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# Product Review: Yeast Nutrients

What to Feed Your Fermentations

by Curtis Phillips

**Stripped down to** its essentials, making wine is extremely simple: one simply has to add yeast to grape juice or must and then wait. Anything else can be considered as finesse.

As with all things, however, it's not really that simple. The problem is that grapes aren't really balanced nutrition for yeast. They are a seed delivery system. There is no evolutionary pressure for the vine to produce grapes that are perfect food for wine yeast (*Saccharomyces cerevisiae*).

Grapes are really candy for birds. The vine succeeds if it can produce grapes that are unappetizing when the seeds are too immature to germinate but irresistible when the seeds are finally mature enough to germinate. The nutritional needs of *S. cerevisiae* are completely out of this cycle of life.

Yeast, which are vital to fermentation, are living organisms, unicellular fungi that need carbon, nitrogen, vitamins, and minerals for growth and reproduction.

Because grapes are not nutritionally balanced for yeast, most musts need additional macronutrients like nitrogen and phosphate, and micronutrients like vitamins, especially thiamine. Balance is the key for both the macronutrients and the micronutrients. If there's too little yeast assimilable nitrogen (YAN), the stressed out yeast are likely to produce stinky sulfur compounds. Too much YAN and they're likely to have diminished fruity aromas. Too much YAN will also cause the yeast to excrete urea, thereby resulting in elevated ethyl-carbamate levels.

The nutritional composition for a particular must can vary by more than an order of magnitude (literally: 10 times as much). For example, in a paper published in 1998, **Purdue** professor **Christian Butzke** found that the YAN varied from 40 to 559 mg/L (*AJEV* 49:2, 220-224). Similarly, **UC Davis** professor **Linda Bisson**, in a 1999 paper, noted that nitrogen and phosphate deficiencies were the "two macronutrients most frequently implicated as causes of stuck fermentations" (*AJEV* 50:1, 107-119).

## Use of Yeast Nutrients

The use of yeast nutrients during winemaking can be divided into four broad categories. Different yeast nutrients are needed: (1) in the beginning, during the aerobic growth phase at the start of fermentation, (2) in the middle, during the anaerobic alcoholic fermentation, (3) as a prophylaxis at the end, to help sluggish, prevent stuck fermentations, and restart fermentations, and (4) for high Brix fermentations.

Nutrients added at the start of fermentation should not contain nitrogen. Wine yeast, *Saccharomyces cerevisiae*, are just one of several microbes that would like to eat the sugar in grapes.

Nutrients added during alcoholic fermentation should contain ammonium and amino nitrogen, phosphate, vitamins, including thiamine and chelated mineral micronutrients.

Complex yeast nutrients often contain autolyzed yeast cells (dead yeast cells that have been treated so that their cell walls have ruptured).

Nutrients added at the end of fermentation should not contain nitrogen but should contain polysaccharides, either in the form of yeast cell walls (AKA yeast hulls) or granulated cellulose. At high ethanol levels, yeast lose the ability to ingest ammonium ions. This is why it's really important to make any nitrogen additions before the fermentation is past the halfway point.

The polysaccharides absorb some of the toxins generated by the yeast during fermentation. Certain sterols and unsaturated fatty acids found in yeast hulls increase the yeast cells' ability to endure higher ethanol concentrations.

High Brix must can cause problems simply due to the higher concentration of sugar. In addition, since the sugar is fermented to ethanol, alcohol toxicity toward the end of fermentation can cause the yeast to die before all the sugar is consumed.

**Yeast Additions**

Ten years ago, the U.S. wine industry standard yeast nutrient addition was 2 lbs/1,000 gallons of DAP. As noted above, Butzke and others found that the nitrogen content of grapes can vary across more than an order of magnitude. This makes a single dosing rate completely inadequate.

These days one really ought to measure the YAN of the must and figure out the nutrient addition from there. I generally shoot for a target YAN of 250 ppm (or 250 mg/L if you prefer). In high sugar situations above 25 Brix, this can be pushed up to 350 ppm.

Below are some examples I've taken from my cellar notes for various vintages over the past 15 years or so. Please note that the nitrogen content of each complex yeast nutrient (CYN) can differ quite a bit from brand to brand. The CYN used for these examples contained about eight percent nitrogen. The nitrogen content of DAP is about 22 percent.

Unless stated otherwise, all additions should be broken down into several smaller additions. Usually, three doses are used. The first at inoculation, the second when the fermentation enters its active phase, and the last when the fermentation has consumed half of the available sugar. For brevity, all additions are assumed to be in pounds per thousand gallons.

**Syrah**

(Brix=27, pH=3.8, TA=5.5 g/L, YAN=160 mg/L)

**Total Addition:** 5 lb / 1,000 gal complex yeast nutrient (CYN) + 5.5 lb / 1,000 gal DAP

Syrah is prone to shrivel and can quickly get to very high sugar levels if the water is turned off too early in a warm climate. Aside from yeast nutrients this must will obviously need a significant acid addition as well. The 160 mg per liter YAN needs to be boosted significantly while the high sugar and high pH mean that there is a pretty good likelihood that the fermentation will stick due to ethanol toxicity. Complicating this is the fact that the high sugar will also slow down fermentation and possibly allow lactic acid bacteria (LAB) to get established before the yeast can dominate the fermentation.

Just considering the YAN, this fermentation needs a lot of nitrogen. With the high Brix of this must, it is critical to spread the additions over several doses. At inoculation, I would add two pounds (per thousand gallons) of a CYN and another two pounds of DAP. If one were to add additional vitamins, this would be the time. The next addition should be made once the yeast get going. This addition should be one and a half pounds of CYN and two pounds of DAP. Once the Brix is below 12 to 15 or so, the last addition of a pound per thousand gallons of a complex nutrient should be made.

**Merlot**

(Brix=24.5, pH=3.45, TA=8.5, YAN=120 mg/L)

**Total Addition:** 5 lb / 1,000 gal CYN + 5 lb / 1,000 gal DAP

This Merlot is short on nitrogen, but otherwise looks pretty good. It's likely that one would just have to add nitrogen. I would still would like to make sure that the must had enough vitamins and micronutrients so I would probably lean toward adding three pounds of a CYN and a pound of DAP at inoculation. The next addition should be two pounds of CYN and three pounds of DAP. The mid-point addition should then be a pound each of a CYN and DAP.

**Pinot Noir**

(Brix=22.5, pH=3.3, TA=6.9 g/L, YAN=200 mg/L)

**Total Addition:** 3 lb / 1,000 gal CYN and 0.75 lb / 1,000 gal DAP

This Pinot Noir looks like it needs a little nitrogen--say about two pounds of a CYN at inoculation and another pound of CYN when the sugars drop to between 12 and 15 Brix. One could argue that it could use a half to three-quarters of a pound of DAP at the initial addition, but I would rather be a bit heavy handed in measuring the complex nutrient for this wine, unless I was using a yeast with high nitrogen requirements like BM45 or ZRB, in which case I would add DAP. Of course, all bets are off if I smell and H2S in the fermentation. In that case, I'd be adding a quarter pound of DAP per thousand gallons per day and aerating the fermentation.

**Sauvignon Blanc**

(Brix=21.5, pH=3.2, TA=7.65 g/L, YAN=260 mg/L)

**Total Addition:** Use a "starter" nutrient that does not contain DAP

This Sauvignon Blanc has plenty of nitrogen so I wouldn't add either a complex nutrient nor DAP to this must unless I wanted to use a yeast with a high nitrogen requirement like BA11, VL3 or W15. In any case, it would probably be prudent to add one of the "starter" nutrients or vitamin blends that do not contain any DAP to make sure the yeast had enough micronutrients.

**Types of Yeast Nutrients**

Yeast nutrients come in several different forms, including inorganic nitrogen (ammonium salts), organic nitrogen (amino acids), yeast extracts and autolyzed yeast, micronutrient blends of vitamins and minerals, and complex yeast nutrients that are a combination of some or all of these. Complex yeast nutrients can also include non-nutritive ingredients like yeast hulls, cellulose, fining agents, like bentonite, and sodium caseinate and tannin.

**Inorganic Nitrogen**

Yeast can readily assimilate inorganic nitrogen in the form of dissolved ammonium salts. The fact that fermentations frequently need additional phosphate as well as nitrogen has made di-ammonium phosphate (DAP) the inorganic nitrogen source of choice for the U.S. wine industry. Outside of the U.S., much cheaper di-ammonium sulfate (DAS) salts, a common fertilizer, often are used as a nitrogen source. Food-grade and FDA-approved, sources of DAS exist, but U.S. winemakers should be aware that DAS is not currently listed on the **TTB** list of materials authorized for the treatment of wine and juice (Title 27 CFR 24.246).

A diet of sugar and DAP isn't really a balanced diet, even for yeast. It's kind of the yeast equivalent of gorging on candy. The yeast live so fast that their cell membranes get flabby, and they die an early death pickled by acid (H+ ion accumulation) and ethanol.

**Organic Nitrogen**

"Organic nitrogen" really means amino acids. Most commonly amino acids used in yeast nutrients are from yeast in the form of yeast extracts or autolyzed yeast. Ideally, one would really like to know the exact composition since some amino acids like proline cannot be used by yeast under anaerobic conditions.

**Nitrogen Blends**

Nitrogen blends are simply a combination of DAP and amino acids. Since DAP is much less expensive, this usually means that any such blend is predominantly DAP. Ideally, one would really like to know the exact ratio between the two as well as the composition of the amino acids.

**Yeast Extracts**

True yeast extracts, as opposed to autolyzed yeast, are relatively uncommon as yeast nutrients. This has more to do with the idiosyncrasies of European regulators than anything else. The concern seems to be that if yeast extract was allowed as a nutrient, unscrupulous producers might add yeast extracts to finished wine to improve the mouthfeel. This could allow producers from "lesser" wine regions to produce better tasting wine, and one mustn't allow that.

Sarcasm aside, this is probably a genuine concern, for European bureaucrats, that is. Unfortunately, since most yeast nutrients are designed in Europe, this means that most yeast nutrients contain autolyzed yeast (see below) rather than yeast extracts. The American-designed Superfood is a notable exception.

**Autolyzed Yeast**

As noted above, autolyzed yeast are simply dead yeast cells that have been treated so that their cell walls have ruptured. Although yeast hulls do have fermentation benefits of their own (see below), it's the yeast extracts inside that matter nutritionally.

Not all yeast are autolyzed equally.

Partially autolyzing yeast is relatively easy: heat them at a particular pH and at least some of the yeast cells will burst and spill their guts. The problem is determining how many have done so. It is not recommended that winemakers rely upon partially autolyzed yeast to provide much nutrition. As any winemaker that has produced a *sur lie* Chardonnay should know, it takes many months for yeast to undergo autolysis in wine. That's why we leave Chardonnay on their lees for five to nine months.

Getting all the cells to autolyze takes a bit more effort. Fully autolyzed yeast are widely available as food additives, but these have been intentionally designed to maximize their meaty, umami flavors and therefore probably would have negative sensory impacts on most wines.

**Micronutrients: Vitamins and Minerals**

Most of the micronutrients used in yeast nutrients come from the dead yeast used to make the nutrients. As winemaking consultant and scientific director of **The Vinotec Group**, **Lisa Van de Water**, noted, "If you are making a yeast nutrient, you grow up a tank full on nice healthy yeasts. You put the yeast cells through heating procedures, some short and not very effective, some longer and much more effective but also more expensive (which explains at least some of the wide differences in ingredient prices). You use the yeast themselves to feed other yeasts. So we don't really know every compound that is in it. We just know that yeasts want these ingredients, or they wouldn't have taken them up into their cells."

The key vitamins for fermentation, Van de Water noted, "Supplement those naturally occurring in the yeast cell, include thiamine, calcium pantothenate, niacin, myo-inositol, pyridoxine (B6) and biotin. The percentages of these are fiercely proprietary, but new vitamin mixtures include a lot of pantothenate because of **Charles Edwards**' work on the key role of pantothenate in sulfide prevention."

**Complex Yeast Nutrients**

Almost all complex yeast nutrients are a blend of autolyzed yeast and DAP, with the addition of varying concentrations of minerals and vitamins accordingly, but most of these are really from the yeast extracts and autolyzed yeast and not separative additives.

**Yeast Hulls and Other Non-nutrient Additives**

Yeast hulls aid fermentation, but they aren't really a nutritional source for the yeast. Yeast hulls are primarily composed of polysaccharides with ß-(1-3, glucan being the most prevalent. More importantly, yeast hulls are a source of sterols for the yeast. They don't consume sterols for energy but rather use them to shore up their cell walls. This is crucial for ethanol tolerance. Yeast can make sterols on their own but only under aerobic conditions.

Besides sterols, yeast hulls are known to absorb some of the yeast autotoxins, that are toxic to the yeast, produced during fermentation. This makes yeast hulls a particularly useful additive when dealing with sluggish or stuck fermentations.

The TTB does regulate the total amount of yeast hulls that can be added. The current limit is three pounds per thousand gallons. This limit seems to be on the low side since one can hit this limit just adding complex nutrients. I'd like to see some winery petition the TTB to raise this limit to six or nine pounds per thousand gallons to give us all some leeway to deal with problem fermentations. It's interesting to note that as a food additive, FDA regulations would permit up to 400 pounds of "Brewer's Yeast" per thousand gallons of wine since dead yeast are "generally recognized as safe" (GRAS). One would hope that it wouldn't be too difficult to convince the TTB to raise the limit a bit.

Inert or inactive yeast, unless autolyzed, are just dead yeast cells. One could probably assume that at most they were partially autolyzed when killed, but most of the yeast extractives won't be available to the fermentation in a timely fashion.

Other non-nutritious components of yeast nutrients are purified granulated cellulose, bentonite, caseinate salts and tannin. Cellulose is a polysaccharide like those found in yeast hulls. It is added to yeast nutrients to perform a similar function of absorbing compounds toxic to yeast. Cellulose does not provide the sterols that yeast hulls do. Bentonite and caseinate salts are fining agents, but hydrolyzed caseinate is used as a protein source for the yeast. **UC Davis** postdoctoral fellow **Kathryn Weiss** and professor Linda Bisson have found that while juice fined with bentonite resulted in slight reductions in the maximum fermentation rate, this effect was not seen if the bentonite were added during fermentation (*AJEV* 53:1, 28-36). One would expect a similar result from caseinate salts. Tannin, of course, has important organoleptic qualities, but isn't considered a yeast nutrient.

**Oxygen: The Free Nutrient**

Yeast are simple things really; without oxygen they produce ethanol. If they have access to oxygen, they don't bother wasting their energy on ethanol and instead make things like cell walls and new yeast cells. In addition, if they have oxygen, yeast can use nitrogen sources like proline that they can't use while fermenting. To this end, aerating the must is sometimes the best "nutrient addition" one can make.

**When to Use Which Nutrients**

The timing of yeast nutrition is fairly important. Nitrogen, especially inorganic nitrogen, should be added after the fermentation gets established, but before it proceeds too far. Vitamins, minerals and yeast hulls can be added earlier. Oxygen and yeast hulls are good things to add when the initial sugars are high and when fermentations are sluggish.

**How to Buy, What to Choose**

Most wineries will probably need a combination of all of the above yeast nutritional types. Both yeast hulls and DAP are relatively inexpensive and store well. Wineries should always overstock these in preparation for harvest. The cost of carrying over some from year to year is trivial compared to the potential cost of not being able to properly feed fermentations. In a similar vein, it is a good idea to stock "too much" of your favorite complex yeast nutrient.

Deciding which complex yeast nutrient to use is a bit problematic because the actual composition information is frequently not available. Finding the right one may take a bit of legwork and experimentation. Don't assume that they are all equivalent. Quite often the cheaper product is cheaper for a reason, frequently because the yeast are only partially autolyzed or even not autolyzed at all. As we noted above, un-autolyzed yeast won't surrender their nutrients fast enough to do any good for the fermentation. By the same token, the most expensive nutrient isn't necessarily the best. At least one product on the market appears to be nothing more than DAP sold at a significant markup. Suspect something if your vendor won't provide a detailed description as to the nutrients' contents.

**Conclusion**

The most important part of yeast nutrition is knowing what the yeast assimable nitrogen (YAN) is before you start throwing food at the yeast. Beyond this, one needs to feed the yeast a balanced diet. It does no good, however, if the nutrition is locked up in dead yeast cells since they won't autolyze quickly enough to feed the living ones.

**Sidebars:**

**Improper yeast nutrition is key to many wine problems, including:**

• Stuck fermentations

• Ethyl carbamate formation

• Hydrogen sulfide production

• In-bottle development of reduced thiol compounds

**Take aways**

• Determine the YAN content of every fermentation and adjust it accordingly

• Feed your yeasts a balanced diet

• Don't rely upon in-situ yeast autolysis to make nutrients available for the living yeast. Use either fully autolyzed yeast or yeast extracts.