PREPARATION 507

THE VALERIAN PREPARATION: CORRELATING SENSORY EXPERIENCE AND PHYSICOCHEMICAL PROPERTIES

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Biodynamics is an alternative farming system that, like organic agriculture, avoids the use of synthetic fertilizers and pesticides. Biodynamics goes further, however, in that it envisions the farm as a self-contained individuality able to provide for its own fertility from within (Steiner, 1993). To meet this goal, biodynamic farmers integrate diverse crops and livestock, return organic matter to the soil, and maintain wilderness areas (Koepf et al., 1976; Sattler and von Wistinghausen, 1992). In addition, biodynamic farmers use special preparations made from a variety of mineral, plant, and animal materials, ideally produced on the farm (von Wistinghausen et al., 2000).

In recent years, an annual conference has been convened to discuss the future of the biodynamic preparations in North America. The focus of the February 2009 meeting in Grass Valley, California, was the valerian preparation, which is made by aging juice pressed from the flowers of *Valeriana officinalis*. This liquid is diluted and then sprayed on manure and compost. According to Steiner (1993), who originally suggested the idea, when "diluted valerian juice is applied to the manure [or compost] in a very fine manner, it will stimulate the manure [or compost] to relate in the right way to the substance we call phosphorus."

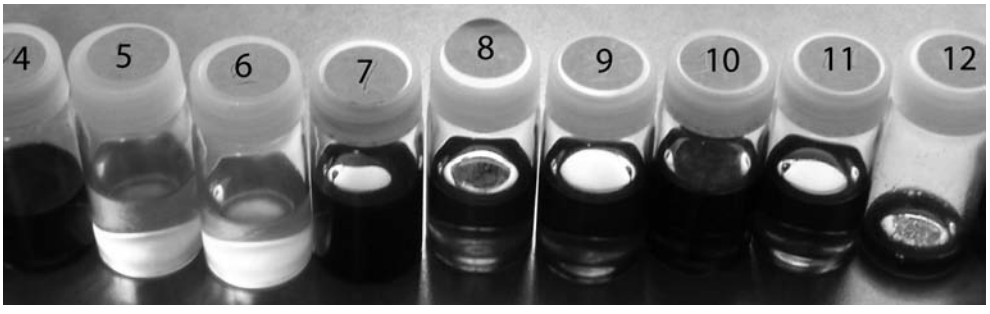
While this is an important claim to investigate, the objective of the research described here was more modest. Different specimens of valerian preparation can vary markedly in their smell and color. Brinton (1983) investigated how these appearances relate to various physicochemical properties of the preparation, including acidity (pH) and dissolved solids content, both of which are readily measured with inexpensive equipment. The valerian conference provided an opportunity to revisit this research. Whereas Brinton reported only his own sensory experiences, one goal of the present research was to collect and compare the experiences of many people. Sensory evaluation panels have been organized informally by preparation makers in Oregon and possibly other regional groups (W. Via, personal communication). In addition to presenting results from the valerian conference, I report here on a follow-up experiment conducted in the summer of 2009, in which fresh valerian juice was monitored during the first 40 days of storage.

METHODOLOGY

Twenty-five specimens of valerian preparation from around the U.S. and Canada, and of various ages, were transferred into identical 20 mL clear glass vials and randomly numbered. With the exception of specimens #12 and #25, for which very little liquid was available, each vial was filled approximately half full (see Figure 1, below). The acidity of the specimens (except #12 and #25, due to insufficient fluid) was measured with a portable pH meter (General PH-501), and the dissolved solids content was measured with a handheld refractometer (ATAC-1).

For the sensory evaluation panel, the 25 specimens were placed in numerical order around the perimeter of a long table. Twenty-nine individuals participated in the panel, ranging from novice to experienced preparation makers. As each specimen was identified only by its number, assigned in private by me, the participants did not know the origin of each specimen. The goal was to have each person evaluate each specimen at least once, and due to time constraints this had to be exactly once. Another constraint was that there was only one vial for each specimen, so the evaluation would have to be coordi-

Figure 1. Valerian specimens from the conference (see Table I for details). This photo can be viewed in color online at www.biodynamics.com/endelman-valerian.



nated. One possibility would be to have one to two people line up at each vial (25 specimens for 29 people), evaluate it, and then shift in unison to the next vial around the table. In such a design there would be 25 rounds, with each person evaluating one specimen in each round. The problem with this design is that one's experience of a specimen is very likely influenced by the specimens just prior to it. To average out this effect, it was desirable that each person evaluate the specimens in a randomized order while assigning at most two people to any one specimen in each round. Had the number of specimens and persons been equal at 25, a 25×25 Latin Square design would serve this purpose (Oehlert, 2000). Anticipating as many as 50 people might come to the conference, I created two 25×25 Latin Squares and then wound up using only four rows of the second square. In this way, every person had a unique, randomized evaluation order but at most two people were assigned to any one specimen in each round.

Participants were asked to rate each specimen on a 1–5 scale. The instructions were to assign a rating of 5 if one would definitely use the specimen, a 3 if one were unsure of its quality, or a 1 if one would definitely not use the specimen, with 2 and 4 for intermediate cases. There was also space on the evaluation form for participants to record details about the scent, color, or other qualities of each specimen. These comments were helpful to participants during our review of the specimens at the conference, but I did not use them in the analysis presented here. (The colors and smells in Table 1 were my own.) In each round of the sensory panel, participants evaluated their specimen and then stepped back from the table. When everyone had stepped back, I called out "next round" and the participants moved to their next specimen. The whole process took around 45 minutes.

RESULTS AND DISCUSSION

VALERIAN PREPARATION CONFERENCE

The 25 specimens studied at the conference are listed in Table 1 (next page), sorted by their average rating from the sensory evaluation panel. The average rating for the specimens ranged from a high of 4.7 (out of 5) to a low of 1.5. There was greater consensus among participants for the specimens at the high and low ends of this range. This can be seen from the column labeled "Variability," which reports the statistical entropy S on a 0–1 scale ($S = -\sum_k p_k \log_5 p_k$, where p_k is the proportion of participants who assigned a rating of k). An entropy of 0 means everyone assigned the same rating (low variability), while an entropy of 1 means the participants were evenly split between all five ratings (high variability). As an example, Specimen #4, which had the highest average rating, was rated a 5 by 21 people, a 4 by 6 people, and a 3 by 2 people, yielding an entropy of 0.46. Specimen #16, which had the highest entropy at 0.99, was rated a 1 by 5 people, a 2 by 6 people, a 3 by 4 people, a 4 by 7 people, and a 5 by 7 people.

Smell appears to have been the dominant sense used by participants in their judgment of the specimens (see Table 1). The specimens that I roughly characterized as sweet were also the most highly rated. There were also nuances to the sweet smells within this group that people most likely used in formulating their ratings. Near the bottom of the list were five specimens whose scent I described as marginal, which included a variety of "off" smells (such as wet hay) and one specimen with barely any scent. Specimens labeled sweet/marginal seemed to have the qualities of both categories, including two specimens (#6, #21) made from valerian species other than *V. officinalis*. Specimen #7 smelled foul, like manure.

Color was also considered by the participants, but secondarily to aroma. Both the highest (#4, #10) and lowest-ranked specimens (#7) were among the darkest, which I labeled "dark brown" in Table 1. These specimens can be seen in the photograph in Figure 1. Dark specimens with a red tinge were labeled "dark red-brown" (e.g., #9 and #11 in Figure 1), while those labeled "red-brown" (e.g., #8 in Figure 1) were even lighter and redder. Specimens #1, #5, and #6 had a gold color (see Figure 1) that was unfamiliar to most people at the conference. In our discussion afterward, it became clear that many people would have rated specimen #5 higher based only on its sweet scent but marked it down because of the color. All three gold specimens were brought from a farm where the flowers are covered with water, allowed to sit for two days, and then pressed through a paper coffee filter. This type of filtering apparently removes much of the pigment, but, as demonstrated by the case of specimen #5 (made in 2008), the development of a sweet aroma is still possible.

Brinton (1983) found that sweet-smelling samples of valerian preparation were acidic (pH 4–5), while foul-smelling ones were neutral to slightly alkaline. Measurements of pH at the valerian conference showed a similar relationship. Of the 23 specimens with enough fluid for a pH measurement, all 4 with an alkaline pH (7–9) had either marginal or foul odors. The development of acidity alone, however, does not appear sufficient to guarantee a high quality smell. Two acidic *V. officinalis* specimens from 2008 (#13, #16) had marginal qualities in their odor (and mediocre ratings). Among the acidic specimens, there was no relationship between pH and average rating (i.e., the more highly rated specimens did not tend to be more acidic).

Brinton (1983) also examined the relationship between odor and dissolved solids using several tech-

Table I. Valerian preparation specimens, sorted by average rating.

Specimen	Origin	Age	Avg. Rating (1–5)	Variability (0–1)	Odor	Color	pH	% solids	Other
4	CA	2006	4.7	0.46	sweet	dark brown	4.5	11.0	
10	CA	2003	4.7	0.45	sweet	dark brown	4.4	11.0	
8	NY	2007	4.6	0.47	sweet	red-brown	4.3	9.7	
9	CA	2001	4.5	0.48	sweet	dark red-brown	4.2	5.8	
19	CA	2007	4.5	0.51	sweet	red-brown	4.6	7.2	
18	CA	2001	4.4	0.59	sweet	dark red-brown	4.4	2.6	
2	CA	2008	4.3	0.63	sweet	dark brown	4.2	11.8	
14	CA	2007	4.3	0.59	sweet	dark brown	4.4	14.5	
23	CA	2008	4.1	0.75	sweet	dark brown	4.9	12.5	
24	OR	2008	4.0	0.78	sweet	dark brown	4.3	11.8	
11	Europe	1975	4.0	0.77	sweet	dark red-brown	3.9	3.8	
15	CA	1995	3.7	0.84	sweet	dark brown	4.2	9.0	10% sediment
22	ME	2008	3.6	0.90	sweet	dark brown	4.7	7.2	30% sediment
25	OR	2008	3.5	0.90	sweet	dark red-brown	---	---	
5	Canada	2008	3.4	0.92	sweet	gold	4.5	0.9	
13	WI	2008	3.2	0.90	sweet/marginal	dark brown	4.5	6.8	30% sediment
16	WI	2008	3.2	0.99	sweet/marginal	dark red-brown	4.5	8.2	30% sediment
6	Canada	2008	3.1	0.96	sweet/marginal	gold	3.9	0.9	*V. sitchensis*
21	UT	2008	3.0	0.92	sweet/marginal	brown	4.7	2.7	*V. occidentalis*
3	CA	2008	2.6	0.92	marginal	dark brown	8.2	2.4	
1	Canada	2005	2.4	0.92	marginal	pale gold	4.4	0.3	
17	---	---	2.1	0.78	marginal	dark brown	7.9	1.0	
20	CA	2007	1.9	0.74	marginal	dark brown	8.7	2.0	
12	OR	2006	1.9	0.76	marginal	dark brown	---	---	
7	---	---	1.5	0.57	foul	dark brown	8.0	3.0	

niques, noting that "samples having little dissolved material smell worse than those having high levels of dissolved matter." In the present study, all specimens with marginal or foul smells had less than 3.0% dissolved solids, while those with sweet smells tended to have a solids content above this level, up to 14.5% (see Table 1). There were, however, some specimens with a sweet smell and low dissolved solids (#5, #18). Among the specimens with either sweet or sweet/marginal scents, there was no relationship between dissolved solids and average rating (i.e., the more highly rated specimens did not tend to have more dissolved solids).

Since eight of the specimens were made by the same individual, ranging in age from 1995 to 2008, these were studied to look for any trends associated with aging (see Table 2, below). The oldest specimen had the lowest average rating, but otherwise there was no consistent relationship between rating and age. Similarly, even though the pH of the newest specimen was at the upper range of that for acidic specimens, overall the acidity showed no trend with age, nor was there a trend for dissolved solids. These data indicate that, under the right conditions, valerian preparation can be stored for many years with little change in aroma, acidity, or dissolved solids.

One of the conference participants brought dried valerian flowers, which when moistened and pressed yielded a dark brown liquid. The pH of this freshly pressed juice was 5.5, making it more alkaline then any of the sweet-smelling specimens but more acidic than the marginal/foul-smelling specimens. This fact suggested a picture of how the specimens had evolved over time: those specimens with a sweet aroma had undergone an acidifying fermentation, while those with marginal scents had evolved toward a more alkaline condition. To directly observe this process, in the summer of 2009 I monitored the evolution of fresh valerian juice during the first 40 days of storage.

TIME-COURSE EXPERIMENT

Valerian flowers were harvested at an early stage of development (along with some stem material) on the morning of June 12, 2009. As it had rained the night before and the morning was overcast, the flowers were quite moist. After sitting overnight, the picked flowers were wrapped in a T-shirt and squeezed with a book press. A single clear 20 mL glass vial was filled with this fluid, labeled A. To prepare more dilute specimens, the pressed flowers were steeped in water overnight, and on June 14 this extract was decanted into three 20 mL vials, labeled B_1, B_2, and B_3.

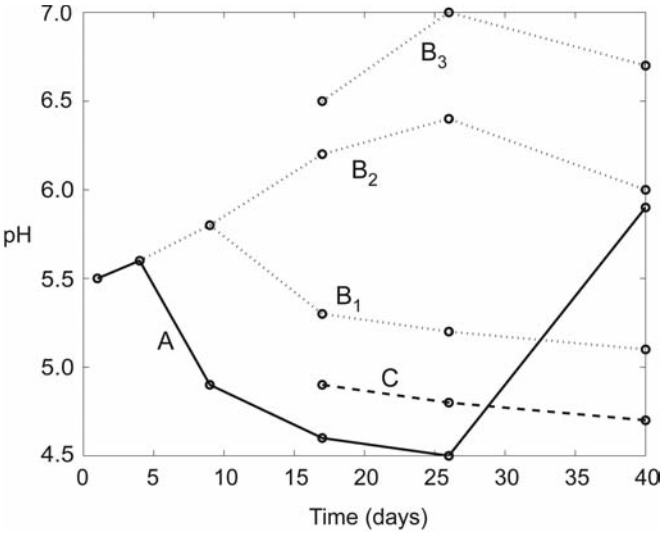
Baseline properties of the specimens were recorded on June 14. The pressed juice (A) was a light brown color, while that of the extracts (B) was even paler. Measurement of the dissolved solids content with a refractometer confirmed that specimen A was more concentrated than B_1, at 3.5% and 2.4% solids, respectively, both of which would be considered low compared with dissolved solids levels of the sweet-smelling specimens from the conference (see Table 1). After sitting for one day, a slight darkening of specimen A was apparent at the liquid surface, along with some sediment at the bottom. Both A and B_1 specimens had a pH of 5.5, the same as that recorded at the valerian conference for a much darker fresh juice pressed from remoistened flowers.

Vials were capped, but not sealed, and stored in closed boxes in a basement closet at 60–65°F. Figure 2 (next page) shows the evolution of pH during the first 40

Table 2. Eight valerian preparation specimens made by the same individual, sorted by age. All had a sweet odor.

Specimen	Age	Avg. Rating	Variability (0–1)	Color	pH	% solids	Other
15	1995	3.7	0.84	dark brown	4.2	9.0	
18	2001	4.4	0.59	dark red-brown	4.4	2.6	
9	2001	4.5	0.48	dark red-brown	4.2	5.8	2nd pressing
10	2003	4.7	0.45	dark brown	4.4	11.0	
4	2006	4.7	0.46	dark brown	4.5	11.0	
14	2007	4.3	0.59	dark brown	4.4	14.5	
19	2007	4.5	0.51	red-brown	4.6	7.2	2nd pressing
23	2008	4.1	0.75	dark brown	4.9	12.5	

Figure 2. The evolution of acidity (pH) immediately after pressing (see Table 3 for dissolved solids levels). Specimen A initially produced acid, but this trend reversed between days 26 and 40. Specimens B_1, B_2, and B_3 were the most dilute, having been made from a 24-hour extract of the same pressed flowers used in specimen A. The longer the B specimens were left undisturbed before beginning to take pH measurements, the more alkaline they became, possibly because of the mold that developed on the specimens. Specimen C was the most concentrated, and by day 40 it was the only one with a decidedly sweet aroma.

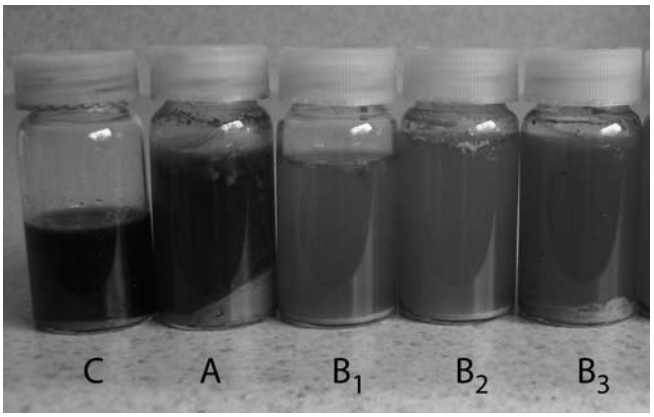


days of storage. Specimens A and B_1 were measured on the same schedule, after 4, 9, 17, 26, and 40 days, whereas specimen B_2 was left undisturbed until day 9, and specimen B_3 was left undisturbed until day 17.

Although all B specimens were from the same extract, the way in which they were handled appears to have influenced their development. Specimen B_1, which was mixed and exposed to air most frequently as part of the pH measurement, showed the least change over the course of the experiment. Its aroma remained marginal—quite "green" and sometimes slightly rank—while its pH first increased and then decreased slightly, remaining between 5 and 6 during the first 40 days. When specimen B_2 was first studied on day 9, it was indistinguishable from B_1, both in terms of aroma and acidity. By day 17, however, B2 had deteriorated relative to B_1, having lost acidity and developed a foul smell. Specimen B_3, first opened on day 17, was even more alkaline and foul-smelling than B_2. Although all three B specimens had some mold on the liquid surface, the film in B_3 was quite heavy, presumably because it had not been disturbed for 17 days.

The more concentrated specimen A initially fared better than the B specimens. After one week its pH had dropped to 4.9, and it smelled like it was developing in the right direction. This trend continued through day 26, but when I looked two weeks later, on day 40, specimen A had deteriorated. It had a heavy film of mold on the surface, very little aroma (but not foul), and the pH had jumped to 5.9. Figure 3 (above) is a photo of how the specimens looked on day 40. I did not decant the specimens during this experiment, so the question of how sediment may have affected fermentation was not addressed.

Figure 3. Valerian specimens on day 40 of the time-course experiment (see Table 3 for details). This photo can be viewed in color online at www.biodynamics.com/endelman-valerian.



On the far left of Figure 3 is specimen C, which was pressed a few days after the others, and in the same manner, but using flowers collected elsewhere (I was not there). It was given to me to observe beginning on day 17 of the experiment and from then on stored in the same manner as the other specimens. As might be expected from its dark brown color, it had more dissolved solids than specimen A (6.7%), and it had a strongly sweet smell. The aroma and acidity of specimen C continued to improve through the end of the experiment on day 40. Although initially taken from a bottle with some mold on the liquid surface, no additional mold appeared on specimen C out to day 40.

Table 3 (next page) shows how the dissolved solids changed over time and in relation to pH. All of the specimens lost dissolved solids during the experiment. The loss of acidity in specimen A between days 26 and 40 was associated with a decline in dissolved solids, from 2.4% down to 1.6%, the same level as that in the B specimens.

GENERAL DISCUSSION

Fermentation has been used for millennia to preserve food and drink. During fermentation, micro-organisms transform sugars into carbon dioxide and a variety of

Table 3. Results from the time-course experiment.

Days	A		B_1		B_2		B_3		C	
	% solids	pH	% solids	pH	% solids	pH	% solids	pH	% solids	pH
1	3.5	5.5	2.4	5.5						
9	2.8	4.9	1.7	5.8	1.9	5.8				
17	2.4	4.6	1.7	5.3	1.7	6.2	1.6	6.5	6.7	4.9
26	2.4	4.5	1.6	5.2	1.4	6.4	1.4	7.0	6.2	4.8
40	1.6	5.9	1.6	5.1	1.4	6.0	1.4	6.7	5.7	4.7

other substances, including alcohols and organic acids. Under the right conditions, ferments can remain stable for long periods of time. Alternatively, the products of fermentation can themselves become substrates for further metabolism, depending on the microbial ecology and biochemistry of the sample (White, 2000). Surface molds can also influence the direction of fermentation in complex ways. These basic principles of fermentation are helpful in understanding the results of the research described here, even in the absence of any molecular or microbiological information about valerian juice.

All of the specimens in the time-course experiment showed a decline in soluble solids during the first 40 days of storage. This result by itself does not indicate what kind of fermentation occurred because sugars, acids, and alcohols are all soluble solids detected by refractometry. However, when organic carbon is converted to carbon dioxide and lost from solution, which is a characteristic of the metabolism of both fermentative and mold organisms, this reduces the soluble solids. Thus, monitoring the soluble solids provides information about the overall level of metabolism. I would expect stable preparations to maintain a fairly constant level of dissolved solids over time.

The pH data provide clues about the kinds of microbial processes responsible for the loss of soluble solids. In specimen A, an acid-producing fermentation was dominant during the first few weeks (see Figure 2). Additional chemical tests could have revealed precisely which organic acids were produced (e.g., acetic acid, lactic acid). Specimen C also underwent an acidic fermentation, which appeared to be stabilizing at the end of the experiment. In contrast, specimen A destabilized between days 26 and 40. The rise in pH and further loss of soluble solids in specimen A suggest that the organic acids produced by the initial fermentation were subsequently consumed by other organisms, including possibly the mold I discovered on day 40. In the case of specimens B_2 and B_3, little to no acidic fermentation occurred before organisms began consuming the organic acids and sugars that were present in the fresh valerian juice (which had a pH of 5.5).

An important question that emerges from this research is why some acidic valerian preparations stabilize while others shift to acid-consuming processes. The available evidence suggests that starting with a sufficiently concentrated juice is important, as is removing any mold that develops on the surface. Brinton (1983) concluded that "the method of production is not so critical so long as the solids content is not overly diluted by additions of water.... Storage life is restricted for samples which, though initially good, have low solids content." The case of specimen A shows that it is not just the deliberate addition of water that is of concern when striving for a sufficiently concentrated initial solution. The flowers used for specimen A were not diluted with any water, but they were picked at an early stage of development, there was heavy dew on them, and they included some stem material, all of which tended to dilute the pressed juice.

Although starting with concentrated juice is undoubtedly good advice, there seem to be other factors at work here that are poorly understood. Specimens #3 and #20 from the conference, made in 2008 and 2007, respectively, were both dark brown, indicating they had at one time been highly concentrated (although some darkening can occur during storage). However, at the conference these had less than 3% dissolved solids, were alkaline, and did not smell sweet. They were brought by the same individual, who suggested he might have let the flowers "sweat" too much before pressing. As excessive heat could denature enzymes and/or kill microorganisms associated with the blossoms that help stabilize the preparation, this is a plausible hypothesis that warrants further research. The case of specimen #5, which had a golden color because of paper-filtering, is also curious. It was acidic and smelled sweet despite the fact that it contained only 0.9% solids at the conference. Although its initial concentration was unknown, based on the other specimens I would have expected spoiling to occur by the time the soluble solids had decreased to that level.

The sensory evaluation panel was a fun and informative exercise to hold at the conference. I have presented the results from the perspective of comparing the valerian specimens, but the panel also provided information about

the humans involved. In studying these data, I noticed that certain participants stood out as having assigned markedly different patterns of ratings compared with the rest of the group. I did not follow up with these people to investigate whether their biographies (e.g., experience, sensory capabilities) explain these differences, but that could be an interesting direction for future research involving sensory panels. Another possibility would be to analyze the written comments of the participants instead of relying solely on a numerical rating. This would allow for a much richer picture of the diversity of human experience than the statistical entropy used here.

SUMMARY

Two studies were conducted to investigate the relationship between human sensory experience of the valerian preparation and its physicochemical properties. In the first experiment, a panel of 29 participants evaluated 25 specimens, for which the pH and dissolved solids were also measured. Highly rated specimens had a sweet aroma, pH in the range 4–5, and generally more than 5% dissolved solids. Specimens with marginal odors were alkaline (pH > 7) and contained less than 3% dissolved solids. Color was not correlated with aroma, acidity, or dissolved solids. To better understand the genesis of these differences, a second experiment was conducted in which fresh valerian extracts were monitored during the first 40 days of storage. From an initial pH of 5.5, the more concentrated specimens became more acidic, while the more dilute ones became more alkaline or showed little change in pH. These trends were not unidirectional, as some specimens changed course during the 40 days. Although starting with a dark, concentrated juice appears to be sound advice for creating a high quality preparation, more research is needed to understand why some specimens stabilize as acidic ferments while others continue to lose soluble solids, turn alkaline, and develop marginal odors.

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