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FRUIT CANNERY WASTE ACTIVATED SLUDGE AS A CATTLE FEED INGREDIENT

Industrial Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

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FRUIT CANNERY WASTE ACTIVATED SLUDGE AS A CATTLE FEED INGREDIENT

by

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for

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Grant No. S803307

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory-Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

"Fruit Cannery Waste Activated Sludge As A Cattle Feed Ingredient" describes an attempt to establish a beneficial use of byproducts from an industrial wastewater treatment system. This use of the byproduct, biological solids grown on the soluble carbohydrates in fruit processing wastewater, could provide a valuable cattle feed supplement while simultaneously providing a more economical disposal of the substance. For further information, contact the Food & Wood Products Branch of IERL-CI.

David G. Stephan
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ABSTRACT

The feasibility of sludge disposal from a fruit processing waste activated sludge treatment system by dewatering and using the dewatered biological sludge solids as cattle feed was evaluated by Snokist Growers at Yakima, Washington. Dewatering of the biological sludge utilizing pilot scale and prototype scale basket centrifuges resulted in a consistent product at 7-1/2 to 9% dry solids. Digestibility and metabolizability of rations containing 2.3% and 4.5% biological solids appeared equal to a control ration but a ration containing 9.2% biological solids appeared lower. Twenty-four uniform yearling steers were divided into four lots of six each and finished with a control ration and rations containing 2.3%, 4.6% and 8.9% sludge solids on a dry matter basis. They did not show any adverse effects of the sludge incorporation into their rations. It appeared that a low quantity of sludge (2.3% dry solids) actually enhanced the weight gain performance and carcass quality of these animals. The cost of a dewatering installation will require that the cannery receive remuneration for use of the waste activated sludge as cattle feed in order to make a full scale dewatering project feasible. The calculated value of the biological solids incorporated into the rations was about $.09 per kg dry solids to $0.15 per kg dry solids.

This report was submitted in fulfillment of Grant No. S-803307 by Snokist Growers under the partial sponsorship of the U.S. Environmental Protection Agency. This report covers a period from July 1974 to June 1976, and work was completed as of June 1975.

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This study was financed and conducted by Snokist Growers of Yakima, Washington, with financial assistance from the U. S. Environmental Protection Agency Research, Development and Demonstration Grant No. S803307. Messrs. Harold Thompson and James Santroch served as EPA Project Officers during this investigation. The project was conducted under the direction of Mr. Jule Graff, Financial Officer, and Mr. Mel Christenson, Cannery Manager, of Snokist Growers. Wastewater treatment, sludge dewatering, and laboratory analyses were directed by Mr. Herb H. Hart and conducted by Ms. Nina Wright, Ms. Jeanne Holdridge and Mr. Bob Hatzenbeler. The Washington State University Irrigated Agriculture Research and Extension Center conducted the cattle feeding trials directed by Dr. Wilton W. Heinemann under contract to Snokist Growers. Specialized chemical analyses were conducted by the National Canners Association, Berkeley, California, the Washington State Department of Social and Health Services laboratories, and by Washington State University. Dr. Larry A. Esvelt, Bovay Engineers, Spokane, Washington, was Principal Investigator for this project.

SECTION I

INTRODUCTION

Snokist Growers, a cooperative located at Yakima, Washington, operates a cannery that processes pears, apples, peaches, plums, crab apples, cherries and other products of the growers. Its principal annual pack consists of canned pears and canned apple products. During a typical season, the cannery processes up to 300 tons of pears per day for about 2 months, about 200 tons of peaches per day for 3 days to a week, and about 100 tons of apples per day for 2 to 4 months. In addition, cherries, plums, and crab apples are processed for limited periods during their harvesting season. For a number of years, Snokist Growers was subjected to increasing pressure from regulatory agencies to upgrade the quality of the wastewaters discharged into the Yakima River. In 1967, the cannery constructed an aerated lagoon facility, and in 1968 it upgraded that facility to an activated sludge treatment system with the capability for limited sludge reaeration. These systems were evaluated under a Federal Water Pollution Control Administration Research Development and Demonstration Grant. The results obtained were widely publicized.[1,2,3] Due to the success of the activated sludge system in reducing the cannery effluent to low BOD and suspended solids levels, the effluent and production data from this plant were utilized by EPA in establishing the Best Practicable Control Technology Currently Available guidelines.

The present treatment system at Snokist Growers consists of facilities as summarized in Table 1 and is shown schematically on Figure 1.

This system has been effective in helping Snokist Growers to reduce the quantity of pollutants in their effluent adequately to meet State and EPA permits which were based on "best practicable technology." The principal costs of operation of the system involve nutrient (nitrogen and phosphorus) addition (the waste is low in these nutrients), the power for aeration and sludge recirculation, and sludge disposal.

Biological sludge production by the wastewater treatment system is about 50% by weight of the chemical oxygen demand (COD) in the process wastewater.[1] Endogenous respiration of the biological organisms consumes a portion of the production and a small amount is lost in the effluent. Excess biological solids approximates 300 kkg per year.

Excess biological solids from the clarifier underflow has characteristically had a concentration of 0.5% to 1.0% solids. The sludge thickener has been

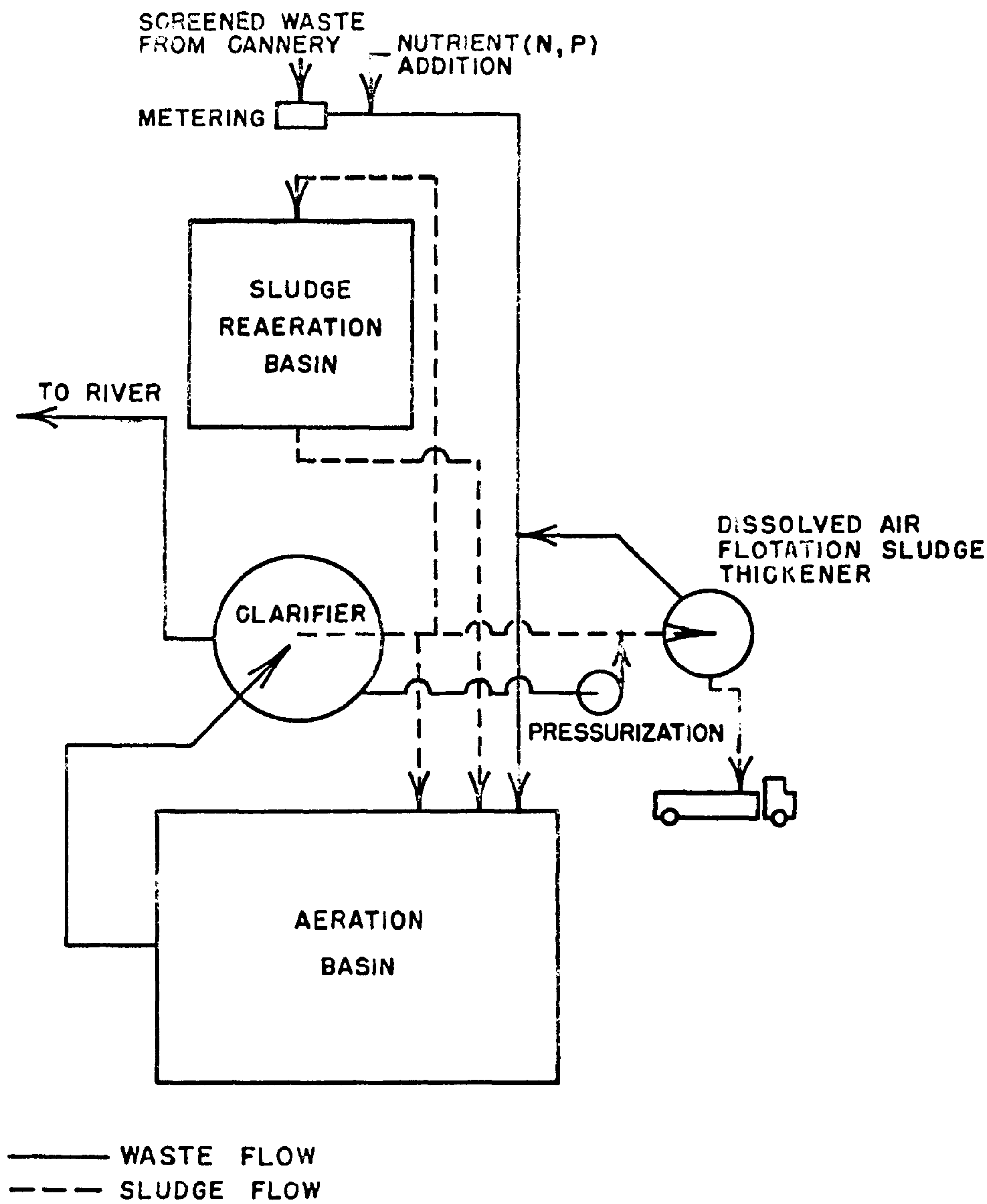

Figure 1. Snokist Growers wastewater treatment system schematic flow diagram.

Table 1. SNOKIST GROWERS WASTEWATER FACILITIES

Facility	Description
1. Screening	8 mesh/cm (20 mesh/in) vibrating screens
2. Aeration Basin	22,700 cubic meter (6 million gallon) earthen dike, PVC lined basin with 5 surface aerators having a total of 292 kw (390 horsepower)
3. Clarification	27.5 meter (90 ft.) Diameter, hydraulic sludge removal, 2.4 m (8 ft.) side water depth, center feed.
4. Sludge Recirculation	Two variable speed pumps each with 6,600 liter per minute (1750 gallon per minute) capacity
5. Sludge Reaeration	5,700 cu. meter (1.5 million gallon) basin with 45 kw (60 horsepower) surface aeration
6. Sludge Thickening	9.2 meter (30 ft.) Diameter pressurized recycle flotation sludge thickener

capable of dewatering this sludge to approximately 2.5%. This slurry is currently hauled by tank truck for disposal on agricultural land. Annual costs for hauling have been increasing each year since the installation of the treatment system because of nominal increases in production at the cannery and because of increased rates by the trucking establishments.

A cost analysis for further dewatering of the solids was conducted at the cannery, and after finding that the solids could be dewatered to only approximately 7% to 8% on a dry solids basis utilizing centrifugal or filter dewatering apparatus, it was concluded that the installation of such dewatering equipment would not be economically feasible unless the solids produced were of sufficient economic value to offset some of the costs for installation of equipment or operation. Use of the solids in a cattle feeding ration was proposed as a higher value usage. The study reported in this document was conducted to determine the value of the waste biological solids when utilized as a portion of a cattle feeding ration.

SCOPE AND PURPOSE

The principal purpose of this investigation has been to determine if there is a feasible alternative to the present methods for disposal of excess wastewater biological solids from Snokist Growers fruit processing plant. The means investigated has been that of further dewatering of the biological solids and its utilization as a cattle feeding supplement in a finishing ration for beef cattle intended for slaughter and human consumption. Further dewatering of the solids would decrease the total quantity of wet solids to be transported, and its utilization as a cattle feed would make efficient use of the nutrients contained in the solids that have been derived principally from nitrogen and phosphorus addition to the raw wastewater to achieve suitable biological treatment. Specific objectives for the study were as follows:

1. To demonstrate that biological solids from a fruit processing wastewater treatment plant can be dewatered by centrifugation sufficiently for use as a portion of cattle feeding ration.

2. To determine the feed value of the biological solids in a total confinement, controlled feeding study.

3. To demonstrate the effect of incorporation of the biological solids in a cattle finishing ration at various levels.

Objective 1 was accomplished utilizing both pilot scale (36 cm diameter) and prototype scale (76 cm diameter) basket centrifuges. Objective 2 was accomplished in a total confinement feeding of eight steers, and Objective 3 was accomplished by controlled feeding on an individual basis of 24 steers to a finished condition. Sludge dewatering was accomplished at the Snokist Growers cannery wastewater treatment facility. The dewatered biological solids were transported to the Washington State University Irrigated Agriculture Research and Extension Center at Prosser, Washington, where all cattle feeding studies were conducted.

WASTE SLUDGE USE AS ANIMAL FEED

Fruit and vegetable processing waste solids including wastewater screenings are commonly utilized as feed to livestock. Dewatered sludge from primary potato waste treatment facilities has been widely used for feeding cattle.[4] Waste activated sludge (biological solids) from citrus processing has recently been reported used as a poultry feed ingredient following dewatering by centrifuge and drying on a rotary kiln.[5] The participant in this project reportedly also fed the dried sludge to cattle but did not report details from the cattle feeding experiment.

Pilot scale centrifuge dewatering of waste biological sludge from a potato-waste processing, activated sludge treatment system was reported to produce

80% recovery and 5.5% centrifuge cake solids.[6] Although an objective of the pilot testing was to produce an animal feed, no feeding results were reported and full scale implementation of the centrifugation has not occurred.

In the mid 1950's, researchers at the University of Illinois tested dried municipal activated sludge as a protein and nitrogen source for sheep, which are ruminants like cattle. The sheep did satisfactorily on a ration with 6.5% sludge by weight (% moisture unspecified). The sludge provided only 11.5% of the crude protein and 18% of the total protein. The total protein in the sludge was significantly less digestible than that in soybean oil meal.[7] In general, the sludge was an acceptable source of nitrogen for the sheep.

Dr. Richard Vetter of Iowa State University reported in 1972 on the feeding of processed cattle manure back to cattle. Manure, including significant amounts of sand and dirt, was treated in an oxidation ditch; the sludge at 6% solids concentration was pumped from the oxidation ditch directly into a feed wagon and mixed with a basal feed ration. The sludge provided from 2% to 4% of the dry matter in the feed and 30% to 60% of the total feed weight. The cattle gained weight normally, were healthy, and the meat flavor was unaffected.[7]

Secondary sludge is not being used for feed, possibly because almost all of the feeding studies have used sludge grown on wastes containing fecal matter. The U.S. FDA reportedly has refused to approve animals fed such sludge for interstate commerce.

Secondary sludge grown on food processing wastes may succeeed as a feed material. Fecal wastes would not be present and the resulting sludge would be free of pathogenic bacteria.

SECTION II

SUMMARY

During the 1974 fruit processing season, Snokist Growers conducted a study of dewatering waste biological sludge from their activated sludge wastewater treatment system and the utilization of the dewatered sludge as a cattle feeding supplement. The waste biological solids were dewatered utilizing pilot scale (36-cm diameter) and prototype scale (76-cm diameter) basket centrifuges. The centrifuges were successful in dewatering the biological solids to a range of 7% to 9% dry solids. The dewaterability of the biological solids appeared to diminish as the organic loading on the activated sludge treatment system decreased during the late stages of the season. Use of the sludge following flotation thickening for the centrifuge feed apparently enhanced dewatering performance. Higher hydraulic loading rate on the centrifuge dewatering system resulted in increased suspended solids in the centrate.

Total containment feeding trials were conducted utilizing eight uniform steers during a period which total feed intake and total excretion of urine and feces were measured and analyzed. The steers were fed a control ration and rations containing 2.3%, 4.5% and 9.2% biological solids in the ration. Digestibility and metabolizability of dry matter and digestible energy and metabolizable energy were not significantly different among the several rations containing various levels of biological solids. However, the dry matter digestibility and metabolizability of rations containing 9.2% biological solids were lower at the 95% level of significance when performance of the individual steers on a ration at that level was compared with performance on the control ration.

A finishing feed trial utilizing 24 steers divided into four groups of six each was conducted over a period of 165 days. The four groups were fed a control ration and rations containing 2.3%, 4.6% and 8.9% biological solids on a dry solids basis. The group fed 2.3% biological solids in their ration experienced a greater rate of weight gain than the control at the 75% level of significance (but not the 90% level). Feed consumption was greater for the groups receiving 2.3% and 4.6% biological solids at the 75% significance level (but not at the 90% level). Feed conversion efficiency was not significantly different from control for any of the groups.

The average value of biological solids contained in the three rations was about $92/metric ton of dry solids (about $84/ton) or about $7.30 per kkg wet sludge at 8% solids by one method of computation where the estimated

value of weight gain for each of the sludge fed groups of steers was based on the cost of feed per weight gain for the control group. An alternate method of computation using the total value of feed per weight gain for each group and attributing decreased costs for sludge fed groups to the sludge, resulted in a value of about $148 per kkg.

The biological solids contained a high crude protein content and would provide a good source of crude protein as well as calcium and phosphorus for inclusion into a feed ration for finishing cattle. Heavy metals, pesticides and microtoxins were not excessive in the biological solids according to tests on the sludge and on carcasses of the finished animals.

The cattle finished during these studies were slaughtered and graded at the termination of the project. The cattle fed at the 2.3% biological solids level had significantly higher USDA grading scores than the control group. Carcass quality on an overall basis was not diminished at any of the biological solids feed levels. The slaughtered cattle were marketed in normal marketing channels following approval for such marketing by the FDA and USDA. However, it would be necessary to obtain U.S. Food and Drug Administration approval of the biological solids as a feed supplement in order to utilize it in this manner on a permanent basis. This approval is given on an individual source basis and, therefore, approval of utilization of waste biological solids from one food processing wastewater treatment facility would not necessarily mean that such approval would be automatically forthcoming for other facilities.

SECTION III

CONCLUSIONS

Specific conclusions derived from the results of this study are as follows:

1. Biological sludge solids from a fruit processing waste treatment system are consistently dewaterable to approximately 8% on a dry solids basis with basket centrifugation.

2. Solids dewaterability was decreased with lower loadings on the biological treatment system (longer sludge age). Dewaterability was enhanced by sludge thickening ahead of centrifugation. Centrate quality deteriorated at higher loading rates on the centrifuge.

3. Inclusion of the biological solids in a cattle feeding ration does not impair the metabolizability or digestibility of the ration at approximately 5% or less biological solids on a dry matter basis.

4. The biological solids incorporated in cattle finishing rations at approximately 9% or less resulted in weight gain and feed consumption equal to that for control fed cattle and may have improved weight gain performance at approximately 2.3% biological solids in the ration.

5. Carcass quality of the cattle fed on rations containing biological solids up to a level of 9% on dry matter basis were at least equivalent to those fed on control ration, and possibly improved at from 2% to 5% biological solids.

6. There were no apparent harmful effects on cattle fed the biological solids. Heavy metals and pesticide residue were not found in significant quantities in the biological solids or the carcasses. Harmful microtoxins were not found in the biological solids.

7. It will be necessary to take financial advantage of the feed value of the waste biological solids in order for dewatering of the solids by centrifugation to be economically feasible compared to the present methods of sludge disposal for the cannery waste treatment system utilized in this study.

SECTION IV

PROCEDURES AND EQUIPMENT

Procedures and equipment utilized in this study were developed appropriate to the three objectives listed in Section I. Facilities at the Snokist Growers cannery, consisting of their wastewater treatment system and rental or on-loan dewatering equipment, were utilized to dewater the excess biological solids from their activated sludge processing waste treatment system. Figure 1 showed a schematic flow diagram of the Snokist Growers wastewater treatment facilities. Figure 2 is a schematic diagram for sludge dewatering operations during these investigations. Facilities at the Washington State University Irrigated Agriculture Research and Extension Center at Prosser, Washington, were utilized for both the total containment metabolism studies and the cattle feeding trials for determining the solids value in a cattle finishing ration.

BIOLOGICAL SOLIDS DEWATERING STUDIES

Solids dewatering investigations were conducted with solid bowl basket centrifuges. The first portion of the investigation consisted of utilizing a 36 cm diameter by 15 cm deep centrifuge (14 in. by 6 in.) to study the dewaterability of the biological solids and concurrently to recover dewatered solids for utilization in the metabolism trials under Objective 2. During the second portion of the dewatering investigation a 76 cm diameter by 46 cm deep centrifuge (30 in. by 18 in.) was used to confirm the pilot scale centrifuge results on a prototype scale unit and to concurrently produce dewatered biological solids for utilization during the cattle finishing feeding trials under Objective 3.

Pilot-Scale Centrifuge Investigations

The pilot-scale (36 cm diameter by 15 cm deep) basket centrifuge was operated from about October 16, 1974 through December 13, 1974 on a 5 or 6-day per week basis. On each day of operation one centrifuge run (test run) was conducted during which the influent to the centrifuge was sampled before and after the run and the centrate was collected in 19 liter (five gallon) batches and each batch sampled. The dewatered solids were entirely removed from the centrifuge following the test run and four samples of the dewatered cake were collected for analysis, one sample near the centrifuge periphery for approximation of the maximum solids content and the other three samples after mixing the entire centrifuge cake discharge to determine an average. Analyses conducted on the test run samples included suspended

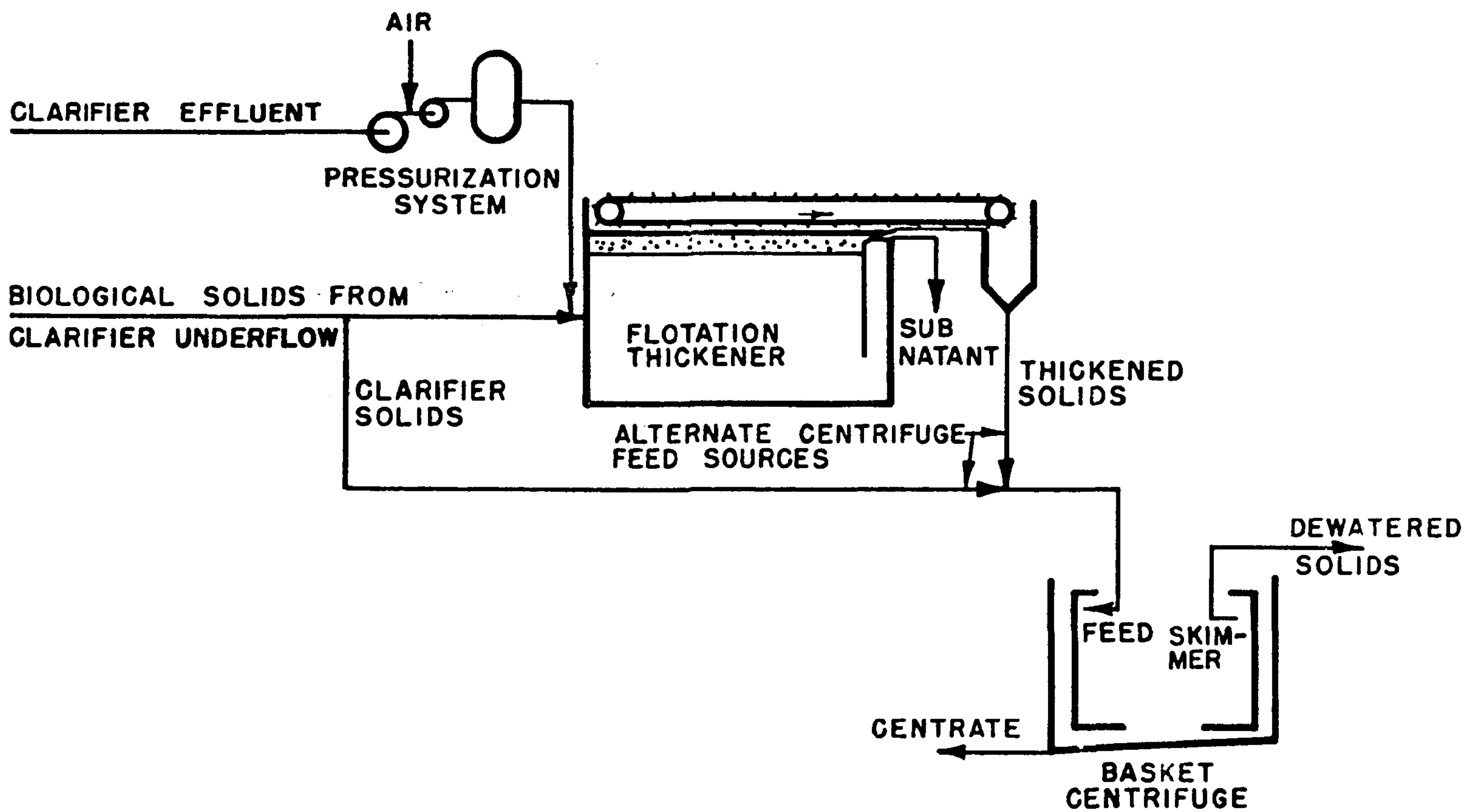

Figure 2. Schematic flow diagram - solids dewatering.

solids on the centrifuge feed and on the centrate, and total solids on the centrifuge dewatered solids (cake). Volatile solids analyses were conducted periodically as were other analyses such as pH, COD, nitrogen and phosphorus. The centrifuge feed came from either the clarifier underflow or from the flotation sludge thickener as shown on Figure 2. During periods of thickener operation, feed, pressurized water, subnatant and thickened solids were sampled for analysis.

The wastewater treatment system received wastes from the pear processing operation up through approximately November 9 and from apple processing for the remainder of the study period.

Prototype Centrifuge Investigations

Operation of the prototype (76 cm diameter x 46 cm deep) basket centrifuge extended intermittently from December 17 through April 14. On each day of operation one centrifuge run was used for data collection at which time the feed stream was sampled before and after the run and the dewatered cake was sampled four times, once in an attempt to get the maximum concentration cake and three times after mixing the entire dewatered solids discharge in an attempt to get the average cake solids. Centrate was also sampled although not on a total collection basis and less frequently than during the pilot scale centrifuge operation. The dissolved air flotation sludge thickener was operated during a portion of the prototype centrifuge operation also, and once again it was monitored for performance.

Apple processing was conducted during a portion of the prototype centrifuge operation, but during the bulk of the operation there was no processing occurring at the cannery and solids dewatered were derived from those stored in the aeration basin under aerobic conditions from the previous processing operations.

METABOLISM TRIAL

Dewatered biological solids from the pilot basket centrifuge were transported to the Washington State University Irrigated Agriculture Research and Extension Center at Prosser, Washington (approximately 80 kilometers) for utilization as a portion of rations fed to eight steers for metabolism feeding trials.

The eight steers were divided into four sets of two for a "latin square" feeding trial where total intake monitoring and excretion collection and monitoring was conducted. Each pair of steers was fed each of four separate rations on a rotating basis such that during any testing period each of the four rations was fed to two of the steers, and during the four testing periods each pair of steers received each of the four rations during one test period. Each test period was divided into a 10-day adjustment period during which the steers were acclimated to the new ration and a 7-day total collection period during which feed intake and feces and urine excretion were monitored.

The four rations consisted of a basic ration (similar to that used during the finishing trials under Objective 3) for a control and three rations which included varying amounts of biological solids in the basic ration. The three biological solids rations contained 2.3%, 4.5% and 9.2% dewatered biological solids on a dry matter (DM) basis.

Samples of the feeds, feces and urine were analyzed for total dry matter (DM) and gross energy (GE). These data were used to determine (1) dry matter digestibility (DMD); (2) dry matter metabolizability (DMM); (3) digestible energy (DE); and (4) metabolizable energy (ME). These were determined as shown in the following formulas:

$$DMD = \frac{\text{DM consumed} - \text{DM feces}}{\text{DM consumed}}$$

$$DMM = \frac{\text{DM consumed} - \text{DM feces} - \text{DM urine} - \text{DM respiration (estimated)}}{\text{DM consumed}}$$

$$DE = \frac{\text{GE consumed} - \text{GE feces}}{\text{GE consumed}}$$

$$ME = \frac{\text{GE consumed} - \text{GE feces} - \text{GE urine} - \text{GE respiration (estimated)}}{\text{GE consumed}}$$

Total feed consumed and feces and urine output was measured each day. Dry matter testing was conducted using high vacuum freeze drying of each of the metabolic composite samples collected over the seven day testing period. Samples stored at 2^{o}C (under toluene for urine and in air tight plastic containers for feces) were analyzed for gross energy in a bomb calorimeter.

CATTLE FINISHING TRIAL

Twenty-four yearling steers of approximately uniform composition were randomly allotted to four lots of six each for feeding four separate rations including a control ration and rations that contained 2.3%, 4.6%, and 8.9% dewatered biological solids on a dry solids basis. Each steer was individually fed the amount of ration that he would consume completely each day (as nearly as practical). Total feed intake and weight gain over a 165-day finishing period were monitored (the cattle were acclimated to the feed for approximately 2 weeks before the initiation of testing).

The cattle were weighed on 28-day intervals with each weighing following a 16-hour period during which feed was withheld. The cattle were full fed, and the small amount of refused feed was weighed and analyzed. Feed testing for dry matter, crude protein, crude fiber, ether extract, ash, calcium and phosphorus was conducted on composite samples collected over a month period on a weekly basis. The biological solids moisture content was determined daily prior to mixing the rations in order to maintain a consistent dry biological solids proportion.

Carcass grades and weights were observed following the slaughter. Pesticide and heavy metals analyses were made of tissue samples from two control and two biological solids fed animals.

ANALYTICAL PROCEDURES

Analytical procedures generally followed Standard Methods[8] and the EPA Methods for Chemical Analysis of Water and Wastes.[9] All testing of wastewaters and wastewater biological solids were performed at Snokist Growers Wastewater Laboratory. Duplicate analyses were performed on approximately 10% of all samples analyzed with duplicate results less than 5% apart with the exception of a few very low strength samples. Additionally, Snokist Growers Wastewater Laboratory conducted analyses on test samples submitted by the EPA Region X Laboratory and the EPA Corvallis Environmental Research Laboratory with satisfactory results. A summary of methodology utilized by the Snokist Wastewater Laboratory is as follows:

pH-electrometrically determined according to Standard Methods.[8]

Total solids-gravimetric following drying at 103^{o}C according to Standard Methods.[8]

Volatile solids-gravimetric following ashing at 550^{o}C according to Standard Methods.[8]

Total suspended solids-glass fiber filter drying at 103^{o}C and gravimetric residual analysis according to Standard Methods.[8]

Volatile suspended solids - ashing of the total solids residual at 550^{o}C followed by gravimetric analysis Standard Methods.[8]

Chemical Oxygen Demand (COD)- $K_2Cr_2O_7$ according to EPA Methods.[9]

Biochemical Oxygen Demand (BOD)-Standard Methods.[8]

Ammonia Nitrogen (NH_3N)-Distillation/titration Standard Methods.[8]

Total Kjeldahl Nitrogen (TKN)-Standard Methods.[8]

Orthophosphate - stanouschloride method, Standard Methods.[8]

Total Phorphorus - Alkaline ashing followed by stanouschloride method.[8]

Preservation was by refrigeration (4^{o}C) of composite samples for next-day analysis. Grab samples were analyzed immediately.

Analyses by WSU were conducted as indicated earlier with dry matter analyses utilizing high vacuum evaporation; gross energy analyses utilizing a bomb calorimeter; kjeldahl nitrogen was determined according to standard methods;[8]

fat was determined as ether extractable material; calcium was determined by nitric/perchloric acid digestion followed by atomic absorption; phosphorus was determined by nitric/perchloric acid digestion and molydivaradophosphoric acid colorimetric analysis.[10] WSU replicated 10% of its analyses with satisfactory duplication of results. Storage was by high vacuum freeze drying and by storage at 2°C under toluene (urine) and in air tight containers (feces).

Pesticide residuals were determined by the Washington State Department of Social and Health Services Laboratory in Wenatchee, Washington by a chromatographic procedure.

Heavy metals analyses were conducted by atomic absorption spectroscopy by the National Canners Association Laboratory in Berkeley, California, and U. S. Testing Company in Richland, Washington.

SECTION V

RESULTS

Solids dewatering studies were conducted with the pilot plant scale (36 cm diameter by 15 cm) basket centrifuge during the period from October 16, 1974, through December 13, 1974. During this same period the total confinement feeding trials were conducted by WSU utilizing solids dewatered with the pilot scale centrifuge. The prototype scale centrifuge (76 cm diameter by 46 cm) was utilized for dewatering solids from December 17, 1974, through April 14, 1975. The finishing feeding trials were conducted at WSU from December 1974 through the end of May 1975 using solids dewatered on the prototype scale centrifuge.

During the 1974 processing season, pears were processed for 59 days, peaches for about 4 days and apples for about 23 days separately from the other fruits. Concurrent apple processing and pear processing was conducted during the last half of the pear processing season. Processing continued from late August through approximately the middle of December 1975 and for a short period during February 1975 when apples were processed. Table 2 shows a summary of the activated sludge process operation during the 1974 season. Mean and standard deviation of the influent chemical oxygen demand (COD), the COD loading on mixed liquor volatile suspended solids (MLVSS), and effluent COD and suspended solids are included by product processed. Mean influent and effluent BOD values are shown even though data was not extensive. Table 2 also contains the mean and standard deviation of waste flow by product processed. The concurrent pear and apple processing is included under pear processing.

SOLIDS DEWATERING INVESTIGATIONS

Dewatering Performance

During solids dewatering investigations with the pilot scale centrifuge hydraulic feed rate to the centrifuge, solids feed rate to the centrifuge and centrifuge rpm were studied as variables in the operation. Centrifuge rpm was adjusted to attain centrifugal forces of 1240, 1340 and 880 g's (2500, 2600 and 2100 rpm). The centrifuge was operated at 1240 g's during the early part of the processing season when pears were creating a heavier load on the activated sludge system and later at 1340 and 880 g's during apple processing when lower loading rates (F/M) were exerted on the biological system. Table 3 contains the solids dewatering performance during these periods.

Table 2. SUMMARY OF ACTIVATED SLUDGE PROCESS - 1974
Mean/Std. Deviation (No. of observations)

Item	Pear Processing (49 days)	Peach Processing (4 days)	Apple Processing (23 days)
Influent COD, mg/l	2740/440	1670/220	550/100
COD Loading on MLVSS (F/M), day^{-1}	0.14/0.04	0.07/0.01	0.024/0.009
Effluent COD, mg/l	52/43	24/6	52/39
Influent BOD, mg/l	1850(6)		400(1)
Effluent BOD, mg/l	7(8)		6(7)
Effluent Susp. Sol., mg/l	19/17	7/1	20/12
Flow, 10^3 m^3/day	5.9/0.6	6.9/1.3	3.8/1.4

It appears that the centrifugal force between 880 and 1340 rpm did not have an important effect on the final solids concentration. Final centrifuge cake concentration did not seem to be affected by solids or hydraulic feed rates as illustrated on Figure 3 (see Appendix Tables A-1 and A-2).

Operation of the prototype scale centrifuge (76 cm diameter) was continuous at 1300 g's throughout its operation. Solids dewatered performance is shown in Table 3 for various operating periods. During January and later dewatering periods loading to the activated sludge system had been low or stopped for a considerable period of time. Apparently centrifuge performance deteriorated as the sludge age increased. During April the centrifuge was fed dissolved air flotation thickened sludge, and the average cake concentration increased notably making it appear that there was benefit in utilizing thickened sludge for the centrifuge feed. This was somewhat confirmed by the pilot results when three days operation on thickened feed averaged 76.9 gDS/kg sludge cake on 11/22-26 compared to operation on clarifier underflow averaging 74.2 gDS/kg sludge cake during the period 11/4 through 12/5 (see Appendix Table A-1).

<u>Centrate Quality</u>

The effect of hydraulic loading on the centrifuge in initial centrate overflow suspended solids concentrations is shown on Figure 4. The three sets of data included in Figure 4 (see Appendix Table A-1) were obtained utilizing different hydraulic detention times ($\bar{t}$) and centrifuge rpm's. It appears that the difference between the lines placed through the three sets

Table 3. CENTRIFUGE BIOLOGICAL SOLIDS DEWATERING PERFORMANCE

Dates	Centrifugal Force g's	Sludge Cake Concn. gDS/kg** Ave.	Std. Dev.
Pilot Centrifuge (36-cm dia) (See Appendix Table A-1)			
10/6-11/13/74	1240	82.1	4.9
11/8-12/4/74	1340	76.4	7.4
12/6-12/13/74	880	74.8	7.9
Prototype Centrifuge (76-cm dia, 1300 g's) (See Appendix Table A-2)			
12/17-12/20/74		84.0	8.7
1/20-2/3/75		80.1	5.6
3/19-3/31/75		70.0	8.9
4/1-4/14/75*		85.9	7.4

*Flotation thickened sludge feed
**Grams dry solids/kilogram wet sludge cake

of data points is time related rather than related to the centrifuge rpm or centrifugal force. This may be related to sludge age, as was the cake concentration discussed above, and again indicates deteriorating centrifuge performance at higher sludge age. It is apparent from Figure 4 though that there is a relation between hydraulic loading and centrate quality in that during each of the three data collection periods centrate quality deteriorated as hydraulic loading increased.

During centrifugation on a batch type basis such as occurs with basket centrifuges, the quality of the centrate deteriorates as the centrifuge bowl fills with cake. Figure 5 contains performance curves for the pilot centrifuge, giving centrate quality versus the feed volume in number of hydraulic detention times. The various curves on Figure 5 were obtained utilizing a wide variation of feed concentration, solids retention times and hydraulic retention times. The hydraulic retention time is defined as the volume of the centrifuge divided by the sludge flow rate. Solids retention time is defined as the volume of the centrifuge times the ultimate cake concentration during the centrifuge run, divided by the solids feed rate to the centrifuge.

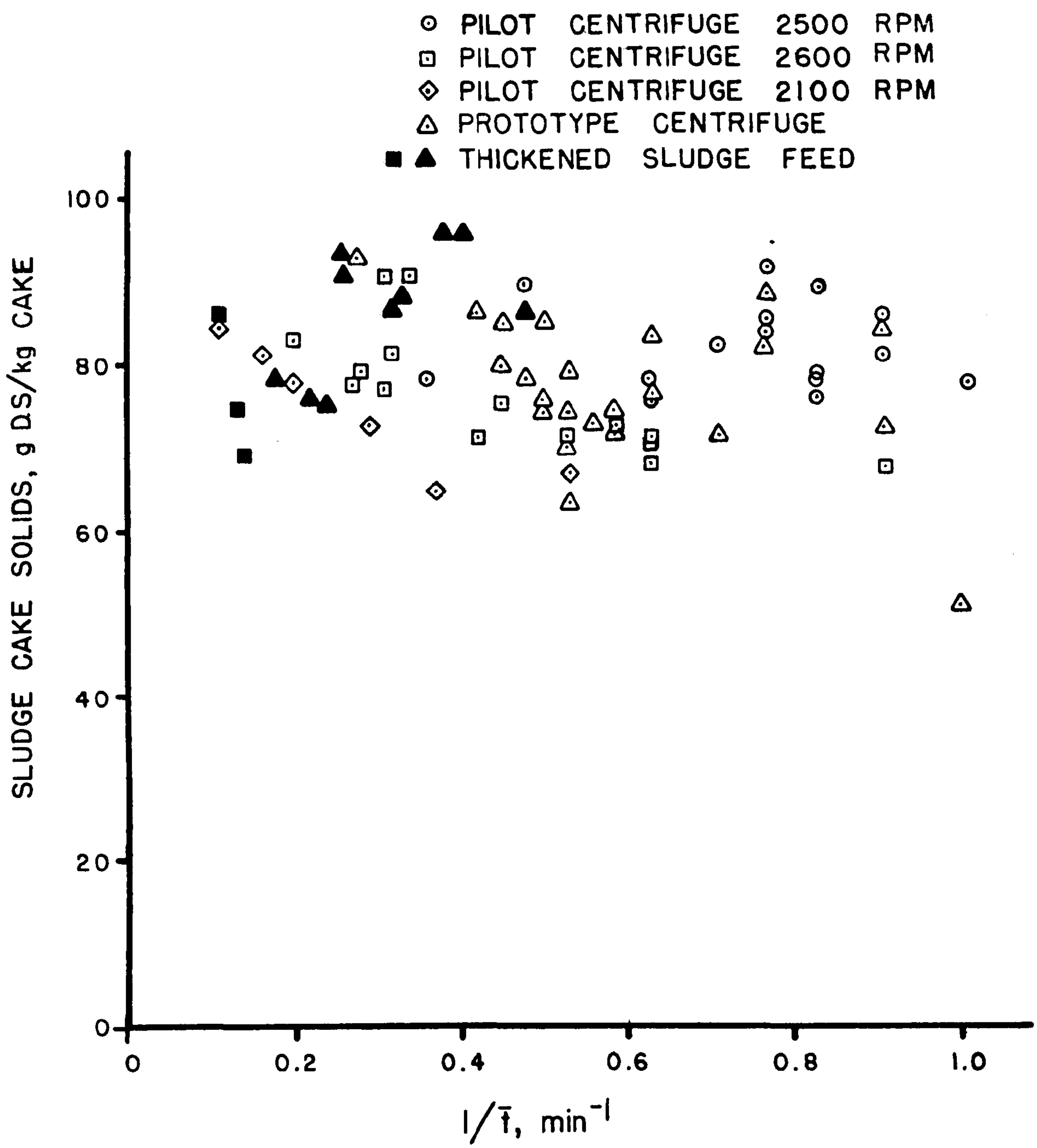

Figure 3. Effect of centrifuge hydraulic loading on sludge cake solids content.

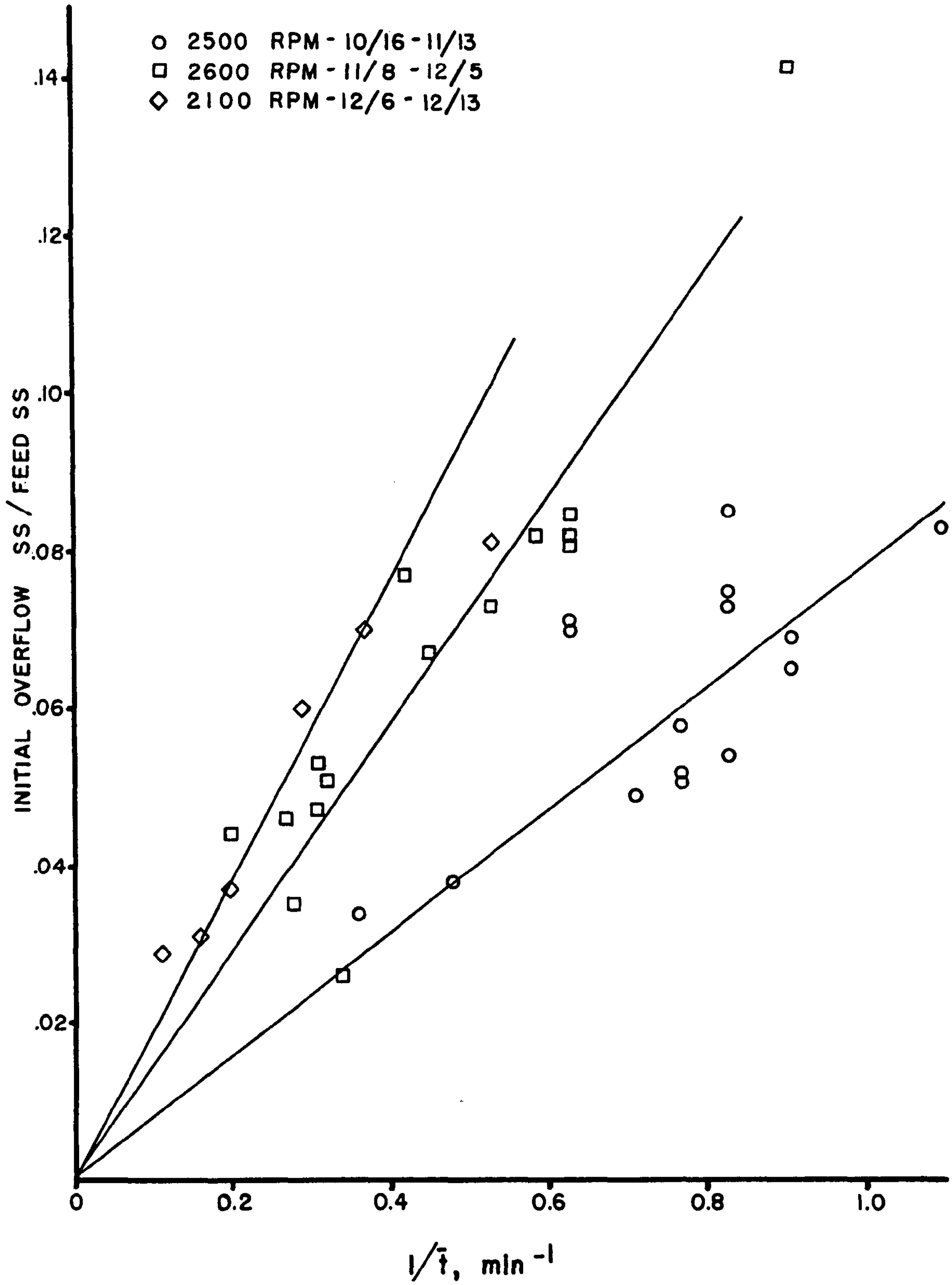

Figure 4. Effect of centrifuge hydraulic loading on initial centrate quality.

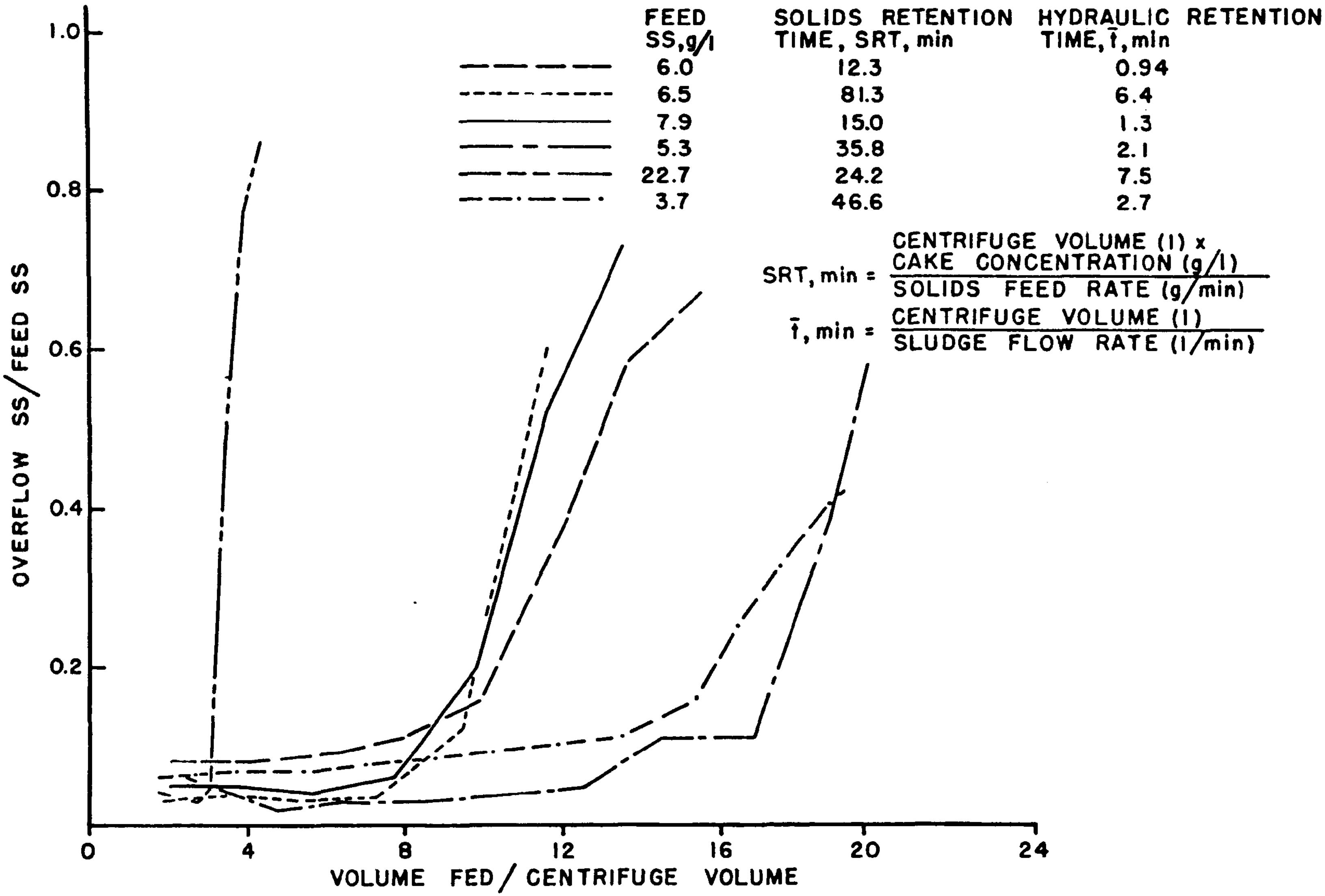

Figure 5. Pilot centrifuge performance centrate quality vs feed volume.

Figure 5 shows the variations in the number of hydraulic retention times required for the centrifuge to fill with solids, at which time higher concentrations of suspended solids in the overflow of centrate occurs. Figure 6 shows the same data runs plotted on the basis of solids retention times. As expected the overflow or centrate quality begins to deteriorate relatively near one solids retention time regardless of hydraulic retention time and feed suspended solids concentration, For virtually all of the runs the centrate suspended solids stayed at or below approximately 10% of the feed solids up through 0.7 to 0.8 solids retention times and subsequently began to increase in an S-curve configuration. Data used to develop Figures 5 and 6 is contained in Appendix Table A-3.

Dissolved Air Flotation Thickener Performance

The existing dissolved air flotation thickener at Snokist Growers was used to thicken biological sludge for wasting during the 1974 processing season and the thickened sludge was used for centrifuge feed on several occasions. Performance of this unit was monitored during two periods, one in late November, early December, 1974 and the other during April 1975. The fall 1974 monitoring period followed shortly the pear processing season and was during apple processing so the biological solids were active and being fed regularly. By April 1975 the solids had not been fed for some time although they had been maintained in an aerobic condition.

Results of the monitoring are shown in Appendix Table A-4.

The mean thickened solids concentrations during fall 1974 and spring 1975 monitoring was 25.7 and 21.3 grams dry solids (D.S.) respectively. Standard deviations were 2.8 and 2.3 g/l respectively. The means were significantly different at greater than the 99% level using Student's t distribution[11] and indicate better thickening during the period of greater biological activity (shorter sludge age). This observation supports the observations of poorer centrifuge performance at lower biological activity (longer sludge age).

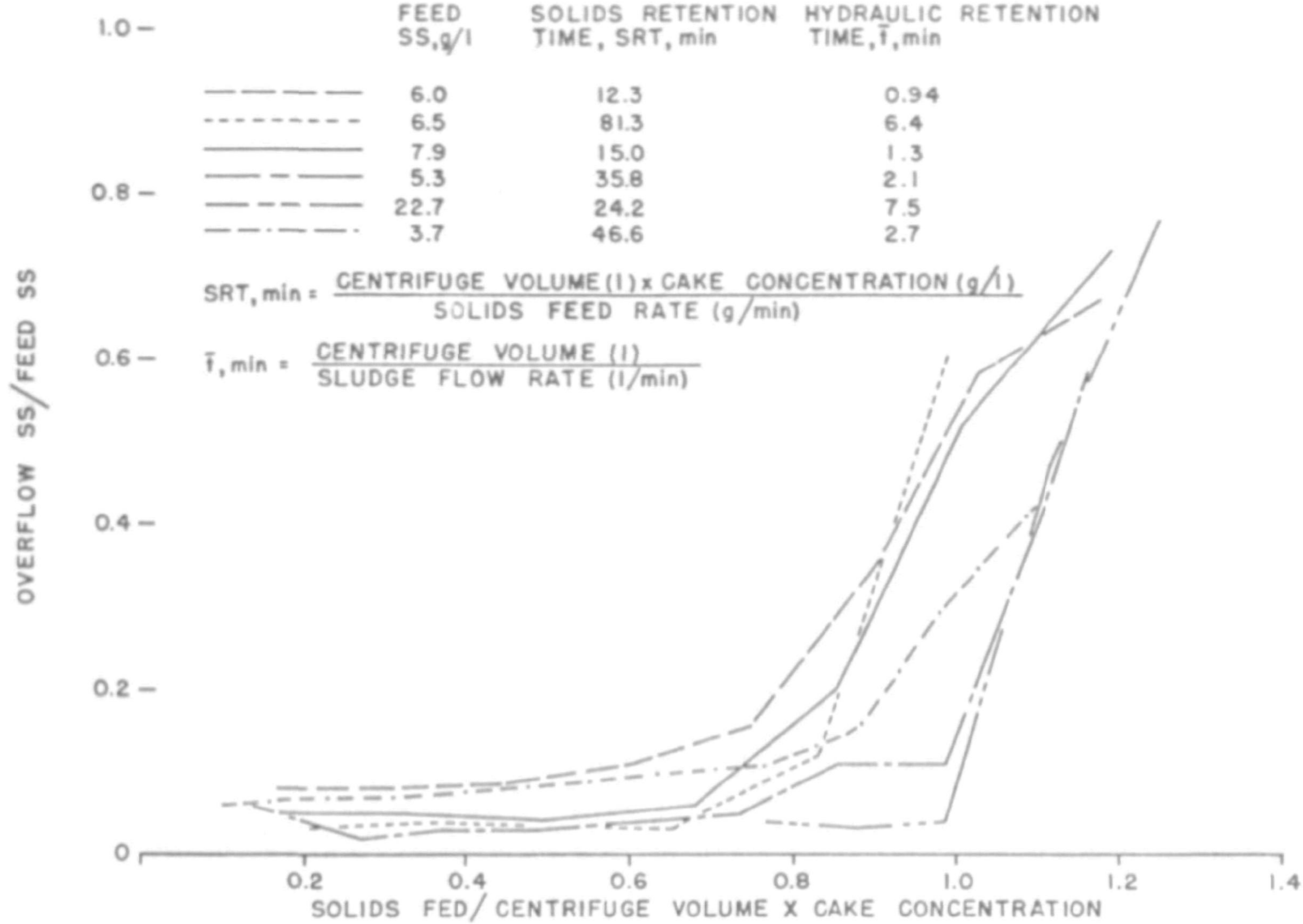

Figure 6. Pilot centrifuge performance - centrate quality vs solids fed.

TOTAL COLLECTION METABOLISM TRIALS

Digestibility and metabolizability data for the four rations were obtained from total collection trials. The rations, feces and urine were quantitated over a seven day period and analyzed for total dry matter (DM) and gross energy (GE). These data were used to determine (1) dry matter digestibility (DMD); (2) dry matter metabolizability (DMM); (3) digestible energy (DE); and metabolizable energy (ME). These were determined as follows:

$$DMD = \frac{\text{DM consumed} - \text{DM feces}}{\text{DM consumed}}$$

$$DMM = \frac{\text{DM consumed} - \text{DM feces} - \text{DM urine} - \text{DM respiration (estimated)}}{\text{DM consumed}}$$

$$DE = \frac{\text{GE consumed} - \text{GE feces}}{\text{GE consumed}}$$

$$ME = \frac{\text{GE consumed} - \text{GE feces} - \text{GE urine} - \text{GE respiration (estimated)}}{\text{GE consumed}}$$

Dry matter and gross energy contained in the respiration of the animals was estimated utilizing constants for the type and weight of animals used which had been developed in other studies.

Figure 7 shows the digestibility of the rations according to their content of waste biological solids. Figure 8 shows the metabolizability of the rations according to the biological solids content. Neither the digestibility or the metabolizability of the dry matter and energy is significantly affected by the inclusion of the biological solids in the rations.

Figure 9 and Figure 10 show the mean relative digestibility and metabolizability and standard deviations, for each of the rations on a dry matter basis. The performance of each individual animal on the control ration was taken at 1.0 and the relative performance was used for rations including the biological sludge. From Figures 9 and 10 there appears to be a decrease in digestibility and metabolizability at the highest concentration of biological solids used. The relative performance is significantly different[11] (95% level, Student's t) from the control only for the ration containing the highest sludge level however. Relative DE and ME values showed much higher standard deviations, and significant differences from the control could not be identified.

Appendix Tables A-5 and A-6 contain individual DMD, DMM, DE and ME data for the steers and rations used in this study.

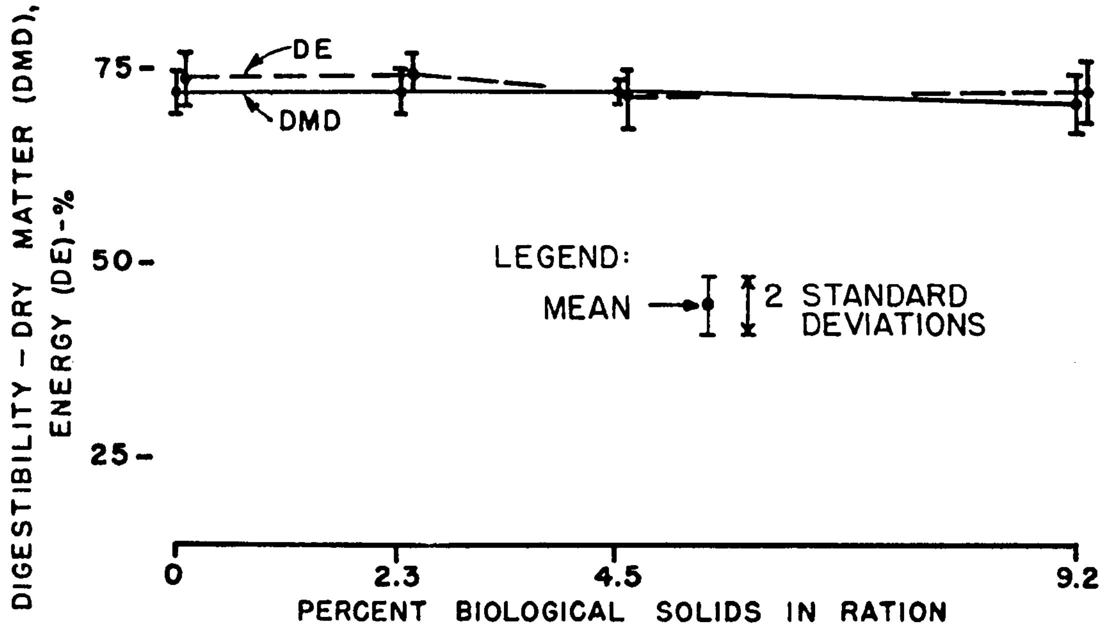

Figure 7. Digestibility of rations by biological solids content.

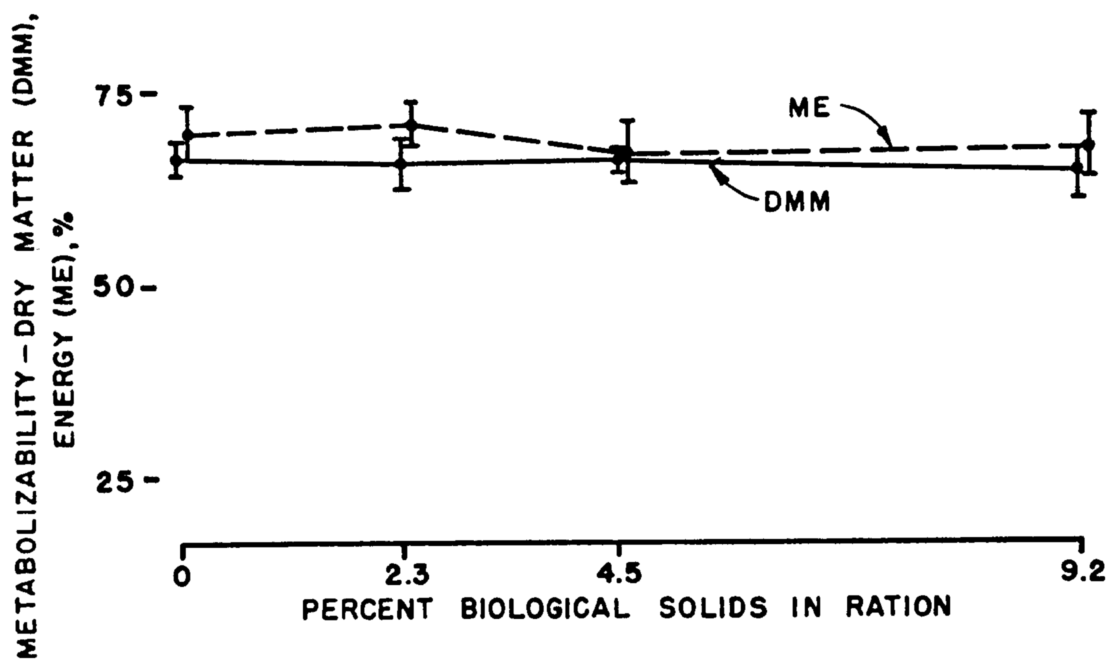

Figure 8. Metabolizability of rations by biological solids content.

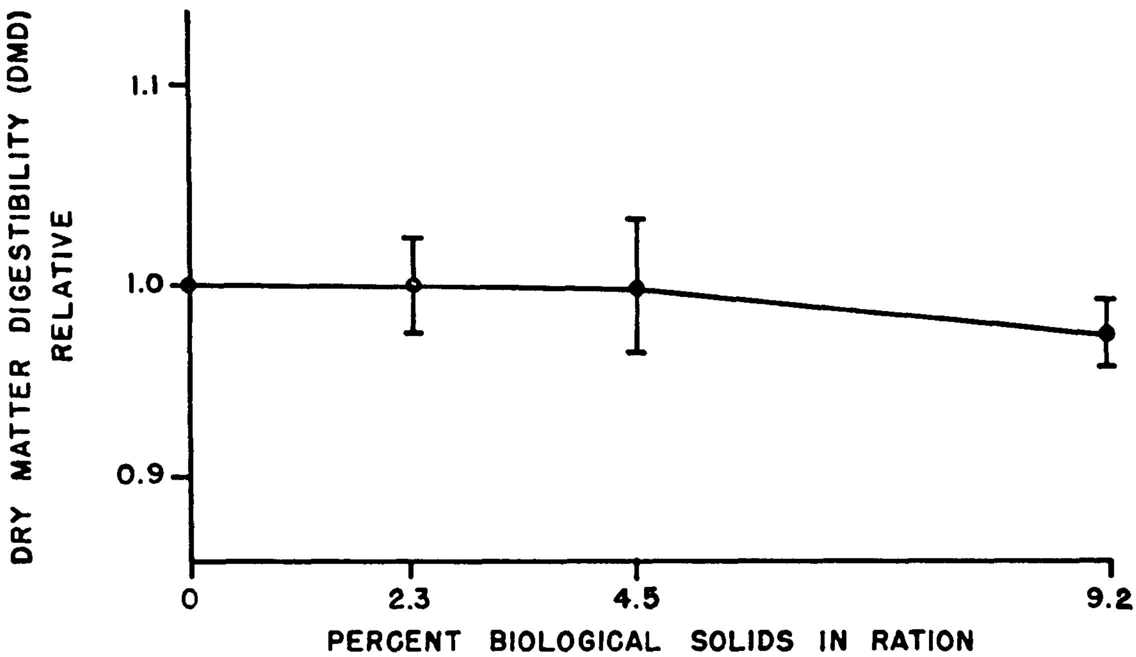

Figure 9. Relative digestibility of rations by biological solids content.

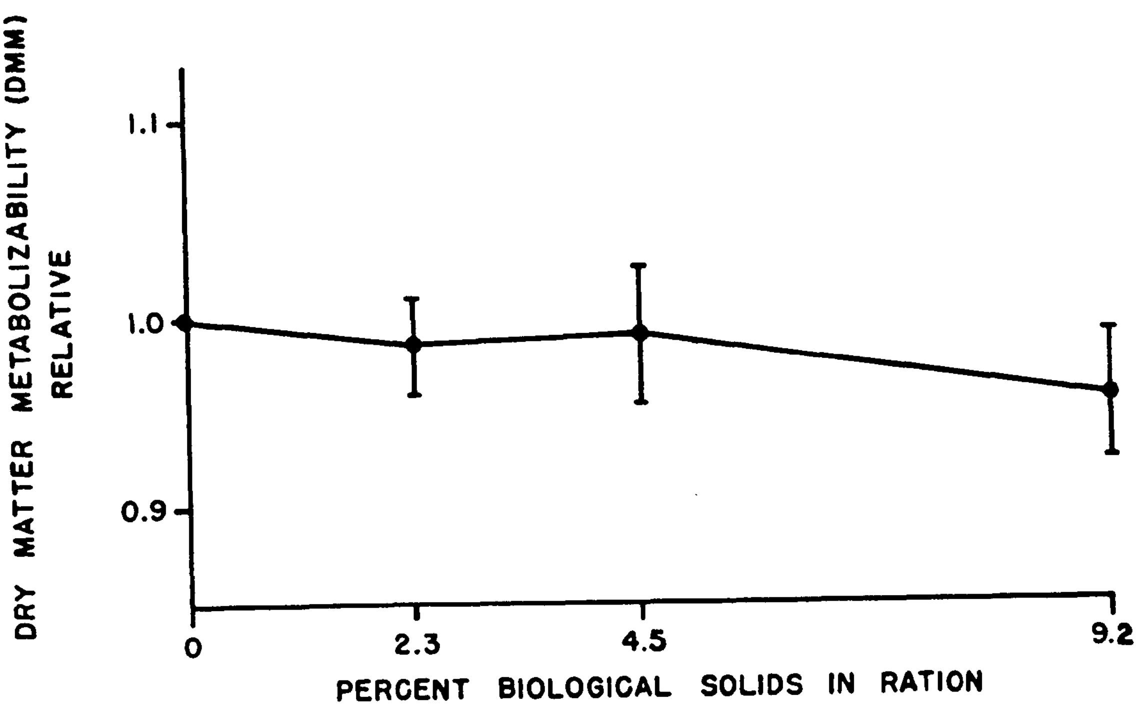

Figure 10. Relative metabolizability of rations by biological solids content.

CATTLE FINISHING TRIALS

Four lots of six uniform yearling beef type steers were individually full fed 165 days to finish on a ration consisting of alfalfa cubes, corn silage, barley, beet pulp, TM salt, Vitamin A and, for three of the groups, dewatered biological solids from the cannery wastewater treatment system. Biological solids were incorporated into the study rations at 2.3%, 4.6% and 8.9% levels as shown in Table 4. Table 5 gives the proximate analysis of the various ration ingredients and the calculated values for the overall rations. The finishing trials were conducted over a period of 165 days.

Table 4. FINISHING RATIONS, DRY MATTER BASIS, ACTUALLY CONSUMED

	Percent in Ration			
Ingredient	Control	Low Sludge	Medium Sludge	High Sludge
Alfalfa Cubes	12.4	12.3	12.4	12.4
Corn Silage	8.5	8.5	8.3	8.2
Concentrate1/	79.1	76.9	74.7	70.5
Sludge Biological Solids		2.3	4.6	8.9

1/ Concentrate consisted of 80.4% Barley, 18.9% Beet Pump, 0.7% Salt and Vitamin A to supply about 20,000 IU per day.

The mean and standard deviation of the weights for each of the four groups of steers before the finishing feeding trial and following the finishing are shown on Figure 11 (see Appendix Table A-7). There was not a significant difference between the groups of steers selected for feeding on the various rations, although the group fed the ration containing 2.3% biological solids appears to be slightly heavier following finishing.

Figure 12 shows the average weight gain rate and the standard deviation in weight gain for the various groups of steers. The group of steers fed the ration containing 2.3% biological solids experienced a significantly greater mean rate of weight gain than the control group at the 75% level but not at the 90% level using Student's t distribution.[11] The 4.6% and 8.9% biological solids groups were approximately equal to the control in weight gain. Weight gain records for each of the steers used in this study are shown in Appendix Table A-7.

Figure 13 shows the mean dry matter consumption rate, and the standard deviation, in relation to body weight for the various groups. Each of the

Table 5. PROXIMATE ANALYSIS OF CONCENTRATES, HAY, SILAGE AND CANNERY WASTE SOLIDS USED IN FINISHING FEED STUDY

Ration Identity or Ingredient	Composition on Dry Basis, %						
	Dry Matter	Crude Protein	Crude Fiber	Ether Extract	Ash	Ca	P
Alfalfa cubes	90.1	18.4	26.30	1.95	8.58	1.35	.32
Corn silage	31.6	7.2	20.30	3.55	8.32	.30	.27
Concentrates (80.4% Barley, 19.9% Beet Pulp, 0.7% Salt)							
Control	90.3	12.8	8.25	1.70	4.08	.17	.30
Low level waste	90.5	13.1	8.20	1.60	4.26	.20	.32
Med. level waste	90.5	13.4	8.30	1.50	3.90	.20	.31
High level waste	90.6	14.4	8.10	1.55	4.36	.25	.29
Cannery waste biological solids	7.42	39.1	3.20	.80	11.64	1.08	1.28
Overall Ration							
Control	78.0	13.0	11.5	1.9	5.0	.33	.30
2.3% Biol. Solids	64.0	13.8	11.4	1.8	5.3	.37	.34
4.6% Biol. Solids	54.2	14.7	11.3	1.7	5.2	.39	.35
8.9% Biol. Solids	42.1	16.5	10.9	1.7	5.9	.46	.38

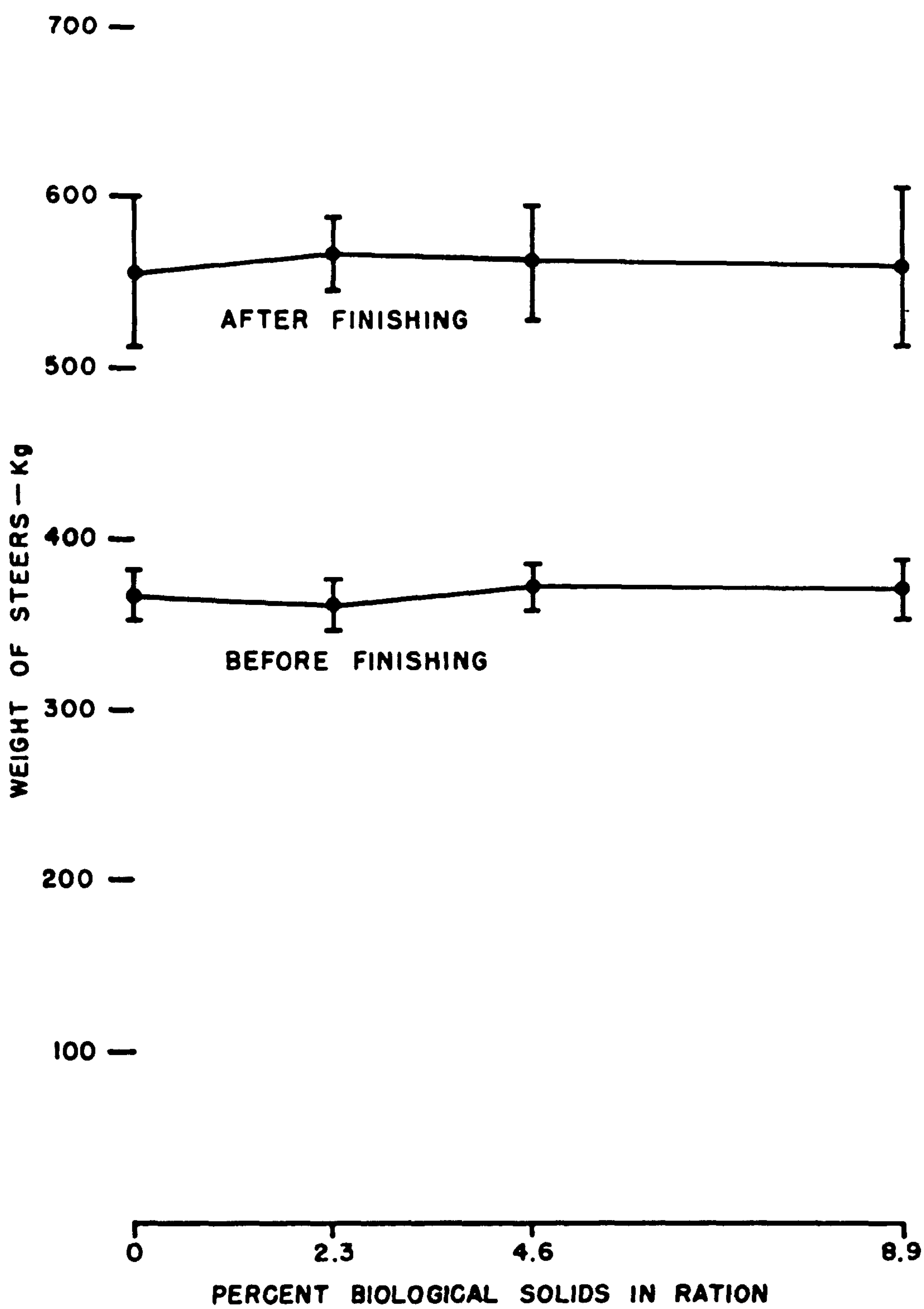

Figure 11. Steer weights before and after finishing feeding study.

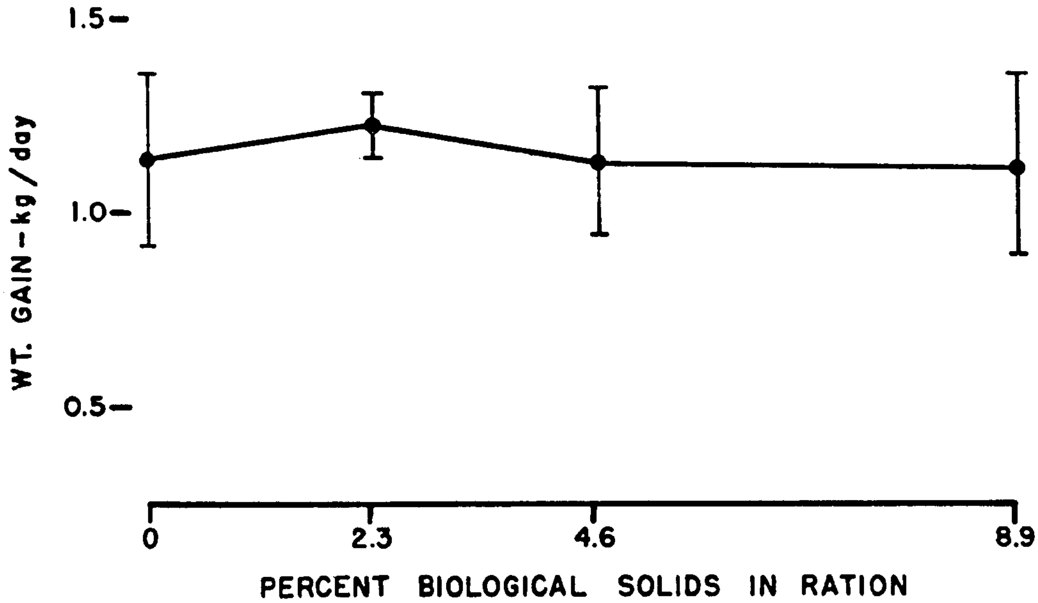

Figure 12. Weight gain by ration biological solids content.

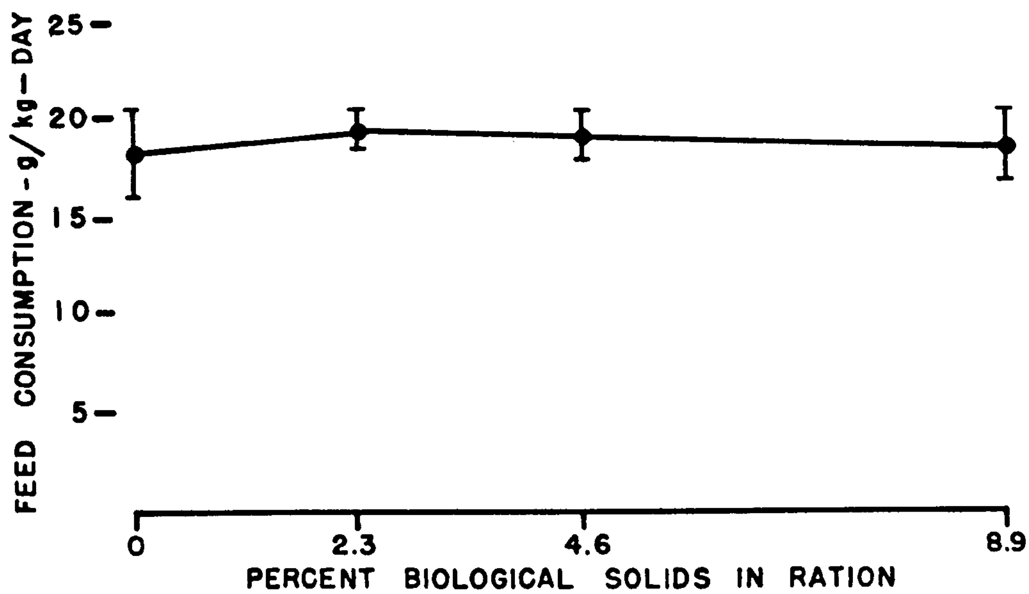

Figure 13. Dry matter consumption in relation to body weight.

three groups fed rations containing the biological solids had a greater average feed consumption than the group on the control ration, and the groups fed 2.3% and 4.6% biological solids were significantly greater at the 75% level, but not at the 90% level, using the Student's t distribution. Feed consumption is shown for the individual steers in Appendix Table A-8.

The mean and standard deviation for the groups of steers of the amount of dry matter consumed is shown on Figure 14. The steers on the control ration and the ration containing 2.3% biological solids were approximately equal in feed conversion efficiency. The overall conversion efficiency on the rations with 4.6% and 8.9% biological solids appear to be slightly less although they are not significantly less at the Student's t 75% level.

CARCASS QUALITY

Following slaughter of the animals used in the finishing feed trials, the USDA grade, yield grade and marbling scores were recorded for each of the carcasses. The USDA grade and marbling scores were given numerical equivalent values to allow the determination of means and standard deviations for the various groups of cattle. Figures 15 and 16 show the USDA grade, marbling score and yield grade mean and standard deviations for the groups. The USDA grade and marbling score are significantly higher at the 95% level

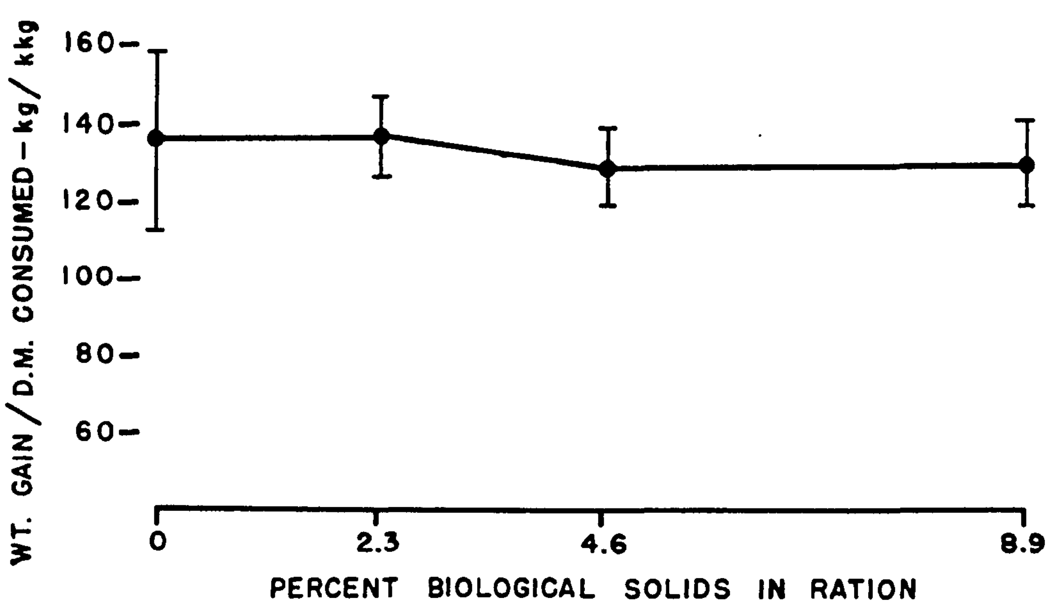

Figure 14. Weight gain in relation to dry matter consumption.

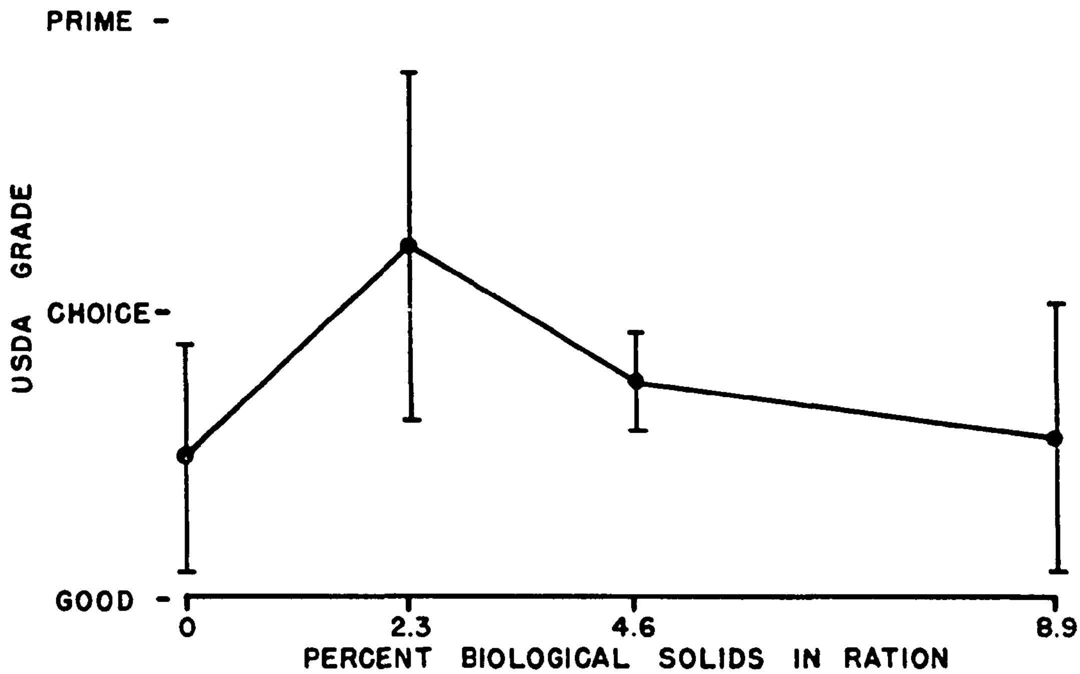

Figure 15. USDA grade by ration biological solids content.

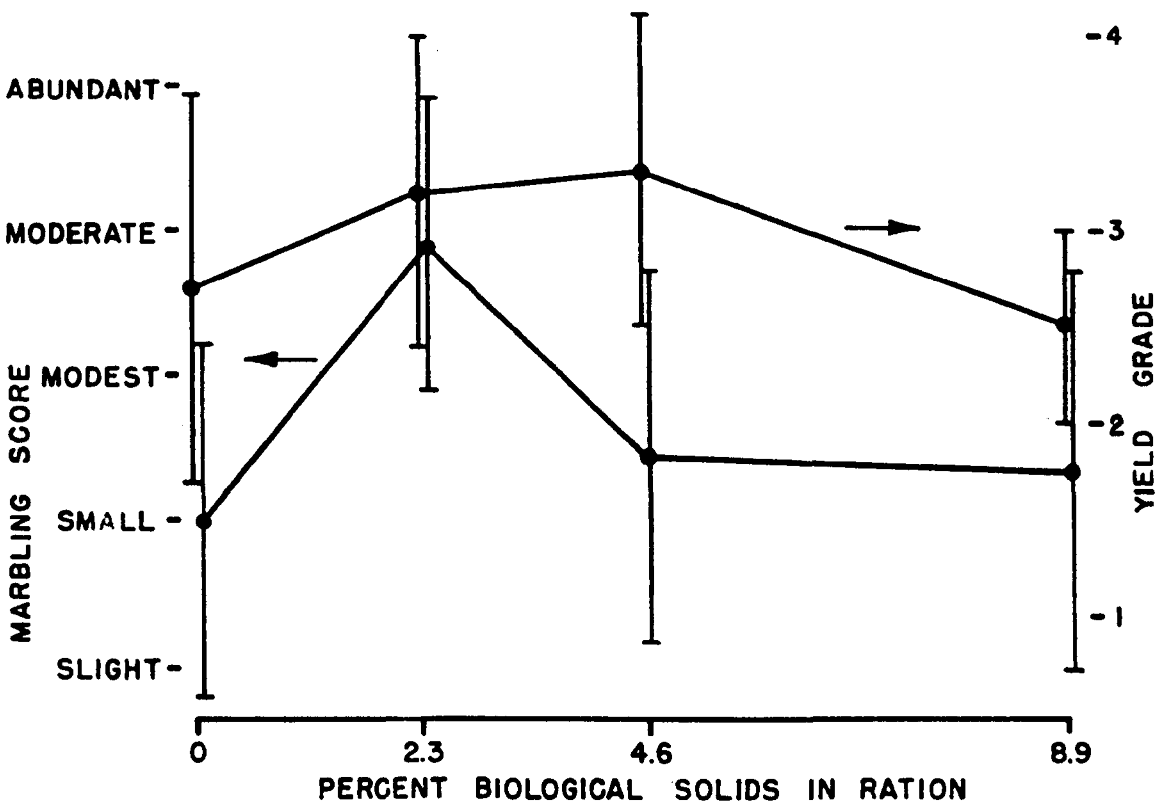

Figure 16. Carcass yield grade and marbling score by ration.

using Student's t distribution for the group of steers which received 2.3% biological solids in their ration. The yield grade for the groups receiving 2.3% and 4.6% biological solids in their rations are significantly higher than the control group at the 75% level using the Student's t distribution but not at the 90% level. It is safe to definitely conclude that carcass quality was not adversely affected by the incorporation of biological solids in the rations at any of the levels used. There may have been some enhancement at low sludge feeding levels. Carcass grading results for all steers are shown in Appendix Table A-8.

The carcasses from all steers used in the finishing feed trials were approved for public sale by USDA and FDA and were sold through normal marketing channels of a commercial slaughterhouse. However, approval of the biological solids as a permanent feed supplement has not been received and will be necessary prior to implementation of a full scale feeding program.

FACTORS AFFECTING THE SUITABILITY OF BIOLOGICAL SOLIDS AS A PORTION OF A CATTLE FINISHING FEED RATION

Protein

Table 5 contains proximate analysis of the various components of the rations. The waste biological solids contained a high content of crude protein and higher concentrations of calcium and phosphorus than the other components of the feed. Appendix Table A-9 contains additional analysis results of the dry solids which confirm their high N and P contents. The solids apparently would provide a good source of protein to be incorporated into a feeding ration. An analysis of the biological solids for amino acid content was conducted and is shown on Appendix Table A-10. Based on amino acid content the solids contained only between 20 and 27% percent amino acid protein on a dry solids basis as opposed to 39 percent calculated from kjeldahl nitrogen. This difference may not be significant due to the inherent difficulty of running amino acids analyses and does not change the overall conclusions that the waste biological solids are a good source of nitrogen.

Heavy Metals

Heavy metals analyses were conducted on the waste biological solids and on tissue samples from four of the steers involved in the finshing feed trials. Two of the steers were from the group which received the control ration and two of the steers from the group which received 8.9% biological solids in their ration. The results of the analyses are shown in Appendix Table A-11. There were no consistent differences in heavy metals retention between steers on the two rations.

Pesticides

Pesticide analyses were conducted on the waste biological solids and on the same tissue samples as for heavy metals analysis. Appendix Tables A-12 and A-13 show the results of these analyses. The pesticides for which residues are shown are the only pesticides for which residues could be determined in a screening analysis for chlorinated hydrocarbon, carbamate and phosphate pesticides. The pesticide residues contained in the biological solids apparently did not result in unacceptable levels in any of the rations fed as there were no consistent differences in the pesticide residue levels in the tissue samples from the cattle that received control biological solids rations.

Analyses for patulin and penicillic acid in the waste biological solids were performed by the WSU College of Agriculture. The analyses were negative for residues of both of these microtoxins.

FEED ECONOMIC VALUE OF BIOLOGICAL SOLIDS

Table 6 contains a calculation of the total cost of the basic ration components in each of the rations fed during the finishing feed studies on a total metric ton dry solids basis. The basic cost of the ration, given the assumed costs for the individual feed components shown, are for all dry matter included in the ration excepting the biological solids. As expected, the rations with higher biological solids have a lower base ration component cost due to the replacement of barley and beet pulp by the biological solids.

The value of the biological solids utilized in the finishing feed rations is calculated in Table 7. For this calculation the average cost of the control ration per kilogram of weight gained on the control group of steers was used as a basic value for average weight gain of the steers on all rations. The calculations utilize mean weight values for the other three groups of steers. They indicate a wide variation in the value of the biological solids incorporated.

A different method for calculating economic value of the sludge is presented in Table 8. This computation uses the mean value for feed components per unit weight gain for all of the steer groups and assigns the cost saving for the sludge fed groups to sludge value. This method results in a higher value for the biological solids than the method in Table 7.

The values placed on the biological solids, while differing in magnitude, place a strong argument for the economics of placing these solids in a cattle feeding ration. The values obtained can be used to place the costs for product dewatering in a proper perspective and give potential cattle feeders an indication of the value of such a feed component.

Table 6. DRY MATTER AND ASSUMED COST FOR BASIC COMPONENTS OF RATIONS USED IN FINISHING FEED STUDY

		Ration							
		Control		2.3% Biol. Sol. DM		4.6% Biol. Sol. DM		8.9% Biol. Sol. DM	
Feed Component	Assumed Cost $/kg DM	% Ration	$/kkg Ration	% Ration	$/kkg Ration	% Ration	%/kkg Ration	% Ration	$/kkg Ration
Alfalfa Cubes	.086	12.4	10.70	12.3	10.60	12.4	10.60	12.4	10.60
Corn Silage	.052	8.5	4.40	8.5	4.40	8.3	4.30	8.2	4.30
Barley	.159	63.6	101.30	61.9	98.40	60.1	95.60	56.6	90.00
Beet Pulp	.110	15.0	16.50	14.5	16.00	14.1	15.50	13.3	14.60
TM Salt	.055	.5	.30	.5	.30	.5	.30	.5	.30
Biological Solids				2.3		4.6		8.9	
Assumed Cost of Basic Ration Components			133.20		129.70		126.30		119.80

Table 7. VALUE OF BIOLOGICAL SOLIDS IN FINISHING RATIONS USING VALUE OF WEIGHT GAIN ON CONTROL RATION

Item	Control	2.3% Biol. Sol. DM	4.6% Biol. Sol. DM	8.9% Biol. Sol. DM
Wt. Gain, kg/kkg DM	136	137	129	130
Cost of Basic Ration, $/kkg total ration	133.20 ($.979/kg gain)	129.70	126.30	119.80
Value of Ration Based on Control ($.979/kg gain), $		134.10	126.30	127.30
Value of Biological Solids in Ration, $		4.40	0	7.50
Value of Biological Solids $/kkg DM		191.30	0	84.30

Average Value of Biological Solids = $92/kkg DM, $7.30/kkg Sludge at 8% Solids.

EFFECT OF STORAGE ON DEWATERED SOLIDS

It was apparent during the study of cattle feeding of the biological solids it would be necessary to store these solids. During the study, storage was in 55 gallon plastic lined drums in a cool atmosphere. The drums were stored indoors in a facility at the WSU Irrigated Agriculture Research Extension Center prior to use, but in effect were refrigerated during the entire period of storage, which was two months maximum during any portion of the study.

In order to determine the effect of long term storage on the dewatered biological solids, one 55 gallon plastic lined drum of the solids was set aside from sludge dewatered on February 3, 1975. This drum was stored in the cannery warehouse (approx. 20^{o}C) up through approximately mid-August at which time necessity to utilize the space required that it be moved from the warehouse. Subsequently it was stored outside of the warehouse area at the cannery, which probably allowed it to get quite warm due to the high ambient daytime temperatures during September of 1975. Sludge stored in the drum was analyzed on the day it was placed and sampled from the top, mid-depth and near the bottom of the barrel on December 1, 1975. The results of these analyses are shown on Table 9.

Table 8. VALUE OF BIOLOGICAL SOLIDS IN FINISHING RATIONS USING COST SAVING PER UNIT WEIGHT GAIN IN SLUDGE RATIONS[1]

Group	Total	Kg DM/kg Gain Alfalfa Cubes	Corn Silage	Concentrate (Barley, Beet Pulp, Salt)	Sludge
Control	7.53	.934	.640	5.936	0
2.3%	7.34	.903	.624	5.644	.169
4.6%	7.82	.970	.649	5.841	.360
8.9%	7.73	.959	.634	5.442	.688

Group	Cost of Ingredients, $/kg Gain: Cubes (@ $.086/kg)	Silage (@ $.052/kg)	Concentrate (@ $.1491/kg)	Total	Sludge Value
Control	.0803	.0333	.8881	1.0017	
2.3%	.0776	.0324	.8416	.9517	.050/.296/kg
4.6%	.0834	.0338	.8710	.9881	.014/.038/kg
8.9%	.0824	.0330	.8114	.9268	.075/.109/kg

Average value of biological solids = $0.148/kg DM = $148/kkg DM = $11.80/kkg at 8% solids.

1. Heinemann, W. W. Personal Communication (May 1976).[12]

Table 9. ANALYSIS OF DEWATERED BIOLOGICAL SOLIDS - BEFORE AND AFTER 10 MONTHS STORAGE

Date	Tot. Solids g/kg	Vol. Solids g/kg	COD g/kg	NH_3-N g/kg	Org. N g/kg	Tot. P g/kg
Feb. 3, 1975	80.2	72.4	95.8	0	5.6	1.29
Dec. 1, 1975						
Top	72.8	56.6	78.8	3.15	3.2	1.26
Middle	67.7	58.4	78.8	2.8	3.0	0.86
Bottom	58.9	51.4	73.0	2.3	3.0	0.99

Data on Table 9 indicates that biological decomposition of the solids occurred during storage in the closed 55 gallon drum over the 10-month period. This is evidenced by the decrease in total solids and volatile solids in the stored sludge as well as an actual increase in fixed solids (total solids minus volatile solids). The biological degradation is also evidenced by the decrease in COD and the conversion of a substantial amount of the organic nitrogen into the ammonia nitrogen form. These degradation changes may result in a decrease in digestibility and metabolizability for the wastewater solids. It may also result in a decrease in the amount of nitrogen utilizable by livestock if it were incorporated into a feeding ration since the ammonia nitrogen would probably at least partially be lost due to volatilization in unconfined storage.

HANDLING OF DEWATERED SOLIDS

Due to the possibility of proceeding to a full scale solids dewatering system, it was felt that some knowledge of the handling characteristics of the dewatered solids should be obtained. Samples were obtained of dewatered sludge during early April 1975, and various experiments on handling of the highly viscous dewatered solids were conducted. In the first experiment a cube of dewatered solids was placed on a sheet of metal and the metal inclined to a point that the solids began to slide down the face of the slope. A cube two inches on each side containing 8.3% dry solids moved down the metal sheet 8 inches in two minutes after it was inclined 64 degrees from the horizontal. A three inch cube of sludge containing 11.9% dry solids traveled down an inclined piece of metal 4 inches in two minutes at an angle of 84 degrees from horizontal, and subsequently fell the rest of the way.

The maximum height of sludge supported on a 6 inch base was 7.4 inches for the 8.3% dry solids sludge and 10 inches for the 11.9% dry solids sludge.

Dewatered sludge at 6.7% dry solids was conveyed through a screw conveyor 5 inches in diameter. It was successfully transported through the conveyor but at an exceedingly slow rate.

These experiments indicate that transport of this dewatered sludge must be carefully planned before construction of handling facilities. Its viscosity would allow it to be moved by a bucket type loader or transported on belt conveyor. It could be pumped by positive displacement pumps, but the pump drive power must be sufficiently high to overcome the high viscosity and friction in discharge piping. Conveying the sludge through a screw conveyor would appear to be difficult to accomplish.

SECTION VI

FEASIBILITY FOR FULL SCALE SOLIDS DEWATERING AND UTILIZATION OF SOLIDS AS CATTLE FEED

A calculation of the feasibility for full scale dewatering of the waste biological solids at Snokist Growers and utilization of the solids as a portion of a cattle feeding ration is shown on Table 10. The excess biological solids production and the basket centrifuge effectiveness are basic assumptions to this feasibility analysis. Feasibility of the centrifuge loading was established during the dewatering trials. The capital cost for installation of the centrifuges, their housing, electrical and other components, is assumed amortized at 7% over a 20 year basis to provide an estimated capital cost per kilogram dry solids dewatered. Operation and maintenance costs and hauling costs were estimated and included in the total estimated cost for dewatering of the solids and delivery to a point where it could be utilized as cattle feed. The present cost of disposal of the solids, which consists of hauling to a site and land spreading, is shown. Table 10 shows that the economic feasibility of proceeding with a full scale dewatering system is heavily dependent upon the dewatered solids having a positive value to a cattle feeder. The calculated feed value (Table 7 and Table 8) subtracted from the estimated cost for dewatering and hauling results in a net estimated cost range for disposal as a cattle feed which is substantially lower than the present costs of disposal. A savings of about $9,000 per year could be realized for the Snokist Growers cannery. A minimum return of $63 per kkg dry solids ($5 per kkg wet sludge containing 8% solids) would appear to be necessary to give the program a break even feasibility. It will take an investigation of cattle feeders' willingness to remunerate Snokist Growers at this minimum level or higher and actual capital financing charges before a final determination of the economic feasibility is made.

Table 10. FEASIBILITY OF FULL-SCALE DEWATERING

Excess Solids Production	30,000 kg DS/season	3500 kg DS/ operating day
Basket Centrifuge 122 cm x 76 cm (48 in. x 30 in.)		
Capacity	---	450 l
Solids Capacity	80 g DS/kg Cake	36 kg DS
Solids Loading Rate	5 g/l min.	2.25 kg/min
Thickened Sludge Flow @ 25 g DS/l	90 l/min.	$\bar{t}$ = 5 min.
Loading Time	75% Recovery	12 min.
Unloading Time	---	8 min.
Cycle Time	3/hour	20 min.
Two Centrifuges at 16 hr/day:		
Estimated Capital Cost ($255,000)	$24,100/yr	$0.08/kg DS
O&M Cost	$100/day	$0.030/kg DS
Hauling Cost ($1.85/kkg wet sludge)	80 g DS/kg	$0.023/kg DS
Total Cost Dewatering and Hauling	$40,000/yr	$0.133/kg DS
Value as Cattle Feed	$92 to $184/kkg DM	$0.092 to $0.148/kg DS
Net Cost of Sludge Disposal	$4,500 to $12,000/yr	$0.015 to $0.040/kg DS
Present Cost of Disposal ($1.85/kkg wet sludge)	$21.000/yr	$0.070/kg DS
Net Projected Savings	$9,000 to $25,500/yr	$0.030 to $0.085/kg DS

SECTION VII

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SECTION VIII

APPENDIX

This appendix contains Tables A-1 through A-13 which present the data in greater detail than was provided in the report text. These data provide backup for the analyzed results for biological solids thickening, basket centrifuge sludge dewatering performance and cattle feeding presented and discussed in earlier sections of this report.

Table A-1. SLUDGE DEWATERING - PILOT (36 cm dia, 9.9 l) CENTRIFUGE

Date	Feed Rate l/min	$\bar{t}$, min	Feed SS g/l	Cake Total gDS	Cake Conc'n* gDS/kg	Max Cake Conc'n**	Initial Centrate Concn, g/l
10/16/74a	8.5	1.2	7.1	710	89.3	113	.6
10/19/74a	7.6	1.3	7.9	790	91.6	103	.4
10/21 a	7.5	1.3	5.8	680	83.7	94	.3
10/22 a	7.1	1.4	7.2	750	82.2	98	.35
10/23 a	7.8	1.3	6.9	800	85.5	89	.4
10/24 a	8.8	1.1	6.2	780	85.7	96	.4
10/25 a	9.0	1.1	5.8	720	81.0	105	.4
10/26 a	4.7	2.1	5.3	830	89.5	99	.2
10/29 a	8.0	1.2	3.7	680	78.8	92	.2
10/30 a	8.3	1.2	5.2	670	78.3	98	.38
10/31 a	6.4	1.6	5.6	660	78.1	94	.39
11/1/74 a	10.5	0.9	6.0	720	77.7	115	.50
11/2 a	8.3	1.2	6.7	710	76.0	94	.5
11/8 b	3.4	2.9	4.6	760	90.6	101	.12
11/9 b	3.1	3.2	6.0	800	90.7	97	.32
11/11 a	3.5	2.8	4.4	620	78.6	85	.15
11/12 b	3.1	3.2	5.7	700	77.5	87	.27
11/13 a	6.4	1.6	5.6	690	75.8	85	.4
11/14 b	5.2	1.9	6.9	600	71.4	90	.5
11/15 b	5.8	1.7	6.7	610	72.7	87	.55
11/18 b	6.4	1.6	5.3	600	71.3	85	.45
11/19 b	6.0	1.6	6.8	630	68.1	84	.55
11/20 b	8.9	1.1	7.05	580	67.3	84	1.0
11/21 b	6.4	1.6	7.3	660	70.7	81	.6
11/22 b	1.4	6.9	24.0@	630	69.4	108	-
b	4.5	2.2	7.0	670	75.8	83	.47
11/25 b	1.11	8.9	24.7@	760	86.1	99	1.4
11/26 b	1.33	7.5	22.7@	680	75.1	85	.85
11/27 b	4.1	2.4	5.56	650	71.6	97	.43
12/2/74 b	2.7	3.6	4.0	740	79.5	92	.14
12/3 b	2.0	5.1	5.7	740	83.1	103	.25
12/4 b	2.7	3.7	5.5	650	77.8	95	.25
12/5 b	3.2	3.1	5.9	700	81.5	94	.3
12/6 c	2.9	3.4	6.7	640	72.7	95	.4
12/9 c	3.7	2.7	3.7	580	65.2	81	.26
12/10 c	5.2	1.9	6.2	620	67.0	92	.5
12/11 c	1.6	6.4	6.5	720	81.3	88	.2
12/12 c	2.0	4.9	5.4	730	78.1	98	.2
12/13 c	1.1	8.8	5.8	750	84.8	91	.17

* Ave. of 3 samples following mixing of cake discharge
** Sample from cake at periphery of centrifuge
a 1240 g's at centrifuge periphery (2500 rpm)
b 1340 g's at centrifuge periphery (2600 rpm)
c 880 g's at centrifuge periphery (2100 rpm)
@ Flotation Thickened Sludge Feed

Table A-2. SLUDGE DEWATERING - PROTOTYPE (76 cm dia, 113 l) CENTRIFUGE

Date	Feed Rate l/min	$\bar{t}$, min	Feed SS g/l	Cake Total kg DS	Cake* Concn gDS/kg	Max** Cake Concn g/kg
12/17/74	103	1.1	2.7	8.2	72.2	140
12/18	52	2.2	2.75	9.6	85.1	117
12/19	56	2.0	3.3	9.7	85.4	148
12/20	31	3.7	3.1	10.6	93.3	112
1/20/75	60	1.9	3.75	8.0	70.7	117
1/21	72	1.6	5.3	9.5	83.7	161
1/22	90	1.3	5.1	8.1	83.5	168
1/23	108	1.1	5.4	9.6	84.6	152
1/24	89	1.3	5.3	10.0	88.2	158
1/27	48	2.4	3.4	9.8	86.2	122
1/28	59	1.9	4.8	9.0	79.2	112
1/29	52	2.2	4.8	9.1	80.0	115
1/30	66	1.7	4.1	8.4	74.2	102
1/31	61	1.9	4.1	8.5	74.6	129
2/3	72	1.6	4.0	8.6	76.2	109
3/19	113	1.0	1.8	5.8	50.9	116
3/20	53	2.1	1.9	8.9	78.4	115
3/21	58	1.9	2.7	7.2	63.4	165
3/24	65	1.7	2.6	8.2	72.5	134
3/25	84	1.4	2.6	8.1	71.4	138
3/26	56	2.0	2.6	8.5	74.6	114
3/27	64	1.8	2.6	8.3	73.0	112
3/31	58	2.0	2.6	8.6	75.9	127
4/1	46	2.5	18.5@	7.9	96.0	162
4/2	55	2.1	19.6@	9.8	86.3	154
4/3	25	4.5	20.0@	8.7	76.3	167
4/4	27	4.2	14.2@	8.6	75.7	157
4/7	20	5.7	14.3@	8.9	78.6	128
4/8	29	3.8	17.4@	9.5	83.6	136
4/9	44	2.6	14.5@	10.9	96.1	145
4/10	38	3.0	17.5@	10.0	88.6	176
4/11	36	3.1	17.3@	9.9	87.3	141
4/14	29	3.9	17.6@	10.3	90.8	179

*Ave. of 3 samples following mixing of cake discharge
**Sample from cake at periphery of centrifuge
@ Flotation Thickened Sludge Feed

Table A-3. CENTRIFUGE PERFORMANCE

Date	10/19	11/1	10/26	12/11	11/26	12/9
Feed SS, g/l	7.94	6.0	5.3	6.5	22.7	3.7
Cake Sol. gDS/kg	91.6	77.7	89.5	81.3	75.1	65.2
Hydraulic Retention Time $\bar{t}$, min.	1.30	0.94	2.1	6.4	7.5	2.7
Solids Retention Time SRT, min	15.0	12.3	35.8	81.3	24.2	46.6
Time, min/Centrate SS, g/l	3.7/0.40	3.0/0.47	7.9/0.30	17.3/0.22	18.7/0.9	6.7/0.21
	6.0/0.37	4.8/0.47	11.7/0.13	27.5/0.23	21.3/0.72	12.0/0.26
	8.6/0.34	6.6/0.53	14.7/0.18	38.8/0.20	23.3/0.94	17.4/0.27
	11.6/0.47	8.4/0.65	20.4/0.16	53.1/0.22	27.0/10.7	22.8/0.30
	13.8/1.59	10.1/0.97	24.4/0.19	67.6/0.78	30.4/17.4	27.9/0.34
	16.6/4.12	11.9/2.07	28.4/0.27	80.7/3.93	33.8/19.5	33.1/0.36
	18.9/5.8	13.7/3.46	32.8/0.60			38.2/0.41
		15.5/4.01	37.9/0.60			43.5/0.55
			40.6/1.99			48.3/1.11
			42.3/3.07			54.1/1.56

Table A-4. FLOTATION THICKENER PERFORMANCE (9 m DIA. CIRCULAR THICKENER)
(Pressurized Recycle Flow = 950 l/min)

Date	Hydraulic Loading l/min sq m	Solids Removal kg DS/hr-sq. m	Thickened Sludge Concn gDS/l	Thickener Effluent Concn gDS/l
11/22/74	15	3.7	28.9	0.16
11/25	31	5.8	23.9	0.17
11/26	15	3.5	28.1	0.17
11/27	31	8.4	23.7	0.15
12/2	31	4.3	22.1	0.3
12/3	15	3.2	27.3	0.2
4/2/75	31	2.7	22.3	0.06
4/3	31	2.8	20.3	0.06
4/4	31	1.7	19.5	0.28
4/7	31	1.1	19.9	0.65
4/8	31	2.3	23.3	0.3
4/9	31	2.3	17.7	0.35
4/10	31	2.1	22.9	0.41
4/11	31	2.3	24.4	0.26

Table A-5. RESULTS OF METABOLISM TRIALS, DRY MATTER DIGESTIBILITY (DMD) AND DRY MATTER METABOLIZABILITY (DMM)

Steer	Ration							
	Control		Low Waste		Med. Waste		High Waste	
No.	DMD	DMM	DMD	DMM	DMD	DMM	DMD	DMM
1	70.8	65.8	71.7	65.4	72.1	64.8	67.2	59.8
2	67.2	62.0	65.2	58.7	70.5	64.6	65.5	58.1
3	75.1	67.2	74.4	69.3	73.5	68.0	75.1	68.2
4	76.1	69.3	73.5	68.2	72.8	66.5	74.3	66.6
5	70.2	66.3	70.7	63.4	71.4	66.6	68.8	62.3
6	69.8	65.1	72.2	66.3	71.9	67.2	68.6	63.2
7	73.1	67.4	73.8	67.0	72.0	64.7	71.7	66.2
8	72.9	67.4	73.7	66.6	69.6	63.5	69.2	64.5

Table A-6. RESULTS OF METABOLISM TRIALS, DIGESTIBLE ENERGY (DE) AND METABOLIZABLE ENERGY (ME)

Steer	Ration							
	Control		Low Level Sludge		Med. Level Sludge		High Level Sludge	
No.	DE	ME	DE	ME	DE	ME	DE	ME
1	73.12	70.02	71.62	68.29	70.67	67.23	65.22	59.91
2	73.96	70.32	69.79	65.69	68.98	64.79	71.71	67.24
3	72.20	65.61	73.88	71.38	68.88	64.93	77.51	72.65
4	79.50	75.86	75.29	72.53	69.53	64.78	76.43	71.37
5	67.63	65.83	76.05	71.82	71.85	68.23	68.30	63.11
6	73.73	71.36	77.17	74.47	79.24	75.57	72.40	69.11
7	71.51	67.98	74.91	71.10	70.76	66.91	71.35	67.38
8	74.12	70.71	72.44	68.83	65.73	62.66	70.76	67.17

Table A-7. INDIVIDUAL WEIGHT GAIN RECORDS - FINISHING FEED STUDIES

Steer No.	Weight as of, kg 12/19/74	1/16/75	2/12	3/12	4/9	5/7	6/2
Control							
12	355.5	392.0	421.5	452.5	492.5	529.0	497.5
18	388.5	436.0	474.5	521.5	557.0	579.0	610.0
32	354.0	390.5	425.0	455.0	489.0	512.5	541.5
42	378.5	393.0	408.5	463.5	498.5	543.0	575.5
83	360.5	408.0	450.0	493.0	527.0	557.5	592.0
96	365.0	373.5	409.5	444.5	474.5	490.5	513.5
2.3% Biological Solids							
36	387.0	419.0	466.5	509.5	554.5	573.5	589.0
43	349.5	396.0	445.5	497.5	501.0	542.5	569.0
62	351.5	386.0	415.0	459.5	497.0	527.0	549.5
95	376.5	419.5	449.5	490.0	526.5	565.5	595.5
105	361.0	398.0	421.5	470.5	507.0	530.0	550.5
118	354.0	391.0	431.0	464.5	500.0	529.5	544.5
4.6% Biological Solids							
31	374.5	424.0	466.0	514.0	557.5	596.5	620.5
69	365.5	396.0	439.5	472.0	510.0	557.5	567.5
81	352.0	382.0	409.0	440.5	476.5	507.0	533.0
97	394.0	422.5	460.0	499.0	534.0	552.0	567.5
98	367.0	376.5	416.5	446.5	477.5	503.5	533.5
106	377.0	404.5	418.5	460.5	494.5	519.0	540.5
8.9% Biological Solids							
15	367.5	408.0	453.0	504.5	534.5	577.0	599.5
19	380.5	410.0	429.0	453.0	480.0	511.5	538.5
56	347.0	380.5	407.0	449.0	479.5	521.0	543.5
78	394.5	431.5	478.5	516.0	558.5	596.5	622.0
91	351.0	356.5	385.5	421.0	452.5	477.5	490.5
102	379.5	407.5	438.0	436.5	493.0	544.5	546.0

Table A-8. 165 DAY FINISHING FEED STUDIES

Steer No.	Beg. Wt. kg	End Wt. kg	Gain kg/d	D.M. Intake kg/day	D.M. Intake kg/kg ave. wt	Wt. Gain DM Intake kg/kkg	USDA Grade[1]	Yield Grade	Marbling Score[2]
					Control				
12	355.5	497.5	0.86	8.33	3.22	103	G (8)	3	Sl- (15)
18	388.5	610.0	1.34	9.98	3.30	135	C (5)	4	Mod (5)
32	354.0	541.5	1.14	8.40	3.09	135	LC (6)	3	Sm+ (10)
42	378.5	575.5	1.19	6.93	2.40	172	G (8)	1	Sl- (15)
83	360.5	592.0	1.40	9.52	3.30	147	LC (6)	2	Sm+ (10)
96	365.0	513.5	0.90	7.25	2.72	124	LC (6)	3	Sm (11)
					2.3% Biological Solids				
36	387.0	589.0	1.22	9.73	3.29	126	C (5)	4	Mod (5)
43	349.5	569.0	1.33	9.10	3.27	146	C (5)	3	Mod (5)
62	351.5	549.5	1.20	8.79	3.22	137	LC (6)	2	Sm (11)
95	376.5	595.5	1.33	8.96	3.04	148	HC (4)	3	Mod+ (4)
105	361.0	550.5	1.15	9.34	3.38	123	HP (1)	4	Ab (2)
118	354.0	544.5	1.15	8.13	2.98	142	C (5)	3	Mod (5)

1. Scale for USDA Grades: HP = High Prime = 1; P = Prime = 2; LP = Low Prime = 3; HC = High Choice = 4; C = Choice = 5; LC = Low Choice = 6; HG = High Good = 7; G = Good = 8; LG = Low Good = 9.
2. Marbling Score: T = Trace = 17; Sl = Slight = 14; Sm = Small = 11; Mt = Modest = 8; Mod = Moderate = 5; Ab = Abundant = 2.

Table A-8 (continued). 165 DAY FINISHING FEED STUDIES

Steer No.	Beg. Wt. kg	End Wt. kg	Gain kg/d	D.M. Intake kg/day	D.M. Intake kg/kg ave. wt	Wt. Gain DM Intake kg/kkg	USDA Grade[1]	Yield Grade	Marbling Score[2]
				4.6% Biological Solids					
31	374.5	620.5	1.49	10.23	3.39	146	LC (6)	3	Sm (11)
69	365.5	567.5	1.22	9.46	3.35	129	LC (6)	4	Sl (14)
81	352.0	533.0	1.10	8.18	3.05	134	LC (6)	2	Sm (11)
97	394.0	567.5	1.05	8.97	3.08	117	C (5)	3	Mod (5)
98	367.0	533.5	1.01	8.30	3.04	122	LC (6)	4	Sm- (12)
106	377.0	540.5	0.99	8.03	2.89	123	C (5)	4	Mod (5)
				8.9% Biological Solids					
15	367.5	599.5	1.41	10.32	3.52	136	HC (4)	2	Mod (5)
19	380.5	538.5	0.96	7.87	2.83	122	HG (7)	2	Sl+ (13)
56	347.0	543.5	1.19	9.08	3.37	131	LC (6)	3	Mod (5)
78	394.5	622.0	1.38	9.34	3.03	148	LC (6)	3	Sm (11)
91	351.0	490.5	0.84	7.18	2.82	118	G (8)	2	Sl- (15)
102	379.5	546.0	1.01	8.03	2.86	126	HG (7)	3	Sm (11)

Table A-9. CONTENT OF BIOLOGICAL SOLIDS
DRY SOLIDS BASIS mg/mg

Date	VSS	Org. N	Org. P	COD
8/27/74	.901	.059	.016	1.28
9/4	.896			1.29
9/10	.889	.066	.016	1.26
9/17	.883			1.25
9/24	.875	.068	.015	1.24
10/3	.888			1.23
10/15	.922		.014	1.29
10/22	.910			1.27
10/29	.907		.013	1.33
10/30/74		.067		
11/6	.901			1.28
11/13	.927			1.25
11/20	.894			--
12/4	.886			1.22
12/11	.890			1.22
1/20/75	.862	.067	.014	1.16
1/27	.892	.070	.016	1.19
2/3	.902	.070	.016	1.19
3/20	.893	.070	.015	1.12
3/25)) D	.864	.069	.014	1.12
3/25)	.871	.069	.015	1.14
4/1) D) Thickener	.886	.076	.016	1.26
4/1) Float	.889	.077	.016	1.27

D = duplicate analyses

Table A-10. AMINO ACID ANALYSIS OF BIOLOGICAL SOLIDS, DM BASIS *

Amino Acid	Nanomoles per mg
Aspartic acid	199.2
Threonine	128.0
Serine	111.3
Glutamic acid	295.1
Proline	92.0
Glycine	202.1
Alanine	266.7
Cystine	51.8
Valine	181.4
Methionine	64.4
Isoleucine	94.1
Leucine	170.6
Norleucine	24.8
Tyrosine	143.3
Phenylalanine	95.6
Lysine	94.9
Histidine	31.6
Arginine	63.8
Ornithine & Tryptophane	129.6

*On basis of amino acid content, biological solids contains between 20 and 27% protein.

Table A-11. HEAVY METALS AND ARSENIC IN BIOLOGICAL SOLIDS AND SELECTED ANIMAL TISSUES OF STEERS FED 165 DAYS

	Residue, ppm as Sampled						
Sample Identity	Cd	Cu	Fe	Pb	Sn	Zn	As
		Steers - Control					
83-adipose	.015	.15	2.6	.15	.3	.70	<.5
kidney	.69	3.56	56	.40	3.5	19.2	<.5
liver	.10	3.40	31	.25	.9	14.8	<.5
96-adipose	.02	.13	4.6	.35	1.4	4.9	<.5
kidney	.095	2.94	56	.48	.15	17.0	<.5
liver	.04	39.5	52	.25	4.9	30.4	<.5
		Steers - 8.9% Biological Solids					
19-adipose	.03	.07	5.0	.02	2.2	5.1	<.5
kidney	.83	.74	60	.59	3.5	20.8	<.5
liver	.14	7.9	39	.40	2.9	33.0	<.5
78-adipose	.01	.20	5.9	.08	.8	1.1	<.5
kidney	.78	2.32	84	.76	4.7	19.2	<.5
liver	.22	34.3	60	.48	7.3	37.6	<.5
		Biological Solids Residue ppm Dry Solids					
Composite of Sludge from Entire Feeding Period		120			330		
May 1975 Sample	< 6	60	19,500	50	400	110	3.5
				60			4.3
Sept. 1973 Sample		90	6,100			200	

Table A-12. PESTICIDE RESIDUES IN WASTE BIOLOGICAL SOLIDS

Sampling* Time	Residue			Conc. ppm D.S.
1	p,p'-DDE			.054
	Thiodan I			.031
	Thiodan II			.090
2	p,p'-DDE			.040
	Thiodan I			.029
	Thiodan II			.093
3	p,p'-DDE			.031
	Thiodan I			.024
	Thiodan II			.072
4	p,p'-DDE			.047
	Thiodan I			.034
	Thiodan II			.093
5	p,p'-DDE			.044
	Thidoan I			.030
	Thiodan II			.096
Averages	p,p'-DDE			.043
	Thiodan I			.030
	Thiodan II			.089
		#1	#2	
4/17/75 Clarifier Sludge	p,p'-DDE	.011	.012	
	Thiodan I	.014	.022	
	Thiodan II	.022	.039	
4/17/75 Centrifuge Sludge Cake	p,p'-DDE	-	.009	
	Thiodan I	.006	.011	
	Thiodan II	.013	.022	

*Each "sampling time" is composed of a composite of weekly samples.

Table A-13. PESTICIDE RESIDUE IN ADIPOSE (OMENTAL FAT), KIDNEYS AND LIVERS OF STEERS FED 165 DAYS

Steer Nume and Ration	Sample Type	Residue	Residue present, ppm	
			Lipid	Tissue
83 - Control	Adipose	p,p'-DDE	.059	.056
		Dieldrin	.014	.013
		Thiodan I	.003	.003
		Endrin	.004	.004
	Kidney	Thiodan I	---	.001
	Liver	None	---	---
96 - Control	Adipose	p,p'-DDE	.100	.080
		Dieldrin	.022	.018
		Thiodan I	.003	.002
		Endrin	.003	.002
	Kidney	Thiodan I	---	.001
	Liver	None	---	---
19 - 8.9% Biological Solids	Adipose	p,p'-DDE	.080	.073
		Dieldrin	.029	.026
		Thiodan I	.003	.003
	Kidney	Thiodan I	---	.055
		Endrin	---	.002
	Liver	None	---	---
78 - 8.9% Biological Solids	Adipose	p,p'-DDE	.066	.055
		Dieldrin	.028	.023
		Thiodan I	.003	.002
	Kidney	None	---	---
	Liver	None	---	---

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

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4. TITLE AND SUBTITLE FRUIT CANNERY WASTE ACTIVATED SLUDGE AS A CATTLE FEED INGREDIENT		5. REPORT DATE September 1976 (Issuing Date)
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15. SUPPLEMENTARY NOTES

16. ABSTRACT

The feasibility of sludge disposal, from a fruit processing waste activated sludge treatment system, by dewatering and using the dewatered biological sludge solids as cattle feed was evaluated by Snokist Growers at Yakima, Washington. Dewatering of the biological sludge utilizing pilot-scale and prototype-scale basket centrifuges resulted in consistently dewatering to 7-1/2% to 9% dry solids. Digestibility and metabolizability of rations containing 2.3% and 4.5% biological solids appeared equal to a control ration, but a ration containing 9.2% biological solids appeared lower. Twenty-four uniform yearling steers were divided into four lots of six each and finish fed a control ration and rations containing 2.3%, 4.6%, and 8.9% sludge solids on a dry matter basis for 165 days. They did not show any adverse effects of the sludge incorpration into their rations. It appeared that a low quantity of sludge (2.3% dry solids) actually enhanced the weight gain performance and carcass quality of these animals. The cost of a dewatering installation will require that the cannery receive remuneration for use of the waste activated sludge as cattle feed in order to make a full-scale dewatering project feasible. The calculated value of the biological solids incorporated into the rations was in the range of $0.092 to $0.148 per kg dry solids.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Civil engineering; Sanitary engineering; Environmental engineering; sludge disposal; Food processing; Canneries; Centrifuging; Byproducts; Growth; Activated sludge process; Waste treatment.	Canners; Animal growth; Sludge treatment.	13/b

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