WASTES GENERATED IN THE MANUFACTURE OF SAUERKRAUT[1]

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Abstract

Forty three surveys were made of two sauerkraut factories to obtain quantitative data on the wastes generated. Trim losses (solid wastes) were over 35 tons per 100 tons of raw cabbage processed and the discarded brine represented about 29% of the salted, shredded cabbage. Other sources of waste effluents were vat soak water, vat wash water, and can cooling water. From 294 to 395 gal of waste effluents were discharged per ton of shredded cabbage processed; the BOD ranged from about 11 to 13 lb. per ton. Brine had enough nutrients (BOD, nitrogen, and phosphorus) for optimal biological stabilization.

Sauerkraut is a clean, sound product, of characteristic acid flavor, obtained by the lactic acid fermentation of properly prepared and shredded cabbage in the presence of 2 to 3% salt. It contains, on completion of the fermentation, not less than 1.5% titratable acidity, expressed as lactic acid *(4)*. Over 10 million cases of sauerkraut are packed annually in the United States with New York State, the leader, producing over 3.6 million *(5)*.

Sauerkraut waste water is unfavorable for conventional waste treatment because of its extremely high BOD, low pH, and high sodium chloride content *(11)*. There is thus a need for improved methods to treat this waste water. Before treatment facilities can be designed, however, data must be available regarding quantities and properties of the wastes. Securing this information was a major objective of this study.

A second objective was to obtain information that might point to changes in processing methods that could be made to reduce waste generation. Other in-plant studies *(3, 9, 10)* have shown that economies in water usage and consequent effluent reduction often can be effected in food processing.

Materials and Methods

The research was carried out during the 1971 season in the factories of two of our larger sauerkraut producers. The analyses and flow data are the results of 43 surveys performed on different days.

Waste water flow rates were measured by the calibrated container-stop watch procedure *(2)*. Samples of waste water were sealed in one-pint polyethylene bags and transported to the laboratory over ice in an insulated chest. The analyses for BOD, COD, pH, total solids, lactic acid, and NaCl were done as soon as the samples reached the laboratory. Samples to be analyzed for Kjeldahl nitrogen, and phosphorus were frozen immediately and stored at −23 C until the tests could be made. Standard methods were used for determining 5-day BOD, COD, and total solids *(1)*. In the BOD test, the modified Winkler method was used to determine dissolved oxygen *(1)*. Lactic acid and NaCl were determined by micro titrations *(12)*. Kjeldahl nitrogen and phosphorus were analyzed by AOAC methods *(6)*.

Results and Discussion

Sauerkraut process

The cabbage is delivered to the factory by truck. It then is transported via conveyor belt to the coring machine. Following this, the cored head is conveyed to the trimming table where outer leaves and bad spots are removed. This latter operation represents a source of solid waste.

Next the cabbage is shredded and transported to the fermentation vat. Salt, 2.25 to 2.5 lb. per 100 lb. of cabbage, is applied evenly as the shreds are distributed in the vat.

Juice is released from the cabbage almost immediately after addition of the salt. To assure a maximum fill of cabbage into a vat, much of this "early brine" may be withdrawn from the vat and discarded during or shortly after the filling. As the data will show, this early brine can be a significant source of liquid waste in the sauerkraut process.

After the vat is filled, it is covered with a plastic sheet that is weighted with water. The fermentation is considered complete when the titratable acidity, expressed as lactic acid, has reached 1.5%, and the shreds are fully cured. This process requires four or more weeks.

The final step is the filling of the fermented cabbage and brine into retail packages (cans, jars, or flexible pouches). Only a portion of this "late brine" is added to the packages, the remainder which must be discarded represents a second important source of liquid waste.

Volumes and properties of waste effluents

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TABLE 1. SOURCES AND VOLUMES OF SAUERKRAUT WASTE EFFLUENTS

	Vat no.		Shredded cabbage in vat	Early brine	Late brine	Vat soak water	Vat wash water
Factory A			(tons)	(gal)	(gal)	(gal)	(gal)
	21		69	3,120	2,290	16,000	132
	24		65	2,280	2,019	15,000	180
	25		69	3,120	3,362	14,500	150
	26		65	1,900	2,139	13,700	135
	29		66	1,920	1,506	14,000	165
	49		65	3,120	750	15,000	150
	53		65	3,000	480	14,000	195
	51		65	1,980	3,744	—	180
	52		65	2,475	1,250	—	—
		Mean	66	2,546	1,949	14,600	161
Factory B							
	9		33	162	1,872	9,000	85
	10		32	24	2,145	10,000	120
	11		34	144	1,963	9,500	—
	12		34	615	2,041	10,000	—
	13		34	372	2,184	9,500	—
		Mean	33.4	263	2,041	9,600	103

In addition to brines, other sources of waste effluent were the vat soak water, vat wash water, and can cooling water. The volume and composition of these different wastes are presented in Tables 1 and 2.

Although the soak water required to maintain vat integrity during the storage season, was very high in volume (Table 1), its strength was relatively low (Table 2). Its low BOD suggests that it should be readily biologically treatable although it could present a problem in hydraulic loading. The trend to the fiberglass lining of wooden vats and the use of other materials for vat construction would indicate that soak water will be even less of a consideration in the future.

The water used to clean vats before filling was of greater strength but the volume was low. Vat wash water, therefore, was not a significant waste source. Use of alkaline cleaning compounds undoubtedly accounted for its somewhat higher pH.

At the time of filling the vats with cabbage, Factory A released considerably more juice, the early brine, than did Factory B (Table 1). This difference in practice is best illustrated in Table 3 where the data are expressed as waste per ton of cabbage and, therefore, compensate for differences in vat capacities. It can be seen that Factory A discharged an average of five times greater volume of early brine than did Factory B. Sooner or later, of course, the excess cabbage juice must be discarded and Factory B which had released the modest amount of early brine had a greater volume of late brine to discharge at the end of the fermentation (Tables 1, 3).

Inspection of data in Table 3 affords a comparison between the two practices. We conclude from the data that the volume of brine generated by the two methods is comparable. Although the total pounds of BOD appear to be higher in the Factory B brines, the difference may not be statistically significant; it is noted that, conversely, Factory A brines seemed to contain the higher total solids. The greater quantity of lactic acid discarded by Factory B resulted from the larger volume of cabbage juice that was retained in the vats during the sauerkraut fermentation. It is likely that the increment in lactic acid generated by Factory B has economic significance since acid effluents generally require neutralization before biological treatment.

Data on cooling water are not presented in the tables because it was not possible to relate water discharge to sauerkraut production. Studies at Factory B showed this water to have a low BOD, 27-40 mg/l, and a discharge flow rate of 590 to 750 gal per hour.

Data on material balance (Table 4) show the quantity of sauerkraut produced from 100 tons of cabbage. It can be seen that about 29% of the salted shredded cabbage is discarded as brine. The data also show that there is a problem of solid as well as liquid waste in the manufacture of sauerkraut. The trim loss of 35.3 tons is an average for 16 different loads of cabbage; individual values ranged from 28.7 to 41 tons. Trim losses were high in 1971, probably because of a wet growing season. Acording to some sauerkraut packers, a loss of 26 to 30% is a more common figure. The solid wastes are generally returned to the growing field.

Because of their high strength, the surplus brines present the greatest problem with respect to treatment. The average BOD of the brines discarded by the two factories was 11.75 lb. per ton of shredded cabbage (Table 3). The total BOD from a 65-ton

TABLE 2. CHARACTERISTICS OF SAUERKRAUT EFFLUENT

Effluent source	Factory	pH	Total solids (mg/l)	COD (mg/l)	BOD (mg/l)	Lactic acid (mg/l)	NaCl (mg/l)	Kjeldahl nitrogen (mg/l)	Total phosphorus (mg/l)
Vat soak water	A	6.5-8.5[a]	168-708	24-140	12-104				
		7.5[b]	478	64	60				
	B	8.4-8.6	378-1,528	22-220	10-85				
		8.5	776	83	43				
Vat wash water	A	9.5-11.0	1,325-9,935	176-520	141-416				
		10.4	2,448	303	236				
	B	9.4-9.5	1,440-1,270	180-260	105-160				
		9.5	1,355	220	132				
Early brine	A	3.7-6.0	46,740-75,040	14,630-25,350	8,250-9,550	450-4,770	32,600-42,300	420-600	70-97
		5.2	56,630	16,620	9,070	1,510	34,000	540	85
	B	3.9-5.9	42,350-64,620	15,000-21,700	9,750-13,000	540-1,710	22,700-45,000	470-600	99-116
		5.2	53,120	17,730	11,140	926	36,800	555	106
Late brine	A	3.3-3.7	53,320-61,700	24,200-32,500	20,500-28,150	14,800-21,900	22,400-28,400	910-1,250	159-220
		3.5	57,730	28,960	24,300	18,600	26,800	1,090	189
	B	3.4-3.8	50,420-61,760	24,000-30,000	21,000-26,000	14,000-16,800	24,000-29,000	870-970	185-264
		3.6	55,450	27,130	23,200	15,850	26,800	927	207

[a]Range of data
[b]Mean of data

vat would, therefore, equal 764 lb. which, when expressed on a population equivalent basis, means that it is equal to that contributed in one day by a population of about 4500 persons.

Since sauerkraut brine has only a limited sales volume and no simple or inexpensive means for reduction of brine is apparent, a solution to the problem of excessive brine formation remains to be resolved. Although the recent report of breeding new high dry matter cabbage for potential reduction of hydraulic loads in sauerkraut fermentation appears promising *(7)*, the relative chemical composition of such newly developed varieties and their effects upon BOD load remains to be established.

It is likely that the extremely high BOD of waste brines may require their segregation for separate treatment. Our analyses of brine nitrogen and phosphorous contents (Table 2) indicate that neither compound would have to be added as a nutrient supplement to achieve optimal biological stabilization. Thus the average BOD:N:P ratio was found to be very close to the recommended 100:5:1 *(8)*.

One possible problem associated with the brines is their high salt concentration; levels as high as 4.5% were found in this study (Table 2). Little of this salt probably would be removed from the waste water by conventional treatment systems. Furthermore, certain concentrations of sodium chloride might interfere with the activity of system's biomass. The ideal solution would be to reduce the amount of salt discharged; the 18 lb. per ton of shredded cabbage (Table 3) represents a loss of almost 40%. Unfortunately, alterations in the sauerkraut process that would waste less salt are presently not known. Unpublished studies by one of us (JRS) have shown the adverse affects of diminished salt content upon the textural properties of the finished product.

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TABLE 3. WASTE LOAD PER TON OF SHREDDED CABBAGE FERMENTED

Factory	Effluent	Volume	Total solids	BOD	Lactic acid	NaCl
		(gal)	(lb.)	(lb.)	(lb.)	(lb.)
A	Soak water	221	0.9	0.11	0	0
	Wash water	2	0.04	0.004	0	0
	Early brine	40	20.5	3.10	0.52	11.7
	Late brine	31	15.5	7.60	4.9	7.1
	Total	394	36.94	10.81	5.42	18.8
B	Soak water	287	1.8	0.10	0	0
	Wash water	3	0.03	0.003	0	0
	Early brine	8	3.7	0.75	0.06	2.5
	Late brine	61	29.0	12.10	8.3	14.0
	Total	359	34.53	12.95	8.36	16.5

TABLE 4. MATERIAL BALANCE OF SAUERKRAUT PRODUCTION (FACTORY A)

	(Tons)
Raw cabbage	100.00
Solid wastes (trim loss)	35.30
Shredded cabbage in vat	64.70
Salt added	1.70
Liquid wastes	
Early brine	11.00
Late brine	8.50
Total	19.50
Yield of finished product	46.90

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THE LEADERSHIP ROLE

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"health," "environmental health," "sanitation," and "preventive medicine." Such programming can and will function within any organization structure providing that structure does not limit ecological programming to the restrictive boundaries determined by tradition. Programs aimed at correcting ecological problems will continue to grow in importance and it makes little difference to the public, to the general governmental organization involved, or even to the eventual solution of the problems, whether or not these activities are performed by a public health agency. The current demand is for results, not internecine combat over organizational structure and responsibility based on misdirected pride.

FUTURE ROLE OF ENVIRONMENTALIST

The present corps of paid professional environmentalists (sanitarians, engineers, wildlife managers, etc.) can play a key role in future ecological programs, but only if they:

(*a*) Understand that ecological problems demand corrective programs which are as multi-faceted as the problems. A limited concern with health, with social problems, with economic concerns, with preservation, or with other restricted goals means an equally limited impact on the problems; and an equally limited degree of support.

(*b*) Are willing to accept leadership. As stated above, it makes no difference to the suffering public who takes this role; and there is no shortage of competitors.

(*c*) Realize that they are currently in a unique position to assume leadership. The local environmentalist is, or should be, the person to whom the locality now looks to for aid and advice in solving ecological problems.

(*d*) Understand and utilize the political, social, and economic factors in their locality in developing solutions.

(*e*) Make use of the current popular interest in, and concern over, environmental degradation. Never before, and possibly never again, will the environmentalist have the public support he now has. Never before has there been the multitude of organizations and individuals concerned with a common goal. Some need leadership, some

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