separate product, and used for drying as a feed ingredient for livestock or pet foods.

(b) Nutritional Characteristics

The chemical composition of tomato pomace or waste from many sources is given in Table 13. It is characterized by a comparatively high content of crude protein (CP), high ether extract (EE) and gross energy (GE) content. The calcium (Ca) and phosphorus (P) content, although not especially high, are equal to that found in good common forages. The crude fiber (CF) level is also about equal to good quality forages.

It is obvious that the protein level is a major factor in the feeding value of tomato pomace. The source of this protein is of considerable interest since seeds, skins and pulp are the major components of tomato waste, their proportions varying with type of waste. The pomace from production of tomato paste contains a higher proportion of seeds than that resulting from canning whole tomatoes. Also, the latter may contain lye if the alkali peeling process is used.

The composition of the seeds and skins was determined by Tsatsaronis and Boskou, (1975), and is shown in Table 14. The protein content of the seeds is much higher (24.5%), than that of the skin (10.0%). Likewise, the levels of phosphorus and magnesium (Mg) are very high in the seeds. The EE content of the seeds is remarkably high (28.1%), but the CF content is much lower than that of the whole pomace, Table 14. Conversely, the CF content of the skins is very high (55.9%), and the EE is very low, suggesting that its digestibility may be low.

Tsatsaronis, G.O. and Boskou, D.G., 1975, Amino acid and mineral content of tomato skin and seed waste. J. Sci. Food and Agric. 26:421-423.

Table 13 CHEMICAL COMPOSITION OF TOMATO WASTE/POMACE

CP	CF	EE	NFE	Ash	Silica	Ca	P	Mg	Cu	K	Mn (mg/Kg)	Energy Kcal/g of DM	Ref- erence
<---Percent of Dry Matter--->													
23.6	21.1	14.6	28.1	12.6	7.9	0.64	0.24	-	-	-	-	-	(1)
23.8	21.4	16.2	27.5	-	-	0.42	0.41	-	-	-	-	-	(2)
20.7	-	-	-	5.7	-	0.35	0.35	-	-	-	-	5.15	(3)
21.9	-	-	-	-	-	0.93	0.38	0.16	-	0.98	-	-	(4)
21.1	26.5	14.6	-	3.6	-	0.16	0.51	-	-	-	-	3.64	(5)
19.8	31.4	11.5	32.1	5.2	-	-	-	-	-	-	-	5.62	(6)
22.6	26.6	10.2	35.1	6.5	-	-	-	-	-	-	-	-	(7)
24.0	33.0	14.0	-	-	-	-	-	-	-	-	-	-	(8)
22.6	32.1	14.6	21.6	3.2	-	-	-	-	-	-	-	-	(9)
23.6	31.5	14.1	-	4.6	-	0.30	0.62	-	-	-	51.4	-	(10)
19.2	44.9	14.6	-	4.5	-	0.50	0.47	-	-	-	-	-	(11)

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Table 14 CHEMICAL COMPOSITION AND MINERAL CONTENT OF TOMATO SEEDS AND SKINS

	g/100 g dry sample					mg/100g dry sample									
Sample	Ash	Crude fibre	Total Sugars (as glucose)	Protein (NX6.25)	Ether Extract	K	Na	Ca	Mg	P	Cl	Fe	Mn	Cu	Zn
Seeds	5.4	19.1	2.9	24.5	28.1	780	110	160	300	690	110	17	6	2	5
Skins	2.7	55.9	7.8	10.0	3.6	1100	95	210	115	130	210	15	2	3	3

Source: Tsatsaronis G.D., and D.G. Baskou, 1975. J. Food Sci. Fd. Agric. 26:421.

The low copper (Cu) content of the skin is also of interest, suggesting that it is not retaining extra Cu from fungicides.

It is apparent from these data that a very high proportion of the nutritional value of the tomato pomace lies in the seed. No data were found giving the ratio of skins to seeds in tomato pomace.

The same investigators also determined the amino acid composition of tomato seeds and skins as presented in Table 15. The differences in amino acid composition are minor. Both are reasonably good sources of lysine and both are very low in methionine.

A comparison of the amino acid composition of the protein of tomato seed with that of other well known protein sources is given in Table 16. The data show that except for the low levels of the sulfur-bearing amino acids, methionine and cystine, tomato protein compares quite favourably with other high quality proteins. Methionine is relatively cheap and is routinely added to poultry and swine rations to correct methionine deficiencies in soybean meal. Hence tomato protein could be readily supplemented.

It is also of interest that the protein content of seed from green tomatoes is fully as high as that from ripe tomatoes.

Information currently lacking is digestibility data on tomato seed and on fermented (conserved) tomato waste.

Jayal and Johri (1976), studied the feeding value of sun-dried and ground tomato pomace for heifers, 18-20 months of age, and for sheep and goats. The pomace, containing 22.6% crude protein (DM basis), was the waste product from juice, chutney and catsup production.

The pomace constituted 39.2, 12.0 and 11.9% of DM fed to sheep, goats and calves respectively, and in the same

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Jayal, M.M., and Johri, S.B., 1976, Agro-industrial by-products as livestock feeds. Dried and ground tomato pomace with concentrate for ruminants Indian Vet. J. 53:793-798.

Table 15 AMINO ACID CONTENT OF TOMATO SEEDS AND SKINS

	g/100g of protein NX 6.25	
Amino Acids	Seeds	Skins
Lysine	4.94	4.41
Histidine	2.20	1.46
Arginine	8.83	3.88
Aspartic acid	9.58	10.60
Threonine	3.01	4.67
Serine	4.98	5.89
Glutamic acid	18.49	15.14
Proline	5.39	4.98
Glycine	4.64	7.56
Alanine	3.72	3.89
Half cystine	0.60	0.49
Valine	3.70	5.00
Methionine	0.78	0.75
Isoleucine	3.52	2.78
Leucine	5.86	5.06
Tyrosine	3.38	2.61
Phenylalanine	3.64	3.08
Tryptophan	0.95	-

Source: Tsatsaronis and Boskou J. Sci. Fd. Agric. 1975, 26:421.

The differences in essential amino acids between seeds and skins is minor. Both are reasonably good sources of lysine and both are miserably deficient in methionine.

Table 16 TEN AMINO ACIDS IN EGG, SOY FLOUR, COW'S MILK, TOMATO SEED, AND OPAGUE-2 CORN, DRY WEIGHT BASIS

	Egg	Soy Flour	Cow's Milk	Tomato Seed (red stage)	Corn Opaque-2
	g/100g Protein				
Isoleucine	6.6	4.7	6.4	4.4	3.4
Leucine	8.8	6.6	9.9	2.6	9.1
Lysine	6.4	5.8	7.8	6.6	4.8
Phenylalanine	5.8	5.7	4.9	3.9	4.5
Tyrosine	4.2	4.1	5.1	3.4	4.0
Cystine	2.4	0.9	0.9	0.2	1.7
Methionine	3.1	2.0	2.4	0.1	2.1
Threonine	5.1	4.0	4.6	7.8	4.0
Tryptophan	1.6	-	1.4	-	-
Valine	7.3	4.2	6.9	4.6	5.1

Source: Brodowski D. and J.R. Geisman, 1980. Protein Content and Amino Acid Composition of Protein of Seeds From Tomatoes at Various Stages of Ripeness. J. Food Sci. 45(2):228.

order it replaced 100, 50 and 33.3% of the concentrate mixture. The replacement was done on an equal protein basis in rations fed to sheep and goats but for calves the pomace replaced wheat bran on an equal digestible crude protein (DCP) basis.

Inclusion of the pomace significantly reduced the overall digestibility of the ration for sheep and the crude protein for goats. The pomace ration was about equal in nutritive value to the control for calves. The energy value (TDN, DE and ME) of the control and pomace ration was about the same for goats and calves.

It was concluded that:

- Tomato pomace was equal in nutritional value to wheat bran for heifers 18-20 months of age.
- The pomace protein was not as well digested as the protein in a common concentrate mixture.
- The energy value of the pomace was equal to a standard concentrate mixture for goats and calves.
- The palatability of the concentrate-pomace mixture containing 39.2% pomace was relatively poor resulting in much lower intakes by sheep. Because of this the pomace is recommended as a protein supplement at about 12% of rations for sheep rather than as an energy-protein concentrate.

The chemical composition, digestibility and feeding value of fresh and dried tomato pomace for sheep was studied at Davis, California by Hinman et al (1978), (Note: The sheep is widely accepted as a pilot animal for beef and dairy cattle). The pomace was fed either alone in the dried form or fresh in various ratios 0, 26, 48, 77.5% of the ration with a high

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Hinman, N.H., Garrett, W.N., Dunbar, J.R., Swenerton, A.K., and East, N.E., 1978. Tomato pomace scores well as a sheep feed. California Agric. 32(8):12-13.

quality alfalfa hay making up the balance. The sheep consumed the pomace readily after an adjustment period of several days.

The composition of the alfalfa and pomace on a DM basis was:

	Crude Protein %	Crude Fat (EE) %	Energy Kcal/g
Alfalfa	20.3	2.3	4.54
Pomace	19.8	11.5	5.62

The digestibility of tomato pomace alone and mixed with alfalfa hay in various rations is given in Table 17. The relatively high digestibility of the protein in the fresh pomace estimated by difference or by extrapolation is in marked contrast to the very low digestibility of the protein in the 100% dried pomace ration. This suggests that heat drying may greatly affect the availability of the protein.

The digestible protein, fat, TDN and energy are shown in Table 18. Although the digestibility of the energy in pomace was low compared with alfalfa (Table 17), the TDN is 10% higher because of the high level of digestible crude fat in the pomace. The digestible protein of 13.2% in the dried pomace, is still a very respectable level and more than adequate for beef cattle. The high levels of digestible fat (ether extract) may or may not make a marked contribution to feeding value of the pomace as ether extract can include a lot of non-fat material, i.e. the TDN values in Table 18 may indicate a higher feeding value than is justified. The conclusions of Hinman et al, 1978 were:

- The fresh pomace is a highly variable product, ranging from 11.9 to 27.5% in dry matter content as derived from the processing plant over a 40-day period.
- Tomato pomace provided 10-12% more digestible energy than did good quality alfalfa hay (on DM basis). This is primarily due to its high ether extract content.

Table 17 DIGESTION COEFFICIENTS* OF ALFALFA-TOMATO POMACE DIETS (SHEEP)

Item	Alfalfa 100% Pomace 0%	Alfalfa 74% Pomace 26%	Alfalfa 52% Pomace 48%	Alfalfa 22.5% Pomace 77.5%	Pomace 100% by difference	Pomace 100% by extra-polation+	Dried pomace 100%
Dry matter	63.8	64.1	66.9	57.6	64.2	58.9	59.4
Organic matter	65.4	65.3	67.9	58.9	64.7	60.0	60.1
Crude protein	76.1	75.0	75.0	69.0	71.9	69.0	58.5
Crude fat	24.1	66.1	78.8	80.3	86.2	88.1	76.0
Crude fiber	46.7	42.2	47.7	32.5	36.6	32.7	31.5
Nitrogen-free extract	75.5	77.2	79.7	75.2	80.7	77.1	83.3
Cellulose	60.0	64.2	69.8	73.6	78.2	78.2	80.2
Energy	62.3	60.5	63.1	50.8	56.7	51.0	53.6

* Assumes digestibility of nutrients in alfalfa remains constant at all levels.

\+ Calculated from linear regression coefficients obtained by correlating digestibility with pomace level of 0, 26, 48 and 77.5 percent fresh pomace diets.

Source: Hinman N.H., W.N. Garrett, J.R. Dunbar, A.K. Swenerton, N.E. East, 1978. Calif. Agric. 32:12.

Table 18 DIGESTIBLE MATTER COMPOSITION AND ENERGY EVALUATION OF ALFALFA AND TOMATO POMACE* (SHEEP)

Item	Alfalfa	Tomato Pomace (dried)
Protein %	15.4	13.2
Fat %	0.6	9.8
Crude fiber %	13.2	10.6
Nitrogen-free extract %	30.5	25.8
Total digestible nutrients %	60.5	70.7
DE, kcal/g	2.83	3.02
ME, kcal/g	2.32	2.62
NE_m,kcal/g	1.42	1.65
NE_g,kcal/g	0.79	1.04

* Values were calculated using the means of the digestion coefficients shown in Table 17.

Source: Hinman N.H., W.N. Garrett, J.R. Dunbar, A.K. Swenerton, N.E. East, 1978. Calif. Agric. 32:12.

- Digestibility of the dried pomace protein was low and provided about 10% less digestible protein than the high quality alfalfa hay. It still provided over 13% digestible protein which is fully adequate for weaned beef and dairy calves.
- Steers weighing 600 lb. could be expected to gain 1.5 lb./day if they consume 12.5 lb. pomace/day (DM basis) with a feed efficiency of 8.3 lb. pomace/lb. gain.

This comprehensive study by Hinman et al (1978) provides an excellent assessment of several of the most important nutritional factors in feeding tomato pomace. It does not give, however, information on a very critical aspect, namely, feed intake.

Rabo and Antunes (1964), fed tomato waste only ad libitum, containing 6.5% DM, 18.5% CP (DM basis), to bullocks 15-22 months of age, for a 60-day period. Digestibility of organic matter and protein were estimated at 67.7 and 53.0% respectively, using the Cr_2O_3 technique. The estimated feeding value in feed units (FU) was 0.05/Kg fresh material. The performance of these animals was compared with similar groups fed almost half the ration as tomato waste, the other half consisting of either 7-9 Kg hay or less hay plus 1 Kg concentrate.

There was little difference between the groups in average daily gain which ranged between 1.11 and 1.13 Kg, in dressing percentage, or in carcass grade. The group on tomato pomace alone ate less dry matter, less digestible protein and had a somewhat lower feed efficiency.

Patel and Shukla (1971) evaluated the use of dried tomato waste at the 8% and 16% level of the concentrate portion

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Ralo, J.A.C. and Antunes, V.S.O., 1964. Retraco de tomate na engorda de novilhas (Tomato waste for fattening bullocks), Bol., Pecuar 32:147-168. (Abstract, Nut. Abs. & Rev.).

Patel, B.M. and Shukla, P.C., 1971. Effect of feeding tomato waste to milch cows. Indian J. of An. Sci. 41:542-545.

of the ration of milking cows. At the 16% level it had no adverse effects on milk yield or fat-corrected milk yields. There was a trend to slightly higher production and higher fat levels in milk from the cows receiving the tomato waste. Hence these authors recommend the use of this waste at 16% i.e. replacing 20% of the protein in the concentrates for lactating dairy cows and claim that this would reduce the concentrate costs by 10%.

Conversely, Tomhave (1931) found that using dried tomato pomace at the 15% level of the total ration of milking cows reduced milk production and percent butterfat as compared with the production on the control ration. However, according to Morrison (1947) tomato pomace at the 15% level was a satisfactory feed for milking cows.

The information available on feeding of tomato waste to dairy cows is much more limited than that for beef cattle.

Tomhave, A.E., 1931. Dried tomato pomace in the dairy ration, Del. Agric. Exp. Station Report Bull. 172:23.

Morrison, F.B., 1947. Chapter XIX, Miscelaneous Concentrates, tomato pomace P. 402 in "Feeds and Feeding", (20th Ed.), Morrison Pub. Co., Ithaca, N.Y.

(c) Feeding Value

Data on practical feeding trials are very limited.

Swenerton (1975-76) carried out a 47-day trial in California using 550 lb steers fed a ration consisting of 85.9 lb (15% DM) tomato pomace (equal to 12.9 lb DM) plus 5.16 lb alfalfa hay/steer/day. Daily gain was 1.4 lb/day. Control steers received 9.5 lb alfalfa hay, 9.1 lb oat hay plus molasses and gained 1.1 lb/day. In a second trial, with no control group, 500 lb steers were fed ad libitum 70-80 lb of fresh (21.5% DM) tomato pomace (equal to 16.1 lb DM), plus about 1 lb wheat straw/steer/day. Oyster meal flour was fed ad libitum. Daily gain was 1.5 lb/day over the 28-day feeding period and palatability of the pomace was excellent. Based on these limited data, Swenerton concluded that fresh high moisture pomace (without lye) fed alone, would not support reasonable daily gains in the feedlot but it would be a valuable feed for stocker steers and heifers and mature beef cows and bulls.

A 28-day feeding trial with 900 lb steers fed a control ration, plus three other rations containing 12.5, 22.5 and 40% of ensiled tomato pomace (ETP) was carried out by a Canadian feed company.* Feed intake, kg/steer/day, was controlled - 9.0; 12.5% ETP - 8.2; 22.5% ETP - 7.5; 40% ETP - 7.4. Daily gains, kg/steer/day, for the same treatments were 0.99, 0.62, 0.59 and 0.56 respectively. The feed intake and daily gain both decreased with increasing levels of ETP. While the feeding trial was well designed and conducted, the ETP was probably low in palatability because it was conserved in a concrete pit without drawing off the excess moisture. Feedlot operators claim that excess moisture must be removed from ETP, otherwise its palatability will be low.

Swenerton, A.K., 1975-76. Tomato pomace-handling, feeding and digestibility studies. Unpublished report of studies carried out at Andco Farming Corp., Yolo County, California.

* Data supplied courtesy of Dr. John Linton, Miracle Feeds Ltd., London, Ontario. Feeding trial supervised by Dr. W. Esdale.

While the above feeding trials (U.S. and Can.) contribute useful information on feed intake, palatability and animal gain on fresh and ensiled tomato pomace, the total information on feeding value (intake, digestibility and animal performance) for various types of tomato pomace (fresh, ensiled, dried) is still very limited. Hence the practical experience of operators of feedlots and dairy units in the following Practical Application section, is of particular importance.

Another approach to the estimation of feeding value is to calculate such values from data available on chemical composition and digestibility of the product in question. It was considered worthwhile to do this in view of the paucity of information on tomato pomace from other sources, Table 19 provides the basic nutrient requirement data for beef cattle and Table 20, the key nutrients from tomato pomace.

These calculations show, Table 20, that in terms of nutrient intake, about 16 lb of tomato pomace DM alone should be capable of producing about 2.9 lb daily gain on a 500 lb steer. However, based on our present knowledge of what tomato pomace can do, when fed at very high levels without energy supplementation under practical feeding conditions, the best that can be achieved is probably 1.5 lb/day.

Table 19 NUTRIENT REQUIREMENTS FOR A 551 lb STEER ONTARIO MINISTRY OF AGRICULTURE AND FOOD FACTSHEET 1980

	Daily Gain (lb/day)			
	1.5	2.0	2.4	2.9
Minimum DM Intake (lb)	12.8	13.7	13.2	13.2
Roughage (or Fiber)(%)	55-65	45.50	20-25	15
Total protein (lb)	1.36	1.52	1.61	1.67
TDN (lb)	8.8	9.9	10.4	11.5
Calcium (lb)	.040	.048	.057	.066
Phosphorus (lb)	.035	.042	.046	.051

Table 20 NUTRIENTS AVAILABLE FROM TOMATO POMACE ASSUMING INTAKE OF 75 LB WET POMACE/DAY BY 500 LB STEER* DAILY GAIN 1.5/DAY

Nutrient Content	Percent	Intake lb/day
**Protein	22	3.69
**TDN	70	11.3
*DM Content	21.5	16.1
**Calcium	0.50	0.080
**Phosphorus	0.40	0.064

*Trial by Swenerton (1975-76, see p. V-24)

**From Tables 13, 17 and 18.

Dickie, D.I., 1980, Daily nutrient requirements of beef cattle. Ontario Ministry of Agriculture Factsheet No. 77-025

(d) Physiological and Metabolic Limitations

Whether fed alone or more commonly, with other feeds there have been very few problems with tomato pomace. Acidosis has been mentioned from starting cattle too suddenly on wastefeed but also generally occurred when the pomace was mixed with other wastes. Magnesium tetany was mentioned by one feeder for lactating cows fed high levels of tomato pomace but was not confirmed by others. However the high potassium (K) content of tomato pomace lends some credibility to this claim. One Ontario feedlot noted selenium (Se) deficiency on rations containing tomato pomace but this was not confirmed by others. There was however general agreement that ground limestone, the "floured" type was said to be most effective, should be fed with rations containing substantial levels of vegetable processing wastes including tomato pomace. It is also advisable to include some alfalfa hay or a trace element supplement to cover any undefined requirements. Since tomato pomace produces yellow beef fat it should be withdrawn from the ration 60 days prior to slaughter.

(e) Practical Application to Beef and Dairy Production

aa) Beef Production

Two fairly large Ontario feedlots use large amounts of tomato waste. The first operation uses tomato waste conserved in concrete tanks on the premises for a substantial part of the rations for the annual production of some 1100-1800 growing-fattening beef cattle in its feedlot. Calves (500 lb) are started on hay but within one week go on to the pomace ration. Between 500 and 1000 lb, the cattle get up to 40% of their ration as tomato waste along with alfalfa and sweet corn canning waste (ensiled). The expected daily gain is 2.0 to 2.5 lb/day.

From 900 to 1150-1250 lbs, less pomace and higher energy feeds are used to increase the rate of gain and achieve satisfactory carcass quality. Rations are formulated by a professional nutritionist who also formulates a custom supplement to match the waste feeding program.

This operator considers the feeding value of tomato waste to be less than ordinary corn silage (DM basis). The high moisture level of the pomace, about 85% as received, is a major limiting factor affecting feed intake, hence the reason for keeping the percentage pomace in the ration at 40% or less. It is also quite clear that relatively low rates of gain are being accepted in order to maximize the use of tomato pomace mixed with sweet corn waste. It should be noted that the tomato pomace is being combined with a second high moisture feed which probably reduces the amount of pomace that can be fed as compared to feeding it with dry feeds.

Physiological and metabolic disorders in this feedlot have been minimal. No bloat, acidosis or pesticide residue problems have been encountered. The animal feces are comparatively liquid and reddish in color but there has been no diarrhea. Tomato waste is removed from rations 60 days or more prior to slaughter to avoid excessive yellowing of the carcass fat. Hardware disease is no more frequent than for regular feeds.

It would appear that in this feeding program some of the high protein content of tomato waste is being used for energy and it may be a relatively cheap source. If energy is in short supply, young animals will use protein for this purpose.

At the second Ontario feedlot the tomato pomace is ensiled in large concrete tanks and used as required. No preservatives are added. This feedlot has a 1200 head capacity. The feeding program includes the extensive use of a number of vegetable processing wastes, eg. tomato, sweet corn, potato, carrot, bean, pea, onion, pepper, etc. Hay is used only in starting rations.

A fairly typical ration was said to be tomato waste 20%, sweet corn waste silage 16%, onion waste 24%, potato waste 30%, grain screenings 10%. These ingredients vary with the season of the year, availability of any particular waste, etc. The rate of gain varies from 1.8 to 3.2 lb/day, depending on the composition of the ration.

Tomatoes and carrots are removed from the ration 30 days and onions 40 days respectively before slaughter. However, if the proportion of these ingredients in the ration is low, it is not necessary to withdraw them.

Problems with bloat, acidosis and other metabolic disorders have been very minor. Selenium (Se) deficiency has been encountered in comparatively high tomato waste rations and hence, Se and Vitamin E are now incorporated into the supplement. Some respiratory problems occurred because the barns get very damp from the high moisture in the feeds, wet feces and the extra urine. Hardware disease* is a concern but probably no more so than in conventional feedlots.

Judging from the rate of gain and the low to modest level of use of tomato waste used in the rations, the feeding value of the tomato waste under these conditions is probably quite high.

A California beef feedlot operator (3000-7000 fat cattle annually), feeds tomato waste plus carrot, peach, apricot, pear, etc. waste. Chemical composition data available indicated the mixed waste (DM basis) is high in protein and fat. The wastes are ensiled in pit silos. Expected gains were 3.5 lb/day and 2.5 lb/day on tomato pomace and other cannery waste respectively. Starting rations contain only 20% waste which is increased to 75-80% over several following

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* Ruminants often consume in their feed small bits of metal such as nails, pieces of baling wire, etc. which may perforate the wall of the first or second stomach and cause illness or death. Processing waste may contain metallic objects from the processing plant, some of which may be non-magnetic stainless steel and cannot be detected and immobilized by magnets at the plant, on farm equipment, or by those inserted into cattle for protection against hardware disease.

weeks. Ration dry matter is monitored and kept around 30%. All rations are formulated by a consultant nutritionist. Finishing rations normally don't include general cannery waste but up to 20% tomato pomace can be used. The energy value of tomato pomace is considered to be between good alfalfa hay and barley and not as high as quoted in the literature. The palatability of ensiled (pit silo) tomato pomace is considered very good but it is extremely important to pump excess water out of the pit silos otherwise the quality of the silage will be poor. Nutrient losses from the effluent are not considered very high. Carrots were claimed to be equal to barley in energy but somewhat lower in protein content. Onion waste can be ensiled and thereby reduce onion odor and it can be fed to beef cattle in limited amounts. However, if fed to milking cows it taints the milk. Acidosis has been encountered but only when waste is introduced too suddenly into the rations. Lime and sodium carbonate are fed. Magnets in the animals are not too effective; they only remove about 30% of the hardware disease problem. No pesticide problems have been encountered.

A second California beef feedlot operator, handling 4500 steers per year, feeds ensiled (bunker silo) high dry matter tomato pomace along with a variety of other wastes including canteloupe silage, fresh or ensiled citrus pulp, cottonseed waste etc. Growing rations contain up to 70% waste including tomato pomace plus conventional feeds. Finishing rations contain the same waste ingredients at the 50% level. Some 20-30 additional days are required for growing-finishing on high waste rations as compared to conventional feeds. Some acidosis has been encountered chiefly from introducing waste too rapidly into the feeding program. No magnesium deficiencies have been found. Limestone and trace elements are fed but no sodium bicarbonate. The tomato pomace silage on this operation had a dry matter content estimated at 30% or higher, and was judged as being of excellent quality; it was being transported about 100 miles from a cannery. Price for the tomato pomace was said to depend strictly on moisture content. Pesticide residues presented no problems.

A third California beef feedlot operator feeding 1000 head, including a high proportion of bulls plus steers was feeding sun-dried tomato pomace often as a "sweetener" to improve palatability and nutrient balance of rations. Numerous other waste materials, mainly dry, high energy types, were also fed, including sunflower seeds, cottonseed, almond hulls, etc. This operator considers tomato pomace to be highly palatable and thought bulls would eat up to 80-90% of the ration as dried tomato pomace but daily gain would only be about 1.5 lb. He emphasized that different types of tomato waste have very different feeding values, ranging from that of a high DM (30%) pulper pomace, to the inferior wet "trash" waste comprising cull tomatoes, leaves, stems, etc. This operator considers tomato pomace to be a highly palatable feed which, being high in protein, can greatly reduce the need for protein supplements. Also emphasized were the many important nutritional interactions between waste feeds because of fiber levels and composition of fiber or other unexplained factors. Hence, experience in combining waste feeds is extremely important. Mineral supplements were said to be important and 2% floured limestone was highly recommended as the base mineral to neutralize excess acidity from waste. It is inexpensive, eliminates acidosis, and cattle can be allowed to consume it ad libitum. This operator felt tomato waste had no significant effect on fat colour or meat flavour at levels generally fed.

A fourth California beef feedlot operator declined to allow a visit to his premises but claimed 25 years of experience in feeding fruit and vegetable wastes. He is currently upgrading low quality feeder cattle, growing them from 450 to 800 lb, principally on ensiled "trash" tomato waste which he obtains free of charge from an adjacent cannery. He offered the following advice on feeding high levels of tomato waste. Cattle should be started slowly, ensiled waste alone will not produce very rapid gain and the fresh product is best. It is very important to drain water off the ensiled waste and should not be fed 60 days prior to slaughter because it causes yellow fat. Supplementation should include limestone to reduce acidity and increase intake of tomato waste; also highly recommended was 4-5 lb. alfalfa hay/steer/day. Ensiling losses are believed to be much less than 40%. Lactating dairy cows may suffer magnesium tetany if fed high tomato waste rations but this is no problem for beef cattle. It should also be noted that green cull tomatoes are better feed than ripe tomatoes; one should be very cautious with onion waste as it can cause bad odors in beef; peach (or similar waste) makes excellent feed when ensiled with straw. No pesticide problems were noted.

The most important conclusions, drawn from the experience of the Canadian and U.S. feedlot operators, are:

- Tomato pomace, fed fresh, ensiled or dried, is a valuable feed for beef production which can be used at much higher levels in the growing ration than in finishing rations.
- Very few metabolic problems are associated with its use. Cattle should be started on feed reasonably slowly and the pomace should be withdrawn from the ration 60 days prior to slaughter to avoid yellow fat problems.
- Supplementation requirements are minimal. It is wise to include a few pounds of alfalfa hay, 2% ground limestone and a good trace element mineral mixture.
- Tomato pomace combines well with a large number of waste and conventional feedstuffs and serves as a protein supplement and a good source of fiber.

From the available data one can conclude that the intake of tomato pomace is limited by its high moisture level and possibly by its palatability in some instances. It is also evident, that feed efficiency is low on pomace alone.

It would appear that the most efficient use of the nutrients in tomato waste can be achieved by mixing it with complementary feeds which can be much lower in protein but must be much higher in energy content, eg. corn ear silage, corn grain, etc., especially for finishing rations.

In practical feeding operations as observed in Ontario and U.S. feedlots, it would appear that tomato pomace silage can be included in feedlot growing rations up to 40-50% of the total ration. At the 40% level, rates of gain will be well below maximum, probably 2.0-2.5 lb/day but the economics are probably good because of the relatively low-cost tomato pomace. For finishing rations, probably no more than 20% tomato pomace silage is advisable especially if other high moisture ingredients, e.g. corn silage, are included. Again, economics come into play but in any event the high moisture content of the pomace silage plus its low NE_G limits its use for finishing beef cattle.

For growing feeder steers tomato pomace silage may be fed at high levels probably up to 60% of the total ration. Replacement beef heifers can also be fed fairly high levels; 50% of the total ration is suggested as the upper limit.

bb) Dairy Production

One California operator who raises about 2000 replacement dairy heifers per year from 400 to 1200 lb and sells them as pregnant heifers, uses mainly vegetable and fruit processing wastes for feed of which about 60% is ensiled tomato pomace. The other 40% includes bean, carrot, cauliflower, broccoli etc. fed fresh or ensiled. Some alfalfa hay is almost always fed, usually second quality, for fiber and its mineral supplemental value. Ration dry matter and specific nutrients, including phosphorus, are continuously monitored. Green bean waste is considered equal to good alfalfa hay or better. Bean leaves are excellent feed, vines are not so good. Excess fresh bean waste is ensiled with other wastes. Tomato pomace is claimed to be a 100% replacement for good alfalfa hay on a net energy for maintenance basis. The fresh tomato pomace is somewhat more palatable than the ensiled. Calcium and sodium bicarbonate supplements are fed regularly. No magnesium tetany has been encountered but nitrates have caused some abortions which were not linked directly with tomato pomace. Occasionally the cattle have diarrhea but this is not a serious problem. Hardware disease causes problems and originates chiefly from non-magnetic stainless steel fragments in the waste. No pesticide problems have been encountered.

In terms of practical application for growing replacement (450-1000 lb) dairy heifers, tomato pomace could easily replace 50% of conventional rations and could probably be used safely up to the 60% level if properly supplemented with energy and mineral supplements. It is a valuable feed ingredient for this purpose.

No dairy herds were found where tomato pomace was being used for milk production. For lactating cows substantial amounts (30-40% of the ration) could be used for relatively low levels of milk production, e.g. 30 lb/day. For higher levels of production a 20% maximum would probably be realistic. In practice, since tomato pomace silage is messy to store and feed and because its variable moisture content poses problems for rationing high producers, not many milk producers would want it on their premises.

cc) General Evaluation

Tomato pomace, as it comes from processing plants, is a variable product. It may be the pure "dry" pulper pomace from paste and juice production around 35% in DM content. Or it can be the same product diluted with water to about 18-20% DM. It can also be the pomace from canning operations containing little seed and a much higher proportion of skin, a lower quality (less protein, more fiber) product. As well, either of the above products may or may not include the "trash" waste, i.e. the cull tomatoes and field residues from the starting point in the production line, which is an extremely high moisture product. Tomato pomace may be fed fresh as it comes from the plant or be modified by drying or ensiling. No accurate estimates of nutrient losses from conservation are available. Most of the pomace appears to be fed in the ensiled form.

Obviously, moisture level has a major effect on quantity of feed nutrients per ton of wet pomace. It can also have an important impact, especially at the higher levels, on feed intake. While moisture level is of little importance when feeding low to moderate levels of tomato pomace with dry feeds, it can seriously limit feed intake when rations high in tomato pomace silage also include other high moisture feeds, as is often the case.

General conclusions concerning utilization of tomato pomace are:

- It is a very useful feed for beef and dairy production. Usually it fits best into fairly large scale operations because of the specialized facilities required for conservation, storage and handling and the capability to absorb the output of the processing plant on a sustained and relatively long term basis.

- It is a valuable protein supplement and can greatly reduce the need for costly purchased supplements.

- The palatability of conserved tomato pomace is not a problem providing the pomace is properly ensiled or dried. The poor palatability ratings given for tomato pomace in some reports are believed due to improperly conserved products. The fresh pomace is very palatable.

- Tomato pomace is well suited for growing rations for beef cattle production, replacement dairy heifers and for low to medium levels of milk production. Its use is limited for feedlot finishing and for high levels of milk production because of its relatively low energy and high moisture content.

- The supplemental needs for tomato pomace are minor. It is wise to include 2% ground limestone and a trace element mixture when high levels of pomace are fed.

dd) Use in Pet Foods

Dried tomato pomace, some of it from Canada, is being used by pet food manufacturers in the U.S. for production of commercial pet foods. Early studies by McCoy and Smith (1940) and a report by Altschul (1958) indicate that tomato pomace has the unique characteristic of being able to prevent loose stools or diarrhea in high carbohydrate diets fed to dogs, mink and foxes. It is claimed to be effective at low levels i.e. 2-5% of the dry diet. Tomato pomace is also a good source of protein and carotene.

Dried tomato pomace (at approximately 85-90% DM) has about an equivalent feed value as barley and as such should be competitively-priced. Information received in the course of the field work, however, showed that it was sold at about $160/ton for pet food as compared with $109/ton of barley. This indicates that it most likely is used as a special feed additive for its characteristics as outlined above where a small addition has very desirable effects and is purchased by an industry with presumably better profit margins than the livestock industry. For details on drying costs please refer to Section VII-E-2.

Altschul, A.M. (Ed.) 1958, Plant residues and pomaces, Chapter 22, pp. 868-869, in Processed Plant Protein Foodstuffs, Academic Press Inc., N.Y., 1958.

McCoy, C.M. and Smith, S.E., 1940. Tomato pomace in the diet. Science 91: 388-389.

2. Carrot Waste

a) Physical Characteristics

This material is of two types:

- Fresh cull carrots (extra large, small, misshapen, cracked, broken, discoloured) which are culled from harvested and stored carrots as they are taken out of storage. Hence the culls are available on a year round basis. The culls will keep fresh 2-4 weeks depending on temperature.
- Carrot waste from the processing plants which includes the tops of carrots, bottoms and peel from carrots canned or made into puree (eg. baby food). This waste is screened out in the processing plant. It tends to spoil quickly and should be fed within 48 hours or ensiled.

The carrot waste from production of specialty foods by an Ontario processor, included carrot top and bottom trimmings, peel from steam peeling (no lye) and fibers. It is very high in moisture, probably about 90%. All of the waste is currently dumped, not fed. Waste from canned carrots would not include the fibers.

Carrot waste from several processing plants in California and Oregon is available in fairly large quantities for livestock feeding. In some instances, the peelings were included, but other plants disposed of the peelings separately. This practice appears to reflect back to past concerns about pesticides on the carrot skins and the use of alkali for peeling. Some of the waste is fed fresh, the rest is ensiled with other feeds.

b) Nutritional Characteristics

The chemical composition of carrots and carrot pulp are given in Table 21. The data indicate that carrots contain about 87% moisture, 10-12% crude protein, and only 9.1% crude

Table 21 Chemical Composition of Carrot, Bean and Beet Waste (DM basis)(%)

Vegetable	Moisture	CP	CF	EE	NFE	Ash	Ca	P	Mg	K	Reference
Carrots	93.8	12.9	35.7	1.3	-	18.2	1.3	0.4	-	-	(1)
	86.2	8.1	-	-	-	-	-	-	-	-	(2)
	87.0	10.3	9.1	1.4	-	15.0	1.94	0.19	0.17	2.50	(3) & (4)
Carrot pulp	86.0	6.4	18.6	7.8	-	8.6	-	-	-	-	(3)
Bean (cannery residue)	90.6	23.5	13.5	3.0	-	2.3	0.37	0.32	0.17	2.50	(3)
Beets (red)	87.3	12.6	6.3	0.8	-	8.7	0.13	0.26	-	-	(3)

References

(1) Data supplied by Monnette, Recuperation des Legumes, 389 Edouard VII, St. Phillippe, Compte la Prairie.
(2) Lee G.Y.J. Food, 1974. Sci. 39:1075.
(3) By-Products and Unusual Feedstuffs in Livestock Rations, 1980 WREP No. 39. Co-operative Extension, USDA, University of California, Berkeley, Ca.
(4) Atlas of Nutritional Data on United States and Canadian Feeds, 1971. National Academy of Sciences, Washington, D.C.

fiber. The Atlas of Nutritional Data on United States and Canadian Feeds 1971, from which the data for carrots were originally derived (ave. of four analyses), indicate, in addition, that carrots are high in copper (11.1 mg/kg), NFE (69.6%), and carotene (932.2 IU/g). Also, the digestibility of the crude fiber is 84%.

The net energy values of carrots for lactation, maintenance and gain given in Table 34, are all high. Taken together with the chemical analyses, these data indicate that cull carrots are essentially a high moisture concentrate. Although no specific chemical or energy data were found for carrot cannery waste, the carrot pulp (62.8% TDN and 6.4% crude protein) is probably a cannery waste fairly high in peel and for that reason considerably lower in feeding value than cull carrots. Both cull carrots and cannery waste are very palatable.

c) Feeding Value

One Ontario beef and dairy producer who obtains large quantities of cull carrots from the Holland Marsh practically the year round, feeds them for both milk and beef production. He uses them as a replacement for corn silage and claims they are superior to corn silage in feeding value for milk production and that that increase milk fat percentage as compared to corn silage. He has not encountered any metabolic problems, eg. bloat, acidosis, diarrhea, and says that the cattle thrive. He has fed 27-32 kg/day to lactating cows. For fattening beef cattle, this operator says some grain must be fed with the carrots to increase ration nutrient density. Otherwise rate of gain would not be satisfactory.

Three other livestock producers in Ontario and Quebec have fed fresh carrot waste and cull carrots to lactating cows, replacement heifers or beef steers with very satisfactory results.

One fairly large dairy (650 high yielding, lactating cows) operator in California, feeds 5000-8000 tons of cull carrots/year. The carrots are either fed fresh or ensiled with hay, almond hulls and dried beet pulp, well compacted. This produces an excellent silage. A typical ration is:

> 40 lb of fresh carrots, 20 lb of silage,
> 10 lb alfalfa cubes, 5 lb cottonseed and
> 20 lb of grain (fed during milking).

The cows are started on 10-15 lb carrots/day and go up to 40 lb in 10 days. The carrots are chopped and mixed with other feeds prior to feeding. Milk fat percentage increases with carrot feeding. There are no problems with milk colour or pesticide residues.

A California feedlot operator with 1000-1100 steers, who obtains 45 tons of cull carrots and carrot waste per day, (March-September), feeds carrots alone or mixed with the waste almost exclusively, plus some hay. He claims daily gains of around 3 lb/day, which seems rather high relative to claims by others.

Three other California-Oregon beef producers provided additional information. One operator who fattens old cows on carrot waste, (including the peels), feeds the waste at 10% of body weight plus 5-6 lb of good hay daily. He has a yellow fat problem which carries a penalty of 8-9¢/lb. The cattle are started on carrot feed quite slowly. He notes that high levels of carrot feeding may cause abortion in pregnant cows. Another operator feeds 30-40 lb/day/steer over a 3-month period. The waste is fed fresh, and the remainder dumped in a pit where it keeps for several weeks and retains its palatability without preservatives; it is presumed that it would ensile. A third operator, feeds about 20,000 tons of carrot waste and peel per year to beef cows and feeder steers. The waste is simply dumped on a concrete slab and fed with some alfalfa hay. No further information was given.

Francis (1980) states that washed cull carrots have a storage life of 10-14 days during winter (in the UK) and that their dry matter varies between 9 and 11%. They are highly palatable to livestock and are usually selected out of any feed containing them. There seems to be no particular limit to the amount which can be offered to beef cattle; 25 Kg/300 Kg animal is a common allowance. Some feeders feed them at ground level to reduce the possibility of a carrot lodging in the gullet.

d) Physiological and Metabolic Limitations

Large quantities of carrots in the ration produce a yellow fat in beef cattle, which can be undesirable and affect carcass grades. To reduce this effect, carrots should be removed from the ration at least 30 days prior to slaughter, some operators say 60 days. However, at low levels of carrot feeding (15-20% or less in the ration) there is no need to withdraw them. There appears to be no problem with milk fat colour.

Overfeeding with carrots has been found to cause diarrhea, although some operators have fed high levels without this problem. One California dairy operator had problems with Clostridium and lost some cows when feeding high levels of carrots but it was not clear if this was due to the carrots.

One feedlot operator engaged in fattening old cows, claimed that high levels of carrot/waste feeding caused

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Francis G.H., 1980. Use of Vegetable and Arable By-Products and Wastes in Animal Feeding. Occasional Pub. #3, Brit. Soc. An. Prod. 1980. (Ed. E.R. Orskov).

abortions in some cows. He suspected it might be associated with excessive carotene intake.

Based on available information, in general, when carrots and/or waste are fed at low (15 lb/day) to medium-high levels (50-60 lb/day) to milking cows or steers or replacement heifers, there was none of the common metabolic problems, eg. bloat, acidosis, ketosis, tetany and other problems, except possibly at extremely high levels of intake. Carrots and carrot waste can generally be considered a high quality and safe feed.

Concerning pesticides, none of the information available would indicate any problems for milk or meat production.

One or two operators suggested it was better to feed whole carrots at ground level as this reduced the possibility of a carrot lodging in a cow's gullet. However, there did not seem to be much concern on this point.

e) Practical Application to Dairy and Beef Production

Fresh cull carrots are generally fed fresh as they come from the grading station. They contain around 88% moisture are highly palatable to cattle, require no processing and can be fed in substantial quantities to lactating cows, replacement heifers and to feedlot beef cattle. Both cull carrots and the waste can be readily ensiled, generally mixed with other feeds.

The very high moisture level in carrots and carrot waste limits the ability of cattle to take in enough energy for high production. For high levels of milk production and rates of gain it is necessary to increase the energy density of the ration with higher energy feeds of lower moisture content.

For high levels of milk production, carrots or carrot waste should constitute less than half of the total ration DM. But for medium to low producers, it is suggested that carrots or carrot waste may make up to about 60% of the ration DM irrespective of the fact that the LCR program pulled in only a 33% portion of carrots in the ration at the 30 lb/day milk production level. The same would be true for growing replacement heifers.

For high rates of feedlot gain, about 2.5-3.0 lb/day, the ration should include no more than 35-40% carrots/waste. For lower rate of gain, eg. stocker steers, the ration could include 60-80% of carrots or carrot waste.

3. Green Bean Waste

a) Physical Characteristics

Processing waste of green beans, also known as wax or snap beans, normally consists of clippings, pieces of beans with some leaves, off color beans, vines and stems. The proportions of leaves, vines and stems appear to vary considerably, depending on the mechanical equipment, operator and field conditions. For example, at one processing plant in the Eastern Townships, the percentage of vines and leaves was estimated at 10-15% by the plant manager, whereas from the examination at the farm, it was thought the proportion was much higher. At a second plant visited, also in the same area, it was estimated that the proportion of leaves, stems and vines relative to the amounts of the clippings and pieces of beans, was very high.

Fresh bean waste spoils quickly and should be fed within 1-2.5 days. It can be ensiled with other feeds such as corn cannery waste, corn silage or straw in a 4:1 bean: straw ratio.

b) Nutritional Characteristics

The bulletin, "By-Products and Unusual Feeds in Livestock Rations",* states, "Cannery waste from snap beans is higher in protein (DM basis) than corn cannery waste but contains only about 10% DM. It can be used to replace the hay or silage in a ration, but because of its high moisture content should not be fed in large amounts to high producing dairy cows." This bulletin also shows bean waste as having 23.5% crude protein, 72.5% TDN and only 13.5% crude fiber, Table 21.

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* See Reference 11, Table 13.

c) Feeding Value

One large-scale dairy operation with 1700 milking cows in Oregon has been feeding large quantities of ensiled bean waste. Four parts of bean waste are ensiled with one part straw (oat, barley or ryegrass straw) and compacted. There is little spoilage. The bean silage is fed with hay, corn silage and grain. Extra limestone or sodium bicarbonate is also fed. This operation considers bean waste to be highly palatable and a stimulant to milk production but the cows lose weight if too much is fed. Hence the cows are limited to 15 lb of bean waste per day.

Two haulage companies in Oregon provide bean waste to 10-11 large dairy operations where the waste is fed fresh within 2.5 days. The waste is considered to be a high protein, very palatable forage which dairy cows will eat to excess and lose body weight unless intake is restricted. Bean waste is considered an excellent feed for milk production. These operators also indicated that bean waste can be ensiled with straw.

A feedlot (1500 beef cattle) in Oregon feeds considerable amounts of fresh bean waste. The waste is regarded as a highly palatable, high protein, low energy feed.

Several producers and/or processors in Quebec and Ontario noted that fresh waste spoils very quickly and claimed it should be fed the same day as processed and received at the farm. Where it can be incorporated into sweet corn cannery waste and ensiled or ensiled with regular corn silage, it has been readily preserved. There were no instances found in Canada where pure bean waste was being conserved by itself, possibly because the volume was usually insufficient to justify putting any special effort or expense into it. Also, it is often mixed with pea and other waste at the plant.

Feeding practices in Canada were generally to dump the fresh bean waste onto a field or in feed bunks, allow the cattle to eat what they wanted and either leave the unconsumed residue in the field to be plowed down as fertilizer, or dumped on the manure pile. No problems, bloat etc., in feeding bean waste were reported.

d) Physiological and Metabolic Limitations

None of the common problems, eg. bloat, acidosis, magnesium tetany,etc. were reported for bean waste.

e) Practical Application to Dairy and Meat Production

Based on the practical feeding experience in Ontario, Quebec and Oregon and the limited analytical data available, one can draw the following conclusions:

- Bean waste, fresh or ensiled, is a high protein, low fiber, high moisture and highly palatable forage with broad application to milk and meat production.
- Its high protein value (23%) gives it some value as a protein supplement.
- For high producing milk cows, it must be fed with high energy feeds and restricted to 15-20 lb/day; as otherwise the cows will eat excessive amounts, thereby reducing their intake of energy and losing body weight. For lower levels of production more bean waste can be included in the ration.
- There is evidence that bean waste is a milk stimulant and might be particularly useful during the latter part of the lactation cycle.

- It is also a valuable feed for beef production and for growing replacement dairy heifers, especially when combined with higher energy feeds.
- No particular physiological or metabolic problems have been identified with the feeding of bean waste other than its high moisture content.
- Until more information is available, it is suggested that livestock producers use caution in feeding extremely high levels of bean waste, i.e. ad libitum, over prolonged periods.

4. Red Beet Waste

Beet waste was not specified as part of this contract, but the consultants were asked to obtain any information readily available, especially concerning the problem of disposal of beet skins.

The solid beet waste consists of the tops of the beet per se, roots, pieces of beets and skins as screened out at the processing plant. At one Ontario plant, the peeling process was said to be proprietary and not divulged. However, it was indicated that neutralization of the waste effluent was required, so it can be surmised that alkali was used. The intense red color of the effluent and drainage from the solid waste was said to be a serious problem and must not be allowed to drip on roads or contaminate waterways. At this plant, waste from other produce and foreign matter were all tossed into the beet waste. The solid waste was dumped, not fed.

At another Ontario plant, the beet waste, (tops, roots and skins) was transported, after allowing the truckload of waste one day to drain, to a local feedlot operator and ensiled with sweet corn cannery waste for feeding to beef cattle. Other information on conservation from California, indicated that beet waste can be readily ensiled with other cannery wastes. Under these conditions, any residual alkali from the alkali peeling process should pose no problem to cattle, providing the beet waste represents a comparatively small proportion of the total silage.

No data on chemical composition, digestibility or pesticides for beet waste were available except for the chemical composition of red beets, given in Table 21, which provides an approximation for the waste. The available data indicate that beet waste should have quite a good feeding value, but probably less than carrot waste.

The feeding value of beet waste, according to one

Ontario feedlot operator was considered to be lower than that of carrots or sweet corn cannery waste. At another feedlot in Oregon, beet waste was being fed at the rate of 40-50 lb/day/1000 lb steer. The waste was stored in a pit with no preservatives. It was highly palatable. Although it caused a reddish tint in the body fat, this disappeared fairly quickly when beet feeding was discontinued. From comments from other feeders, beet waste appears to be a good feed.

None of the canning companies or livestock producers visited pinpointed any particular problem associated with beet skins. Beet waste disposal is definitely more of an environmental problem than most other cannery waste because of its red pigment.

F. FEEDING PRACTICES

1. Introduction

This section contains combined details of feeding practices obtained in the course of the field research in Ontario and Quebec as well as in California and Oregon.

Vegetable processing wastes are characterized by very high and variable moisture levels. Most of the wastes become available in large quantities over comparatively short periods and they are usually a highly perishable product. These factors dictate preservation practices and feeding systems to a very high degree.

There is a considerable variation in methods of putting together waste rations. Where large amounts of waste are available relative to animal numbers, the cattle producer may opt for high levels of waste in the ration, and slower rates of milk or meat production. Conversely, low levels of waste in the rations may be treated like any other high moisture feed, e.g. corn silage, as part of "conventional" feed rations without essentially any special precautions. There are numerous variations of feeding practices between these two extremes.

2. Breaking-In Period

In the U.S., as in Canada,most feedlot operators started feeding tomato pomace, bean and carrot waste to cattle gradually over a period of time ranging from 1-3 weeks. One feedlot operator starts his cattle on 10-15 lbs. of carrots per day, increasing the ration to forty pounds in ten days. Another rancher feeds seventy percent of mixed waste to growing cattle, with a finishing ration of 50%. He indicated an obvious fact that the average daily weight gain is not as high when using waste, as compared with regular feed rations.

A rancher, who uses tomato pomace to sweeten his feed, often mixed the following waste portion with the tomato pomace:

- 50% grape pomace
- 25% apple pomace
- 25% pear pomace

The cattle loved this mixture. He felt that tomato pomace could be fed at 80-90% of the ration to bulls without problems. However, the rate of gain would only be 1½ lbs. per day. Dairymen frequently are forced to limit carrot rations several hours prior to milking because the cows love to fill up on carrots and will not eat enough grain during the milking period. He suggested that the carrots be mixed to produce a better feed ration, and to prevent the "picking out" of carrots by the cows.

Another feedlot operator feeding tomato pomace has a break-in period of one week. Gradual introduction of bean and pea waste feeding also is very important, usually one week. Not all feedlot operators use a break-in period, however.

The proportion of waste in the ration also determines the length of the break-in period. A relatively small portion of 10-15% does not require a break-in period.

The regularity of feeding especially fresh waste, once the season started and the cattle were used to it, is an important factor. Some feedlot operators monitor the operations of the processors. They enquire about possible shutdowns, due to temporarily-limited supplies, weather conditions, etc. Prior to planned temporary shutdowns, they stretch the available supplies over this period until new supplies became available.

3. Feeding Methods

Feeding practices vary considerably among farm and feedlot operators. Basically, three methods are being used:

- The dumping of bean and carrot waste on piles or pasture land for free choice feeding.
- The mixing of waste with regular feed rations without analysis and recording of quantities in open barns.
- The use of sophisticated methods, using least cost rations and exacting weigh-mixing wagons to dispense the measured rations to troughs for each lot, according to age and gain objectives.

Several farmers, using bean waste, dump it on fields in piles, where it is eaten fresh by the cattle. The bean waste, left uneaten, rots. It is only dumped on the pasture in the last year of the crop rotation which are plowed in the fall or in the following spring.

Pea waste, like bean waste, has been found to deteriorate within a few hours. Anything left over from the previous day's feeding is dumped. Thus, daily fresh feeding of pea waste is a prime requisite. To reduce or eliminate bloating dangers, one farmer mixed the pea waste with extra free-choice hay. He stated that it's almost impossible to preserve pea waste, with high protein levels. The only way may be mixing it with corn silage.

One farmer feeds waste to his cattle in an open feedlot barn and cement trough. When culled carrots are available, they represent 40-43% of daily ration. The remainder consists of sweet corn silage, potatoes, grain and elevator sweepings, and a premix.

Another farmer feeds his cattle culled carrots within a few days of receipt. He claims that while feeding carrots to his dairy herd, milk production increased 5-10%, and the general health of his animals improved. To fatten his beef cattle he mixes the carrots with grain. Another farmer, who has been feeding bean and corn waste for approximately 30 years, uses the bean and corn wastes as a supplement in late summer and early fall, when the pastures are getting thin, and not providing sufficient feed on a daily basis for his herd. He claims his cattle rush toward their feed bins and seem to be in much better shape, than if no bean waste were being fed.

A feedlot operator feeds fresh tomato pomace on a daily basis. When quantities became too large to be used up daily, he mixes it in a pit on the basis of 10% tomato pomace and 90% corn silage. He recommended that no more than 40% of the feed ration for the cattle consist of waste feed, due to its palatability.

One farmer used a variety of vegetable wastes. He did not mix it with his own silage corn, because of different harvesting times. He could use up practically all the vegetable waste supplied to him on a daily basis, except in the peak harvesting season. Instead, in the summertime and fall, he mixed the waste with hay.

The larger feedlot operators utilize mixer trucks of various makes, such as Harsh. One of the farmers designed his own mixing truck, because the commercial trucks broke down too often, since the mixing of partial and whole corn cobs was too hard on the equipment. Front-end loaders are used to load the corn silage, fermented tomato pomace, and other waste feeds on the mixing trucks in predetermined proportions. The ration is then metered out into the concrete or combined concrete/wood troughs for each feedlot, depending on the number and age of the animals. Some of the larger feedlot operators use least cost formulas, allowing them to achieve the optimum efficiency in fattening beef cattle.

4 . Physiological Aspects

None of the feedlot operators indicated any physiological problems with the cattle while being fed waste products. One feedlot operator indicated that as long as the rations were well balanced, no problems occurred. One problem mentioned was the loss of weight or lower weight gains per day of the cattle when they were taken off the waste feed.

One rancher stressed the interaction between various feeds which, for some, are still not fully researched or explained, e.g. ground almond hulls are a great feed but he cannot use more than 10%. The fibre content as well as its composition is extremely important: he indicated that some feeds with 25% fibre digest better than other feeds with only 5% fibre. He indicated as examples that small cull sunflower seeds, relatively high in fibre, are as digestible as corn.

Two farmers experienced some feeding problems for which no solution could be found. Only three feedlot operators indicated problems with diarrhea especially from feeding high levels of carrot waste. This was eliminated by feeding higher proportions of forage and dry feedstuffs.

5 . Palatability

Most of the feedlot operators had no problems with the palatability of the waste feed; in fact there were some feeding problems from high palatability of carrot and bean waste. Rations were changed by some ranchers to include more grains and roughage to decrease the palatability.

Tomato pomace was considered rather palatable by several farmers and feedlot operators although one researcher at the University of California does not agree, especially for dairy cows. One farmer feeding fresh tomato pomace did not have any problems with mold sometimes associated with ensiled pomace.

No difficulties of feeding bean and carrot waste were reported by farmers visited. Some ranchers in California have the advantage of feeding fresh culled carrots and carrot waste originating from the processors who use carrots from the fresh market packing sheds as well as directly from the packing sheds all year round.

6. Supplements

Some feedlot operators add supplements to the cattle rations. One dairy operator added calcium and sodium bicarbonate. One dairy farmer monitors the phosphorus content carefully because he is "growing", not fattening his cattle. Nitrates, he has found, can abort heifers, when contained in high concentrations. He adds urea supplement to low protein waste feed.

Tomato waste fed in large quantities was cited as a possible cause of magnesium deficiency and tetany in dairy and pregnant cows. This was not the case with steers and bulls.

One farmer visited indicated that he had no problems with magnesium deficiency, or acidosis. Another, a feedlot operator and a rancher, recommended the feeding of floured limestone because it reduces the acidity in the waste products and increases the feed intake. Alfalfa hay (4-5 lbs. per day) per steer eliminates supplementation problems in feeding waste.

One feedlot operator found selenium deficiencies from feeding large portions of tomato waste low in Vitamin E. Now, the Vitamin E level is being controlled with supplementary grain pre-mixes, containing selenium and Vitamin E.

7. Absorption of Colour

The feedlot operators interviewed incurred few problems with absorption of colour in their cattles' body fat, milk or meat, due to waste feeding. Most feedlot operators found it necessary to stop feeding waste products, especially tomato pomace, several weeks prior to slaughtering. Two feedlot operators indicated that feeding of tomato pomace to livestock has to be stopped some 60 days prior to the slaughtering, so that the natural colour of the meat would return. One farmer had problems with colour absorption in fat until he stopped feeding carrots and beets, at least 30 days prior to slaughter.

Another feedlot operator eliminates the absorption of tomato pomace colour in the fat of his feedlot operation by withdrawing the feeding of tomato pomace even 90 days prior to slaughter. He also reduces the pomace portion in the feed ration after the animals have reached 900 lbs. Once they have reached 900 lbs., he feeds them more husklage, while the animals are in the finishing yard during the last phase. The gain during this period is between 2-2½ lbs. per head per day.

Another feedlot operator mixes all his wastes in small quantities with corn silage and other waste feeds. He has no difficulties with the absorption of colour from carrots or tomatoes. They are not fed to the animals up to 30 days prior to slaughter; and onion waste, 40 days (because of possible odour problems). One dairy farm visited indicated no problems with the colour absorption in the milk.

Beans caused odours in milk. The beans stimulate milk production but the cows lose body weight. One dairyman feeds 15 lbs. of bean waste per head per day. Onions cause serious odour problems in meat. One feedlot operator advised that they be kept out of beef cattle diets.

8. Losses of Animals

Most feedlot operators indicated that few cattle died due to the effects of waste feeding. Two extreme cases however were cited. One operator lost 94 steers on one night because of nitrate poisoning. Another large farmer loses about 25-30 head per year, possibly due to hardware disease or feeding. He had cows with clostridium, a disease of excessive eating. These cows were "free choice" fed in the pen and manger, picking out the carrots, in particular. This operator is now vaccinating his cattle to help eliminate his losses from disease.

Another farmer loses approximately one cow per year. This is about 2%, the generally accepted loss for herds. Since these cattle were fed waste products, this is considered to be an excellent record! A few cattle, (2-3), who are sickly, are put back in the pasture. He also felt that carrot waste should not be fed to pregnant cows. The cows may abort the calf, because of excessive amounts of carotine.

Nitrate and bleeding problems led to the death of a few cattle, belonging to one farmer. Lima beans are no longer fed because of bloating and reduction in milk production. The farmer did not recommend the use of lima bean waste for milk cows. Another feedlot operator also noted a few losses of cows when they ate excessive amounts of lima beans. Pea waste was preferred because it is high in protein and milk production increased rapidly. The cows, however, seemed to lose weight, which caused a slight loss in the fat content of the milk. One feedlot operator reportedly lost several steers when too high a proportion of onions was fed.

Hardware disease problems can present a major problem. Many farmers are inserting magnets in the rumen. Many reported that waste, depending on the plant and workers' diligency, still contained varying amounts of nails, cans, tins, glass, wood, pieces of metal, etc., despite implicit instructions to separate these items. There does not appear to be a ready solution. Some processors are using magnetized stainless steel in their operations to separate out pieces of metal. However, glass and wood are still undetected in the waste.

Respiratory problems, due to damp barns and unduly wet feed, have been reported by one feedlot operator. His mortality rate was still low. One feedlot operator lost several head of cattle due to feeding of very heavy portions of onion waste, some years ago.

9. Manure Characteristics and Disposal

In many cases feedlot operators in Canada are forced to a liquid manure system - whether they want it or not under the climatic conditions. In California, where sun drying is feasible, the feedlot operators questioned did not have special problems with the extra quantity or consistency of the manure and its disposal. A change in colour, due to feeding tomato pomace was found in the manure. In this case, the manure turned a reddish-brown in colour.

The increased quantity of water consumed with the waste resulted in greater urine production. Its characteristics or disposal, as reported by feedlot operators, did not constitute a problem other than being more liquid.

10. Conclusions and Recommendations

The information obtained from the numerous farmers, feedlot operators and ranchers can be summarized as follows:

- A much higher proportion of the waste is fed in the ensiled form in the U.S. as compared to Canada, with the possible exception of tomato pomace. Ensiling techniques are much more highly developed south of the border among producers but the information is not readily available. Essentially any of the high moisture waste products can be satisfactorily ensiled, and is frequently mixed with other feeds.

- Most of the waste is fed in large operations where sizeable equipment and storage facilities are available.
- The high and variable moisture content of fruit and vegetable wastes is of paramount importance. It is not only the major factor in additional handling and transportation costs but it is of critical importance in the development of balanced rations with adequate energy levels. Whereas high producing dairy cows will consume 3.0% or more of their body weight on dry feeds, their intake on wet feeds is likely to be around 2%, or some 33% less. Many of the larger operators obtain the chemical composition and moisture levels in each large batch of waste and employ a consultant nutritionist to formulate their rations.
- Most waste is fed mixed with other waste feeds and/or conventional feeds, corn silage, hay, grains, protein supplements, etc. The feed is usually prepared in large mixer-weigher wagons and dispensed mechanically into feed bunks as complete mixed diets. Lactating cows are fed concentrated rations during the milking period.
- In most instances cattle are started slowly on waste at low levels, the levels being increased to maximum over a 10-day - 2 week period.
- While vegetable and fruit processing wastes are fed to all classes of cattle, as with other feeds, the higher quality waste is reserved for higher producing animals, e.g. low quality tomato waste would be unfit for high producing milk cows whereas 35% DM tomato pomace silage would be very acceptable.
- There is usually little need for protein supplementation when appreciable quantities of waste are being fed. This would not generally be true for

high producing dairy cows because of their high protein requirements and the need to restrict waste intake due to its high moisture content. It does, however, apply to most other classes of cattle. For most classes of cattle protein is often fed well in excess of the requirements and then some of it is used for energy.

- Mineral supplementation is of considerable importance. Many good operators recommended the feeding of limestone (floured type preferred) or sodium bicarbonate to reduce the acidity of the conserved waste and to increase feed intake. A vitamin-trace element mixture is frequently fed. Selenium and Vitamin E should be included. When high tomato waste rations are fed extra magnesium should be added as magnesium tetany was mentioned on a few occasions and is believed linked to the high potassium levels in tomatoes.

G. PESTICIDE RESIDUES

1. Introduction

NOTE: Due to similarities on pesticide residual aspects, it was felt advisable to combine the Canadian and United States information.

The term pesticide is used here to cover insecticide, miticide, bactericide, fungicide, nematicide and herbicide as in the Vegetable Production Recommendations, OMAF, 1981.

The application of pesticides to commercial vegetable crops in Canada is now a highly regulated system. Firstly, these chemicals must be registered under the Federal Pesticide Control Products Act. Secondly, they must be applied in accordance with recommendations from Provincial Spray Calendars which specify the approved chemicals and conditions for application. Thirdly, most, if not all processing companies have their own field staff who monitor application of the chemicals to conform to the contract with the grower. And fourthly, in Ontario at least, the Ministry of the Environment licences agricultural spray operators and monitors their performance.

The major source of pesticide residues is that remaining from the direct field application of pesticides to the crops. A second source is from pesticide chemicals in the soil from applications to the current or previous crops, and from spray drift or misuse of pesticides.

The old chlorinated hydrocarbon insecticides, eg. DDT, lindane and dieldrin, etc. produced residues which had a bad reputation for accumulating in animal products such as meat and milk fat and have been largely replaced in Canada by organophosphorus compounds such as parathion, malathion and diazinon. The latter compounds decompose much more rapidly and have less tendency to accumulate in mammalian tissues and products. This shift in emphasis is reflected in the Ontario

Spray Calendar, 1981. However, there are still one or two of the organochlorine types authorized for use namely, endosulfan and dicofal, which are of some concern.

During visits to the processing plants, most managers were not prepared to discuss pesticide residues other than to state that their field staff monitored the application of chemicals carefully in accordance with their contracts with producers and the current Ontario and Quebec Spray Calendar recommendations. As a consequence, they indicated they were not having any residue problems in their products and claimed this is confirmed by their own pesticide residue monitoring procedures. It is noteworthy that some contracts between processor and grower permit the processor to reject produce containing harmful levels of residues but it would appear this would be a rather rare occurrence.

One processor did supply copies of independent chemical analyses of residues for 67 of the currently recommended pesticides. Without exception, these analyses showed that residues were well below the permissible levels.

2. Regulatory Aspects

To further investigate possible problems arising from pesticide residues, a number of Provincial or Federal Government Agencies with specific responsibilities for controlling or monitoring use of pesticides on vegetable crops were consulted.

Mr. Garry Rieger of the Food Production and Inspection Branch, Agriculture Canada, Chatham, who assists in administering the Feedstuffs Act in Kent, Essex and Lambton Counties, has not heard of any problems or complaints (August 1981), relating to pesticide residues in vegetable processing wastes fed to livestock. He noted that changes proposed in the Feedstuffs Act would enable Federal inspection of feeds grown on the farm and presumably also include any vegetable waste used as feed. Present procedures are to check commercially available registered feeds and any suspected animal products (meat or milk) for residues. Likewise, Dr. Samuel S. Low, Food Production and Inspection Branch, Agriculture Canada, Chatham, who has no specific responsibilities in this area but has good contacts with local veterinarians, had not heard of any pesticide residue problems associated with feeding vegetable wastes. He referred us to Dr. F.J. Harden of the Veterinary Service Laboratory, OMAF, Ridgetown, where the diagnostic veterinary work on farm livestock is done for Essex, Kent and Lambton counties. Dr. Harden indicated that over the past 10 years he has not encountered any animal health problems associated with residues from pesticides in vegetable processing wastes that were used for feed on farms.

A Representative of the Ontario Ministry of the Environment, Mr. Harold E. Collins, District Pesticide Officer, Chatham, is responsible for the Southwestern Region and licenses custom agricultural sprayers and monitors application of pesticides to crops. Mr. Collins was not aware of any problems caused by residues from pesticides in vegetable processing waste fed to cattle.

Dr. R. Frank, Director, OMAF Pesticide Laboratory, Guelph, with responsibilities for investigating pesticide residue problems in Ontario, stated that only a limited number of processing wastes have been examined and to date no significant residues have been found. Carrot tops were one material with unacceptable levels of organophosphorus pesticides, (parathion), and probably were the result of treating the crop for insects. Potato peelings and chips contain few, if any residues. Some residues were found on sweet corn waste but these disappeared after ensiling. Heavy metals, such as mercury, have not been found above normal background levels.

Mr. Peter R. Bennett, Head, Agricultural Chemicals Section, Chemical Evaluation Division, Bureau of Chemical Safety, Health and Welfare Canada, was consulted. This section has specific responsibilities for evaluation of pesticides for use on food crops. He indicated they were concerned about pesticides used on corn and potatoes and the possibility of crop waste being fed to livestock and resulting in residues in animal tissues. He was not aware of any specific problems with pesticide residues resulting from feeding tomato, bean or carrot processing waste. He is however, concerned about two types of pesticides which cause problems namely:

(a) organochlorine compounds currently registered and recommended for use on fruits and vegetables including in particular, endosulfan and dicofol. Lindane is also of some concern but current usage is minor. There do not appear to be specific data available to establish if endosulfan and/or dicofol could be a hazard in relation to use of vegetable processing wastes for feed.

(b) synthetic pyrethroids which are now extensively used overseas and, like the organochlorine compounds, can be concentrated by the animal in meat and milk. These are not yet registered for use in Canada for vegetables but some chemical companies are interested in obtaining such registrations.

Mr. Bennett cautioned that all monitoring data are based on food, not crop waste, so residues on crop waste could be higher.

The Bureau of Field Operations, Field Operations Directorate, Health and Welfare Canada, was also contacted. This Directorate has specific responsibilities for monitoring pesticide residues in foods. Information obtained from Ms. Geraldine Graham and Mr. J.G. Lee indicated that:

- The Market Basket Survey for pesticide residues (total diet checks) was terminated several years ago because of the low incidence of residues found. This is indirect evidence that residues are unlikely to be a problem. Currently, this Directorate is providing surveillance on individual commodities, eg. tomatoes, locally produced or imported. Residues are seldom above the permitted tolerances and are generally much lower.

- Generally speaking, very few pesticide problems and none of widespread concern have been encountered in recent years. They have residue data for organochlorine compounds on vegetables which they provided so that it could be evaluated in relation to the possibility of concentrating residues in meat or milk if wastes are used for feed.

3. Residual Levels

In the absence of hard data on the actual pesticide residue levels in carrot, bean and tomato processing waste, levels of pesticide residues on the vegetables represented the best available information. The data source was a computer printout of the analyses for pesticides performed by the Field Operations Directorate regional laboratories, Health Protection Branch, Health and Welfare Canada, on tomatoes, carrots and green beans, 1979-81. The samples of the fresh,raw product were obtained from growers, wholesalers and retailers across Canada. The regions of pickup were: Western Region (BC and Alberta); Central Region (Sask. and Man.); Ontario Region; Quebec Region; Atlantic Region. Multi-residue analyses were performed on each sample.

Concerning organochlorine residues in tomatoes, endosulfan (0.069 ppm) was found in only one sample of the approximately 48 samples of tomatoes analysed, indicating that from April-December 1979-81, this chemical appeared to be used very sparingly by growers. All other organochlorine analyses were negative.

In the case of carrots, five samples out of approximately 124 samples were found to contain endosulfan, the levels ranging from 0.001 ppm to 0.070 ppm. In addition, a considerable number of carrot samples from one area showed traces of dieldrin at about the 0.025 ppm level. It is probable these latter residues occur as a result of soil contamination with dieldrin from crops grown previously when this chemical was registered for use on crops.

Green beans showed negative organochlorine residues except for two samples where lindane was found at the 0.023 and 0.001 ppm levels out of about 21 samples tested and presumably was due to seed treatment.

According to Mr. Peter Bennett of the Health Protection Branch, of Health and Welfare Canada, the levels of endosulfan (up to 0.070 ppm) would not likely cause undesirably high levels of endosulfan in meat or milk f the vegetables were fed to cattle. In fact, he thought considerably higher levels, (up to 2.0 ppm) could be tolerated on some waste products used for feed. On the other hand, much lower levels of dieldrin, as low as 0.010 ppm would be of concern. In this respect, a considerable number of dieldrin analyses for carrots contained around 0.025 ppm, which exceeded the maximum. However, the levels of feeding and length of feeding period would all have a pronounced effect on the buildup of dieldrin in meat or milk. Considering the comparatively small quantities of cull carrots and carrot processing waste available for feeding in Canada the hazards are likely to be minor.

Endosulfan is recommended for use on tomatoes and green beans but not for carrots in the Ontario 1981 Spray Calendar.

Comments and analysis of the data have focussed on the residues which Health and Welfare Canada feel are of some concern although analyses are included for many other compounds.

Maximum residue limits for agricultural chemicals on crops are set by Health and Welfare Canada under the Food and Drugs Act. These residue limits are set "... at a level that will permit the effective use of the chemical in accordance with label instructions". Table 22 lists the maximum residue limits for those agricultural chemicals used on beans, carrots and tomatoes in Ontario and Quebec (except soil fumigants).

The 1981 Vegetable Production Recommendations for Ontario include a cautionary note concerning bean wastes. It

Table 22 Maximum Residue Limits for Agricultural Chemicals in Beans, Carrots, and Tomatoes

(In parts per million)

A. Weed Control

Chemical Trade and/or common name	Negligible Residue Basis(1)	Beans	Carrots	Tomatoes
Amibeu (chloramben)	*	*	-	*
Basagram (bentazon)	*	*	-	-
Eptam (EPTC)	*	*	-	-
Treflan (trifluralin)		*	0.5	*
Patoran (metabromuson)	*	*	-	-
Afesin (monolinuron)	*	*	-	-
Linvron	*	-	*	-
Herbicidal Oil (mineral or petroleum)	*	-	*	-
Maloran (chlorbromuron)	*	-	*	-
Dymid (diphenamid)	*	-	-	*
Tillam (pebulate)	*	-	-	*
Lexone, Sencor (metribuzin)	*	-	-	*
Gesagard (prometryne)	*	-	*	-

(1) Use according to label instructions should not result in significant residues remaining in or upon human food.

* Recommended for use on this crop

(Source: Food and Drug Regulations, Division 15, Table II, February, 1982)

Table 22 cont'd

B. Disease Control

Chemical	Negligible Residue Basis (1)	Beans	Carrots	Tomatoes
Trade and/or common name				
Beulate (benomyl)		1 (2)	5	2.5
thiram		-	*	7
captan		25	2	25
mancozeb) Manzate, Dithane	*) carrots	-	*	4) calcu-
maneb)	*) only	-	*	4) lated as zineb
zineb (Ziram)		-	-	4
Bravo (chlorothalonil)		5	1	5
Copper compounds		-	-	50
Difolitan (captofol)		-	-	5
Dyrene (anilazine)		-	-	10

(1) Use according to label instructions should not result in significant residues remaining in or upon human food.

(2) Do not feed bean refuse to livestock or poultry if crop is treated with Benlate.

(*) Recommended for use on this crop.

Table 22 cont'd

C. Insect Control

Chemical Trade and/or (common name)	Negligible Residue Basis (1)	Meat Residue Limits	Poultry Residue Limits	Dairy Product Residual Limits	Beans	Carrots	Tomatoes
diazinon	-	-	-	-	0.5	0.75	0.75
lindane	-	2.0	0.7	0.2	*	-	3.0
Sevin (carbaryl)	-	-	-	-	5	5	5
Furadan (carbofuran)	-	-	-	-	-	0.5	-
Guthion (azinphos-methyl)	-	-	-	-	2.0	-	1.0
Thiodan (endosulfan) (2)	-	0.1	0.1	0.1	1	-	1
Cygon (dimethoate) (2)	-	-	-	-	1.0		0.5
Malathion	-	-	-	-	2	0.5	3
parathion	-	-	-	-	0.7	0.7	0.7
Phosdrin (mevinphos)	-	-	-	-	-	-	0.25
Imidan (phosmet)	*	-	-	-	-	*	-
Lannate (methomyl)	*	-	-	-	*	-	*
Systox (demeton)	-	-	-	-	-	-	0.3
Thuricide (3)	-	-	-	-	-	-	*
Dibrom (naled)	-	-	-	-	0.5	-	0.5
pyrethrins	-	-	-	-	1	-	1
piperonyl butoxide	-	-	-	-	8	-	8
methoxychlor	-	3	-	-	14	14	14

(Soil fumigants for pre-plant control of nematodes in carrots are not included)

(1) Use according to label instructions should not result in significant residues remaining in or upon human food.
(2) Do not feed bean refuse to livestock or poultry if crop is treated with this chemical.
(3) Exempt from agricultural chemical regulations.
(*) Recommended for use on this crop.

Table 22 cont'd

D. Chemical Fruit Ripening	Beans	Carrots	Tomatoes
Emrel (ethephon)			2.0 ppm
E. Crop Preservative			
maleic hydrazide (MH)			30 ppm

states:

> "Do not feed bean refuse to livestock or
> poultry if the crop was treated with endosulfan,
> Thiodan, Cygon or Benlate".

This statement was discussed with Dr. Freeman McKewan, University of Guelph, and chairman of the Ontario Ministry of Agriculture and Food committee reviewing pesticide recommendations for Ontario. He explained that the cautionary note was included because there is not enough information available at the present time concerning possible residues from these chemicals to ensure safe use of bean waste from treated beans. This suggests that bean wastes from beans treated with the above chemicals should be fed to livestock at low levels until additional work has been carried out on residue analysis. A program of residue analysis in bean wastes for endosulfan, thiodan, cygon and benlate should therefore be carried out under the auspices of the OMAF Pesticide Laboratory in Guelph.

The Pesticide Registration Office, Plant Products Division, Agriculture Canada, Ottawa, supplied the following information, courtesy of Mrs. Jean Stalker:

- Captan - under review by a special Consultative Committee.
- Lindane - uses are very limited - only for seed treatment of beans, not for carrots or tomatoes.
- Malathion - relatively high tolerances are allowed in feed and food because the chemical decomposes rapidly after application.
- Toxaphene - no longer allowed (not registered) for crop use in Canada, but is registered for certain uses in livestock. In the U.S. it can still be used on crops but is under review and registration may be cancelled. See Rebuttable Presumption, Federal Register, Part IV, Environmental Protection Agency, May 25, 1977.
- Pesticides registered for Canadian use (see previous section on regulations).

Since U.S. vegetables are not imported in any quantity to Canada for processing and since all the waste generated in the U.S. plants is either disposed of or utilized in the vicinity of the processing operations, pesticide residues in the U.S. are of little or no concern to Canada. In the course of visits to processors, ranchers and farmers in California, there was little or no concern about pesticides in vegetable waste being fed to livestock. The only pesticide of concern was toxaphene which is still allowed in the U.S. The maximum permissible levels of toxaphene in feedstuffs were said to be 2 ppm for dairy cows and 7 ppm for beef cattle. According to information received from the University of California and the Sun Dry Products Co., a maximum tolerance in milk was claimed to be 0 ppm.

4. Persistance of Pesticides in Vegetable Crops

In California, toxaphene residues on tomato pomace were studied by Swenerton (1975). The maximum permissible levels were 7 ppm in meat and 2 ppm in finished feeds. Although feeding tomato pomace containing levels as high as 79.6 ppm toxaphene to steers for 47 days resulted in 3 ppm in tissue fat, the toxaphene essentially disappeared during the following 113-day feeding period when no pomace was fed. While it was considered that the toxaphene residues in the tomato waste could be tolerated for feeding beef cattle, providing it was monitored and kept within permissible limits, where toxaphene was used tomato pomace was considered unfit for dairy cows, Swenerton (1975). Thus toxaphene, a typical organochlorine compound, exhibits a persistent behaviour pattern in tomato pomace and in animal products.

Malathion, one of the organophosphorus group of pesticides has been widely used in the past on fruits and vegetables in North America and continues to be an important pesticide. It is noted for its specific toxicity to insects, low toxicity to warm blooded animals and is included for insect control on beans and tomatoes in the 1981 Ontario Spray Calendar. Many studies have been carried out concerning the rate at which malathion degrades in the field and methods of reducing residues for commercial use or preparation of vegetables for home use. These include studies on spinach, Yao and Geisman (1972); on green beans, Elkins et al (1968), Smith Giang and Taylor (1955); on tomatoes, Farrow et al (1968), Wolfberger and Van Middlelem (1955). The conclusions were as follows:

- Very rapid decomposition of malathion occurs in the field especially in the first day after application and continues more slowly thereafter both in the field and during storage.
- Washing procedures, even with cold water, removed 70-95% of the residual malathion and the addition of a detergent increased removal to 97-99%.
- Blanching and cooling further reduced or removed any traces of residue still present after washing.

While the behaviour pattern for malathion is not identical to all organophosphorus pesticides, it does generally reflect the behaviour for this class of insecticides which are much less persistant and less likely than the organochlorines to pose a residual problem in animal feeds and in animal products such as meat and milk.

Under commercial vegetable processing conditions, the vegetables are thoroughly washed on entering the plant and often receive a second wash in detergent solution. Hence, it would appear highly unlikely that malathion residues would be a problem in wastes from tomatoes, beans or carrots, even if present prior to processing.

5. Conclusions

The amount and type of pesticide residues on vegetable crops has undergone important changes in recent years. Highly persistent types have been largely replaced by less persistent rapidly degradable types. These changes are due to the following reasons:

- Currently, the application of approved pesticides to commercial vegetable crops intended for processing is carefully controlled by the grower and processor and highly regulated/monitored by Provincial and Federal government agencies.
- The widespread adoption of the newer organophosphorus type of pesticide has greatly reduced the possibility of accumulating potentially harmful residues on vegetable products consumed directly or from feeding vegetable processing wastes.
- Washing of the vegetables with plain or detergent fortified water as they arrive in the plant frequently removes a very high proportion of pesticide residues remaining after field application.
- The evidence from Provincial and Federal laboratories responsible for monitoring for pesticide residues indicates that residues, when present, are generally well below permissible tolerances for human use in either fresh or processed vegetable products.
- While Provincial and Federal sources have indicated that no data are available to indicate that there are any pesticide residue problems arising from feeding tomato, bean or carrot processing wastes to livestock, Health and Welfare Canada officials have some concerns about possible residues arising from the use of the organochlorine compounds, endosulfan (Thiodan) or dicofol (Kelthane) on vegetable crops and their possible transfer and concentration into milk or meat when processing wastes are used for feed. In this connection, endosulfan is recommended for the control of four different insect pests on tomatoes and one insect on green beans in the 1981

Ontario Spray Calendar, but dicofol is not. Since producers generally have alternative pesticides available they are not necessarily using endosulfan at the present time. It is suggested that producers and processors be cautious about the use of endosulfan or dicofol on vegetables if the processing wastes are to be used for feed. Moreover, information on the actual levels of endosulfan and dicofol in some specific vegetable processing wastes, eg. tomato, should be obtained.

- Health and Welfare Canada officials expressed some concern about the possible future use of synthetic pyrethroids for insect control on vegetables in relation to possible concentration of such residues in meat and milk from animals fed the processing wastes. None of these are registered for use on vegetables as yet although there is commercial interest in obtaining such registrations. There may be some need for additional information on this aspect of vegetable waste.
- No direct evidence was found which would indicate that the level of any of the pesticide residues for beans, carrots and tomatoes might be of concern or higher in the processing waste than in the food product. Hence, the use of processing waste for livestock should not pose any more residue problems than the consumption of the commercial food products (eg. catsup) by humans. However, additional information would be useful on the possible accumulation of certain pesticide residues on tomato skins.

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H. COSTS

1. Material Costs of Waste

Practically all processors provide tomato, bean and carrot waste free of charge to feedlot operators or dairy farms. However, most processors, who ship the waste in their own trucks, charge for the transportation; or, conversely, the farmers, who haul the waste on their own or have truckers do the custom hauling, pay for the costs. Only in a few isolated cases is the waste supplied and hauled to the farm or feedlot free of charge.

There appear to be several reasons for the free supply of waste products. One reason could be the lack of knowledge of the nutritional and economic value of various waste products. A second was indicated to make the proposition attractive enough for interested feedlot operators to provide an efficient and reliable pick up service during the season when the plants' efforts are concentrated on the supply and processing of vegetables. A third reason could include the elimination of processors' liabilities from the feeding of waste by the farmer by providing the product free instead of selling it; further details are contained in the section on Contractual Arrangements. A fourth reason could be based on the processors' desire to eliminate the disposal and related costs.

One processor provides tomato pomace free of charge to a feedlot operator under multiyear contractual arrangements with the stipulation that the farmer accepts all pomace and erects a trench silo at his own cost. Thus, while the pomace as such is free, there is nevertheless a charge associated with it for the hauling, and the amortization and interest charges of the silo whose capital cost was $36,000. A combined charge for the waste and transportation has been estimated at $1.25-1.50/ton. Another processor charged a nominal amount for all waste supplied; the average per ton would amount to approximately 10¢.

Another variation involves arrangements under which more popular wastes such as sweet corn waste, are provided at a moderate cost with the condition that the less desirable wastes such as pomace, carrot and bean and other wastes are picked up regularly.

Some processors either provide or sell all their seasonal waste products to a custom hauler who is free to resell and haul the waste to feedlot operators. One custom hauler charges $2.50/ton of bean waste or the same as for waste corn husks, cobs, etc. He charges $5.00 per ton for the corn skins which are firmer and contain more nutrients. The following interesting observation was made that sweet corn waste could be sold at prices up to $13.00 in the Essex and Kent Counties where it was well known and extensively used, but only at $7.00 in the Brant and Waterloo Counties where farmers, having heard of the problems and difficulties associated with waste feeding, were less interested in it.

In some cases the "charges" for the waste products represent a combination of material and transportation costs. Some farmers pay for the waste as such, and/or for the hauling or approximately $5.00 per ton; others pay from $1.00-$3.00 per ton. Only a few farmers are provided waste free of material or transportation charges, mostly by smaller processors; their farms are within a radius of 10-15 miles from food processing plants.

One farmer, located 20 miles from a processing plant, had been purchasing over 3,000 tons of waste corn. This waste was ensiled and mixed at the same time with the whole corn silage or haylage. The total cost to this farmer was $7.25 per ton for the corn and delivery charges. He also wants to explore the feeding of other food processing waste, and plans to contact additional food processing companies in his area.

Surprisingly, neither processors nor feedlot operators mentioned a relationship of cost of waste in relation to prices for commercially-available feedstuffs, or a relationship of supply and demand. Such a relationship could more likely apply to the more valuable sweet corn waste than to tomato pomace, bean and carrot waste.

Since the material and transportation costs are often combined, the Table 27, summarizing them, will be shown in Section 4 of this chapter.

2. Transportation Costs

The transportation of waste takes one of the five following options:

- Contract haulage by private carriers.
- Farmer haulage with own trucks or trailers.
- Farmer haulage with leased trucks or trailers.
- Delivery by processor at cost.
- Delivery by processor at no cost.

The first two options appear to be favoured by the feedlot operators interviewed. Some of the larger operations had their own vehicles and thus absorbed the hauling costs. The arrangements as to pick up and delivery varied from case to case. One farmer has a 36 ft. trailer with a 35 ton capacity for sweet corn; a 20-22 ton capacity for apple pulp; and 20-22 ton capacity for tomato pomace. The hauling costs are about $5.00 per ton for a 20-25 mile radius (or about 20-25¢/ton mile), providing the waste can be loaded quickly. This farmer is also interested in "roll off-roll on" container units that could be left with the processor and picked up when filled. Another large feedlot operator hired a hauling company.

There are general transport companies hauling waste to landfill sites, farms or dumps, mostly under contractual arrangements with processors. One such company in Ontario has hauling contracts ranging from 150 to 4,000 tons of waste feed, which it transports to some 15 feedlots. The company chops the corn waste before loading. This reduces the volume and breaks up the cobs, so that they can be eaten more easily.

The hauling costs of this company are shown below:

Hauling Costs

	Hauling Costs per Ton	Computed Costs per Ton Mile (max. distance)
1-7 miles	2.60	37¢
7-11 miles	2.90	26¢
11-16 miles	3.20	20¢
17-21 miles	4.10	20¢
21-25 miles	4.40	18¢
25-30 miles	4.70	18¢

The hauler indicated that the value and thus charges for bean waste would be about the same as for cornstalks or $2.50 per ton. In addition to corn and bean waste, this hauler also transports cooked carrot waste, grape pomace, cull carrots, and other waste products.

Some processors prefer to ship the waste themselves in order to have complete control over this operation, rather than be dependent on farmers, feedlot operators, or haulers.

The costs associated with handling can vary greatly with the type of waste being fed and the type of livestock consuming it. Costs generally fall into the following categories:

- Specialized storage (trench silos).
- Specialized mixing (feed mixer).
- Pre-feed processing (dryer).

To evaluate cost/benefit ratios and establish an economic radius for utilizing processing wastes for livestock feed, transportation and hauling costs should be included with any charges by the processor for the waste.

To compare the costs of hauling food wastes, unit costs were established for contract haulage and private (farmer) haulage using purchased equipment. Cost of vehicle ownership and operation (plus fuel) was calculated for a semi-trailer unit in the Maple Ble Study* to be $0.975/mile. Assuming current fuel cost in the order of $1.90/gallon, the following estimates were calculated as the cost per ton to transport food wastes, Table 23.

Table 23 Computation of Hauling Costs

	15 ton load	25 ton load
Ownership and operation	$0.975	$0.975
Fuel cost: 1.90 gal.	(6 miles/gal.) 0.317	(4 miles/gal.) 0.475
Cost/mile	$1.292/mile	$1.45/mile
Cost/ton	0.086/ton mile	0.058/ton mile

Interviews with farm operators indicated similar figures. Although there were situations where rather expensive equipment was being used, in general, the average unit cost given by the farmers was about 20¢/ton mile with variations from 10¢ to 30¢. The cost of contract haulage varied with distance. Short distances had much higher unit costs. Average rates varied between 40¢/ton mile for less than 10 miles to 15¢/ton mile for distances over 50 miles. In situations where the processor was delivering wastes at cost to the farmer, the average charge was approximately 12¢/ ton mile.

From the above costs for transportation it appears that, on the average, a farmer can expect to pay around 20¢/ton mile for his feedstuff. This figure can be used to determine the threshold distances which he can travel to obtain the waste products.

Estimates of the economic distance that waste products can be hauled for livestock feed were prepared, based on dry matter and total digestible nutrients (TDN) as an index of

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* "A Feasibility Study of an Integrated Food Waste Processing Cattle Feedlot Operation", Contract 1SZ 79-00261, Agriculture Canada.

feeding value. Table 24 compares the dry matter content and TDN of corn silage and high quality alfalfa hay with four selected waste products:

Table 24 Dry Matter and Total Digestible Nutrients (TDN) of Selected Feeds and Waste Products

	DM %	TDN/ DM %	TDN % As Fed	TDN in lbs/ton As Fed	Price/ Ton	Price/lb. TDN ¢
Corn silage	35	65	23	460	$18.00	3.91¢
High quality alfalfa	85	70	60	1200	60.00	5.00
Tomato pomace "dry"	30	67	20	400	3.00	.75
Tomato pomace "wet"	15	67	10	200	1.00	.50
Bean Waste	18	73	13	260	1.50	.58
Carrot Waste	15	82	12	240	2.00	.83

The going price for corn silage was taken as $18.00/ton, which, at 460 lbs. TDN/ton, translates into 3.91¢/lb. of TDN. Alfalfa was priced at $60.00/ton which, at 1200 lbs. TDN/ton, is equivalent to 5.00¢/lb. of TDN. Using these prices, the comparative value of each waste product was calculated on the basis of its TDN content and value, in comparison with corn silage and alfalfa. These comparative values are shown in Table 25 below:

Table 25 Comparative Value of Waste Products with Corn Silage on Cost/TDN Basis

	Corn silage basis Percent	Alfalfa basis Percent
Tomato pomace "dry"	19.2%	15.0%
Tomato pomace "wet"	12.8%	10.0%
Bean Waste	14.8%	11.6%
Carrot Waste	21.2%	16.6%

The following Table 26 shows the economic radius of waste transportation under the assumption that the transportation costs are identical with the material costs. The comparison with corn silage is based on its radius of 90 miles ($18.00 divided by 0.20 per ton mile). The comparison with alfalfa hay is based on the radius of 300 miles ($60.00 divided by $0.20 per ton mile):

Table 26 Approximation of Economic Transportation Radius for Selected Waste Products Compared with Corn Silage and Alfalfa

	Corn silage basis (miles)	Alfalfa basis (miles)
Tomato pomace "dry"	17	45
Tomato pomace "wet"	12	30
Bean waste	13	35
Carrot waste	19	50

The above comparisons show that the radius on the corn silage basis is considerably shorter than with alfalfa. A comparison with corn silage is more realistic although the radius would appear to be rather short; the opposite is the case in the high quality alfalfa comparison. In conclusion, we would suggest that a mid point between the two values would be a representative economic radius.

Schematic maps were prepared of Ontario and Southern Quebec to demonstrate the relative accessibility of livestock feeders to sources of food wastes. Visual analysis indicates the major concentrations of livestock in Southern Ontario are virtually all within 100 mile trucking distance of food processing plants. Exceptions are the Bruce Peninsula, Renfrew County north of Renfrew and that part of the province lying east of Kemptville (see attached map). A similar map for Southern Quebec suggests that farmers in Eastern Ontario are within the 100 mile trucking distance from processing plants south of Montreal. To the east the 100 mile distance extends to Thetford Mines on the south shore of the St. Lawrence River and to Quebec City on the north shore.

3. Additional Costs

Additional costs of feeding waste must be considered in order to compute realistic cost/benefit ratios. The quantification of these costs are based on rather conservative estimates.

The acidity, especially of tomato pomace, has a deteriorating effect on the cement silos, resulting in pitting and a shorter life of the silo. No exact data are available but it is felt that a shorter life and thus higher rate of depreciation should be taken into account. Assuming that a $40,000 silo with a 4-600 ton capacity would last only 10 instead of 15 years, the additional depreciation would be approximately 20-30¢/ton.

The acidity also affects the durability of the mixing truck, especially the augur, side plates, liner and other parts. Any foreign materials, such as stones, cans, containers, 2x4's, glass and others, reduces the life of the mixing mechanism and mixing box. One feedlot operator modified his mixing trucks by utilizing heavier gauge steel plates and mixing mechanism. Accelerated depreciation of a portion of the mixing truck and the silos would lead to higher operating costs. Assuming that the mixing mechanism and box of a mixing truck (estimated at approximately $5,000 of the total truck cost) would last only 5 instead of 10 years for a 5,000 ton waste feeding operation, the extra depreciation would be approximately 10¢ per ton.

Increased costs of hauling and handling larger quantities of higher moisture feeds, than with regular rations, is another additional cost. The extra handling costs are based on the additional quantity of waste vs. conventional or "dry" feed. These costs also include the extra work of cleaning the mangers more often of left-over waste, stones, cans, as well as the handling of the considerably larger quantity of liquid manure. These extra overhead costs, including interest charges, according to one feedlot operator, are currently four times higher than 2 years ago. The extra quantities of waste feed requirements change from ration to ration. One way of determining them would be a comparison of the TDN in lbs. per ton as fed for waste and for corn silage as shown in Table 26 . The average TDN of the four products (including dry and wet pomace) is 275 lbs. vs. 460 lbs. for corn silage; thus, about 67% more or, in some cases, the double quantity of waste must be fed to equalize the same TDN's of corn silage. Assuming an extra handling of 20 extra tons of waste per hour with mechanized equipment, including pick up, hauling, mixing, feeding at an hourly wage rate of about $7.00, is about $0.35 per ton to which an estimated $0.15/ton is added for the extra cleaning of mangers, handling extra quantities of liquid manure, etc., totalling $0.50 per ton.

The potential loss of animals from hardware disease, bloating, selenium deficiency, nitrate problems and other factors, particularly related to feeding waste, must also be taken into account. However, the losses were not much greater than with regular feed. We suggest to add another one percentage point to the customarily-used 2% loss factor, resulting in an estimated mortality rate of 3%. The quantification of the extra loss is based on the value of a feeder steer and the quantity of waste fed as follows:

Value of feeder steer: Ave. weight 775* lbs. during growing and finishing phase (450-1100 lbs.) x $.85 = $659.

Extra mortality loss 1%	$ 6.59

Feed Requirements to gain 650 lbs.:
200 days x 10 lbs DM = 2000 lbs. of mixed and waste feed, at ave. 20% DM = 10,000 lbs. as fed or 5 tons.

Est. waste portion 50% = 2.5 tons

Loss per Ton of Waste Feed: $\frac{\$6.59}{2.5T} = \underline{\$2.64}$

* Includes weight and value of calf.

To sum up, the total of the four additional costs add to a total of about $3.50 per ton of waste feed.

4. Total Costs

This section summarizes the various cost figures including charges for waste products where applicable and transportation.

The details as shown in Table 27 indicate total costs of tomato pomace ranging from Nil to $1.25-1.50 to $3-4.00 based on three examples. An estimated average of $3.00 would be a realistic figure to use for the computations of the economic benefits. This would be for "dry" pomace; an approximate value of $1.00 would be applicable for "wet" pomace.

The variation for bean waste is even greater from nil to $3.00 and $4-5.00. The figure of $4-5.00 would appear to be on the high side with an average of $1.50 representing a realistic figure.

The carrot waste costs range from nil to $1.50 and $3.10 with an average of approximately $2.00.

For comparison purposes, values for sweet corn waste and for sugar beet pulp have been added. As already indicated earlier, the regional difference in price are noteworthy. A novel way to sell sugar beet pulp on a price for DM basis was initiated by the St. Hilaire Sugar Refinery, details are also included in Table 27.

The following summarizes the total costs of waste in order to compute the cost benefits (including the material, transportation and additional costs). Since many feedlot operators and farmers' operations are a fair distance from the processors'plants, it is felt that the indicated transportation costs either do not reflect the actual costs based on 20¢/ton mile or, where paid by the processors, may be partly subsidized. We therefore add another estimated $1.50 to the combined material and transportation costs in Table 28.

Table 27 Charges to Farmers/Feedlot Operators of Waste Products on per Ton Basis

	Charges for Waste	Charges for Hauling	Total Cost FOB Farm
Sweet Corn Waste			
Feedlot A	$5.00	$5.00	$10.00
Farmer B	$7.50		7.50
Essex/Kent Counties			13.00
Brant/Waterloo Counties			7.00
Tomato Pomace			
Feedlot C	Nil	3-4.00	$3-4.00
Feedlot D	$1.25-1.50*		$1.25-1.50
Farmer E	Nil	Nil	Nil
Bean Waste			
Farmer F	Nil	$1.00	$1.00
Farmer G	approx. 10¢	3.00	3.10
Farmer H	Nil	$4-5.00 (High!)	$4-5.00
Farmer E	Nil	Nil	Nil
Carrot Waste			
Farmer I	Nil	$1.50	$1.50
Farmer G	approx. 10¢	3.00	3.10
Farmer E	Nil	Nil	Nil
Sugar Beet Pulp			
Refinery St. Hilaire			
20% DM	$16.00	Extra	
21% DM	16.80	"	
22% DM	17.60	"	
23% DM	18.40	"	
24% DM	19.20	"	
25% DM	20.00	"	

* Based on multiyear contractual commitment to accept all pomace, costs of erecting a silo, 10 year amortization and interest divided by the annual tonnage of pomace received.

The summarized costs would thus be as follows (Table 28):

Table 28 Total Actual/Estimated Costs of Selected Waste Products Delivered to Farm or Feedlot and Fed to Livestock

	Material Cost	Transportation Cost	Supplementary Transp. Cost	Additional Costs	Total Costs
		- Dollars per Ton -			
Tomato Pomace "Dry"	-----3.00-----		1.50	3.50	8.00
Tomato Pomace "Wet"	-----1.00-----		1.00	3.50	5.50
Bean Waste	-----1.50-----		1.00	3.50	6.00
Carrot Waste	-----2.00-----		1.50	3.50	7.00

These costs are to be considered minimum costs which do not include the commitment, overall risk, extra silage pits and handling equipment and, where a feedlot operator owns his hauling trucks, the additional high costs of the depreciation and interest charges in the long off season in Canada if the equipment cannot be fully utilized during that time.

Furthermore, additional management efforts are required to handle waste products and to generate specialized rations for feeding. Farmers must undertake additional planning and have equipment capable of handling waste all the time.

These efforts and costs are essentially charges which vary substantially from farm to farm and cannot be quantified accurately. For some operations, however, these costs could easily add another $2-4 of costs to each ton of waste feed.

I. CONTRACTUAL ARRANGEMENTS

Contractual arrangements between processors and feedlot operators consist of verbal understandings, a handshake, simple and more detailed written agreements. The major stipulations include the supply by the processor and acceptance by the feedlot operator of a designated tonnage or of the entire plant's waste, charges for waste if any, haulage details and charges, and liability exemption for the processor.

Many processing companies find it important to have a written contract, even if it is just a letter with the processor's and the feedlot operator's signature. The types of contracts vary, according to the individuals involved. Some were formal; others informal. One processor had a strict written and signed agreement with a feedlot operator, who was a friend. Other contracts, mostly by smaller processors, where the two parties knew each other well, are verbal agreements or handshakes.

One processor has a written contract with a feedlot operator, stipulating that the processor must supply "clean dry" waste with no foreign articles and no flume waste. The contract also stipulates that the feedlot operator has to take all the waste up to a specified tonnage which was the estimated quantity for the year. Any tonnage above that had to be either negotiated between the processor and feedlot operator, or the processor had to find other ways of disposal or utilization. No additives, or preservative treatments are used for the waste. One processor maintains strict rules for clean-up times during which no feedlot or operator trucks are allowed on the premises, so as not to contaminate the waste with harmful cleaning chemicals. Contracts generally contain separation clauses; in some it is on a seasonal basis, in others a 2-week separation clause.

The processing companies stressed the fact that they must be able to depend on feedlot operators to provide a reliable pick-up service. Unless feedlot operators could be relied on, processors wanted to control the shipping themselves. One food processing company had been shipping its feed waste to a neighbouring farmer free of transport charges for eight years. It was approached by another feedlot operator who offered to absorb the transportation costs. Upon enquiry, the processor found out that this feedlot operator reportedly did not provide a reliable pick-up and therefore was not interested in the offer.

A feedlot operator, on the other hand, who collected waste from a nearby processing plant, found that the quantities were not large enough to establish a regular feeding routine during the processing season. He considered the availability on a seasonal basis, and the inconsistency of the waste with regards to water content, a drawback. On some days the waste was very watery; on other days, almost dry. Since he could not guarantee the processor that he would take all the waste on days when the quantities available were large (a requirement stipulated by the processor), he had to decline the future pick up of waste from this processor.

Most waste delivery or pick up included either the total tonnage of a plant including all products or a stipulated tonnage with quantities above that to be negotiated. Some processors also developed a scheme to charge a relatively modest amount for the valuable sweet corn waste with the condition that the hauler or feedlot operator also take all less desirable waste such as onions, peppers, asparagus and others at no cost.

All processors visited provided waste, free of charge to the feedlot operators. Some, however, charged the transportation costs; further details are contained in the transportation section. One processor ships the waste at his own expense. He delivers the waste with an 8 ton company truck, between 1 to 3 times per day, depending on the season. The annual cost, including the interest, depreciation, operating costs and salaries, was about $6,000.00. For a total of approximately 2,300 tons of waste, this works out to be approximately $2.60 per ton.

Another processor also pays for the transportation costs, using his own trucks to ship the waste to a local feedlot operator about 8 km from the plant. In turn the feedlot operator had to commit to making an investment of about $36,000.00 for the construction of a cement pit for the storage and fermentation of tomato waste and other installations, as required. The tomato waste is supplied free of charge.

There are also several feedlot operators who haul waste at their own cost either with their own trucks or trailers or hiring custom haulers. Details of the arrangements and costs have already been reviewed in the previous section.

For most processing companies, the contract with the feedlot operators relieves them of any liability on the utilization of the waste products fed to livestock. One processor, however, indicated a clause in earlier contracts concerning glass, tin and other contaminations in the waste. Whenever there were contaminants in the waste, the farmer would, upon finding glass, metal and other contaminants, spread that load of waste, plow it under, and charge the cultivation costs to the processor.

The contract for another processor includes an indemnity clause, to hold him harmless for any bloating, hardware disease or loss of animals. A sample contractual agreement, holding the processor harmless as a result of feeding waste products, reads as follows:

> "The processor shall not be liable for any damages, losses, costs, charges or expenses or for any claim for loss, damage or injury to persons or property associated or

> resulting from, or for any breach by the disposer for any statute, regulation, by-law or other law relating to the performance or non-performance by the disposer of his duties and obligations hereunder and the disposer hereby agrees to indemnify the processor and hold the processor from and against any and all such damages, losses, costs, charges or expenses and from and against any and all such claims or breaches."

The strong concern of indemnity by processors may be one reason why waste is provided free of charge instead of being sold which might present more difficulties in a litigation.

VI. UTILIZATION OF SELECTED WASTE PRODUCTS IN CALIFORNIA AND OREGON

A. INTRODUCTION

The U.S. food processing industry generates over 10 million tons of food residuals per year. The largest quantities of waste are from citrus fruit, corn and potatoes, followed by tomatoes, pineapples, apples, peaches and miscellaneous vegetables.

In 1979, the (U.S.) Food Processors Institute collected relevant data and information and issued a report entitled "A Guide for Waste Management in the Food Processing Industry" edited by Dr. Katsuyama of the Western Research Laboratory of the National Food Processors Association.

The report contains previously-collected statistics of the tomato, bean and carrot waste generated as shown in Table 29:

Table 29
Generation of Solid Waste Products by the Food Processing Industry, 1968

	Total Produce Processed	Solid Residuals	% Residuals
Tomatoes	6,970,000 T	520,000 T	7%
Carrots	280,000 T	140,000 T	50%
Snap Beans	630,000 T	130,000 T	21%

The relatively low waste percentage could be due to special varieties and excellent conditions for mechanical harvesting.

In view of the extensive vegetable industry with particular regard for tomatoes, beans, carrots and beets, visits were made to 9 food processors and 15 feedlot operators to collect details of waste disposal and utilization and elicit suggestions. A visit was also made to one of the largest feedlot operations with 40,000 steers. Details are given in the section on Feeding Practices.

The waste characteristics, being practically identical in the U.S. as well as in the Canadian food processing industry, have already been described in the previous Canadian section. Peculiarities applicable to U.S. conditions have also been included in that section. The nutritional details have also been included in the Canadian section; as a matter of fact, many nutritional research projects and experiments originated in the U.S.

Various details of U.S. regulatory aspects and pesticide residues have already been described in Section IV-B dealing with the disposal of processing wastes and in Section V-G dealing with pesticide residues and related aspects of the utilization of waste products. They will therefore not be included in this Section.

B. SEASONALITY, TREATMENT, PRESERVATION

The harvesting and processing season is much longer in the U.S. than in Canada as evidenced in the following Table 30:

Table 30

Seasonality of Selected Solid Food Processing Waste Availability in the U.S., 1968

In 000 Tons

Month	Tomato Pomace	Snap Bean Waste	Carrot Waste
J	7	-	6
F	7	-	3
M	6	-	4
A	6	2	5
M	10	2	4
J	70	7	5
J	140	37	9
A	150	41	10
S	110	35	23
O	6	9	33
N	6	1	26
D	-	-	12
TOTAL	520	130	140

It should be noted that these seasonalities include all vegetable-growing areas of the U.S.

In California and Oregon, the processors and feedlot operators also reported a much longer seasonal supply of waste feed than in Canada. The climate is more conducive to extended growing periods. Waste feed, in some cases, can be fed fresh all year round. Storage facilities are not as crucial to the crops as in Canada, allowing costs to be substantially less than in colder areas.

Depending on the product, the season varied from two to twelve months. The carrot season in California can be year round, depending on the grower, the fresh processing and canning. One feedlot operator reported 11 months' supplies, with interruptions in December and January; while another received fresh carrot waste from March to September, a 6 month period. One processor noted that if the fresh market is strong, he receives small amounts of carrots; conversely, if the fresh market is slow, he receives more carrots.

The tomato season is about three months, starting in early July to the middle of October. One farmer received fresh tomato waste from March to mid-October.

Beans are harvested from mid-July to mid-September. Broccoli and peas have a much shorter season, 3-4 weeks.

Like in Canada, processing waste is neither chemically nor biologically treated.

The preservation and silaging is less prevalent than in Canada. A portion of the waste is fed fresh in feeding troughs. Since corn waste is extensively ensiled, many of the other waste products are also ensiled with it. The ensiling is mostly done in stacks on either dry, hard ground or cement surfaces. Trench silos are rare because of the limitations due to irrigation and groundwater. A large trench silo was being used on a farm located on some slightly higher land. Solid waste is often chopped to reduce space requirements and facilitate compressibility of the material which is done after each fresh supply of waste products.

C. FEEDING PRACTICES AND SYSTEMS

Feeding methods for larger cattle operations and ranches in the United States are similar to those used in Canada. (See Canadian section on Feeding Practices). They include semi-manual and fully-automated methods, either outside or inside a barn. Most feeding, however, is done outside with the steers on the open ground and the feed put either into cement troughs or on cement slabs adjoining to the bars holding the animals back.

One large feedlot operator scoops the tomato pomace in the mixer truck, which is equipped with scales to measure the exact rations. The trucks have been remodelled with extra heavy plate, stainless steel augers, and mixing equipment. This increases the life of the trucks from 1½-2 years to 3-4 years. Another farmer, using a regular mixing truck, feeds the mixed waste into troughs. A regular mixing truck was used by a feedlot operator to mix cull carrots.

A front-end loader is used by another rancher to put tomato pomace and other waste into a feeder box, encased with heavy gauge steel, and mixing augers made of regular steel. Pitting doesn't seem to be a serious problem. This rancher has one pit silo, holding 10,000 tons of semi-dry tomato pomace, which cost about $40,000 to construct. He estimated that the juice seeping from the tomato pomace is approximately 10-20% of the total waste. He indicated, however, that there was no drop in daily weight gain, when feeding ensiled pomace, as compared to fresh pomace.

A large dairy farmer has a package arrangement with a processing company, ¼ mile away. He receives the solid waste free of charge, but must haul the waste at his own cost. The processing plant also irrigates his pastures with the waste water and effluent. The company installed a piping system to his fields, at a cost of $250,000-$300,000. The carrot slurry, from diced carrots, peeled with caustic, is pumped into a holding pond and subsequently spray-irrigated on this farmer's fields.

Another rancher recommended a cross of a mechanical mixer-weighter-wagon with an hydraulic feedbox and mixer. With this arrangement, the acid pomace does not come in contact with the bearings. Some parts are made of stainless steel. It is his feeling that stainless steel equipment justifies the extra costs, as it considerably lessens the extent of corrosion from vegetable waste.

The feeding rations used by the farmers varied, depending upon the availability of feed waste, grains, etc. The objective is to have healthy cattle with good daily weight gains.

One rancher feeds his dairy cattle a daily ration of:

- 10 lbs. alfalfa hay
- 20 lbs. corn or oat silage
- 120 lbs. pea, cauliflower or broccoli waste
- 15 lbs. grain

A typical ration for another feedlot operator was:

- 40 lbs. of fresh carrots
- 20 lbs. of silage
- 10 lbs. alfalfa cubes
- 5 lbs. cotton seeds
- 20 lbs. grain, fed during milking in the parlour

Another rancher feeds his cattle 5-6 lbs. of medium quality hay, plus carrot waste of 10% of the animal's present weight per day. Hay is fed separately. When hay is mixed with carrot waste, the leftover portions become mouldy and decay rapidly. The only added supplements were salt and minerals. Another feedlot operator, using the culled and processed waste carrots, uses them at times separately; at other times, mixed together. On that ranch, carrots are fed exclusively in the manger with hay added about twice a week. Excess carrots are left on the ground for "free choice" feeding. This farmer indicated a weight gain of about 3 lbs. per day which would appear to be rather high in view of the portion of the carrots and other waste feed use in the feed ration.

A visit was also made to the Fat City Feed Lots, Inc. at Gonzales, California. At that time, some 40,000 steers were being fattened; the capacity is 80,000 head. It comprises of 430 acres and includes a feed mill and related improvements.

The feed pens are constructed of steel rods welded to pipe posts set in concrete. The feed mangers are formed concrete designed to minimize feed losses and to permit automatic filling from the feeding trucks. An eight foot concrete apron for cattle to stand on is behind each feed manger and water trough.

The facilities also include paved roadways between the pens for feed trucks, work alleys connecting pens with five separate intensive care units located throughout the feedlot to minimize the distance sick cattle must be walked, two separate cattle receiving and shipping areas to minimize the distance fat cattle are driven and a water system supplying each pen from two interconnecting wells, each of which is capable of supplying the water needs of the entire feedlot. There is also complete outdoor lighting and music systems to help pacify the cattle and two induction centers where newly arrived cattle receive initial health and identification processing.

The automated feed mill comprises enclosed grain storage for 600,000 bushels of grain, with outside (open) storage for an additional 250,000 bushels, and milling capabilities of 60 tons per hour, including steam flaking of grains to enhance the nutrient digestibility of the cattle. The mill utilizes a unique gravity flow concept for conveying the many feed ingredients required in the scientifically formulated rations.

The operations are shown in Flow Chart Fig. 3 . Fat City purchases feeder cattle directly from ranches or auction markets or through commission agents or livestock brokers, in various parts of the United States and Mexico.

The Gonzales feedlot facility is able to receive cattle round-the-clock every day of the week. Cattle are typically transported in truck trailer units. Upon arrival, the cattle are counted, inspected for general physical condition and group weighed by walk-on platform scales. They are then transferred to nearby receiving pens where fresh water, hay and resting space is provided.

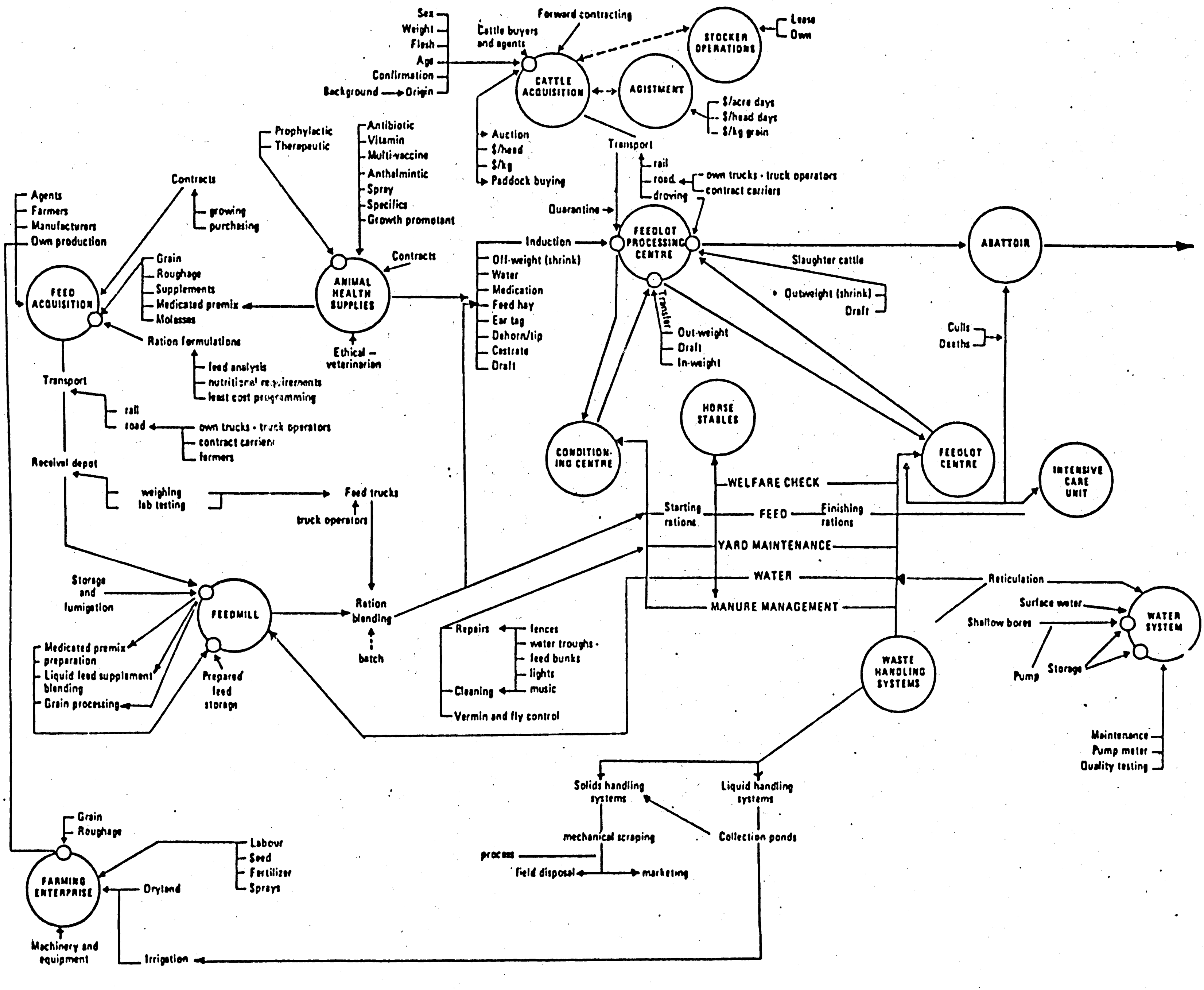
Within a period of a few days, the newly arrived cattle have been assigned an accounting lot number and are transferred to the induction center by cowboys on horseback. It is here that the animals receive health treatments prescribed by Fat City. These are largely preventative in nature and include vaccines, vitamin injections, dewormers and implants. Other treatments conducted are dehorning and castration, when necessary, ear tagging or fire branding for lot identification purposes, and treatment in a dipping solution for control of external parasites. The induction center is capable of processing 100 cattle per hour and includes feeding pens so that cattle are on feed and water before and after processing.

The next phase involves cowboys gently moving the animals to a pen (or pens) assigned on the basis of square footage and manger space. The Gonzales feedlot facility contains over 200 individual feeding pens with animal holding capacity ranging from 120 to 1,000 head.

Fat City acquires feedstuffs from a wide geographical area. Purchasing decisions are based on rations formulated by least cost programming methods. Individual ration ingredients are stored and processed at the feed mill. A battery of specially designed feed trucks with hopper scales obtain precise quantities of individual ingredients from the mill to form a batch. The batch of ingredients is blended into

FIG. 3

FLOW CHART FOR INTEGRATED FEEDLOT



Prepared by: FAT CITY

——— Cattle/Beef Product Flows
Input Flows/

a uniform ration by mixer augers inside the truck mounted feed boxes. This operation occurs while the feed trucks are enroute from feed mill to mangers.

Cattle are fed on a pen-by-pen basis with feed that discharges from a chute on the side of the feed trucks into the mangers. The quantity of feed discharged is recorded by cab-mounted printing scales. Cattle initially receive a roughage-type ration and graduate to an ultimate finishing ration high in grain concentration. The feeding program occurs every day of the week. Animals receive fresh feed several times throughout an 18 to 24 hour feeding day.

A considerable number of waste feeds are used such as grape pomace and waste from celery, lettuce, broccoli, cauliflower, brussel sprouts, artichokes, drybeans, sugar beets and other cash crops. Tomato pomace has not been fed so far; the nearest cannery is 35 miles away.

Horse-mounted cowboys ride amongst the cattle inspecting every animal each day. Animals showing signs of sickness are gently removed to the intensive care units where they receive therapy.

As animals near completion of the fattening cycle, they are sorted into uniform groups and presented for sale to meat processors whose representatives visit the Gonzales feedlot facility regularly.

D . COSTS

Processors in the U.S. are less reluctant to charge for the waste product. Even as some companies still provide waste free of charge due to lack of storage space, danger of polluting the environment, and limited benefits to the company, others charge for tomato pomace, carrots and beans. A large processor charges between $1.50-2.00/ton of tomato pomace depending on the moisture content. Another processor charges $1.75/ton of bean waste. Carrot waste was sold by a processor to a dairy for $7.50/ton; this would appear to be a rather high price.

Transportation represents the largest cost item due to longer distances than in Canada.

In California and Oregon, transportation of waste was provided in most cases by the farm operators and ranchers, but also by the processors and commercial haulers. Proximity to the canneries or processors results in relatively inexpensive feed costs. A farm operator, in close proximity to the processing plant, was paid $6.00/hour by the processor to haul carrot waste and culls. This includes fuel, labour, trucks and maintenance. The hauling cost per ton was approximately $1.25. In contrast, a dairy operator hired a hauler at $3.00/ton of carrot waste. His cost for the carrot waste was $7.50/ton with a total cost adding to $10.50/ton of waste feed.

One farmer, whose operation was 4 miles from the processor's plant, indicated a cost of $1.50/ton (or about 40¢/ton mile) for transportation, including fuel, depreciation, operating costs and labour. He mentioned that the cost would double with a commercial hauler. Another rancher, using his own trucks, transports the waste for $3.50/ton, plus $1.00/ton for labour.

In another case, transportation is provided by the cannery through a hauler. The hauling arrangements are made by the feedlot operator and the trucking company.

One farm operator has two distinct contracts: one with a processor, and one with a hauler. He takes all waste (tomatoes, beans, carrots, etc.) from some of the company's plants and pays a hauler $6.00/ton to truck waste feed. From other plants, he hauls only specific products, using his own trucks.

One hauler sells bean waste to five dairy herds, and corn waste to 15-20 dairy herds. He pays the processor $1.75/ ton for the bean waste. He charges $3.00 for the waste plus a delivery charge of $3-$7/ton, depending on the distance. For a distance of 10-12 miles at $10.00/ton the hauling cost per ton mile would be about $0.90. This hauler also transports dirty waste, consisting of stems. If it is "relatively clean", he sells it to dairy owners at cost. Unsold waste is spread onto fields.

Another commercial trucker hauls corn and bean waste for a processor; he does not pay the cannery for the waste products.

One ranch visited was about 100 miles from the processing plant. It was reportedly one of the early ranches obtaining large quantities of tomato pomace from a large processor under favourable contractual conditions and has maintained the hauling of it with its own trucks. The feed bins, storage and mixing facilities were acquired from a previous operation at presumably moderate costs which may account for the continued feeding of tomato pomace at, what we believe, rather extensive costs. Other waste feed utilized include canteloupes, orange pomace, cotton seeds, sugar beet pulp, cotton fibre and corn screenings.

The additional costs such as the pitting of cement slabs and silo walls from the acid tomato pomace for instance, as well as the more rapid deterioration of the mixing trucks, the extra handling of waste material with considerably more moisture and increased possibilities of hardware disease were also mentioned by farmers and ranchers visited. Details are already contained in the Canadian section.

E. CONTRACTUAL ARRANGEMENTS

Arrangements discussed with processors included written documents signed by both parties; verbal agreements; or, simply, a handshake. A written agreement is beneficial for the protection of both parties.

One processor has a five year contract with a feedlot operator. The conditions of this contract, which is attached at the end of this section, are summarized as follows:

- The farmer hauls the waste.
- He maintains the trucks in sanitary conditions.
- The processor is held harmless in the event of cattle death.
- The farmer provides insurance certification for the trucks.
- The farmer assumes the responsibility for the usage of the waste feed, either on his own ranch, sold to other parties, or dumped.

Another processor has contracted 10,000 tons of cauliflower, beans, corn and pea waste per year to a feedlot owner. He has contracted to transport the waste to the farm at a cost of $5.00 per ton with the following conditions for a 3 year contract:

- The farmer has to take all the waste on a 24 hour per day basis. The plant's holding tanks store only 4-6 hours output.
- The farmer has to dispose of the waste to meet environmental regulations.
- The farmer must discourage fly-breeding media.

In most cases, the processors indicated that their responsibility for the waste ended when it had been delivered by the company, or picked up by the feedlot operator. Most written contracts hold the processor harmless in the event of death of cattle, possibly due to the contamination of the waste. This could probably be a major reason of why farmers are seldom charged for the feed as such but only transportation costs.

A written contract is not always used between the processor and feedlot operator. The more informal approach, based on trust, of a verbal agreement or a handshake, is often used between good friends or long-time business acquaintances.

One processor has leased its ranch to a farmer. The conditions of this lease are:

- The rancher must accept all waste.
- The waste feeding is subject to a permit and an inspection by county authorities.
- The flume waste, solid and effluent waste has to be physically separated. The solid waste is shipped to the ranch.

No tests are conducted for pesticide residues by this processor. The processing company also purchased mainly magnetic rather than stainless steel equipment. This protects their operations from foreign metal objects which can be more easily picked up and also protects the cattle as much as possible from hardware disease.

One knowledgeable rancher suggested the following contractual arrangements.

- To conclude contracts for as long a period of time as possible, especially for tomatoes, beans, and carrots. Prices will probably increase. Therefore, the feedlot operator's investment will pay off in the long term.
- To price tomato pomace at $6-$7 per short ton F.O.B. plant. It should be picked up by the

farmer, with a transportation cost of $3.00 per ton, bringing the total cost to the farm depending on distance to approximately $9.00 per ton.

- To test pesticide residue levels.
- To have the feedlot operators take all the waste products from one plant. This would depend upon the amount of the processing company's output of waste, and the size of the ranch or herd.

The following is an example of a contract between a processor and a waste hauler, covering price, equipment, liability, insurance, disposal, etc.:

WASTE HAULING AGREEMENT

This Agreement made and entered into on by and between hereinafter referred to as PROCESSOR, and hereinafter referred to as WASTE HAULER.

It is agreed between PROCESSOR and WASTE HAULER as follows:

1. The PROCESSOR's premises where the services of WASTE HAULER as hereinafter set forth shall be performed are located at:

2. The WASTE HAULER shall furnish all labor, trucks and equipment necessary to perform the services enumerated herein, and the WASTE HAULER shall obtain any and all permits and licenses required in the performance of said services. The WASTE HAULER shall comply with all statutes, ordinances and regulations of any and all state, county, municipal or other governmental or quasi-governmental agencies, boards and commissions regulating or having jurisdiction of the removal, storage, transportation, or disposition of waste materials and trash herein set forth at no cost to PROCESSOR.

3. In each operation and function as herein set forth and contemplated, the WASTE HAULER shall perform the same as an independent contractor. The WASTE HAULER shall provide for proper and sufficient workmen's compensation and public liability insurance and shall hold PROCESSOR free and harmless from any and all claims, loss, damage, or liability for injuries to or death of any and all persons or injuries and damage to property caused or occasioned in any manner in the performance of said services by the WASTE HAULER.

4. The WASTE HAULER agrees to keep in force during the term of this agreement public liability and property damage insurance with a company acceptable to PROCESSOR. The property damage insurance shall be with a limit of not less than one hundred thousand/three hundred thousand dollars ($100,000/$300,000) and the public liability insurance shall be with limits of not less than one hundred thousand/three hundred thousand dollars ($100,000/$300,000). The WASTE HAULER agrees to furnish forthwith to PROCESSOR a copy of such policy or policies or a certificate of insurance containing a provision that such coverage shall not be changed or cancelled without thirty (30) days prior written notice having been given by registered mail to PROCESSOR.

5. The WASTE HAULER agrees to hold PROCESSOR harmless from any and all claims arising from or by reason of the sale and/or use of waste from PROCESSOR. All such products picked up are on an "as is" basis only.

6. The WASTE HAULER shall provide for suitable disposal of waste in a manner which shall meet all the requirements of the city, county and state sanitation and health authorities and will not allow the waste to become a public nuisance.

7. PROCESSOR's right, title and interest in and to the said waste materials and trash shall pass to and be vested in the WASTE HAULER at the time the WASTE HAULER shall take possession of the said waste materials and said trash.

8. It is hereby agreed that it is imperative to PROCESSOR's operations that its waste hopper be emptied as often during each day or night as may be necessary to permit the said hopper to accommodate PROCESSOR's wastes as the same accumulate during operations. The WASTE HAULER agrees to furnish trucks at intervals adequate in the opinion of PROCESSOR to accomplish this purpose without delay to or hindrance to PROCESSOR's operation.

9. Both parties agree to the waste and trash classification and rate schedule established in Addendum #1.

10. It is agreed by both parties that the rate schedule established in Addendum #1 will be in effect from the date of this agreement, June 1, 1981 to May 31, 1986.

11. In the event of any breach of this agreement by either party, the other party may terminate the same upon thirty days' written notice. The waiver of any breach of the agreement shall not be construed as the waiver of any subsequent breach thereof.

12. The WASTE HAULER agrees to submit billing for services under this agreement weekly during season and monthly off season and all bills submitted will have a copy of hauler's individual loan receipts attached. Loan receipts will contain (a) load yardage, (b) classification as to type of waste, and (c) signature of authorized PROCESSOR's weigher. In turn, PROCESSOR agrees to pay for services within ten days after receipt of WASTE HAULER's billing.

By____________________________ By ____________________________

Page 1
Addendum

ADDENDUM #1 TO WASTE HAULING AGREEMENT

(Contract period April 1, 1981 to March 31, 1986)

1. Wet vegetable trimmings from PROCESSOR's waste hoppers or rejected raw product and canned goods dumped in the WASTE HAULER's bins located at PROCESSOR's selected locations.

(a) The agreed price PROCESSOR will pay the WASTE HAULER is $5.31 per cubic yard to haul and dispose of this material.

2. Dry waste, non-compacted, not segregated, dumped in the WASTE HAULER's bins located at PROCESSOR's selected locations.

(a) The agreed price PROCESSOR will pay the WASTE HAULER is $2.50 per cubic yard to haul and dispose of this material.

3. Clean corrugated fiber, segregated, broken down, dumped in the WASTE HAULER's bins located at PROCESSOR's selected locations.

(a) PROCESSOR agrees that material in the category must meet the requirements herein stipulated and that the WASTE HAULER may reject and load or part thereof if these requirements are not met.

(b) If contaminated or mixed with trash, the corrugated fiber will be hauled as dry waste at the rate of $2.50 per cubic yard.

(c) WASTE HAULER shall pay PROCESSOR as follows:

1,000 lbs. - 1,999 lbs.	NC
2,000 lbs. - 2,999 lbs.	$12.50 per ton
3,000 lbs. - 3,999 lbs.	$15.00 per ton
4,000 lbs.- 4,999 lbs.	$17.50 per ton
5,000 lbs. - over	$20.00 per ton

4. Mud pumper service as required by PROCESSOR:

(a) The agreed price PROCESSOR will pay the WASTE HAULER is $45.00 per hour for pumping and an additional $2.50 per ton for removal to the landfill.

5. The WASTE HAULER will have first refusal on any saleable or salvagable waste, except PROCESSOR reserves the right to use all or part of the waste for the research and development of by-product development and utilization.

6. Saturday and Sunday services shall be provided by WASTE HAULER for the rates set forth above plus ten percent. Holiday services shall be provided for the rates set forth above plus twenty percent.

7. In addition to the charges set forth above, the PROCESSOR shall pay any charges established by Stanislaus County for a contaminated load.

8. The rates set forth above shall be adjusted on June 1, 1982 and annually thereafter by WASTE HAULER and PROCESSOR.

9. Miscellaneous:

   (a) Any contaminated load of fruit waste or tomato pulp not suitable for livestock feed shall be hauled to   County Landfill, and PROCESSOR shall pay any landfill dumping fee. The present fee is $3.50 per ton and subject to change.

VII. TREATMENT TECHNIQUES

A. INTRODUCTION

Food processing waste is also used for other purposes than cattle feed such as dog and pet food and as a supplement for other animal feeds. Since this application requires packing and hauling over long distances, the feed must be in dry form.

With present fuel costs, the extraction of water especially from low-value feedstuffs renders almost any process uneconomical unless the raw material is acquired at minimum or low costs, the product can be upgraded, or the end-product sold at good prices.

One processor visited has in the past undertaken several experiments of varying drying methods such as drum-drying, sludge-drying and others. The results achieved have shown neither the anticipated results nor the expected economic benefits.

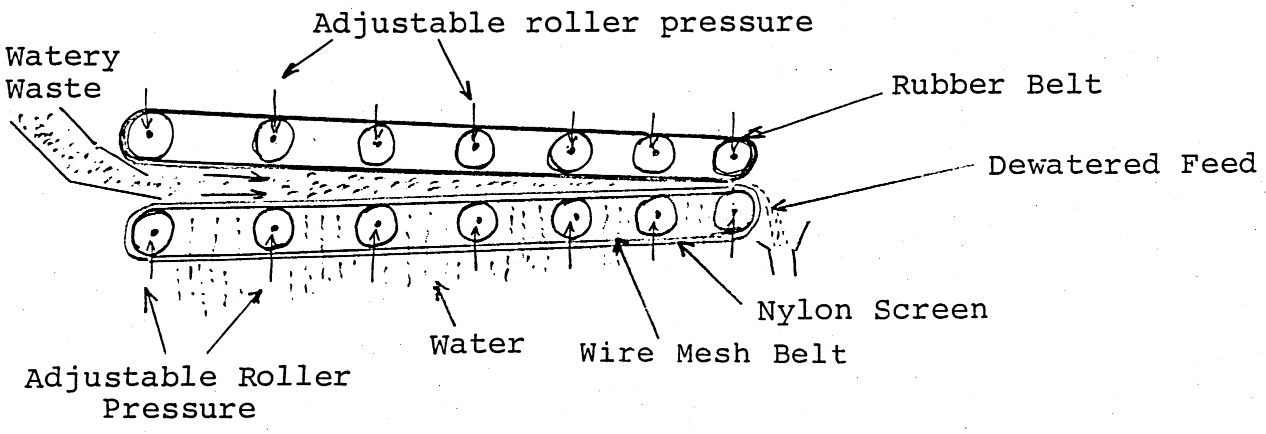
Despite these negative results, there are currently three methods of drying food processing waste known to us and one anaerobic digestion in use as described in the following sections. An attempt by one processor to ferment and distill waste products has not proven successful.

B. DRYING METHODS

1. Roller-Presser Drying

One large food processing company visited in California uses a custom-designed roller-presser. The top part is a ¼ inch thick endless rubber belt approximately 2 feet wide and reinforced by rollers. The bottom is an endless stainless steel conveyor mesh belt covered with a nylon screen; this belt is also supported by rollers. Both belts, whose clearance is adjustable, move synchronously in the same direction. The wet waste is fed between the two belts.

The drawing below shows the principal concept for which there reportedly does not exist a patent or proprietary copyright.

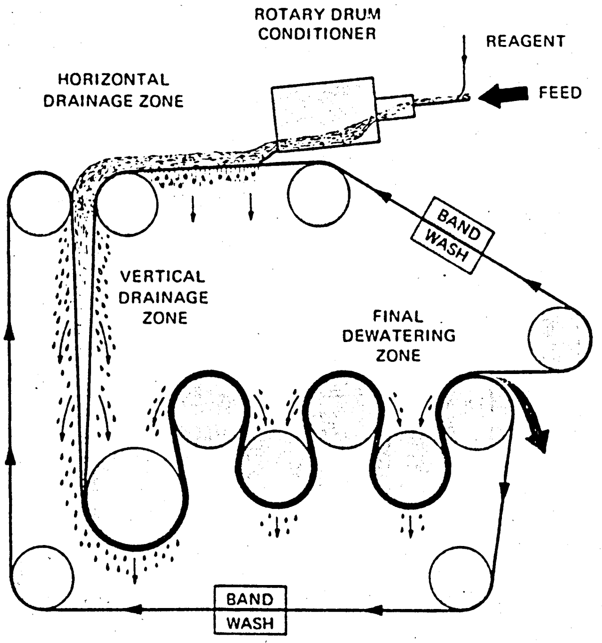


Prior to the utilization of this roller-presser, the company dried the pomace with waste heat from the boilers but gave it up because it became more economical to be paid by Dun Dry Co. for the tomato pomace instead of it being picked up by haulers at no charge in the past.

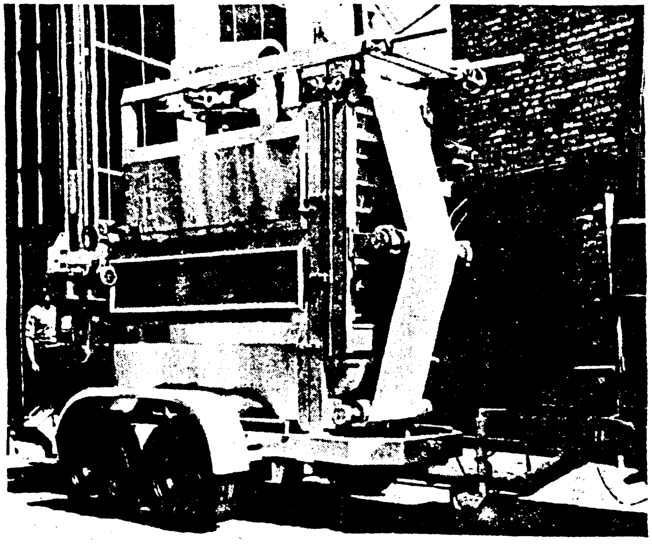
Double sieve-bands squeeze water from sludge

Continuous production of friable cake suitable for direction incineration achieved at low cost

A. J. Bolwell, Correspondent in England



Sludge dewatering machine



Transportable version of sludge dewatering machine.

A new development in sludge-dewatering techniques employs the principles of gravity and shear-force for water extraction to produce a very dry, friable sludge-cake at a low cost.

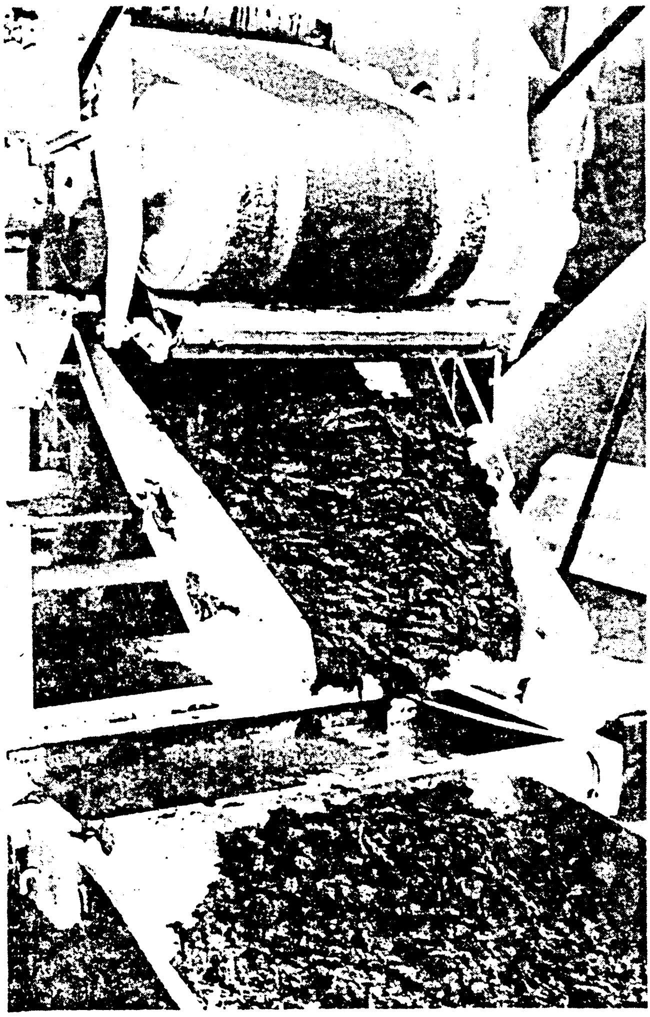
A machine called the "Winklepress' uses double sieve-bands of a synthetic fiber-mesh to act as the conveying, pressing and water-expelling medium. A tubular steel frame supporting a number of rollers carries two endless bands of the fiber-mesh. The rollers provide three basic dewatering zones: a horizontal feed-zone for initial treatment and dewatering; a vertical V-shaped zone for further drainage; and a lower contact zone for final dewatering by shear action.

Correct alignment of each band is maintained by a band-alignment roller operated by a sensing arm. Band tensioning is by dead weight rollers.

In operation, the sludge is fed to a rotating drum fitted internally with helical lifting flights. Immediately before the drum, polyelectrolyte conditioning reagent is pump-metered into the main feed line. The reagent and sludge are intimately mixed by the tumbling action of the drum and the mixture passed on to the horizontal feed-zone. Here it is retained by guide plates with the band supported on a fixed, smooth plastic grid. Initial dewatering takes place here; the water drains through the band and the grid and is collected in a separate trough for disposal.

The partially dewatered sludge then enters the vertical V-shaped zone. Two sides are formed by the downwards – moving bands and the end walls by foam rubber wedges fixed to the frame. Further gravitational dewatering takes place here through the bands and the rigid plastic grids supporting them. The level of sludge in the vertical zone is controlled to remain virtually constant to insure that there is no free-flowing water before entry into the final zone.

The two bands meet at the end of the vertical zone to form a band sludge band sandwich that winds around a large perforated drum roller. The water entering the drum is guided by internally fitted scoops to discharge ports at one end of the drum roller. The sludge continues between the bands around a series of rollers arranged to give large angular changes of direction. During this passage, final dewatering takes place. The



Delivery end of machine, showing discharge of friable sludge-cake.

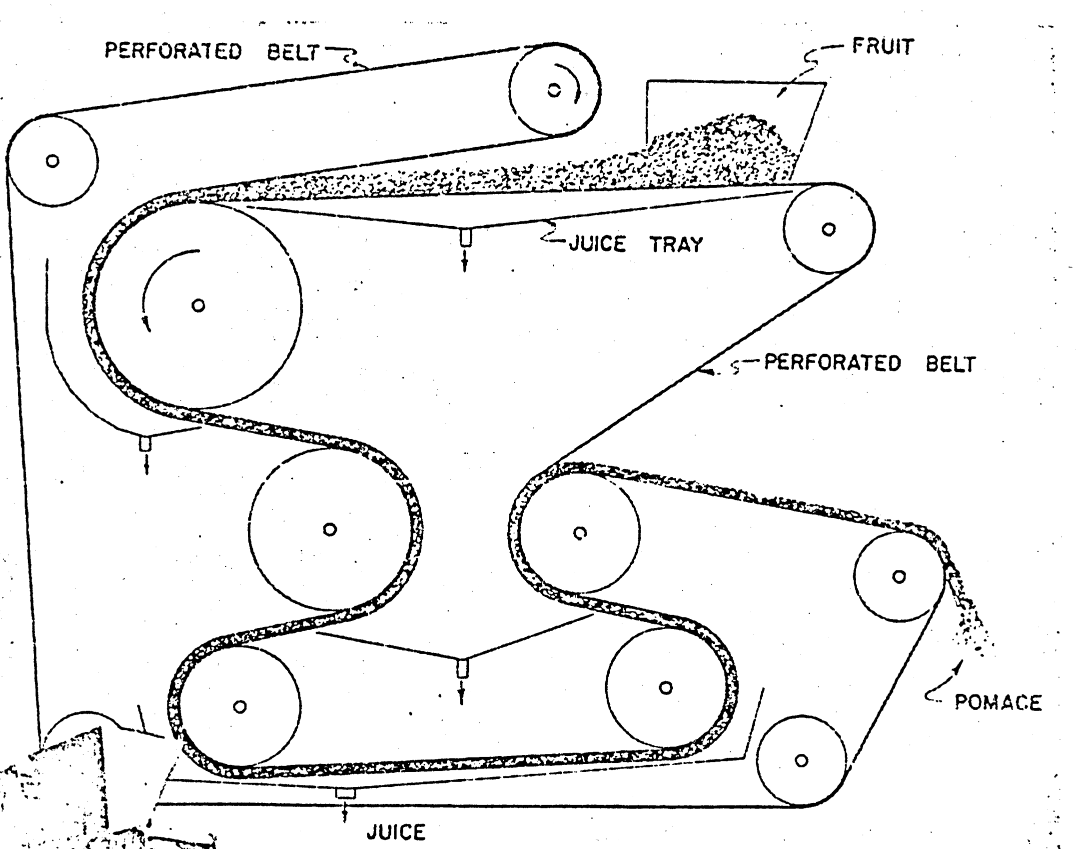
bands separate after passing over the last roller, causing the dewatered cake to be discharged for disposal.

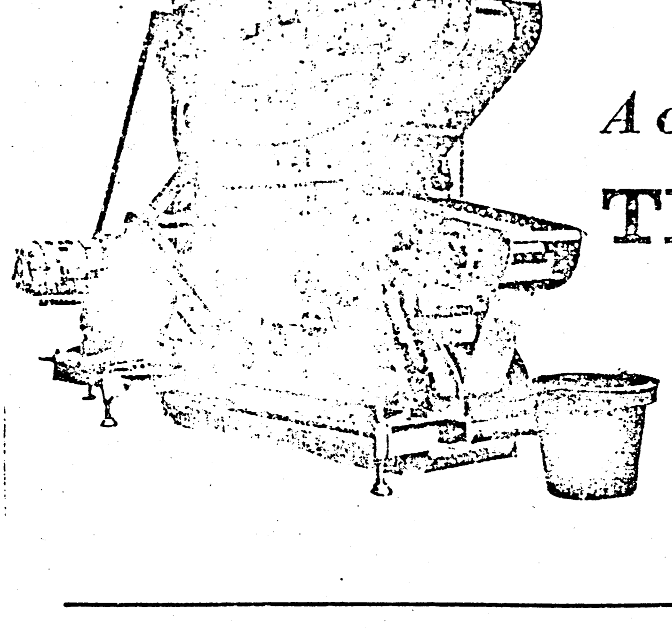
In the process, the only pressure applied is due to the natural tension in the sieve bands. By simple adjustment of the bands' speed of travel, the production rate can be made to suit the ease of dewatering of any particular sludge. Similarly, lower or higher solids concentration can be produced as required.

A range of effective bandwidths from 0.5 to 2.0 m have nominal digested sludge capacities from 3.5 cu m/hr to 14.0 cu m/hr respectively, requiring drive from 2.0 to 10.0hp.

A friable cake of 35% dry solids is produced that is easy to handle and, being autothermic, is suitable for direct discharge to multiple hearth furnaces and other types of incinerators.

The "Winklepress" is a development of Simon-Hartley Ltd., Stoke-on-Trent, England in conjunction with their licencees Gebr. Bellmer AG, Niefern, West Germany.



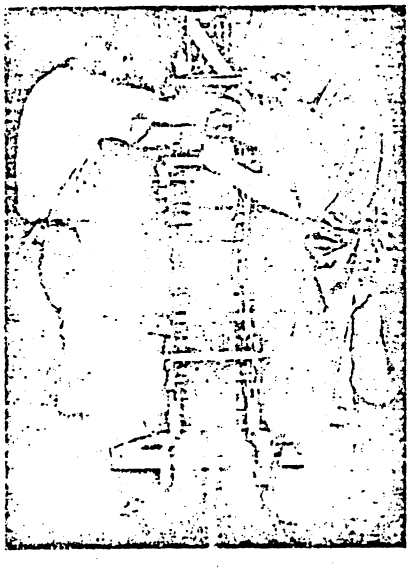


A continuous-crush press for the
The Serpentine Frui

R. J. COFFELT

The prototype of the new continuous-flow fruit press described in this report was developed mainly for wineries, but the flexibility of layout, light weight and low power requirements allow the press to be built in a large number of configurations and sizes. The average yields of liquid from grapes increased 9% above the conventional basket-pressing method. A commercial sized machine modeled after the prototype but with 36-inch-wide perforated-plastic belts and nine pressing stages could handle 125 tons of crushed grapes per hour and require only 10 hp—many times less than the power needed for other fruit presses of the same capacity. This machine has been patented and is being produced by commercial manufacturers.

CONCEIVED AS the solution to one part of a project to improve materials flow and handling in wineries, this continuous-flow fruit press lends itself easily to being constructed in a large number of configurations and sizes. Light weight, low power requirements, and feeding flexibility make it possible to place this machine in any part of a processing line without disrupting the present layout. If desired, it can be built elongated instead of in the present compact vertical style and used as a conveying and pressing machine and perhaps suspended from a ceiling away from normal traffic. Fruit



Hand feeding crushed grapes onto the plastic belt of the Serpentine Fruit Press.

grape industry . . .

Press

can be fed into the machine from the top, as shown in the photo above to right, or from the bottom by reversing belts.

The prototype press has a capacity of five tons per hour of crushed fruit and somewhat less with whole fruit such as clusters of grapes or whole berries. This capacity is based on the present machine with its 6-inch-wide perforated-plastic belts moving at a velocity of 200 feet per minute and carrying a 4-inch-wide by ½-inch thick layer of crushed fruit with a density of 60 lbs per cubic foot. The present machine, with its five pressing stages, can be operated with a 1 hp motor.

Commercial size machines may be built with 12-, 24- or 36-inch wide belts and with from five to 15 pressing stages. A typical press having a 36-inch wide belt and nine pressing stages could be expected to handle 125 tons of crushed grapes per hour and would require only a 10 hp motor—which is many times less power than other fruit presses of the same capacity.

To date the press has been used to obtain juice from crushed apples, crushed and stemmed grapes, clusters of grapes and to de-water spinach. Nine lots of grapes (five varieties) have been pressed. Average yields of liquid from these grapes was 109% compared to basket pressing at 100%. The average solids content of the Serpentine press yield of liquid was 2.4% more than the basket-pressed control. Taste testing of the wines made from both the basket-pressed juice and the Serpentine press juice were almost equal in scoring with the wines processed from basket pressed juice scoring higher in some cases and those from the Serpentine press scoring higher in others.

Nonabsorbent plastic belts and juice trays and a baked epoxy coating on most of the metal parts allows easy cleaning and sanitary operation.

The material from which the liquid is to be expressed is gravity fed from the hopper onto the moving feed belt. As the material rides on the belt into the press, guides and scrapers shape it to a height of ¾-inch and to a width of 2 inches less than the belt width, leaving a margin of 1 inch on each side. In the case of the prototype, the belt width is 6 inches and the material width is held to 4 inches before it enters the first pressing station.

If the free run liquid from the crushed fruit has not been drained previous to entering the hopper then much of it will drain through the perforated feed belt into the juice tray as the fruit travels into the press from the hopper. As the material moves into the throat, the upper belt which has the same perforations as the lower feed belt and which is moving at the same velocity as the lower belt makes contact with the upper surface of the material. At this moment of contact, pressing begins.

As the belts continue to move and rotate around the first pressing stage pulley, the material between the belts has a tendency to spread out toward the edges of the belts. Extrusion of the material at the edges of the belts is prevented by two factors which keep it confined. (1) The perforations in the belts hold the layers of material nearest the belt surface and exert some lateral restraining force throughout the thickness of the material. (2) The upper belt like the lower is of plastic and is slightly resilient. Thus it tends to curve over the mass of material and in so doing the upper and lower belts "kiss" at their outer edges sealing the material between the belts into what amounts to an oval, plastic, perforated tube carrying material for the subsequent pressing operations.

The compressive force for liquid expression at all stages comes from tension in the belts which tries to force them closer to the pulley surface. The material to be pressed is between the belts and the compressive force of the outside belt trying to force itself to the pulley surface is transmitted through the material. This compressive force acting on the material is what expresses the liquid. The actual pressing force obtained in the prototype press is from five to seven pounds per square inch. Much greater pressures could be exerted through the pneumatic control system activators, but this has not been necessary for materials handled to date.

Passing around the first pulley, liquid is expressed through the perforations of the outside belt and into a juice tray. Liquid is prevented from going through the perforations of the inside belt by the intimate contact this belt makes with the pulley. The belts, with what is now the press cake between them, travel on to the next pressing stage. At this stage liquid is expressed from the cake through the perforations of the belt that was nearest the pulley on the preceding stage. Stage by stage the liquid is forced from the cake, first from one surface and then the other. Between stages the pressure is lessened and the cake has a chance to relax and open up new channels for the escape of liquid. The alternate flexing of the cake as it bends first one direction on one pulley and then the opposite direction on the next pulley also helps to open up new channels for the escape of liquid.

This coming fruit season, further evaluations of the press are planned with grapes and a variety of other products.

Robert J. Coffelt is Assistant Research Engineer, Department of Agricultural Engineering, University of California, Davis. Testing and evaluation of the press was done in cooperation with Department of Viticulture and Enology, Davis. Patent No. 3,130,667, Serpentine Fruit Press, R. J. Coffelt, April 28, 1964, has been assigned to The Regents of the University of California.

This processor has two types of tomato waste, the first being pomace from chopped and cooked tomatoes for catsup or puree with a dry matter of about 30-35%. The second type, consisting of peelings and some whole, culled tomatoes, is the "wet" waste.

Both types of pomace are transported by flumes to the disposal area, where water is extracted first through worm screws and sieve-like outer shells. It should be noted that the original dry matter from the cooker pomace is of course higher than the dry matter content of the waste passed through the worm screw separators. The reason why both wastes are transported by flume is that it is the least expensive way over a distance of 300 feet; changes due to the existing plant layout may be more expensive than they are worth in eliminating those worm screw water extracting units.

Both pomaces are subsequently passed through the roller-presser. The water extraction was, however, still insufficient to increase the DM from the original 5% to 15%. It nevertheless facilitated the transport of the waste by the Sun Dry Products Inc. for air drying on the airstrip as will be described in a subsequent section.

2. Rotary Drum Drying

In the Niagara Peninsula there was a company which custom-dried food processing waste during the 1981 processing season. A processor on whose premises the drying operation was located, collected tomato pomace from two other processors under a 5 year contract, and was also supplied some pomace from a third processor for experimental purposes. The drying company leased space and facilities on the premises of this processor.

The pomace used is relatively dry, containing skins, seeds, some vines and impurities. Since the tomatoes are hand picked, there are fewer vines in the harvested crop, than there would be with mechanically-harvested tomatoes. By machine washing the tomatoes, the processor claims that there is very little residue of pesticides or fungicides on the tomatoes. The composition of pesticides and fungicides have broken down towards the end of the growing season. The remainder is washed off, to a large extent, in the washing process and tumbling cycle of the tomatoes prior to processing.

Details of the drying process are proprietary. The concept, in general, includes a gas fired furnace heating a rotary drum, and a draft for heating and drying the pomace uniformly. The pomace's moisture is reduced to 10% in a counter current drying cycle. It is then fed through a hammer mill, passed through a predetermined mesh screen and packaged. The drying temperature is the critical element and is measured with sophisticated automatic controls. High temperatures destroy the protein and lycines, thus, reducing the nutrient contents and qualities. Details of the drying temperatures were not provided.

The dried material is sold as dog and other pet food. An analysis was provided by the processor showing a protein content of 20-22% on a DM basis. The processor attempted to provide the dried tomato pomace to several Canadian manufacturers of dog food. Due to reluctant attitudes and slow action, he has turned to the U.S. market.

The processor has regulatory approval for the dried tomato pomace from the U.S. FDA and by the Agriculture Canada Plant Products Division. U.S. inspectors check truckloads periodically. He provided a detailed confidential list of pesticide residue analysis, which was initiated by a U.S. laboratory to substantiate the fact that the residues of the compounds were well below required maximum tolerance levels.

The drying company has a contract to sell the dried tomato pomace through an agent to a major U.S. manufacturer of dog and pet food at a very attractive price. It would appear that this price would render the operation economically viable!

Pollution is a drawback to this 24-hour operation. Neighbouring residents objected to the noise and smell. According to a newspaper report, seen in early 1982, the company was given only a conditional permit of operation. We have since learned that the drying company was acquired by another company engaged in this business and was planning to move the drying operations to a less populated area.

3. Dehydration Cost Comparisons

Methods

Energy costs in dehydration are directly related to the quantity of moisture to be removed from the material, as well as the techniques, equipment chosen to undertake the drying, and its efficiency.

In view of ever increasing energy costs representing such an important factor, the parameters, inputs and other related details were discussed with members of the statistical research section of the Engineering and Statistical Research Institute. The section staff prepared a nomograph and a computer program for a preliminary assessment of energy costs for waste dehydration. The following information and our evaluation is based on a nomograph entitled "Dehydration of Food Processing Wastes" prepared by G.E. Timbers and D. Marshall.

Logically, any free or easily separated water should be removed by some physical technique rather than by evaporation. A wide variety of screens have been employed for solids recovery and several types of belt filter presses are available commercially. The energy costs of such mechanical separations are considerably less than of any evaporative processes. Considering the recovery of solids, equipment such as a belt filter press can be employed for reducing the initial moisture content. Manufacturers claim that belt filter presses can reduce the moisture content down to 70%. A rough calculation of the energy required for dewatering can be derived from manufacturers literature and, based on certain parameters, is only about 4.2 kJ/kg H_20

removed. It should be emphasized that this energy need is about one thousands of the evaporative energy need of a regular drier (3-4 MJ/kg H_2O removed) and one one five hundredth of a newer, more efficient drier (2 MJ/kg H_2O removed)!

The energy required to remove water by evaporation, after any preliminary separation has been accomplished, depends on the initial and final moisture contents and on the drier efficiency. There is a wide range of efficiency in drier performance. Some more sophisticated designs can reduce the energy requirements considerably. Lucas (1980) describes a drier used for alfalfa or sugar beet pulp which requires about 182 kJ/kg H_2O removed from products that had been pre-pressed to remove free liquid.

The nomograph (Fig. 4) allows the direct determination of operating costs based on the same parameters of initial and final moisture contents, drier efficiency and fuel costs. A sample calculation, using the nomograph, is also provided as follows:

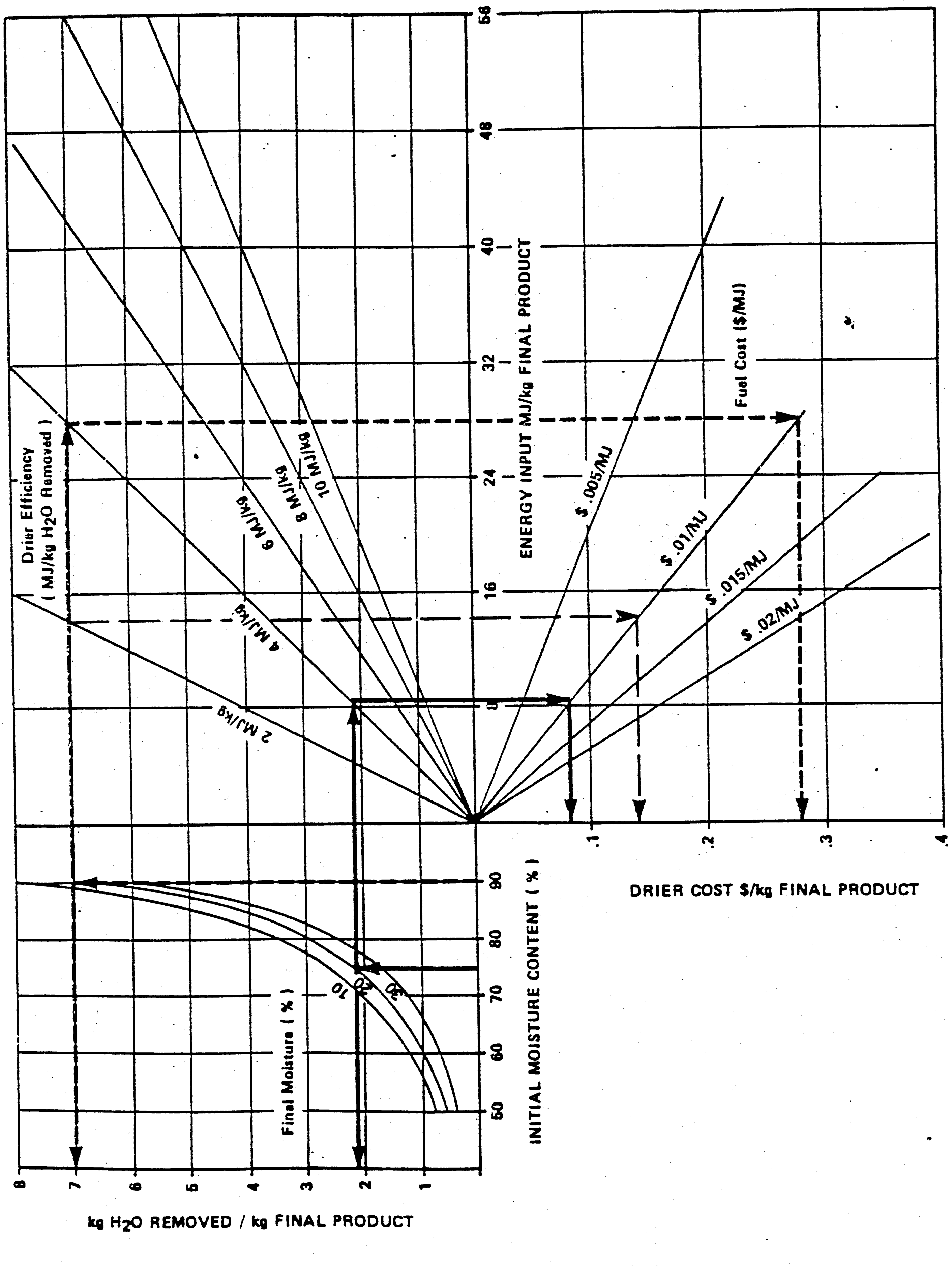
Given or assumed values:
  Initial moisture: 75%
  Final moisture: 20%
  Drier efficiency: 4MJ/kg H_2O removed
  Fuel cost: $0.01/MJ

From the Nomograph:
  Moisture removed by dewatering: 4.8 kg H_2O/kg final product
  Moisture removed by drying: 2.2 kg H_2O/kg final product
  Drier energy input: 8.1 MJ/kg final product
  Cost of drying: $0.09/kg final product

A brief computer program was also written to estimate the energy and costs for different drier options. The model, used to evaluate different product drier options, consists of two main sections.

Nomograph of Dehydration Costs of Food Processing Wastes

Fig. 4



The first section is comprised of a drier performance calculation and energy consumption calculations of a single "regular" and a "new" (or more efficient "replacement") drier. The values, determined from data developed jointly by the staff and authors of this report, were as follows:

- Drier performance (MJ/kg H_2O removed): Less efficient drier 3.0; more efficient drier 2.0.
- Yearly capacity of final product: 500 MT.
- Initial moisture contents: 85%; 70%; 50%.
- Final moisture content: 10%

Using these data, the amount of moisture that must be removed to attain the desired moisture level is calculated, as well as the energy requirement, based on drier performance. If the replacement option has been selected, these values are calculated based on the data for both systems. Using these values and the user inputted values for the amount of product processed, the yearly energy requirements are determined.

The second section of the program utilizes the cost information for the various fuels in order to determine the yearly energy costs for the drier(s) using the different fuels. The data developed were as follows:

- Capital cost of the system: Less efficient drier $90,000,
  More efficient drier $140,000.
- Interest rate: 18%
- Number of periods: 15 years
- Amount that energy costs will increase above inflation: 5%/year (Note: this represents an increase over the regular inflationary rate already reflected in the 18% annual interest rate).
- Cost of Fuel: Oil #2 Bunker 27.5¢/litre (=$0.0076/MJ; natural gas 17.5¢/m^3 (=$0.0051/MJ); propane 18¢/litre (=$0.0082/MJ).

The economic analysis is based on the "Sum of the Net

Present Value Method". The values used for the yearly operating costs are based upon the yearly energy consumption and fuel cost figures.

The results are shown in the following Table 31:

Table 31 SUMMARY OF DRYING COSTS OF SOLID FOOD PROCESSING WASTE PRODUCTS.

	Propane	Oil	Natural Gas
	cents per kg of Final Product		
REGULAR DRIER			
Moisture Reduction			
85% to 10%	12.27¢	11.46¢	7.72¢
70% to 10%	4.91¢	4.58¢	3.09¢
50% to 10%	1.96¢	1.83¢	1.24¢
EFFICIENT DRIER			
Moisture Reduction			
85% to 10%	8.18¢	7.64¢	5.15¢
70% to 10%	3.27¢	3.06¢	2.06¢
50% to 10%	1.31¢	1.22¢	0.82¢

The results are striking in several ways. As anticipated the costs of the oil and propane-based evaporation are considerably higher than natural gas. The surprising fact, however, is that the reduction of the moisture content of the original waste material from 85% to 70% saves 60% for each of the three fuels in a regular drier. A reduction from 85% to 50% saves a substantial 84% of the moisture evaporation costs for each of the three fuels in addition to the greatly lower costs of mechanical extraction of free moisture already mentioned previously!

The savings in total costs for a new, more efficient replacement drier, which uses only 2 MJ/kg H_20 removed as compared with 3 MJ/kg H_20 for a regular drier, are approximately one third higher despite the increased estimated capital costs of $50,000 for such a unit. The proportional savings for the reduced moisture contents of the initial waste are identical to those of a regular drier.

4. Sun Drying

The Sun Dry Products Inc. of Vernalis, California utilizes an unused military airport with 75 acres of asphalted runways to dry food processing wastes. Waste is brought fresh from the processing plants and dried immediately. It is crucial that tomato pomace, in particular, be dried quickly. The waste is spread on the asphalt runways, 20 feet wide, in layers of 1/8-1/4 and up to 1/2-1 inch thick depending on the product. It is dried in 24 hours.

The secret, we were told, was to dry the waste as quickly as possible, while the material was fresh. Every two hours, a scraper device, pulled by a pickup truck, turns the waste material. This action allows faster evaporation. The material is then put into rows by sweepers, and pushed into larger rows by tractor-drawn graders. The waste is picked up by a snowblower-type machine, positioned in front of a truck, with a conveyor belt into the truck box. Scales on the truck maintain tight control over the inventories. The dried waste is placed in piles, 10-15 feet deep, until it is sold. Tomato pomace is sprayed with Masonex to seal the top of the pile.

Drying of waste materials on asphalt is extremely efficient as the temperature reaches 120°-138°F. This allows absorption of large amounts of heat, which is released slowly. Also, there is a cool, dry breeze, with a 20% humidity over the drying site, which removes the moisture.

Various tests are performed on the dried waste for molds, salmonella, etc. Two pesticide regulations for dried materials are enforced for pet foods and are being met. The waste products dried are tomato pomace, grape pomace, prune pomace, olive and peach waste and others. Green bean waste is not used since it takes too long to dry. The products are sold to ranchers or farmers as feed supplements and to feed mills, as supplement for feed formulations. The company does not produce ready feedstuffs.

The prices as of Spring 1982 in bulk, cash basis, FOB Vernalis were:

Tomato pomace	3/8" Grind	$ 95 per ton
Tomato pomace	1/4" Grind	$100 per ton
Tomato pomace	1/8" Grind	$105 per ton
Prune waste	1/4" Grind	$ 55 per ton
Grape pomace	1/8" Grind	$ 44 per ton

The company's nutritionist does not recommend dried waste ingredients for dairy cows, unless they are sufficiently diluted. Dried tomato pomace, in particular, is highly palatable to dairy cattle. Dairy cattle would eat 60% of their ration in the form of pomace, if allowed. However, milk production would fall, and possible metabolic problems and magnesium deficiencies could result. It was indicated that the seeds of dried tomato pomace are digestible by ruminants, fresh tomato seeds are not.

Sun drying on an airstrip was also described by another company utilizing it as a "piece of cake". They would use the following procedure:

- Bring the waste to the airstrip to be flattened with a manure spreader.
- After 3-4 hours use a sweeper to windrow the semi-dry material.
- Dry it completely and collect it for milling and packaging.

C. FERMENTATION/DISTILLATION

In the course of the Canadian field research work, a processing company was visited which at one time evaluated the fermentation and distillation of its processing waste to produce alcohol. Details were not provided except that the company found this alternative for its operation technically and economically not feasible.

For food processors in Canada, with a relatively short processing season, it would appear that satisfactory answers to a number of problems must be found before fermentation/distillation can become a viable alternative of processing waste disposal. Some of the questions and problems are listed below:

- Are the quantities of waste products during the processing season large enough for an economic fermentation/distillation unit.
- Which alternative products are available for distillation in the relatively long off-season; are their quantities sufficient to maintain the fermentation/distillation unit.
- Are the sugar/energy contents of tomato, bean and carrot and other wastes sufficient for the fermentation.
- What are the yields from the three above-mentioned and any other wastes.
- What are the fermentation/distillation equipment requirements; what capacities would be needed.
- What type of alcohol would be obtained; and how would it be marketed.
- If the answers to the above questions are in the affirmative, would the price of the alcohol make an operation economically viable.

In the course of the U.S. portion of the field work, discussions with processors in California and Oregon indicated that some of them were also considering the fermentation/distillation of selected processing wastes. Compared with their Canadian counterparts, they have two distinct advantages, namely, a longer processing season and much greater quantities of waste products. In California, the season for some of the crops ranged from 3 to 8 months and for others almost one year. Two or three crops and processing seasons per year would provide for substantial sources of waste material for fermentation/distillation operations.

D. ANAEROBIC DIGESTION

Anaerobic digestion of waste water, effluents and other organic matter has received considerable attention in Canada and the U.S. in the past years. It serves the two purposes of waste treatment or elimination, and of resource recovery. Wastes are converted in part into energy, and in part into fertilizer components and/or soil improvement media. Even though the process has been utilized in waste water treatment for several decades, recent research and development has concentrated on its increase in efficiency and reliability.

A recent paper by L.F. Diaz, J.C. Glaub et al from Cal Recovery Systems Inc., Richmond, California, entitled "Quantitative Modelling of Integrated Energy-Agro-Waste Complexes" (Paper No. 81-6011, presented at the June 1981 meeting of the American Society of Agricultural Engineers) provides a number of models and their utilization for the engineering analysis of the proposed complexes. One model also contains parameters for the anaerobic digestion of all types of organic wastes which would also include food processing wastes with methane, carbon dioxide, supernatant and sludge as possible recycled outputs.

In the course of the field research in California, a processing company was visited which had constructed an anaerobic digester to produce methane from carrot, peach and other waste products. The waste available is 30-40,000 tons of carrots, peaches, etc. The facility, through which the waste is cycled, is "almost the size of a football field" and 25 feet deep. The processor felt that methane was worth $15-$20 per ton, resulting in a considerably higher yield than if carrot waste was used for feed. The anaerobic process also eliminates the need for treating effluents in an aerobic lagoon. The company expects to replace the natural gas (costing $300,000 per year) with the methane.

Excess methane may be used to generate electricity for other operations. The sludge, which comes from the digester, becomes an excellent fertilizer for sandy soil, containing calcium phosphate, potassium, magnesium, etc.

VIII. FEEDING COST/BENEFIT ANALYSIS AND EVALUATION

A. INTRODUCTION, METHODOLOGY AND INPUTS

1. Introduction

In the course of the field research in California, Dr. John Dunbar, Extension Animal Scientist, and Dr. Donald L. Bath, Extension Dairy Nutritionist, of the University of California (UOC) at Davis, offered to run the least cost rations (LCR's) on the UOC computer. The department has extensive experience in waste feeding, and the two researchers as well as other associates are the authors of the unique publication entitled "By-Products and Unusual Feedstuffs in Livestock Rations", a Western Regional Extension Publication (WREP No. 39) whose second expanded edition was issued in October 1980. The department also has two programs for computing LCR's for beef and for dairy cattle with a large number of different waste feeds, much more numerous and indigenous to California crops and livestock operations. The authors are most grateful for Dr. Dunbar and Dr. Bath's assistance which, we believe, is not yet available for waste feeds in Canada.

2. Methodology

A methodology and matrix of maximum levels of vegetable processing waste use in least cost rations (LCR's) were developed for six different livestock schemes, namely for:

- Straight Feedlot Operations
  - Growing Steers
  - Finishing Steers
- Feeder/Feedlot Operations
  - Growing Steers
  - Finishing Steers
- Dairy Cattle
  - Replacement Heifers
  - Milking Cows

For each of the schemes, a number of levels of utilization for tomato pomace, green bean waste, and carrot waste was specified as shown in Table 32. Furthermore, conventional rations (without waste) and combined waste rations were added for comparison of the nutritional requirements as well as of the cost/benefits. The UOC used two separate computer programs, one for beef and one for dairy cattle.

On the beef side, the LCR's for growing steers and finishing steers were compared separately for straight feedlot operations. The operations covered the period from the weaning of the calves to market weight. The growing steers were assumed to grow from 450 to 750 lbs. at 2.25-3.0 lbs. gain per day and the finishing steers growing from 750 to 1,100 lbs. For the finishing steers, the same concept applied with six rations computed. Three of these were formulated for the feeder steers coming from a high roughage background.

In the feeder/feedlot operations, the growing phase includes production of steers usually away from the feedlot (mostly on pasture operations), and finishing them in a feedlot. Due to the pasturing and feeding of cheaper feeds and higher levels of forage, we assumed a gain from 450 to 750 lbs. for growing steers at a lower daily gain of 1.0-1.5 lbs. A total of seven rations were computed whereby the program eliminated three different levels of beans and of carrot waste as will be described later. The finishing steers of the feeder/feedlot operation were assumed to grow from 750-1,100 lbs. at the daily gain of 2.5-3.0 lbs. per day for which five rations were computed.

The dairy cattle operations were split into two parts, namely growing replacement heifers, growing from 600-1,000 lbs. at 1.5-1.8 lbs. daily gain for which eleven LCR's were computed. For the milking cow operation, we assumed an average of a 1,400 lb. cow with levels of daily milk production at 30, 60 and 90 lbs. respectively and correspondingly decreasing proportions of waste feed in relation to milk production. A total of fifteen LCR's were computed for that group.

Table No. 32 MATRIX AND OUTLINE OF MAXIMUM LEVELS OF VEGETABLE WASTE IN LEAST COST RATIONS FOR VARIOUS TYPES AND LEVELS OF BEEF PRODUCTION (GAIN) AND MILK PRODUCTION, AND REFERENCE TO COMPUTED LEAST COST RATIONS (LCR)

Animals	Type of Production	Ration Production Requirements	"Conventional" Rations		Selected Maximum Percentage of Waste in Ration on Dry Matter Basis, and LCR Ref. No.							
			No Re-strictions	LCR #	Tomato Pomace %	LCR #	Green Bean Waste %	LCR #	Carrot Waste %	LCR #	Combined Waste %	LCR #
Beef Cattle	Straight feedlot i.e. weaning to market weight	Growing Steers (450-750 lb LW) 2.25-3.0 lb/day	-	B-1	20 30 40	B-2 B-3 B-4	- 30 50	- B-5 B-6	20 40 60	B-7 B-8 B-9	-	B-10
		Finishing Steers (750-1100 lb LW) 2.5-3.0 lb/day	-	B-11	20) 30)	B-12	20) 30)	B-13	40 100	B-14 B-15	-	B-16
	Feeder/Feedlot operation	Growing Steers (450-750 lb LW) 1-1.5 lb/day	-	B-17	40 60 80	B-18 B-19 B-20	40) 60) 80)	B-21	40) 60) 80)	B-22	-	B-23
		Finishing Steers (750-1,100 lb) 2.5-3.0 lb/day	-	B-24	20) 30)	B-25	20) 30)	B-26	40 100	B-27 B-28	-	B-29
Dairy Cattle	Replacement Heifers	Growing Heifers (600-1,000 lb LW) 1.5-1.8 lb/day	-	D-1	20 40 60	D-2 D-3 D-4	20 40 60	D-5 D-6 D-7	20 40 60	D-8 D-9 D-10	-	D-11
	Lactating Cows	Milking Cows (1,400 lb cow) Level of milk Production										
		30 lb/day	-	D-12	60	D-15	60	D-18	60	D-21	-	D-24
		60 lb/day	-	D-13	30	D-16	30	D-19	30	D-22	-	D-25
		90 lb/day	-	D-14	20	D-17	20	D-20	20	D-23	-	D-26

The matrix also shows the details of the "conventional" ration as a control against which the costs of waste rations can be compared. The three types of waste, namely tomato pomace, green beans and carrots, were put in at various maximum levels. The computer was programmed to pull in the lowest proportion per gain. In addition, the UOC also ran combined waste rations, totalling 10 LCR's for this group with no restrictions on the selection of any feed from the total list supplied.

3. Inputs

In addition to the matrix described above, a list of feeds and prices was provided to the UOC Extension Department for the calculation of the least cost rations. The prices represented Canadian market prices prevalent in the spring of 1982 as shown in Table 33. The details for the tomato pomace, bean waste and carrot waste prices were described in the previous Section V. Prices used included only the feed cost of the processing plant excluding of transportation and other costs.

Details regarding feedstuffs and their application and/or restrictions were also provided by the contractors to the UOC Extension Department for the calculation of the LCR's (see "Guidelines for Selection of Waste and Other Feeds").

Table No.33 LIST AND COST OF FEEDS USED FOR THE COMPUTATION OF LEAST COST RATIONS

	Prices Can.$/ton
Barley	109
Corn, grain (84.5% DM)	103
Corn, high moisture (28-30% moisture)	93
Oat grain	116
Wheat middlings	164
Shorts	144
Corn silage (35% DM)	18
Haylage (45% DM)	23
Alfalfa hay (17% CP)	60
Rapeseed meal (37% CP)	224
Soybean meal (44% CP)	266
Tomato pomace silage (29.5% DM; 67% TDN)	3
Bean waste (18% DM; 72.5% TDN)	1.50
Carrot waste (14% DM; 82.0% TDN)*	2
Ammonium Phosphate	570
Limestone	23
Vitamin A, D and E	760

* A TDN value of 82%, representing the value of whole carrots, was inadvertently used for the computer program instead of an intermediate value (between carrots of 82% and pulp of 62.8%) of 72%.

GUIDELINES FOR SELECTION OF WASTE AND OTHER FEEDS FOR THE COMPUTATION OF LEAST COST FORMULAS[1)]

1. Rapeseed meal: Analyses from By-Products and Unusual Feeds (BPUF) to be used.[2)] No restriction on its use; new Canadian rapeseed meal has no palatability problems for cattle.

2. Tomato Pomace Silage: An estimated 67% TDN is appropriate for the material used in Canada.

3. Bean Waste: Analyses in BPUF for bean cannery residue to be used.

4. Carrot Waste: Average analyses of whole carrots and carrot pulp in BPUF to be used.[3)]

5. Minerals and Vitamins: Formulas, which in the judgement of Dr. Dunbar and Dr. Bath, UOC are appropriate, for that type of waste to be used. Mg to be kept high for lactating dairy cows for tomato pomace rations. Special attention to be given to Mg tetany for lactating cows on tomato waste.

6. Fibre Factor: Appropriate fibre factors at the judgement of Dr. Dunbar and Dr. Bath, UOC, for each type waste to be used.

7. Other Feeds: Other feeds can be desirable and, data available added assuming they are commonly used in Canada.

8. Ration for Growing Replacement Heifers: Special attention will have to be given to P, Ca levels because of the very rapid bone growth of heifers.

Footnotes to "Guidelines"

1) Trace elements and vitamins were not included in the rations; they are left at the discretion of the individual producer; the costs are minimal.

2) "By-Products and Unusual Feedstuffs in Livestock Rations"; Western Regional Extension Publication No. 39, October 1980 by Donald L. Bath, John R. Dunbar et al, Cooperative Extension, University of California, Davis, California.

3) The value of whole carrots rather than the intermediate value was inadvertently used (see also Table No. 33).

B. LEAST COST FORMULAE

The Extension Department of the UOC ran a total of fifty-five LCR's, twenty-nine for beef operations and twenty-six for replacement heifer and dairy cow operations. The program did not pull out LCR's for each portion of waste as specified because the requirements for weight gains called for larger proportions of conventional feedstuffs thus greatly reducing the waste need (which, for some cases, were considerably below the lowest stipulated portion). Upon further examination and consultations, the UOC ran four supplementary LCR's eliminating daily weight gain and other restrictions and thereby increasing the waste usage. This approach is also applied in practical feedlot operations. Details of the LCR's (which are with the scientific authority), will be described in the subsequent nutritional and economic analysis chapters.

For comparison purposes, the LCR's were classified as shown in the Reference Table 32. B1-29 for beef and D1-26 for replacement heifers and milking cows. Reference numbers for the respective four supplementary rations, B-11 Suppl., B-12/13 Suppl., B-17 Suppl., B21/22 Suppl. have also been included in the analysis tables for easy comparison.

C. EVALUATION OF NUTRITIONAL ASPECTS

1. Feed Stuffs and Feed Selection

The three designated waste products, tomato, carrot and green bean are basically high quality feeds on a DM basis as indicated in Table 34, their main production limitation being associated with their high moisture content. All have good NE_L and NE_M values. But NE_G is rated as very low for tomato pomace and green bean wastes, whereas carrot cull waste is much superior to both and also to haylage or corn silage, Table 33.

Tomato pomace silage was selected because, firstly, the pomace form represents about 80% of all solid tomato processing waste, and secondly, the ensiled product is the one most commonly fed at the present time. The 30% DM selection was arbitrary; feedlots are feeding silages ranging from about 18 to 35% DM.

The feeding values used for carrot waste in the LCR's were those for cull carrots and which are higher than in carrot pulp, see Table 34.

In the protocol given for types and levels of animal production and levels of waste for beef and dairy production (Table 32), the maximum levels specified for waste are higher than was commonly found in feeding practices in feedlots in order to allow greater freedom to select waste feeds and increase the scope of the economic analyses.

Vegetable processing wastes vary considerably in their composition or feeding value within a given type of waste, especially in moisture level. Hence a relatively short list of conventional feeds was selected for the LCR formulations as a more elaborate listing seemed pointless.

2. Beef Rations

The beef cattle LCR programs placed no direct constraints on dry matter content or roughage level in the rations. However, there were some constraints on energy content which were mediated by the daily gains as specified, Table 32.

Table 34 Composition and Feeding Value Data For Vegetable Wastes and Some Conventional Feeds Used in Least Cost Rations

FEED	TDN	CP	NE_L	NE_M	NE_G	As Fed DM
	%	%	M CAL/LB			%
Tomato Pomace Silage	67	19.8	0.69	0.67	0.27	30
Green Bean Waste	73	23.5	0.75	0.72	0.33	18
Carrot Culls	82	10.3	0.85	0.88	0.59	14
Carrot Pulp	63	6.4	0.64	0.64	0.32	14
Haylage	65	17.0	0.66	0.58	0.28	45
Corn Silage	66	7.3	0.67	0.66	0.36	35
Corn Grain	90	9.7	0.92	1.02	0.67	90

*Feeding values for whole cull carrots inadvertently used in LCR ration instead of values intermediate between carrot pulp and whole carrots as intended.

a) Straight Feedlot - Growing Steers

The rates of gain show great uniformity on all LCR rations and slightly below the minimum specified. Likewise, feed efficiencies are uniform and quite high indicating that all the rations should be high quality for growing steers, Table 35.

The "as fed" feed intakes vary considerably because of moisture levels in the waste, those on carrot and combined wastes being especially high and probably at the upper extreme for maintaining adequate levels of feed intake. Since carrots are extremely palatable, these carrot rations in practice would probably produce the gains as shown during the latter half of the growing period but at lower body weights (450-600 lb.), it is somewhat doubtful if they could do it. From an economic viewpoint, somewhat lower gains might be quite acceptable.

Actual percentages of waste included in the rations was constrained (45.9%) only for the 60% carrot ration, Table 35.

Since the LCR program pulled in comparatively large amounts of haylage and/or corn silage which are low in NE_G, it is concluded that NE_G was not a limiting factor.

These LCR programs indicate that tomato, green bean and carrot wastes should be all highly useful feeds for growing steers (450-750 lb.) in the feedlot.

b) Straight Feedlot - Finishing Steers

As for growing steers, the rates of gain and feed efficiencies are very uniform with gains only slightly above the minimum specified. Feed efficiencies are very good, Table 35.

The LCR program did not pull in significant amounts of tomato (6.2%) and bean waste (9.5%). This is believed due

Table 35 Comparison of Least Cost Ration Daily Gains, Feed Efficiencies and Feed Intakes of Straight Feedlot Growing and Finishing Steers for Different Levels of Wastes and Conventional Feeds

	Growing (450-750 lb)							Finishing (750-1100 lb)						
Feed	Level of Waste in Ration (% DM basis) Selected	Level of Waste in Ration (% DM basis) Actual	Daily Gain lb	Feed DM/ lb Gain lb	Feed Intake DM	Feed Intake As Fed	LCR Code No.	Level of Waste in Ration (% DM basis) Selected	Level of Waste in Ration (% DM basis) Actual	Daily Gain lb	Feed DM/ lb Gain lb	Feed Intake DM	Feed Intake As Fed	LCR Code No.
Conventional Ration	0	0	2.3	7.7	17.7	42.2	B-1	0	0	2.5	7.5	19.0	26.2	B-11
Tomato Pomace Silage	20	20	2.3	7.6	17.4	45.4	B-2	20/30	6*	2.5	7.5	18.9	25.1	B-12
	30	30	2.3	7.5	17.2	44.8	B-3							
	40	40	2.2	7.7	17.0	44.3	B-4							
Green Bean Waste	30	30	2.3	7.5	17.3	58.5	B-5	20/30	10*	2.5	7.5	18.7	32.8	B-13
	50	50	2.2	7.7	17.0	66.0	B-6							
Carrot Waste	20	20	2.3	7.8	17.9	62.9	B-7	40	40	2.6	7.5	19.3	73.1	B-14
	40	40	2.4	7.4	17.7	76.5	B-8	100	48	2.6	7.5	19.4	83.4	B-15
	60	46	2.4	7.4	17.7	79.0	B-9							
Combined Waste	100	84 (carrot) (tomato)	2.3	7.4	17.0	82.9	B-10	100	45 (carrot)	2.6	7.5	19.3	79.0	B-16

* Specified rate of gain and hence energy requirements did not match nutrient level (NE_G) in waste products.

to the very low NE_G for these two products which presumably would not satisfy the higher demands for energy required by the finishing steer. Conversely, the carrot waste, because of its much higher NE_G, was able to fully enter these rations at the 40% specification and reach 48.3% at the 100% requirement. Without a specified minimum weight gain, no doubt the tomato and green bean would have been pulled in at much higher levels because of their very low cost/unit DM.

It is noteworthy that corn grain comes into all of these rations, usually in substantial amounts, indicating the need for a very high NE_G feed to complement lower energy feeds.

The "as fed" feed intake requirements for the carrot and combined waste rations are high, Table 35, but should not prove to be a limiting factor at these moisture levels.

At the weight gains specified here for finishing steers, the tomato, bean and carrot wastes are unlikely to enter finishing steer rations to the same extent as for growing rations. This is to be expected because of the higher energy needs for finishing operations.

c) Feeder/Feedlot - Growing Steers

The rates of gain on the various LCR rations again show good uniformity and tend to be somewhat higher than for the conventional rations. Feed efficiencies (lb DM/lb gain) are substantially poorer than for the straight feedlot operation because of the much lower rates of gain, Table 36.

The LCR program did not pull in significant amounts of either the bean waste (7.8%) or the carrot waste (0.7%). This can be explained on the basis that the 1.5 lb maximum rate of gain specified probably excludes carrot and green bean wastes, both with a higher NE_G and TDN than tomato, Table 36. In other words, carrot and bean waste are too good for a 1.5 lb. daily gain but by specifying a higher rate of gain more of these wastes would likely enter the rations.

Table 36 Comparison of Least Cost Ration Daily Gains, Feed Efficiencies and Feed Intakes for Feeder/Feedlot Growing and Finishing Steers for Different Levels of Wastes and Conventional Feeds

Feed	Growing (450-750 lb.) Level of Waste in Rations (% DM basis)				Daily Feed Intake			Finishing (750-1100 lb) Level of Waste in Rations (% DM basis)				Daily Feed Intake		
	Selected	Actual	Daily Gain lb	Feed DM/ lb Gain lb	DM lb	As Fed lb	LCR Code No.	Selected	Actual	Daily Gain lb	Feed DM/ lb Gain lb	DM lb	As Fed lb	LCR Code No.
Conventional Ration	0	0	1.5	13.7	18.0	40.1	B-17	0	0	2.9	6.6	19.0	26.0	B-24
Tomato Pomace Silage	40	40	1.6	12.5	18.0	48.6	B-18	20/30	6 *	2.9	6.6	18.9	25.0	B-25
	60	60	1.6	12.0	18.0	53.0	B-19							
	80	75	1.6	11.6	18.0	56.3	B-20							
Green Bean	40/60/80	8 *	1.5	13.6	18.0	44.4	B-21	20/30	9 *	2.9	6.6	18.9	32.3	B-26
Carrot	40/60/80	0.7 *	1.5	13.8	18.0	40.4	B-22	40	40	2.9	6.7	19.3	72.7	B-27
								100	46	2.9	6.7	19.4	81.2	B-28
Combined Waste	100	85 (tomato) (bean)	1.6	11.4	18.0	61.3	B-23	100	45 (carrot)	2.9	6.7	19.4	79.4	B-29

* Specified rate of gain and hence energy requirements did not match nutrient level (NE_G) in waste products.

The tomato pomace entered these rations as specified at the 40, 60, 80% levels, except for a minor restriction (75%) at the highest level. It is believed its very low NE_G permitted it to fit the specifications laid down for growing feeder steers at 1.0-1.5 lb/day.

The "as fed" feed intake requirements for either tomato pomace or the combined waste rations are fairly high (Table 36), but should not restrict feed intakes significantly.

d) Feeder/Feedlot - Finishing Steers

The rates of gain and feed efficiencies were again very uniform for all rations and feed efficiencies were high, possibly due to the high roughage background (HRB). In this instance, the computer selected a rate of gain closer to the maximum than minimum and very substantial amounts of corn grain were pulled in to provide the necessary NE_G. This HRB program differs somewhat from the straight feedlot finishing ration.

The LCR program did not pull in significant amounts of either tomato or green bean waste for the same reasons as given under the section, Straight Feedlot - Finishing Steers. However, again carrot waste came in at substantial levels, 40% and 46.3% for the 40% and 100% specified levels respectively. Rates of gain and feed efficiencies for the carrot rations are rated as at least equal to the high corn grain conventional ration. The combined waste came in at the 45% level but only the carrot waste was selected, Table 36.

The "as fed" feed intake requirement for the carrot and combined waste, Table 36, is high but is well within the 10% of body weight thumb rule for beef cattle. It should not limit intakes, especially with a high palatability feed such as carrots.

e) Supplementary LCR Beef Rations

Two of the LCR beef programs were modified to evaluate the extent to which the vegetable wastes would come into the rations when:

aa) The feeder/feedlot - feeder steer ration was not constrained by an upper limit on daily gain, and the program was allowed to select any waste or conventional feed on the list. No restrictions were placed on DM content, but a 15% minimum of corn silage was designated to ensure adequate fiber levels. This LCR program was designated as "B-21/B-22 Suppl." (Table 41).

bb) The straight feedlot finishing ration where no constraint was placed on the minimum daily rate of gain or on DM content of the ration and any feed on the list could be selected. Again a 15% corn silage minimum constraint was included. This program was designated "B-12/B-13 Suppl." (Table 40).

The B-21/B-22 Suppl. LCR feeder steer program now calls for high levels of bean (39.4%) and carrot (45%) wastes leaving out tomato pomace. Predicted daily gains are now much higher, 2.43 lb. instead of the 1.5-1.6 lb., specified for the original B-21 and B-22 LCR rations. This confirms the earlier conclusion that restricting daily gain limited the use of bean and carrot waste in B-21 and B-22 rations.

The B-12/B-13 Suppl. LCR straight feedlot finishing program now pulls in high levels of carrot (45%) and green bean (39.7%) wastes. The daily gain is now only 2.2 lb. which is below the minimum specified for the original B-12 and B-13 LCR rations (Table 35).

The extremely high moisture levels of these supplementary LCR rations raises the question as to whether they could function effectively under practical feeding conditions. It seems very doubtful if steers fed the B-12/B-13 Suppl. finishing ration, containing only 17.0% DM, would produce the predicted 2.2 lb. daily gain. Likewise it is questionable if the B-21/B-22 Suppl. ration (17.0% DM) for the feeder steers would produce the predicted 2.4 lb./day. However, it is suggested that the B-21/B-22 Suppl. ration would have a practical application as feeder steers are not normally fed to grow at such a rapid rate. A lower feed intake and a lower rate of gain would still be quite satisfactory for this phase of beef production.

3. Dairy Cattle Rations

a) Growing Dairy Heifers

The growing heifer LCR program for the 600-1,000 lb. animal, with 1.6 lb/day specified gain, has a number of constraints which are not in the beef programs including minimum TDN, CP, Ca, P, Ca, P, and CF. It also has a higher maximum rate of gain specified than for the growing feeder steer ration.

None of the three waste products had any difficulty in entering this ration except at the highest levels (60%) specified and even here the restrictions were minor, as actual levels were 52% for bean and 48% for carrots.

The combined waste ration came in at 99% for selected tomato waste only, Table 37. On an "as fed" basis, there should be no problem with intake of DM. However, the practical feeding data are currently inadequate to recommend such a ration for long term feeding, but it could probably function effectively for short feeding periods.

Feed efficiencies were very uniform and satisfactory on all rations with indications that those for carrot waste are superior to tomato, bean or conventional rations.

Table 37 Comparison of Least Cost Ration Feed Intakes and Feed Efficiencies for Growing Dairy Heifers for Different Levels of Waste and Conventional Feeds at 1.6 lb Daily Gain

Feed	Level of Waste in Ration (% DM basis) Selected	Level of Waste in Ration (% DM basis) Actual	Feed DM/lb Gain lb.	Daily Feed Intake DM lb	Daily Feed Intake As Fed lb	LCR Code No.
Conventional Ration	-	0	10.6	17.0	43.3	D-1
Tomato Pomace Silage	20	20	10.5	16.8	47.4	D-2
	40	40	10.5	16.7	51.3	D-3
	60	60	10.6	17.0	53.7	D-4
Green Bean Waste	20	20	10.3	16.5	54.4	D-5
	40	40	10.1	16.2	63.8	D-6
	60	52	10.4	16.7	66.0	D-7
Carrot Waste	20	20	10.2	16.3	56.3	D-8
	40	40	9.8	15.7	68.3	D-9
	60	48	9.7	15.5	73.0	D-10
Combined Waste	-	99* (tomato)	10.6	17.2	58.1	D-11

* Based on tomato pomace only and not considered practical for long term feeding without further information.

The "as fed" feed intake requirements, Table 37, should not restrict feed intakes.

Based on these LCR programs, tomato, green bean and carrot wastes should provide excellent feed ingredients for inclusion in growing dairy heifer rations, (600-1,000 lb.) up to the 50% level (DM basis).

b) Lactating Dairy Cows

The LCR programs for lactating cows had a number of nutritional constraints placed on them including an 80% maximum for corn grain and minimum levels for ^{M}Cal, CP, CF, Ca, P and Ca:P ratio. Also in these programs the wastes were separated into roughage (tomato pomace) and concentrates (green beans, carrots) principally on the basis of their CF content. However, no constraints were placed on roughage, concentrate or total DM.

The tomato pomace entered the LCR program at the 20%, 30% and 60% levels as specified indicating a valuable and flexible feed ingredient for milk production, Table 38.

At the 20% and 30% levels the green bean and carrot waste also entered the LCR program as specified. The 30% is especially significant as it coincides with what is regarded as a first class level of milk production for top commercial herds namely 60 lb/cow/day (California average is 55 lb/day). It is however, surprising that at the specified 60% waste level and 30 lb/day production level, not more of the bean and carrot waste, which actually entered at the 39% and 33% respectively, were pulled in. It may be that these wastes are good enough that the 30 lb milk/day limitation actually restricts their input as is suggested by their relatively high NE_L values, Table 38.

It is noteworthy that no protein supplements were required except for the 90 lb milk/day rations.

Efficiency of milk production (feed DM/lb milk) increased uniformly with increasing milk production specifications, as would be expected. The DM feed intakes followed the same pattern. The "as fed" feed intake requirements for the waste rations should not restrict feed intakes providing there are no palatability problems such as poor conservation of the waste feeds. The high producing dairy cow is a much more sensitive animal than the beef animal and relatively minor changes in the quality of the feed can have major effects on milk production. For this reason alone the utilization of processing wastes for milk production is much more limited in scope than for beef production.

The combined waste program produced two rations which are completely impractical, D25 and D26, for milk production and illustrate what happens when waste feed of high feeding value (DM basis) are used without a restriction on total moisture or DM in the feed, Table 38.

Table 38 Comparison of Efficiency of Milk Production, Feed Intakes and Waste Input Levels For Selected Processing Waste and Conventional Rations in Least Cost Ration Formulae For Lactating Cows

Feed	Level of Waste in Ration (% DM basis)		Specified Daily Milk lb.	Feed DM/lb Milk Produced lb.	Daily Feed Intake		LCR CODE No.
	Specified	Actual			DM lb	As Fed lb	
Conventional	0	0	90	0.59	53.1	60.0	D-14
	0	0	60	0.67	40.3	71.5	D-13
	0	0	30	1.02	30.6	66.8	D-12
Tomato Pomace Silage	20	20	90	0.56	50.5	34.2	D-17
	30	30	60	0.66	39.6	40.3	D-16
	60	60	30	1.23	36.8	74.9	D-15
Green Bean Waste	20	20	90	0.60	54.1	60.0	D-20
	30	30	60	0.70	41.7	69.5	D-19
	60	39	30	1.04	31.1	67.1	D-18
Carrot Waste	20	20	90	0.59	53.4	76.2	D-23
	30	30	60	0.69	41.1	88.2	D-22
	60	33	30	0.94	28.3	66.9	D-21
Combined Waste	100	(Tom 34 * (Carr 44 (Beans18	90	0.57	51.2	282.2*	D-26
		(Tom 55 * (Carr 44	60	0.66	39.5	185.5*	D-25
		(Tom 67 * (Carr 32	30	0.94	28.2	128.2*	D-24

* Rations not included in protocol but run on experimental basis. D-25 and D-26 are considered completely impractical because of excessive moisture content. D-24 is borderline as any limitation on palatability would also limit feed intake.

D. EVALUATION OF ECONOMIC ASPECTS

1. Introduction

For the economic evaluation of the various rations, two new sets of matrices were developed for each of the livestock categories and each of the waste products.

In the first set, Tables 39 to 44, the columns showed first the selected maximum percent and, adjoining, the actual percent of dry matter of selected waste products in the rations; the second column was required because the program could not always accept the stipulated maximum percent of waste. The following three columns of production/day/head, feed intake, and cost of rations were primarily included for general knowledge and comparison purposes. The important columns, however, are the feed costs per lb. of gain, and the savings of waste rations over conventional rations per lb. of gain representing the difference between the conventional ration listed first and the waste rations shown underneath. The next column consists of the total costs of rations per feeding and/or milk production phase, and the final column represents the total savings per feeding phase of the various rations utilizing food processing waste rations over the conventional feeding rations.

The second set, Tables 45 to 48, has been designed to obtain the dollar savings per ton of waste feed as fed over the full feeding/lactation period. They follow the same basic classification as in the first set for each livestock category and each waste product. The quantity of waste products as fed for the period was taken from the LCF's (see Appendices). The total savings per feeding phase were taken from column 10 of the Tables 39 to 44. The savings per ton of waste as fed are the result of dividing the total savings by the total quantity of waste feed.

The following analysis is based on the first batch of LCR's as obtained. As some additional LCR's were subsequently computed without weight gain restrictions in order to increase the use of waste products, the results are described at the end of each of the following chapters.

2. Analysis of Total Savings per Feeding Phase - Beef Rations

a) Straight Feedlot-Growing Steers (450-750 lbs.)

The savings of feeding tomato pomace at the 20, 30 and 40% proportion ranged between $9.87 to $15.03 or representing 13% to 19% (Table 39). The savings for bean waste at 30-50% of the ration ranged from $16.59 to $24.30 or 21% to 31% respectively. The average for beans is about 36 percent higher than that of tomato pomace at the 40% level, and is due to the lower material cost for bean waste and a slightly higher TDN.

The savings from feeding carrot waste at the 20, 40 and 46% proportion is considerably higher than either the tomato and green bean waste, and range from $21.15 to $37.77, or 27% to 49% respectively. It should be pointed out again, as already indicated previously, that the value of the carrot waste was inadvertently used at a somewhat higher TDN value than originally planned. Despite this somewhat overstated figure, the savings are still substantial especially at the 60% level where the savings represent almost one half the conventional ration.

An unusually large saving of $55.53 or 72% of the ration was, according to the LCR, achieved by feeding a combined 43% carrot waste and 41% tomato pomace ration. As already indicated in the nutritional analysis section, it appears rather unusual that the cost of this ration would only be $21.81 or 28% of the conventional, non-waste ration cost of $77.34. These extraordinary savings may have resulted from the way the ration program was designed and thus would have to be checked further before being fed to livestock. It would appear these waste products fit this class and type of beef production better than feedlot finishing as will be evident in the following discussions.

Table No.39 COMPARISON OF GAINS/PRODUCTION, COSTS AND SAVINGS OF SELECTED PROCESSING WASTE RATIONS WITH CONVENTIONAL RATIONS FOR STRAIGHT FEEDLOT-GROWING STEERS (450-750 lbs.)

Conventional/Waste Feed Ration		Selected Max. Percent DM of Waste in Ration %	Actual Percent DM of Waste in Ration %	Gain/Production per day/Head lbs.	Feed Intake DM per lb. of Gain lbs.	Cost of Ration per cwt DM $	Feed Cost per lb. of Gain $	Savings of Waste Ration to Conventional Ration per lb. of Gain $	Total Cost of Ration per Feeding Phase $	Total Savings per Feeding Phase $	Reference Least Cost Ration No.
Conventional Ration		-	-	2.30	7.7	3.34	.2578	-	77.34		B-1
Tomato Pomace		20	20	2.27	7.6	2.93	.2249	.0329	67.47	9.87	B-2
		30	30	2.26	7.5	2.83	.2163	.0415	64.89	12.45	B-3
		40	40	2.24	7.7	2.73	.2077	.0501	62.31	15.03	B-4
Green Bean Waste		30	30	2.26	7.5	2.65	.2025	.0553	60.75	16.59	B-5
		50	50	2.23	7.7	2.32	.1768	.0810	53.04	24.30	B-6
Carrot Waste		20	20	2.31	7.8	2.42	.1873	.0705	56.19	21.15	B-7
		40	40	2.40	7.4	1.90	.1400	.1178	42.00	35.34	B-8
		60	45.9	2.39	7.4	1.79	.1319	.1259	39.57	37.77	B-9
Combined Waste	carrot	-	43.2	2.33	7.4	1.00	.0727	.1851	21.81	55.53	B-10
	tomato		41.1								
	bean										

b) Straight Feedlot/Finishing Steers (750-1,100 lbs.)

The cost of a conventional ration for finishing steers was $139.62. In view of the stipulated daily gain constraints, the program pulled in a very low waste portion of only 6.2% for tomato pomace and 9.5% for green bean waste whereas the original matrix asked for 20 and 30% for each of those two wastes. The results therefore are not significant and cannot be accepted as such, subject, as already indicated in the nutritional section to further trials and LCR computations.

The feeding of the carrot waste at 40 and 48%, however, showed again significant savings of $50.68 and $58.24 respectively. This represents a 45% and 51% saving over conventional rations. It is noteworthy that even though the matrix calls for 100% carrot waste, the program pulled out a maximum of only 48%. The combined waste LCR's pulled in only 45% of carrot waste and no other tomato or green bean waste. The savings, as expected, were $56.11 or 49%, ranging between $50.58 and $58.24 of the previously indicated 40 and 48% of carrot waste fed respectively (Table 40).

c) Feeder/Feedlot/Growing Steers (450-750 lbs.)

The savings by feeding tomato pomace to these steers with a stipulated daily gain ranging between 1.55 to 1.61 lbs. are considerably higher than those for a straight feedlot operation. In the 40, 60 and 75% (rather than the stipulated 80%) portion of tomato pomace, the savings were $39.27, $54.90 and $66.15 respectively. These are substantial savings and represent 39%, 54% and 65% respectively of the conventional rations (Table 41).

It is interesting to note that for these animals with the lower daily gain, the program brought in very little green bean waste of only 7.8% and practically no carrot waste with almost no savings which, without a further review of these rations, should not be considered significant. (See Section VIII-C on nutrition for further explanation.)

Table No.40 COMPARISON OF GAINS/PRODUCTION, COSTS AND SAVINGS OF SELECTED PROCESSING WASTE RATIONS WITH CONVENTIONAL RATIONS FOR STRAIGHT FEEDLOT-FINISHING STEERS (750-1,100 lbs.)

Conventional/Waste Feed Ration	Selected Max. Percent DM of Waste in Ration	Actual Percent DM of Waste in Ration	Gain/Production per day	Feed Intake DM per lb. of Gain	Cost of Ration per cwt DM	Feed Cost per lb. of Gain	Savings of Waste Ration to Conventional Ration per lb. of Gain	Total Cost of Ration per Feeding Phase	Total Savings per Feeding Phase	Reference Least Cost Ration
	%	%	lbs.	lbs.	$	$	$	$	$	No.
Conventional Ration	-	-	2.54	7.5	5.35	.3989	-	139.62	-	B-11
Tomato Pomace	20/30	6.21*	2.53	7.5	5.31	.3959	0.0030	138.57	1.05*	B-12
Green Bean Waste	20/30	9.49*	2.53	7.5	5.09	.3793	0.0196	132.76	6.86*	B-13
Carrot	40	40	2.57	7.5	3.39	.2541	.1448	88.94	50.68	B-14
Waste	100	48.3	2.58	7.5	3.09	.2325	.1664	81.38	58.24	B-15
Combined Waste Carrot	-	45	2.58	7.5	3.18	.2386	.1603	83.51	56.11	B-16
Supplemental LCR's (No Constraints)										
Conventional Ration	-	-	1,78	13,2	2,58	.3396	-	118.86	-	B-11 Suppl.
Combined Waste										
Bean	-	39,7)	2,17	9,8	0.96	.0939	.2457	32,87	85.99	B-12/ B-13 Suppl.
Carrot	-	45,0)								

* Specified rate of gain and hence energy requirements did not match nutrient level (NE_G) in waste products.

Table No. 41 COMPARISON OF GAINS/PRODUCTION, COSTS AND SAVINGS OF SELECTED PROCESSING WASTE RATIONS WITH CONVENTIONAL RATIONS FOR FEEDER/FEEDLOT-GROWING STEERS (450-750 lbs.)

Convention-al/Waste Feed Ration	Selected Max. Percent DM of Waste in Ration %	Actual Percent DM of Waste in Ration %	Gain/ Produc-tion per day lbs.	Feed In-take DM per lb. of Gain lbs.	Cost of Ration per cwt DM $	Feed Cost per lb. of Gain $	Savings of Waste Ration to Conventional Ration per lb. of Gain $	Total Cost of Ration per Feeding Phase $	Total Savings per Feeding Phase $	Reference Least Cost Ration No.
Conventional Ration	-	-	1.46	13.7	2.74	.3384	-	101.52		B-17
Tomato Pomace	40	40	1.55	12.5	1.78	.2075	.1309	62.25	39.27	B-18
	60	60	1.58	12.0	1.37	.1554	.1830	46.62	54.90	B-19
	80	75	1.61	11.6	1.05	.1179	.2205	35.37	66.15	B-20
Green Bean Waste	40/60/80	7.8 *	1.47	13.6	2.64	.3240	.0144	97.20	4.32 *	B-21
Carrot Waste	40/60/80	0.7 *	1.46	13.8	2.73	.3375	.0009	101.25	0.27 *	B-22
Combined Waste										
tomato	-	75	1.63	11.4	0.87	.0966	.2418	28.98	72.54	B-23
bean		9.8								
Supplemental LCR's (No Constraints)										
Conventional Ration	-	-	1.90	9.45	2.64	.2493	-	74,79	-	B-17 Suppl.
Combined Waste										
Bean	-	39.4)	2.43	6.80	1.05	.0716	.1777	21.48	53.31	B-21/
Carrot	-	45.0)								B-22 Suppl.

* Specified rate of gain and hence energy requirements did not match nutrient level (NE_G) in waste products.

The program's combined waste proportion of 75% tomato and 9.8% bean waste, where there were no restrictions on feed selection, showed the highest overall gain of $72.54 which is almost too good in view of practical feeding requirements. The savings would represent 71% of the conventional ration whereby the actual cost would only amount to $28.98 versus the cost of a conventional ration of $101.52.

d) Feeder/Feedlot-Finishing Steers (High Roughage Background; 750-1,100 lbs.)

The stipulated and actual computed gains of this group were approximately 2.85 lbs. per day. The cost of the conventional ration was $124.95 (Table 42).

The program, with an input requirement of 20 and 30% respectively of tomato as well as green bean waste, pulled in only 5.9% tomato waste and 9.1% green bean waste. This was again due to the gain restrictions. The savings therefore are insignificant for the tomato pomace and also very limited for the green bean waste of $5.81 or 6% of the total cost of the conventional ration. The reasons for these restrictions are given under Section VIII-C on nutrition.

The carrot waste, at 40 and 46%, showed substantial savings of $44.07 and $47.81 or 43% and 47% respectively.

The combined waste selection pulled in only 45% carrot waste with very similar savings to those indicated above.

e) Results of Supplementary Least Cost Rations for Beef

A second run of the conventional ration (B-11 Suppl.) for the straight feedlot finishing steers without gain and energy requirement constraints, resulted in a reduced total cost of the ration of about $21, reducing the savings of the waste rations accordingly. The combined waste ration (B-12/B-13 Suppl.) showed a dramatic decrease in total costs with a theoretical saving of $86 per feeding phase; the large quantity and high moisture content, however, would make it very difficult to obtain a daily gain of 2.17 lbs.

Furthermore, although the cost of the conventional ration per lb. of gain in this feedlot operation was considerably lower, the number of days the steers have to remain in the feedlot (due to reduced daily gain from 2.54 lbs. to 1.78 lbs.) is greatly increased. Hence, it is questionable if a significant overall economic improvement can be achieved. Also, a 1.78 lb. gain probably would not provide an adequate finish to the animals, resulting in low grade penalties which can be very costly to the producer. Without further elaborating on the feedlot management aspects, which are not part of the terms of reference of this contract, it can be concluded that, first, the B-11 Suppl. ration would not be a practical ration, and secondly, that an initial concept of rate of gain restrictions was certainly warranted, and third, that considerable more in-depth research, evaluation, experimentation and practical feeding trials would be required to obtain concrete results.

The second run of conventional ration (B-17 Suppl.) for feeder-feedlot growing steers without restrictions shows a higher daily gain at an overall lower total feed cost. The combined waste LCR (B-21/B-22 Suppl.) shows a 26% decrease in costs from the original LCR (B-21 and B-22).

In view of the practical feeding limitations of the LCR B-16 Suppl. and the relatively small change of the LCR B-21/22 Suppl. from the original B-21 and B-22, no further analysis is extended for them in the subsequent sections.

3. Analysis of Total Savings for Dairy Cattle Rations

a) Replacement Dairy Heifers (600-1,000 lbs.)

The stipulated daily gain for these heifers gaining 400 lbs., ranged between 1.5-1.9 lbs. with an LCR average gain of 1.6 lbs. per day. With these requirements, the program showed a relatively even portion as stipulated in the matrix. By feeding 20, 40 and 60% respectively of tomato pomace, the savings were $20, $35 and $52.48 respectively representing a percent range from 18% to 47%.

A very similar pattern emerged from feeding green bean waste at 20, 40 and 52% ration with similar savings ranging from 18% to 41% of the conventional ration.

Table No. 42 COMPARISON OF GAINS/PRODUCTION, COSTS AND SAVINGS OF SELECTED PROCESSING WASTE RATIONS WITH CONVENTIONAL RATIONS FOR FEEDER/FEEDLOT-FINISHING STEERS (HIGH ROUGHAGE BACKGROUND (HRB); 750-1,100 lbs)

Conventional/Waste Feed Ration	Selected Max. Percent DM of Waste in Ration %	Actual Percent DM of Waste in Ration %	Gain/Production per day lbs.	Feed Intake DM per lb. of Gain lbs.	Cost of Ration per cwt DM $	Feed Cost per lb. of Gain $	Savings of Waste Ration to Conventional Ration per lb. of Gain $	Total Cost of Ration per Feeding Phase $	Total Savings per Feeding Phase $	Reference Least Cost Ration No.
Conventional Ration	-	-	2.86	6.6	5.38	.3570	-	124.95	-	B-24
Tomato Pomace	20/30	5.9*	2.85	6.6	5.35	.3545	.0025	124.08	.88*	B-25
Green Bean Waste	20/30	9.1*	2.85	6.6	5.13	.3404	.0166	119.14	5.81*	B-26
Carrot Waste	40	40	2.89	6.7	3.46	.2311	.1259	80.89	44.07	B-27
	100	46.3	2.90	6.7	3.30	.2204	.1366	77.14	47.81	B-28
Combined Waste Carrot	-	45	2.90	6.7	3.33	.2226	.1344	77.91	47.04	B-29

* Specified rate of gain and hence energy requirements did not match nutrient level (NE_G) in waste products.

Table No. 43 COMPARISON OF GAINS/PRODUCTION, COSTS AND SAVINGS OF SELECTED PROCESSING WASTE RATIONS WITH CONVENTIONAL RATIONS FOR GROWING REPLACEMENT DAIRY HEIFERS (600-1000 lb.) FOR 1.6 LB/DAY GAIN

Conventional/Waste Feed Ration	Selected Percent DM of Waste in Ration %	Actual Percent DM of Waste in Ration %	Gain/Production per day lbs.	Feed Intake DM per lb. of Gain lbs.	Cost of Ration per cwt DM $	Feed Cost per lb. of Gain $	Savings of Waste Ration to Conventional Ration per lb. of Gain $	Total Cost of Ration per Feeding Phase $	Total Savings per Feeding Phase $	Reference Least Cost Ration No.
Conventional	-	-	1.6	10.6	N/A	.2750	-	110.00		D-1
Tomato Pomace	20	20	1.6	10.5	N/A	.2250	.0500	90.00	20.00	D-2
	40	40		10.5		.1875	.0875	75.00	35.00	D-3
	60	60		10.6		.1438	.1312	57.52	52.48	D-4
Green Bean	20	20	1.6	10.3		.2250	.0500	90.00	20.00	D-5
	40	40		10.1		.1813	.0937	72.52	37.48	D-6
	60	52		10.4		.1625	.1125	65.00	45.00	D-7
Carrot	20	20	1.6	10.2		.2250	.0500	90.00	20.00	D-8
	40	40		9.8		.1813	.0937	72.52	37.48	D-9
	60	48		9.7		.1625	.1125	65.00	45.00	D-10
Combined	-	100				.0563	.2187	22.52	87.48	D-11

The savings for the carrot waste feeding was identical to that of the green bean waste feeding; no particular reasons could be detected for these relationships.

The largest savings with 100% waste rations was $87.48 or 79% of the total ration. As indicated in the previous section, it is almost inconceivable that the cost of the total ration for the feeding phase of 400 lb. gain was only $22.52; a further review of the details of the LCR's and of nutritional aspects would be advisable before putting this ration into practice.

b) Lactating Dairy Cows at Various Production Levels

There appear to be significant differences in feed costs per lb. of milk of the LCR's when compared with feed costs from the Provincial Dairy Summary of 117 Selected Dairy Farms (1980 Report, published by the Ontario Ministry of Agriculture and Food, June 1981). The feeding costs per lb. of milk for the LCR's conventional rations range from 2.8-3.1¢, whereas the costs derived from the Ontario study range between 6.39-7.8¢ per lb. Several reasons account for the differences: First, the feed costs of the LCR's are based on the actual, computed feed quantity consumed by the cows during the production phase only using NRC standards which are generally based on minimum requirements not allowing for any waste or feeding inefficiencies. Second, the quantity of feed in the Ontario study is based on total annual consumption per cow for 365 days vs. 305 days for the LCR's. Third, the Ontario study also includes the feed requirements for replacement heifers which, dependent upon the makeup of the herd, can be substantial and are,of course, not included in the LCR's. Fourth, the total feed requirements (and thus costs) in the Ontario study are based on the farm production as recorded and an on-farm inventory taken annually with the difference between the beginning and the end-inventory assumed to be either fed or not used. This is a rather simple measurement of feed consumption especially if any purchases,

Table 44 COMPARISON OF MILK PRODUCTION, COSTS AND SAVINGS OF SELECTED PROCESSING WASTE RATIONS WITH CONVENTIONAL RATIONS FOR LACTATING DAIRY COWS AT VARIOUS PRODUCTION LEVELS

Conventional/Waste Feed Ration	Selected Percent DM of Waste in Ration	Actual Percent DM of Waste in Ration	Specified Milk Production per day	Feed Intake DM per lb. of Milk	Cost of Ration per cwt DM	Feed Cost per Litre of Milk	Savings of Waste Ration to Conventional Ration per lb. of Milk	Total Cost of Ration per 305 day Lactation Period	Total Savings per 305 day Lactation Period	Reference Least Cost Ration
	%	%	lbs.	lbs.	$	$	$	$	$	No.
Conventional	-	-	30	1.01	N/A	.0283	-	258.94	-	D-12
	-	-	60	.67		.0265	-	484.94	-	D-13
	-	-	90	.59		.0312	-	856.42	-	D-14
Tomato Pomace	60	60	30	1.23		.0157	.0126	143.65	115.29	D-15
	30	30	60	.66		.0217	.0048	397.10	87.84	D-16
	20	20	90	.56		.0270	.0042	741.13	115.29	D-17
Green Bean	60	39	30	1.04		.0190	.0093	173.85	85.09	D-18
	30	30	60	.69		.0177	.0088	323.90	161.04	D-19
	20	20	90	.60		.0237	.0075	650.55	205.87	D-20
Carrot Waste	60	33	30	.94		.0187	.0096	171.10	87.84	D-21
	30	30	60	.69		.0165	.0100	301.94	183.00	D-22
	20	20	90	.59		.0249	.0063	683.49	172.93	D-23
Combined Waste	-	(Tom. 67 * (Carrot32	30	.94		.0063	.0220	57.64	201.30*	D-24
		(Tom. 55 * (Carrot44	60	.66		.0048	.0217	87.84	397.10*	D-25
		(Tom. 34 * (Carrot44 (Bean 18	90	.57		.0048	.0264	131.76	724.66*	D-26

*Rations not included in protocol but run on experimental basis. D-25 and D-26 are considered completely impractical because of excessive moisture content. D-24 is borderline as any limitation on palatability would also limit feed intake.

sales or other uses for calves and other livestock would not have been accurately accounted for. Fifth, from the above description, it is evident that any spoilage or wastage of feed is also included in the Ontario costs. Sixth, the feed prices used for the LCR computations closely approximate those of the Ontario farm study and thus would not account for a difference of a few percentage points. Seventh, it should be noted that 1982 feed prices are reportedly about 15-18% lower than in 1980 on which the Ontario study was based.

A very similar pattern emerged from feeding green bean waste at 20, 40 and 52% ration with similar savings ranging from 18% to 41% of the conventional ration.

The savings for the carrot waste feeding was identical to that of the green bean waste feeding; again no particular reasons could be detected for this relationship.

Our concept included the following parameters of varying levels of waste proportion which, as expected, decreased proportionately with increasing milk production at 30, 60 and 90 lbs. per day. The feed intake per lb. of milk also proportionately decreased with increasing milk production. The lactation period was assumed at 305 days.

The savings for each of the three waste products as well as the combined waste products showed a fairly regular pattern. The savings for feeding 60, 30 and 20% of tomato pomace for a daily milk production of 30, 60 and 90 lbs. respectively were $115.29, $87.84, and $115.29 or 45%, 18% and 13% respectively when compared to the total cost of the rations per 305 day lactation period. The relatively lower level at the 30% tomato pomace for 60 lbs. of daily milk production vs. 90 lb./day was presumably due to the relatively high levels of tomato pomace and haylage, both much lower in cost/unit of TDN compared with the 90 lb./day ration.

The feeding of green bean waste at the levels of 39% (instead of the maximum 60%), 30 and 20%, respectively, for the same pattern of milk production, were $85.09, $161.04, and $205.87 or 33%, 33% and 24% respectively. For bean waste, the pattern was also a proportionate increase in savings with increased milk production.

A similar pattern emerged for carrot waste where the maximum again was 33% rather than the stipulated 60% with savings were $87.84 to $183.00 and $172.93 or 34%, 38% and 20% respectively.

The results derived from feeding a combined waste, where the computer program was left free to select the most economical ration, appear rather unrealistic. The costs of rations with various wastes and proportions, were only approximately 20% of those of conventional rations leaving purported savings of about 80%. A review of the program under elimination of some restrictions should be undertaken and the results again reviewed before any actual feeding program is initiated.

4. Savings per Ton of Waste Feed

a) Straight Feedlot Operations

An economic analysis requires that the savings be brought to a common denominator for comparison purposes. The LCR's as supplied by the UOC provided not only information on a DM basis but also on a waste quantity requirement basis as fed per lb. of gain. This information was multiplied for the entire feeding cycle, for the growing as well as finishing phases and compared with the savings from the previous tables 39 and 40 for the identical phases. These savings were then divided by the total waste quantity on an "as fed" basis in order to provide uniform results.

For the growing phase of steers the gross savings per ton of waste feed being fed on a 20, 30 and 40% of the ration, range between $9.87 and $12.88.

The savings per ton of green bean waste ranged between $7.67 and $8.67,while the savings per ton of carrot waste, due to the higher TDN value used in the computer program than previously planned, ranged between $10.42 and $12.74. With the original TDN value as stipulated, the savings per ton of carrot waste would closely resemble those of the tomato pomace. Even the feeding of a combined waste ration of 43% carrot and 41% tomato waste, resulted in a similar saving of $11.40 per combined ton of these two wastes.

For the finishing steers, the computations for tomato and green bean waste, as already indicated previously, are not significant. The savings for carrot waste were slightly higher than for those for the growing steers ranging between approximately $12.85 and $13.51. The program on the combined waste pulled out only 45% of carrot waste; the savings of $13.29 per ton of waste however were the second highest in this group. These relatively high benefits demonstrate again the need to review and try new alternatives of input including fewer restrictions to arrive at practical rations.

Table No. 45 GROSS SAVINGS PER TON OF SELECTED WASTE FEED ON AN AS FED BASIS FOR STRAIGHT FEEDLOT OPERATION

Waste Feed Ration	Actual Percent Waste Feed %	Waste Quantity on As Fed Basis for Feeding Phase lbs.	Savings per Feeding Phase $	Savings per Ton of Waste Feed $	Reference Least Cost Ration No.
A. <u>GROWING PHASE</u>					
Tomato Pomace	20	1,533	9.87	12.88	B-2
	30	2,292	12.45	10.86	B-3
	40	3,045	15.03	9.87	B-4
Green Bean Waste	30	3,826	16.59	8.67	B-5
	50	6,339	24.30	7.67	B-6
Carrot Waste	20	3,320	21.15	12.74	B-7
	40	6,325	35.34	11.17	B-8
	45.9	7,249	37.77	10.42	B-9
Combined Waste: Carr	43.2)	6,738	55.53	11.40)	B-10
Tom	41.1)	2,992		)	
B. <u>FINISHING PHASE</u>					
Tomato Pomace	6.21 *	539	1.05	*	B-12
Green Bean Waste	9.49 *	1,375	6.86	*	B-13
Carrot Waste	40.0	7,503	50.68	13.51	B-14
	48.3	9,063	58.24	12.85	B-15
Combined Waste Carr	45	8,447	56.11	13.29	B-16

* Specified rate of gain and hence energy requirements did not match nutrient level (NE_G) in waste products.

b) Feeder/Feedlot Operations

The savings for growing steers in this operation are approximately 45% higher than for growing steers in the straight feedlot operations due to the fact that the daily gain as stipulated is lower, allowing a greater proportion of waste feed to be fed at 40, 60 and 75% (as compared with 20, 30 and 40% for the straight feedlot operation). The savings per ton of tomato pomace ranged from $15.75 to $16.87. Similarly, a slightly lower saving was shown in the combined waste of 75% of tomato pomace and 9.8% of bean waste with a benefit of only $14.38.

The savings for green bean as well as carrot waste are insignificant due to the factors already explained previously.

The same comments as above also apply to tomato and green bean waste for the finishing steers. The savings per ton of carrot waste however, being fed at 40 and 46% were between $12.40 and $13.40.

c) Dairy Cattle Operation

The LCR's provided the waste quantity of pounds "as fed" per daily gain for replacement heifers and per daily milk production for cows, from which the total waste quantity fed for the growing phase or lactation period could be computed as shown in Columns 1 and 2 of Table 47. The daily savings for the growing and for the lactation periods were taken from Table 44 thus enabling the computation of the savings per ton of waste "as fed".

For the replacement heifers of this operation, the savings per ton of tomato pomace ranged from $14.04 for feeding 20% to $12.12 for 60%. The higher benefits for the 20% ration than for the 60% appears to be an anomaly and can only be explained by the specific changes in the proportions of each of the three rations.

The savings per ton of bean waste, similar to that of the straight feedlot, were somewhat lower and within the same range of $7.48 to $8.74. Again, one would expect the benefits

Table No. 46 GROSS SAVINGS PER TON OF SELECTED WASTE FEED ON AN AS FED BASIS FOR FEEDER/FEEDLOT OPERATIONS

Waste Feed Ration	Actual Percent Waste Feed %	Waste Quantity on As Fed Basis for Feeding Phase lbs.	Savings per Feeding Phase $	Savings per Ton of Waste Feed $	Reference Least Cost Ration No.
A. GROWING PHASE					
Tomato Pomace	40	4,655	39.27	16.87	B-18
	60	6,826	54.90	16.09	B-19
	75	8,399	66.15	15.75	B-20
Green Bean Waste	7.8 *	1,591	4.32	*	B-21
Carrot Waste	0.7 *	175	0.27	*	B-22
Combined Waste: Tom	75)	8,293)	72.54	14.38)	B-23
Bean	9.8)	1,797)		)	
B. FINISHING PHASE					
Tomato Pomace	5.9 *	460	.88	*	B-25
Green Bean Waste	9.1 *	1,169	5.81	*	B-26
Carrot Waste	40	6,673	44.70	13.40	B-27
	46.3	7,735	47.81	12.36	B-28
Combined Waste: Carr	45	7,514	47.04	12.52	B-29

* Specified rate of gain and hence energy requirements did not match nutrient level (NE_G) in waste products.

Table 47. GROSS SAVINGS PER TON OF SELECTED WASTE FEED ON AN AS FED BASIS FOR DAIRY OPERATIONS

Waste Feed Ration	Actual Percent Waste Feed	Waste lbs. as Fed/Daily Gain or Daily Milk Production	Total Waste Quantity Fed per Feeding Phase or Lactation Period	Savings per Feeding Phase	Savings per Ton of Waste Feed	Reference Least Cost Ration
	%	lbs/lb	lbs.	$	$	No.
A. <u>GROWING HEIFER</u>						
Tomato Pomace	20	11.4/1.6	2,850	20.00	14.04	D-2
	40	22.68/1.6	5,670	35.00	12.35	D-3
	60	34.63/1.6	8,658	52.48	12.12	D-4
Green Bean Waste	20	18.31/1.6	4,578	20.00	8.74	D-5
	40	36.05/1.6	9,013	37.48	8.32	D-6
	52	48.12/1.6	12,030	45.00	7.48	D-7
Carrot Waste	20	23.33/1.6	5,833	20.00	6.86	D-8
	40	44.93/1.6	11,233	37.48	6.67	D-9
	48	53.48/1.6	13,370	45.00	6.73	D-10
Combined Waste Tom	100	58.08/1.6	14,520	87.48	12.05	D-11

/cont'd

Table 47 Cont'd

Waste Feed Ration	Actual Percent Waste Feed	Waste lbs. as Fed/Daily Gain or Daily Milk Production	Total Waste Quantity Fed per Lactation Phase or Lactation Period	Savings per Lactation Phase	Savings per Ton of Waste Feed	Reference Least Cost Ration
	%	lbs/lb	lbs.	$	$	No.
B. LACTATING COWS						
Tomato Pomace	60	74.91/30	22,846	115.29	10.09	D-15
	30	40.25/60	12,276	87.84	14.31	D-16
	20	34.21/90	10,434	115.29	22.10	D-17
Green Bean Waste	39	67.12/30	20,470	85.09	8.31	D-18
	30	69.50/60	21,196	161.04	15.19	D-19
	20	60.05/90	18,315	205.87	22.48	D-20
Carrot Waste	33	66.87/30	20,395	87.84	8.61	D-21
	30	88.16/60	26,888	183.00	13.61	D-22
	20	76.21/90	23,244	172.93	14.88	D-23
Combined Waste						
Tom. Carr.	67) * 32)	64.07) 64.14) 30	*	201.30	*	D-24
Tom. Carr.	55) * 44)	73.63) 123.90) 60	*	397.10	*	D-25
Tom. Carr. Bean.	34) * 44) 18)	59.67) 159.47) 90 52.92)	*	724.66	*	D-26

* Rations not included in protocol but run on experimental basis. D-25 and D-26 are considered completely impractical because of excessive moisture content. D-24 is borderline as any limitation on palatability would also limit feed intake.

to increase from the lower to the higher portion of waste fed, but the same observations as above also apply here.

The savings from feeding carrot waste, surprisingly, were considerably lower ranging from $6.67 to $6.86 per ton. The explanation may again lie in the costs of other feeds supplied because the benefits per ton for the replacement heifers with a lower daily gain, as compared with those for growing steers in the straight feedlot were approximately 15% higher for tomato pomace, about the same for bean waste but about 40% lower for carrot waste. It should also be noted again that these dairy operation results were derived from a different LCR program than the beef results. For lactating cows, the savings per ton were unrealistic as already explained in the previous section.

E. EVALUATION OF NET BENEFITS

1. Processors

The evaluation of the processors' benefits to utilize rather than dispose of the waste products represents considerable difficulties due to the plant size, waste quantity and moisture content; plant and processing efficiencies; distance to private or municipal dumps; hauling arrangements, logistics and other related factors. Due to the limited information received, savings for the three designated wastes of tomato pomace, beans and carrots cannot be shown separately.

As a general principle, the benefits to processors consist of the elimination of disposal hauling and dumping charges, as well as any payments for the waste from feedlot operators where they apply. While payments for waste in Canada are not prevalent, they were found to be more common with processors and feedlot operators in California and Oregon. The principal reasons would be considerably larger quantities, better equipped feedlot operations, larger number of varieties of crops extending the season to close to 12 months with commensurate waste hauling and feeding economics.

The savings for Canadian processors vary widely as already shown in Section III-D. In one case, the savings would amount to $16/ton of waste which had to be transported some 25 miles (or at about $.65/ton mile). Another processor paid $3.00/ton of screening waste for a hauling distance of 3 miles, while a third processor paid $4-4.50/ton for an undisclosed distance to a dump. The least expensive disposal was reportedly a processor hauling the waste with its own trucks, at little out-of-pocket costs on company-owned low productive land. We would, however, venture to estimate that the hauling and land-owning or/and renting costs would still be in the range of $2-3.00/ton depending on the hauling distance.

The cost of dumping in municipal dumps also varied greatly. Some communities do not levy extra charges (which might well be already included in the overall municipal assessments of processing plants). One community charges $1.00/ton, and another a reportedly $7.00/cu. yard of waste; this latter charge appears to be rather high. One processor reported a total hauling and dumping charge of $1.00/ton of waste.

Information on the in-plant equipment depreciation and extra handling costs of solid waste is not available for Canada. Based on a survey in the U.S. (described in Section IV-D), the estimated in-plant costs were about U.S. $3.94/ton of solid waste. It appears rather certain that special in-plant costs were not considered or included with the waste disposal expenditures provided in the course of visits to processors.

In conclusion, we estimate the range of savings to Canadian processors through the elimination of the waste disposal hauling, dumping and estimated in-plant handling costs, to be approximately $5-7.00 per ton of solid waste for each of the tomato pomace, bean waste and carrot waste products.

2. Feedlot and Dairy Operators

This section contains the final economic evaluation of the benefits to the feedlot and dairy operators feeding various types and proportions of waste.

The computations show, separately for each waste product, the savings per ton which represent the difference between the total cost of a "conventional" ration and that of a "waste" ration at various waste proportions. The "material costs" of waste are included in the LCR's, as are the "material costs" for the conventional rations. The cost difference between the two rations thus represents the GROSS SAVINGS from the feed substitution. The waste "material" costs for the LCR's, based on information obtained during the field research, were $3.00/ton for tomato pomace, $1.50/ton for bean waste and $2.00/ton for carrot waste (Table 33).

The feeding of waste incurs additional charges such as supplementary estimated transportation costs (compared with farm-grown feeds) of $1.50/ton for tomato pomace and carrot waste, and $1.00/ton for bean waste (Section V.H.4, Table 28), and extra wear and utilization of silos and equipment as well as higher mortality (Section V.H.3, Table 28) computed at $3.50/ton of solid waste. These costs have to be deducted from the gross savings to obtain the RETURNS. The returns, however, do not represent the profit to the feedlot operator or farmer, but a measure of return for the commitment, risk and overall management of feeding waste products. These are factors, which have already been described in the previous sections dealing with costs, but for which a monetary value was not entered due to considerable differences in operations, size, feeding efficiencies, etc.

The final results show some rather unexpected differences. The returns per ton of waste feed, are reasonably close for particular applications when the proportion is increased, but for others, they change considerably and even decrease with increasing proportions of waste feed. Furthermore, the returns per ton for the same waste product show a rather wide difference with the product used in one operation vs. another operation. There are a number of interrelated reasons which include complementary effects of waste products when fed with conventional feeds, differences in metabolism, the stipulated constraints in gain and waste proportion, energy requirements for maintenance, vs. requirements for gain or milk production. Many of these relationships have already been explained in the previous section on the nutritional evaluation and, as such, will not be repeated in detail in this economic evaluation which reviews the overall trends only. It is recommended for the practitioner and feedlot operator, to select the LCR's most suited for his operation, review the constraints, limitations, waste proportion, and complementary feedstuffs, quantity and concentrates from the nutritional, moisture, total energy, gain and other aspects, and compare them with others from the economic point of view.

The returns per ton of tomato pomace for the straight feedlot growing steers range between $7.88 (20% tomato pomace) and $4.87 (40%) as shown in Table 48. It appears that the complementary effect of tomato pomace with other feeds is higher at the lower proportions in the ration than at higher levels.

For feeder/feedlot/growing steers at lower gains per day, the returns are rather even ($10.75-$11.37/ton) for various tomato proportions. Here, tomato pomace is used more efficiently due to its high net energy for body maintenance. The similar observation also applies to dairy heifers with net benefits ranging from $7.12-$9.04/ton.

The wide difference in returns for lactating cow rations is due to two principal factors. The extremely high, computed net benefits of $17.10/ton of tomato pomace (at 20%) were derived because of the very costly conventional rations for dairy cows at 90 lbs. of milk per day; furthermore, the interaction of tomato pomace with other feeds at high levels of milk production provides a higher net energy level for the lactation and thus higher net benefits. With increasing proportions, in accordance with the above explanation, the net benefits decrease to $9.31 for 30% and to $5.09 for 60%

In conclusion, the extremes in returns per ton from a low of $4.87 to a high of $17.10/ton of tomato pomace make an averaging unrealistic. In view of the facts that tomato pomace is predominantly used in beef rather than dairy operations, that some of the LCR's, as discussed earlier, are impractical from a feedlot management point of view, and that the results are so widely divergent when used for

Table 48 GROSS SAVINGS, COSTS AND RETURNS PER TON OF TOMATO POMACE FOR FEEDLOT AND DAIRY OPERATIONS

Operation	Percent Waste	Gross Savings per ton [1]	Estimated [2] Addit. Costs per ton	Returns per ton	Ref. LCR
Straight Feedlot - Growing	20	$12.88	$5.00	$7.88	B-2
	30	10.86	5.00	5.86	B-3
	40	9.87	5.00	4.87	B-4
- Finishing	6.2	*			B-12
Feeder-Feedlot - Growing	40	16.87	5.00	11.87	B-18
	60	16.09	5.00	11.09	B-19
	75	15.75	5.00	10.75	B-20
- Finishing	5.9	*			B-25
Dairy - Heifer	20	14.04	5.00	9.04	D-2
	40	12.35	5.00	7.35	D-3
	60	12.12	5.00	7.12	D-4
- Lactating Cows	60	10.09	5.00	5.09	D-15
	30	14.31	5.00	9.31	D-16
	20	22.10	5.00	17.10	D-17

1) Excluding of "Material Costs" of $3.00/ton (Table 33) already deducted in LCR comparison.

2) Supplementary Transportation and other Additional Costs (Table 28).

* Specified rate of gain and hence energy requirements did not match nutrient level (NE_G) in waste products.

different operations, we are inclined to use a rather conservative range of returns of \$5.50 to \$7.50 per ton. It should also be pointed out that the gross savings from the substitution of regular feeds only (prior to the deduction of supplementary transportation and other additional costs) would thus range between \$10.50 to \$12.50 per ton of tomato pomace.

The overall returns for bean waste are lower than those for tomato pomace. The lowest amounts were \$3.17 - \$4.17 for straight feedlot growing steers, Table 49. For dairy heifers, they were similar. Bean waste represents an excellent feed ingredient for dairy heifers.

For lactating cows, the ratio of returns follows the same pattern as that for tomato pomace. The interesting part of the dairy cow LCR program (which is a different program from that of the beef cattle), was that bean waste was pulled in under "concentrates" rather than roughage which was due to its crude fiber content. One of the reasons for the relatively high returns of \$17.98/ton at 20% waste for a daily 90 lb. milk production was that this ration did not require any protein supplements. The divergent returns of \$3.81 for 39% bean waste, and \$10.69 for 30% bean waste may be due to different rates of feed complementation and metabolism.

In conclusion, the variance of returns per ton from \$3.17 to \$17.98 for the bean waste is even greater than that for tomato pomace. There are two distinct values, namely \$3.17 and \$4.17 for growing steers in straight feedlots, and \$7.62 to \$9.54 for dairy heifers. Using the same precepts as for tomato pomace, we would assign bean waste a return ranging between \$3-\$4/ton. It should also be pointed out that the gross savings from the substitution of regular feed would thus range between \$7.50 and \$8.50 per ton of bean waste.

The returns of the carrot waste for both the growing and finishing steers of a straight feedlot and feeder/ feedlot were relatively uniform averaging about \$6-\$7/ton

Table 49 GROSS SAVINGS, COSTS AND RETURNS PER TON OF BEAN WASTE FOR FEEDLOT AND DAIRY OPERATIONS

Operation		Percent Waste	Gross Savings 1) per ton	Estimated 2) Addit. Costs per ton	Returns per ton	Ref. LCR
Straight Feedlot	- Growing	30	$8.67	$4.50	$4.17	B-5
		50	7.67	4.50	3.17	B-6
	- Finishing	6.2	*			B-13
Feeder Feedlot	- Growing	7.8	*			B-21
	- Finishing	9.1	*			B-26
Dairy	- Heifers	20	8.74	4.50	4.24	D-2
		40	8.32	4.50	3.82	D-3
		52	7.48	4.50	2.98	D-4
	- Lactating Cows	39	8.31	4.50	3.81	D-18
		30	15.19	4.50	10.69	D-19
		20	22.48	4.50	17.98	D-20

1) Excluding of "Material Costs" of $1.50/ton (Table 33) already deducted in LCR comparison.

2) Supplementary Transportation and Other Additional Costs (Table 28).

* Specified rate of gain and hence energy requirements did not match nutrient level (NE_G) in waste products.

(Table 50). Carrots are very palatable and would produce the stipulated gains. For the finishing steers of the feeder/ feedlot, the rates of gain and feed efficiencies were rated at least equal to conventional high corn grain rations.

The very low returns ranging between $1.60-$1.96/ton for dairy replacement heifers, may be due to a less efficient utilization with a larger animal (600 lbs.) and a considerably lower gain (1-6 lbs/day vs. 2.3-2.4 lbs/day for straight feedlot steers) resulting in a low value for the carrot waste.

The wide range of returns from $3.61 (for 33% carrot waste for a daily milk production of 30 lbs.) to $8.61 (for 30% carrot waste for a daily milk production of 60 lbs.) may be due to a combination of different feeds and feed costs with two rations, and relatively lower net energy requirements for maintenance for a cow with a 60 lb. milk production per day resulting in higher benefits.

In conclusion, the average range of returns per ton of carrot waste as taken from Table 50 (disregarding the extremely low value obtained for dairy heifers derived from a different program than for feedlots) would be between $6.00-$7.00 per ton. Since these results are based on a higher TDN content in the LCR's than originally stipulated (see Section on Nutritional Evaluation), the returns should be reduced to $5.00-$6.00 per ton. In terms of the substitution of regular feeds only, (prior to the deduction of supplementary transportation and other additional costs), the gross savings would thus range between $10.00 and $11.00 per ton.

Table 50 GROSS SAVINGS, COSTS AND RETURNS PER TON OF CARROT WASTE FOR FEEDLOT AND DAIRY OPERATIONS

Operation		Percent Waste	Gross Savings[1] per ton	Estimated[2] Addit. Costs per ton	Returns per ton	Ref. LCR
Straight Feedlot	- Growing	20	$12.74	$5.00	$7.74	B-7
		40	11.17	5.00	6.17	B-8
		45.9	10.42	5.00	5.42	B-9
	- Finishing	40	13.51	5.00	8.51	B-14
		48.3	12.85	5.00	7.85	B-15
Feeder Feedlot	- Growing	0.7	*			B-22
	- Finishing	40	13.40	5.00	8.40	B-27
		46.3	12.36	5.00	7.36	B-28
Dairy	- Heifer	20	6.86	5.00	1.86	D-8
		40	6.61	5.00	1.61	D-9
		48	6.73	5.00	1.73	D-10
	- Lactating Cows	33	8.61	5.00	3.61	D-21
		30	13.61	5.00	8.61	D-22
		20	14.88	5.00	9.88	D-23

1) Excluding of "Material Costs" of $2.00/ton (Table 33) already deducted in LCR comparison.

2) Supplementary Transportation and other Additional Costs (Table 28).

* Specified rate of gain and hence energy requirements did not match nutrient level (NE_G) in waste products.

IX CONCLUSIONS AND RECOMMENDATIONS

A. BENEFITS TO THE FOOD PROCESSING INDUSTRY

The benefits from the utilization rather than the disposal of the tomato pomace, bean and carrot waste are considerable. In terms of tonnage (Chapter II) and overall disposal costs consisting of transportation, dumping and other charges, including estimated in-plant costs, (Chapter VIII, p. 44), the computed savings, at uniform rates for each of the three waste products, represent the following ranges:

Tomato pomace 25,300 - 50,600 tons
at $5.00 to $7.00 per ton = $126,500 to $354,200
Bean waste 5,700 tons
at $5.00 to $7.00 per ton = $28,500 to $39,900
Carrot waste 7,700 tons
at $5.00 to $7.00 per ton = $38,500 to $53,900
The total range would thus be $193,500 to $448,000

The reasons for the relatively large ranges in waste proportions for the produce acquired and the values, have already been outlined. In addition to the quantifiable expenditures, there may be other, non-quantifiable expenses for a processor such as the extra time and efforts required during the very busy processing season to organize the logistics for pick up and delivery of waste, selection and purchase or rental of private dump sites or municipal dumps on which waste can be spread, annoyance of and poor public relations with local residents if dumped or deposited waste smells (which last year happened at two known locations), and other related factors. The additional savings from the elimination of these supplementary charges and efforts have not been quantified or included in the above estimates.

B. BENEFITS TO AGRICULTURE

The benefits to agriculture from feeding food processing wastes to livestock are substantial. First, waste products replace considerable tonnages of regular feedstuffs such as hay, grain corn silage and others. Second, waste products, available at much lower costs, represent considerable savings. Third, they provide additional benefits and returns to the feedlot operators and farmers for the risk-taking, commitment, and other related management efforts.

The substitution of regular feedstuffs has been computed in terms of DM, TDN, and TDN per ton as fed for corn silage and alfalfa hay (Table 24). Using the tonnages of the three selected waste products available (Section II), and the substitution factors, the following replacement can be effected for corn silage (rounded):

25,300 - 50,600 tons of dry tomato pomace at 19.2% =	4,900 - 9,700 tons
5,700 tons of bean waste at 14.8% =	840 tons
7,700 tons of carrot waste at 21.2% =	1,600 tons
Total corn silage replacement	7,340 - 12,140 tons

The substitution for alfalfa hay is as follows (rounded):

25,300 - 50,600 tons of tomato pomace at 15%	3,800 - 7,600 tons
5,700 tons of bean waste at 11.6%	700 tons
7,700 tons of carrot waste at 16.6%	1,300 tons
Total alfalfa hay replacement	5,800 - 9,600 tons

The GROSS SAVINGS, representing the difference of the costs of a "Waste LCR" and a "regular feed LCR" have been computed on a per ton of waste basis for each product in Section VIII, Tables 48, 49 and 50. Applying these gross savings to the waste tonnages, results in the following overall savings (rounded):

25,300 - 50,600 tons of dry tomato pomace
x $10.00 - $12.00 = $253,000 - $607,000
5,700 tons of bean waste
x $7.50 - $9.50 = 43,000 - 54,000
7,700 tons of carrot waste
x $10.00 - $11,000 = 77,000 - 85,000
Total Estimated Gross Savings = $373,000 - $727,000

It is interesting to note that these results, derived from the LCR's, are similar to the computed savings using the substitution for each of the three products for alfalfa hay priced at $60.00 per ton. The savings range from $344,000 to $571,000.

The RETURNS to the feedlot operators and farmers represent the gross savings minus the supplemental transportation and other additional costs. They are the benefits for their risk-taking, commitment and other managerial efforts to feed waste to livestock. Utilizing the tonnages of available waste and applying the returns indicated in Section VIII and Tables 48, 49 and 50, the following results are achieved (rounded):

25,300 - 50,000 tons of tomato pomace
x $5.50 - $7.50 = $139,000 - $375,000
5,700 tons of bean waste
x $3.00 - $4.00 = $ 17,000 - $ 23,000
7,700 tons of carrot waste
x $5.00 - $6.00 = $ 39,000 - $ 46,000
Total Returns = $195,000 - $444,000

The above annual returns, at current prices, represent considerable benefits to feedlot operators and farmers and are expected to increase with inflationary trends in future years.

C. CONCLUSIONS AND RECOMMENDATIONS

The results of this evaluation show that the feeding of tomato pomace, bean and carrot waste to livestock is nutritionally safe (if ordinary precautions are taken) logistically and operationally feasible, and economically viable both for the processors as well as the feedlot operators.

The estimated waste of the three products available from the processing industry would replace about 7-12,000 tons of corn silage or about 6-10,000 tons of alfalfa hay.

The gross savings, representing the difference between the costs of regular feed LCRs and those of waste LCRs, range between approximately $373,000 and $727,000 per year. While these values, representing explicitly conservative estimates, may not appear dramatic, their cumulative benefits over time will be substantial. In five years only, at an assumed 10% inflationary rate, the cumulative benefits will add to about $2,500,000 - $4,900,000, a remarkable result.

The combined savings of disposal expenditures by processors and the returns to the feedlot operators (representing the benefits for their risk taking, commitment and other related management tasks) indicate even better results as summarized below:

	Processors' Savings	Feedlot Operator Returns	Total
	In Thousands of Dollars		
Tomato pomace	$127-354	$139-375	$266-729
Bean waste	29-40	17-23	46-63
Carrot waste	38-54	39-46	77-100
TOTAL	$194-448	$195-444	$389-892

The practically identical benefits for the processors and the feedlot operators are purely coincidental particularly in view of the completely divergent origins of the figures.

The combined cumulative benefits, at an assumed inflationary rate of 10% per year, would add to $2,600,000 to $6,000,000 in five years. The cumulative savings and benefits over a 10 year period (including inflationary factors), would range from about $6-$14 million. These results should provide sufficient incentives for the processing and agricultural industries to actively pursue further research and development work in this field.

Although a good beginning has occurred in changing from the disposal to the utilization of processing waste, there remains much work to be done. From the field research results, it is evident that, with some exceptions, where waste feed is considered as a seasonal feed to substitute part of the feed ration in smaller farm operations, the waste feeding requires medium to larger farm and feedlot operations. Only operators with a good knowledge in nutrition including the possible use of LCR's, will be able to take full advantage of waste feeds. At the same time, the economies of scale also render the construction of pit silos and ensiling of waste economically feasible. A large scale operation and commensurate transportation means provide a better safeguard for a processor of a reliable pick up of the waste than several smaller operators.

One area, where information is sadly lacking, is the availability of data from Canadian feeding experiments. It would appear that until recently, feeding experiments with waste products were rather unimportant. We strongly recommend that more research on waste feeding be undertaken by federal, provincial, and private interests.

Feeding trials should research the intake of ensiled tomato pomace (and possibly also bean and carrot waste), the digestibility of protein in fresh, ensiled and dried tomato pomace, and the reasons why drying appears to reduce the digestibility of tomato pomace protein. They should also include waste products other than the three products evaluated in this report.

Preservation research should include the quantification of nutrient losses from ensiling, and the search for answers to what happens to the protein in case of fermentation losses or in the conversion of protein to ammonia and non-protein nitrogen.

Pesticide research should, for instance, focus on the actual residual levels of endosulfan and dicofol in selected vegetable wastes as well as on the possible accumulation of certain pesticide residues on tomato skins.

An improvement in the local publicity of the availability of particular waste products, approximate tonnages etc. by processors in suitable media read by livestock operators is required. The publication of waste availability in the Canadian Waste Exchange bulletin, published by the Ontario Research Foundation, is a step in the right direction; the coverage, depending on the participation of the processors, is likely incomplete and it appears that not many feedlot operators are aware of this information.