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Do Biological or Chemical Additives Really Control Vault Toilet Odors?

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INTRODUCTION

During the winter of 1990, the San Dimas Technology and Development Center (SDTDC) evaluated a variety of biological and chemical products (see cover photograph) to control the unpleasant odors that emanate from vault toilet waste. **A 2-mo study of treated vault waste (sewage) concluded that use of such products, in the laboratory study, did not significantly demonstrate effectiveness in eliminating the unpleasant odors emanating from this type of waste.**

What Is Odor?

The theory pertaining to operation of the "sense of smell" has been well documented. Basically, the operation is two part. First, detected odor is converted into a perception by the olfactory (nasal) system; and second, the perception is conveyed to the brain where it is classified—on the basis of previous experience and association—as "pleasant" or "unpleasant."

In regards to classification of pleasant or unpleasant, a particular odor might be offensive to one person and not to another. However, where sewage odor exists, it is almost always objectionable. Another important factor is the intensity of the odor and frequency of exposure; i.e., individuals who are frequently exposed to particular odors develop immunities or insensitivity to smell and, thus, are less likely to be offended or complain unless the intensity exceeds the threshold of acceptability.

The "taste" sense may also enter into the reaction towards unpleasant odor.

Unpleasant odors in toilet vaults are the result of bacterial action on organic (fecal) waste and, in addition, to the inherent odor of other materials (such as beer, flammable chemicals, etc.) deposited into the vault. The process of organic material decomposition produces a biochemical reaction that releases unpleasant gases, resulting in the majority of the foul odors we smell.

What Is a Vault Toilet?

Figure 1. Typical vault toilet provided at remote outdoor recreation sites.

The typical toilet provided in remote recreation sites is the vault toilet (fig. 1). The vault toilet, not to be confused with a "pit" toilet (pit toilets have no sealed containment for the waste), incorporates the use of a sealed vault or tank (usually constructed of concrete) to contain raw fecal and urine wastes. The vault toilet is a waterless system having a typical capacity of 500 to 1,000 gal. The vault contents must be manually removed (pumped out) when full, and then properly disposed of in a sewage treatment plant or approved landfill.

BACKGROUND

Products on the market claiming or implying practical application to control odor in toilet vaults accomplish this by:

- Masking (fragrances)
- Altering bacterial activity (use of bacteriostats or bactericides)
- Inducing beneficial bacteria associated with decomposition.

The latter method of treating sewage odor is a natural process, and is the basis for the operation of treatment plants. By inducing conditions favorable for aerobic digestion (bacterial action in the presence of oxygen)—the gas byproduct, odorless carbon dioxide (CO_2)—is produced, thereby displacing foul sulfur dioxide gases (fecal odor). **The biological and some chemically based additives attempt to eliminate vault odor by either of the latter two methods—altering bacterial activity and inducing beneficial bacteria.**

There have been numerous attempts to demonstrate the value of using vault additives to eliminate odors. In 1978, SDTDC evaluated two biological products to determine their odor-eliminating characteristics on vault waste. Several unpublished comments by personnel within the Forest Service, National Park Service, and State Park units indicate independent studies have been conducted with limited success. The results have been inconsistent and conclusions subjective at best. During the 1989 field season, SDTDC evaluated several products on national forest sites. The results were inconclusive due to inconsistent treatment procedures and subjectivity in odor detection.

To reduce duplicating efforts by field units, SDTDC took on the task of studying vault additives, using a more uniformly controlled study environment. The study was conducted during the winter of 1990 at the San Dimas facilities, which are located in Los Angeles County, California.

STUDY OBJECTIVES

The study had two major objectives:

1. The *primary* focus of the study was to evaluate claims that products added to vault sewage waste will eliminate unpleasant odors.

2. The *secondary* focus of the study was to evaluate claims that biological products provide the added benefit of decomposing (digestion) sewage waste resulting in reduced pumping/treatment cost.

STUDY PARAMETERS AND PROCEDURES

The study included monitoring changes on vault waste samples treated with chemical or biological products. Each sample consisted of 1 pint of liquefied, macerated, vault waste placed in quart-size Mason jars (glass containers). The samples were placed in an unlit warehouse without temperature control, simulating the natural (though somewhat warmer) conditions of a toilet vault. A synopsis of the procedure used is provided in the four topic discussions that follow.

Acquisition of Waste

Vault waste (10 gal) was acquired from a toilet vault located in the Lake Hemet picnic ground, San Jacinto Ranger District, San Bernardino National Forest, CA (fig. 2). Prior to containment and transport in 5-gal plastic containers, the vault was mixed with a macerator pump for 10 to 15 min. The vault contained a high proportion of liquid as normally expected of a picnic area. Therefore, no additional water was added to the vault during maceration.

Figure 2. Collecting waste samples.

Sample Preparation

At the SDTDC facility, the 10-gal waste sample was remacerated in a metal container and additional nondegradable debris removed (fig. 3). The macerator pump provided a uniform mix of solids and liquid waste. As the liquefied waste recirculated through the pump, 1-pint samples were taken and placed in quart jars. Every tenth sample was segregated, and used as a "control" sample to monitor uniformity of sample content.

Figure 3. Preparing waste samples.

As suggested by one of the manufacturers, a hot dog was used to supplement monitoring of the bacterial action on organic matter. The hot dog sample consisted of a hot dog (or "frankfurter") sliced lengthwise, folded open to expose the content, and immersed in purified water. After the initial samples were created, no additional waste was added—as there would be in an existing vault—for the remainder of the evaluation.

Treatment

Participating manufacturers were requested to donate a sample of their product for the study and provide instructions on application (dosage and treatment frequency), along with a materials safety data sheet (MSDS). Each product from the various manufacturers was allocated two waste samples for treatment evaluation, in addition to one hot dog sample.

Evaluation

All sample jars were kept unsealed (no lids) and monitored weekly (fig. 4). The control samples were used for baseline information, serving as comparison standards (treated vs. untreated) for detecting any changes in odor and appearance. The hot dog samples were observed and changes noted. All comments were documented and study conditions (such as room temperature, etc.) noted. Photographs were taken throughout the study to augment documentation.

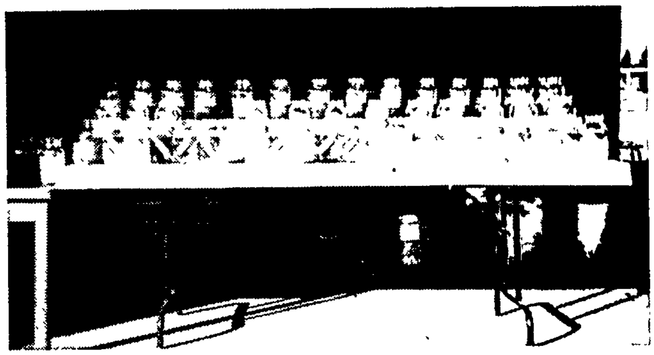

Figure 4. Study samples.

Immediately following sample preparation, three control samples were sent to the laboratory for measurement of pH, percent moisture content, percent organics, and percent inorganics. The latter three measurements were performed using standard laboratory methods, i.e., total residue dried at 103 to 105 °C and total volatile and fixed residue at 550 °C.

After 4 wk, a container of each treated sample was sent to the laboratory along with three more control samples. Each sample was evaluated for percent moisture content, percent organics, and percent inorganics. It was noted that evaporation had occurred and additional water (100 ml) added to all samples.

At the end of 8 wk, the remaining treated samples and three controls were sent to the laboratory for evaluation. The final samples were evaluated for pH, percent moisture content, percent organics, and percent inorganics.

RESULTS

Demonstrated Results Under Laboratory Conditions

Though the study was not designed to be a scientific experiment, the control environment provided uniform conditions unattainable in field study conditions, thereby reducing some of the subjectivity experienced in previous evaluations.

Odor (Sensory Analysis). The subjectivity of odor detection makes classification of smells into categories difficult—unless the evaluation is completed by one or two people (fig. 5). In the study, "unpleasant" vs. "pleasant" odors were the two categories established.

Figure 5. Evaluating odor.

Of the 27 products evaluated, 9 contained specially formulated fragrances. These fragrances, which were highly concentrated, enhanced the treatment. However, a fallacy exists in the value of adding fragrances to additives. Fragrance often leads to bias in evaluating the effectiveness of an odor eliminating product. The conclusion is, they are simply "masking" agents or odor counteractants, giving a false impression of the product's function. Coincidentally, six of the nine scented products recommended weekly treatment application.

The smell evaluation confirmed "scented" products reduced the odor intensity for 3 to 5 days on the average following treatment but the odor returned after 1 wk—leading the observer to raise a question about such products: "Odor eliminator or odor cover-up?" Furthermore, for a biological product to be effective, it should be mixed into the waste. However, any disturbance to the waste greatly magnifies the emission of unpleasant odor. To reduce bias due to fragrance, the smell evaluation was conducted prior to treatment after the first week.

Ambient room temperature was monitored, documenting correlation to odor detection. With cool winter temperatures assisting in simulating vault-like conditions (vaults normally average 56 °F), ambient room temperatures ranged from 45 to 75 °F. General observations concluded that, at temperatures above 60 °F, odors were most obnoxious. During the sixth week, warm temperatures and intense odors attracted flies to the study area. This temperature variation in relation to odor production could explain the variable results obtained in field evaluations. Early in the laboratory study, it was determined that the odor evaluation should be conducted in the afternoon when the temperatures were the warmest (worst case scenario). Even the warmest temperatures during the study were not nearly as warm as most temperatures encountered during the summer months in most recreation areas. However, each product container was evaluated against control samples and, since the temperatures of both were the same, temperature was relative.

Digestion. The visual analysis is seen in figure 6. Containers on the far left and far right are sample controls.

The hot dog samples confirmed chemical products do little to digest waste. All of the chemically treated hot dogs showed little or no bacterial activity. However, the biological products showed varying effects on the hot dog, ranging from very rapid digestion in the first week to no activity over the period of the study. The majority of biological products, however, did demonstrate rapid bacterial activity within the first month. The rate of digestion could be proportional to treatment frequency and dosage, but probably is closely related to product potency or strength.

Week 8

Figure 6. Evaluating changes to samples treated with biological products.

In one treatment, two products were mixed together. The net effect was reduced digestion—this would suggest a biochemical counteraction had occurred. It was also noted that bacterial activity on the hot dog was most noticeable in the first few weeks but tapered off, regardless of the number of supplemental treatments.

Laboratory Analysis of Control Samples

pH. The control samples at the beginning of the study had measured pH's of 7.44, 7.45, and 7.48 for the three samples analyzed. Additional controls analyzed after 8 wk measured 8.1, 8.2, and 8.3. A supplemental control sample analyzed after 14 wk measured 7.4.

The results indicate some change over the duration of the study. No pH analysis was conducted in the fourth week. The rise in pH measured in the eight week can be attributed to the water added to the samples in the fourth week. Because the pH of the water added during the fourth week is unknown, it is difficult to verify whether the change in pH was caused by the water or if it occurs naturally.

Percent Organics. Samples analyzed at the beginning of the study measured 1.41, 1.43, and 1.49. Fourth-week analysis measured 1.53, 1.58, and 1.64 percent. Eighth-week analysis measured 1.24, 1.48, and 1.55 percent.

The percent organics remained relatively stable throughout the study with very little variance between samples. This analysis gave a good indication of the uniformity in waste samples. The data suggest, that under the study conditions, very little bacterial activity progressed.

Percent Inorganics. Samples analyzed at the beginning of the study measured 1.10, 1.13, and 1.14 percent. Fourth-week samples measured 1.39, 1.56, and 3.23 percent. Eighth-week samples measured 1.42, 1.51, and 1.65 percent.

The percent of inorganics is a measurement of the nondegradable materials within the sample. As measured, this remained relatively consistent throughout the samples, with a minor exception being the one 3.23 percent measurement seen in the fourth week. This anomaly can probably be attributed to possible sediment passing through the macerator pump during sample preparation.

Percent Moisture. Samples analyzed at the beginning of the study measured 97.36, 97.44, and 97.49 percent. Fourth-week samples measured 95.13, 96.86, and 97.08 percent. Eighth-week samples measured 96.80, 97.01, and 97.34 percent.

The moisture content, measured by proportional weight to total volume of the sample, indicate sufficient moisture available for biological activity. The slight variance between samples is attributed to evaporation and expected variance in sample preparation, including possible inaccurate measurement of water added during the fourth week. This value was not significant to any study results but was taken to verify the amount of moisture present in a vault environment.

Laboratory Analysis of Treated Samples

pH. The laboratory analysis did not include pH measurements for the fourth-week samples. Measurements for pH only on the eighth-week samples were incomplete due to confusion by laboratory personnel. The communication error was not detected until the remaining ten samples. However, of the several biologically treated samples measured, the data indicated close association between low pH and low moisture content (e.g., 5.3 pH with 60.85 percent moisture) and high pH and high moisture content (e.g., 7.7 pH with 97.96 percent moisture). Other parameters, such as treatment frequency and product pH, are not factored into this conclusion.

Percent Organics. The analysis showed an average increase, overall, for the biological products. Though the data showed significant changes in some products over others, there was no significant decrease for any product (including the chemical products).

Percent Inorganics. This measurement actually increased for the majority of the products requiring weekly treatment—the result of additional nondegradable material (carrier or catalyst) in the product being added to the treated sample. In some samples, the inorganics increased by as much as 47 percent between the fourth and eighth week. This fact would lead one to believe tha t such biological additives would counter any benefit of digestion—since the overall volume (by weight) increases.

Percent Moisture. Moisture content was adequate for biological activity. Again, the percent moisture is not significant to any study results but was taken for general interest.

Comparison of Laboratory Analysis

Frequency of Treatment (Weekly vs. Monthly, or "As Needed"). The analysis shows no significant difference between products, based on treatment frequency. It was anticipated that with the weekly disturbance of the waste sample, due to mixing in the product, some changes would occur. However, the data showed no significant change.

Chemical vs. Biological. The laboratory analysis did not show any significant differences between the two product categories.

ANTICIPATED RESULTS UNDER FIELD CONDITIONS

There was a misunderstanding on the part of some manufacturers, or their distributors, as to the application of their product in a vault toilet system. Unlike a septic system, a vault system has no outlet and is simply a large holding tank (usually constructed of concrete) with typical capacity of less than 1,000 gal. The vault must be frequently pumped. However, field experience shows this frequency to be "as needed" rather than scheduled.

Most important, the vault system is a *waterless* system; the only effluent supplied is from human defecation and urine. Because of the very high concentration of organic waste in vault systems, unlike conditions experienced in treatment plants or septic systems, the resulting biochemical oxygen demand (BOD) can be 50 or more times greater. The high BOD can have a counter effect on any biological additive, dependent on aerobic activity to eliminate odor.

Odor is also produced or emitted from the concrete walls of the container above the waste level. Concrete is very absorbent and, over the years, the concrete becomes saturated with odor. Even if the waste is pumped out completely, a tremendous odor problem still exists and cannot be solved by biological or chemical additives.

Our understanding of chemically based additives is that they are generally formulated to hinder bacterial activity, performing as "bacteriostats" or "bactericides." The result is less unpleasant odors produced from odor-causing bacteria. This being the case, the waste must be treated frequently (daily), as the development of a waste cone beneath the toilet riser will emanate odor.

The value of waste digestion by biological products is questionable. The problems encountered during pumping are the result of the nondegradable debris (cans, bottles, plastic containers, etc.), not the waste itself. This debris, once deposited in the vault, displaces volume and inhibits any benefit gained in reducing the cost of waste removal from the vault. Sample controls used in the study showed that organic material submerged in purified water breaks down unassisted (without the aid of additives) within 2 mo. The only advantage to biological decomposition is that when the waste is delivered to a treatment plant it reduces the shock load on the plant.

Although product handling was not a major focus in the study, questions still exist about the practical application of using *any* chemically and/or biologically based products (fig. 7). This is a concern, due to safety considerations, for employees who must handle the products and the public who may be using the facility following treatment. Although the concern may appear to be merely psychological, it does exist in the minds of the ecologically astute public, potential users, and experienced users of similar products.

Figure 7. Product treatment and handling.

Under actual field conditions the control of unwanted substances (i.e., chemicals, nondegradables, etc.) induced into the toilet vault by the public is impossible, to say the least. This problem could very well have occurred with any waste sample. However, determination of what substance (chemical or otherwise) affects what product was beyond the scope of this study. The likelihood of foreign substances contaminating vault waste is very real and this adds to the burden of evaluating the *practical* application of using any chemical or biological additive to control odor.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The conclusions reached in our study are that increasing the size of the vault vent and proper cleaning procedure still appear to be the best method of eliminating odors in the user compartment of vault toilets. It has been recognized that maintenance of a water level above the waste (without additives)—coupled with more frequent vault pumping—can be a major factor in reducing the intensity of vault odors. Though most manufacturers commented that their product performs best when water completely covers the surface of the waste mass, this is difficult and impractical to accomplish because of floating debris and a bridging effect from the toilet paper and inorganic material.

The ***practical*** application of using additives may have limited value due to the required treatment frequency (usually weekly for majority of biological additives). For effective treatment, where no water level exists, the products must be mixed into the waste. However, mixing vault waste results in intolerable odor production for days and finding volunteers for this type of task is difficult.

Recommendations

Recommended tips on vault toilet odor control:

Venting—

• Undersized vent pipes (the vent that exhausts odor out the vault through the roof and into the atmosphere) are one major cause of odor siphoning back into the toilet user compartment. The objective of venting in vault toilets is to keep air flowing ***DOWN*** the toilet seat opening and ***UP*** the vent. To accomplish this in vault toilets, the cross sectional area of the vent pipe must be equal to or larger than the cross sectional opening of the toilet seat opening.

Frequent Pumping—

• Frequent pumping is a requirement for vault toilet systems. Contrary to popular belief, vault toilet systems require maintenance. In an effort to reduce cost, field units in the past have gone to larger (usually deeper) vaults. The result is more capacity, less frequent pumping and more odor. The frequency of pumping should be determined by the smell senses—rather than visual senses. The minimum pumpout frequency should be once a season.

Vault Water Level—

• Maintaining a water layer reduces odor intensity. Providing a water layer over the waste will reduce the total surface area of the waste mass and thereby reduce the area available to produce odor. By recharging the vault with no less than ***10-in (depth) of clean water*** following pumping, new effluent discharged into the vault will have an opportunity to disperse rather than form a cone. Remember, pumping maintenance should also include hosing down the vault walls during pumping.

Surface Sealant—

• Sealing the concrete walls of the vault will also assist in odor reduction. The odors emitted from unsealed concrete surfaces above any treated waste is outside the influence of that waste and therefore independent of odors emanating from the sewage.

Cleaning—

• Eliminate the less obvious sources of odor. Look for odors emanating from cracks and crevices inside the user compartment, to include contact points between toilet riser and concrete floor slab. Wood, cinder block and concrete wall surfaces can also absorb and emit odors if improperly sealed.

Evaluating the merit of any biological or chemical product to eliminate odor should focus on the conditions at the time of evaluation. Factors such as toilet design, wind direction, temperature, humidity, volume of vault waste, amount of use etc., should be noted by the observer. Evaluation should be done repeatedly to fully assure the merit of the product. The evaluator should avoid premature conclusions based on several short visits to the site. Remember, odor is subjective and the public user often only distinguishes one of two conditions: "pleasant" or "unpleasant."

The cost of assisting with a manufacturer's attempt to prove his/her product's "applicability" should be incurred by the manufacturer or its distributor. Such costs should include any special costs associated with vault cleaning prior to treatment to assure interference by previous used additives or cleaning agents (specifically cleaning and deodorizing products) do not bias the results. If the product being evaluated is a chemical product—the manufacturer should provide documented evidence assuring the disposal of treated vault waste is acceptable to the local treatment plant or landfill. The manufacturer should also be willing to assume any post-treatment liability for repair of the vault resulting from prolonged use of his/her product. Some products are known to deteriorate the vault containers or surface sealants.

Based on field demonstrations, biological additives have shown practical application for eliminating odor in ***aerated*** vault toilet systems. Future studies will be considered for other applications, such as composting toilet systems.

At this time, SDTDC does not plan to expend additional funds to continue studying vault additives—to the extent already evaluated. However, specialists at the Center will continue to monitor changes in technology pertaining to the use of additives in vault toilets. Any significant developments will be conveyed to field personnel as they occur.

SUMMARY

In summary, the products that were evaluated did not perform satisfactorily in reducing obnoxious odors. Some products changed the odor (mostly those products that contained a fragrance), but the resulting odor was still not acceptable.

Because it is not practical to control the unwanted substances (chemicals, cleaning agents, nondegradables, etc.) induced into the toilet vault by the public, field testing of vault additives is difficult to evaluate. Many of the biological products are affected by other chemicals—such as those used for cleaning and disinfecting. Some chemical additives can cause chemical reactions when mixed with other chemicals, resulting in vault conditions far worst than anticipated.

There may be a product, other than the ones we tested, that are effective in reducing the obnoxious odors. We feel that the "burden of proof" for these products for practical application in vault toilets should be the manufacturers' responsibility. This would apply to *any* manufacturer who sells *any* product. The table that follows represents a summary of the biological and chemical product samples used in this study.

Table 1. Study summary, biological and chemical additives for vault toilets

Manufacturer	***Product Name***	***Type*** Biological (B) Chemical (C)	***Treatment*** Weekly (Wk) Monthly (Mo) Other (0th)	***Remarks*** (See NOTES) 1/	2/
Alco Products, Inc. 13126 Saticoy St. N. Hollywood, CA 91605 *(800) 274-6464*	"Vaultzyme" (w/fragrance)	B	Wk	7	Y
Applied Bio-Chemist, Inc. 5300 W. County Line Rd. Mequon, WI 53902 *(800) 558-5106*	"Septictrine" (w/fragrance)	B	Wk	2	Y
Bidall Maintenance Products 7821 N. Faulkner Rd.	"Enzymes 300"	B	Wk	1	Y
Milwaukee, WI 53224 *(800) 776-7039*	"Liquid Enzyme" (w/fragrance)	B	Wk	7	Y
Bio Cal *[Distributor]* 650 Ward Drive, Suite E Santa Barbara, CA 93111 *(805) 683-8851*	"Biozed"	B	Oth	7	N
Bio-cide International, Inc. 2845 Broce Dr.	"Odor-Con"	C	Oth	n/c	Y
Norman, OK 73070 *(405) 329-5556*	"Emulophagene"	C	Oth	n/a	Y
Century Products 6001 South Huson Tacoma, WA 98409 *(206) 473-4802*	"Always Fresh" (w/fragrance)	C	Oth	n/c	Y
Drummond American Corp. Des Plaines, IL *[No addr/phone available]*	"NIX" (w/fragrance)	B	Wk	n/c	Y
Earth Science Corp. P.O. Box 327 Wilsonville, OR 97070 *(503) 678-1216*	"Condor Digester Surfactant"	C	Oth	n/c	N
Enviro-zyme, Inc. Stormville Mtn. Rd. Stormville, NY 12582 *(914) 878-3667*	"Enviro-zyme O" (w/fragrance)	B	Wk	5	Y
Fifco International, Inc. Del Mar, CA *[Out of Business]*	"Bio-septic"	B	Mo	4	N
InnoVet, Inc. 141 N.W. 20th St. Boca Raton, FL 33431 *(407) 394-0621*	"InnoVet Odor Eliminator"	C	Wk	n/c	N

Medina Agric. Prod. P.O. Box 309 Hondo, TX 78861 *(512) 426-3011*	"d-part"	C	Wk	n/c	N
	"dp-5"	B	Mo	n/c	N
Merrick-Racicot, Inc. P.O. Box 891 Wilsonville, OR 97070 *(800) 752-0798*	"Holly's Sentry"	B	Oth	5	N
	"Sea-Zyme"	B	Oth	1	N
Misco Int'l Chem., Inc. P.O. Box 130 Wheeling, IL 60090 *(800) 231-0915*	"Bio-cycle"	B	Wk	1	Y
Munichem Corp. 850 Industrial Way Reno, NV 89531 *(800) 648-1153*	"Plac 100" (w/fragrance)	B	Wk	1	Y
NuTech Environmental Corp. 5350 N. Washington Street Denver, CO 80216 *(800) 321-8824*	"Pit Stop Odor Eliminator" (w/fragrance)	C	Oth	n/c	N
Nutri-Basics Co. P.O. Box 464 Highland, IL 62249 *(618) 654-4424*	"Bio-Ade"	C	Wk	n/c	N
Sorber Chemicals, Inc. P.O. Box 650 Holdrege, NE 68949 *(308) 995-2271*	"SCI-62"	C	Oth	n/c	Y
Tri Synergy, Inc. 10601-A Tierrasanta Blvd. San Diego, CA 92124 *(619) 747-6076*	"RM 41" (w/fragrance)	B	Mo	7	Y
	"DWT 360"	B	Mo	1	N
	"RM 41" (w/fragrance) "DWT 360"	B	Mo	2	Y
Vector Laboratories 388 McClurg Road Youngstown, OH 44512 *(800) 331-0347*	"Biograde X-7" (w/fragrance)	B	Wk	n/c	Y
	"Biograde X-7"	B	Wk	n/c	N

NOTES: 1/ "number" indicates what week hot dog first showed signs of digestion.
"n/c" indicates no change.
"n/a" indicates no hot dog sample available.

The week of digestion does not necessarily reflect the effectiveness of one product over another—the dosage per treatment also affects the rate of digestion; i.e., products requiring larger dosages (1 tablespoon) per monthly treatment can give the same end results as applying smaller dosages (1 teaspoon) per weekly treatment.

2/ "Y" indicates detectible difference in odor from control sample; however, detected odor was still unpleasant.
"N" indicates no detectible difference in odor from control sample.