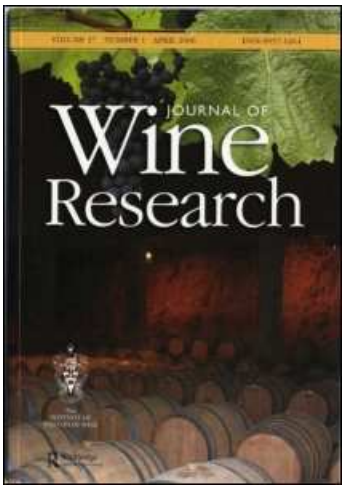

Journal of Wine Research
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713436778

Difference Testing of Merlot Produced from Biodynamically and Organically Grown Wine Grapes

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Online Publication Date: 01 July 2009

To cite this Article Ross, Carolyn F., Weller, Karen M., Blue, Robert B. and Reganold, John P.(2009)'Difference Testing of Merlot Produced from Biodynamically and Organically Grown Wine Grapes',Journal of Wine Research,20:2,85 — 94
To link to this Article: DOI: 10.1080/09571260903169423
URL: http://dx.doi.org/10.1080/09571260903169423

Journal of Wine Research, 2009, Vol. 20, No. 2, pp. 85–94

Routledge
Taylor & Francis Group

Difference Testing of Merlot Produced from Biodynamically and Organically Grown Wine Grapes

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Original manuscript received, 17 August 2008

Revised manuscript received, 28 April 2009

ABSTRACT *The objective of this study was to determine if perceptible sensory differences existed between biodynamically and organically grown Merlot wines. Wine grapes were raised biodynamically or organically on a commercial vineyard with wines produced from 2001 to 2004. Sensory difference testing was performed to evaluate possible differences between the two wines within each vintage. Results of the triangle tests only showed a notable difference ($p < 0.1$) between the 2004 biodynamically and organically grown wines. Results of the directional paired difference test showed that the 2003 biodynamically grown wine was higher in musty/earthy aroma ($p < 0.05$) and bitterness ($p < 0.1$). However, the 2003 organically grown wine was preferred ($p < 0.1$). The 2004 organically grown wine was higher in musty/earthy aroma and flavor ($p < 0.05$), astringency and bitterness ($p < 0.1$), and had a longer finish ($p < 0.05$) compared to the same vintage biodynamically grown wine. Results indicate perceptible sensory differences between the 2003 and 2004 biodynamically and organically grown wines.*

Introduction

Currently, wines that are commercially available include not only wines produced from conventionally farmed vineyards but also wines that are produced from organically and biodynamically farmed vineyards (also called biodynamically and organically grown wines). Organic farming virtually excludes the use of synthetic fertilizers and pesticides, relying instead on crop rotations, green manures, compost, natural fertilizers and pesticides, biological pest controls, mechanical cultivation, and modern technologies to build soil quality, to supply plant nutrients, and to control pests (Reganold, 2004). A biodynamic farm is similar to an organic farm, but in biodynamic farming, several unique agricultural methods are also employed, including field, crop, and

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ISSN 0957-1264 print/ISSN 1469-9672 online/09/020085-10
DOI: 10.1080/09571260903169423

compost amendments, called preparations, and often usage of an astrological calendar to determine times of planting and harvesting (Koepf *et al.*, 1976).

Wines produced from both biodynamically and organically grown grapes have received increasing attention from the wine industry in recent years with many notable wine grape growers, particularly in France, Chile, and the United States, converting to either biodynamic or organic practices (Walker, 2003; Robin, 2006; Nigro, 2007). About 500 hectares of vineyards were certified biodynamic in the United States in 2003, with many other wine grape growers experimenting with biodynamic practices (Reeve *et al.*, 2005). Overall organic grape production, including wine grapes, is also on the increase, particularly in California, Oregon, and Washington, where pest and disease pressures are low. In 2005, certified organic grapes (all) were grown on 14,315 acres in California alone (Klonsky and Richter, 2007) and accounted for 2.43% of total US grape acreage in 2005 (Economic Research Service, 2008).

The most controversial aspect of biodynamic farming is the use of the unique biodynamic preparations. Research of the preparations shows that they may benefit or have no effect on soil quality and crop quality across different crop production systems (Carpenter-Boggs *et al.*, 2000; Koepf, 1993; Mäder *et al.*, 2002; Reganold, 1995). Few of these studies have been done with wine grape production systems. In one example with replicated wine grape plots either treated or untreated with the biodynamic preparations, Bourguignon and Gabucci (2000) found no differences in the surface soil but significantly more macro- and micronutrients and microbial activity in the subsoil of the biodynamically treated plots.

In another more detailed study measuring the impact of biodynamic preparations on soil and wine grape quality, Reeve *et al.* (2005) showed no significant differences in soil quality between the biodynamic and organic treatments during the six-year course of the study. Indicators of wine grape quality such as nutrient status of leaf tissue, clusters per vine, yield per vine, and cluster and berry weights also showed no significant differences between the two treatments. However, the ratio of yield to pruning weight was consistently and significantly lower in the biodynamic treatment, indicating that the biodynamic treatment had better vine balance. With regard to berry chemistry, biodynamically grown wine grapes had significantly higher Brix, total phenols, and total anthocyanins in the last harvest year.

While the viticultural effects of biodynamic practices on wine grapes have been investigated, the general effect of these practices on the final quality of the wine has only been reported in one article in the popular press (Reilly, 2004). In this blind taste test, ten wines were presented in pairs, one biodynamic and one conventional. The wine pairs were matched by proximity of vineyard sites, price range of wine and vintage. The seven tasters, all of whom were professionally familiar with wines, were asked to evaluate the two wines in blind sensory tests and determine which wine was of higher quality. Out of the ten pairs of wines, eight of the biodynamically grown wines were judged superior to their conventionally grown counterparts, only one of the conventionally grown wines was judged to be superior to its biodynamic counterpart, and wines in one pair tied. While this taste test did give an indication of the potential differences between wines, it was not published in a peer-reviewed journal and it did not examine the distinct effect of the preparations as it compared wines produced from biodynamic and conventional systems.

No scientific study to our knowledge has tested the use of the biodynamic preparations on the final wine product by comparing biodynamically grown wines with organically grown wines. Thus, the purpose of this study was to test the hypothesis

that perceptible sensory differences existed between wines produced from Merlot grapes grown under biodynamic versus organic cultural conditions, where the only management difference was the addition of the preparations to the biodynamic treatment. Specifically, the null hypothesis corresponded to no differences between treatment samples, while the alternative hypothesis corresponded to perceptible differences between treatment samples. The current study represents the sensory evaluation work on wines from four vintages prepared from wine grapes raised in the same study as described by Reeve *et al*. (2005).

Materials and Methods

Experimental Site and Management

We began a long-term replicated field experiment in 1996 comparing biodynamic and organic wine grape production on a commercial vineyard in Mendocino County, California. The study area was part of 60 ha of biodynamic vineyards on a diversified 170 ha certified biodynamic farm called McNab Ranch, near Ukiah, California, which started its transition from organic to biodynamic certification in 1996 and became fully certified biodynamic (Demeter, Junction City, OR) in 1997. The experimental area was 4.9 ha, part of a commercial vineyard block (*Vitis vinifera* L. cv. Merlot, grafted onto 5C rootstock), and consisted of two treatments, biodynamic and organic (the control), each replicated four times in a randomized, complete block design. All soil and vine management practices were the same in all plots throughout the experiment, except that the biodynamic preparations (500, 501, and barrel compost spray) were only applied to the biodynamic plots, as described by Reeve *et al*. (2005).

Wines

Wines were made at Fetzer Vineyards using standard vinification procedures, except for aging the wine in oak, as discussed below. Grapes were hand-harvested at commercial maturity, hand sorted and destemmed using a Delta destemmer (Vaslin Bucher, Chalonnes sur Loire, France) with the rollers half open, keeping the lots separate.

Each treatment was pressed in a Marzola basket press (S-50: Logrono, Spain) and transferred to seven-year-old neutral barrels open top (one head removed) for fermentation. Using manufacturers' instructions, fermentation was conducted using *Saccharomyces cerevisiae* (Lalvin ICV D80 yeast; Lallemand Inc., France) at a rate of 120 mg/L. The caps were punched down initially every four hours for 48 hours, every six hours for the next 48 hours, and finally every eight hours for the final 48 hours. Following completion of fermentation (six days), the lots were pressed and the wines were settled for two days and racked off the gross lees into six 19-L glass carboys. The wines were inoculated with freeze-dried malolactic culture (1.5 g/250 L); Chr. Hansen, Denmark) for secondary fermentation.

On completion of malolactic fermentation, the experimental groups in the six 19-L glass carboys were racked and consolidated into five 19-L glass carboys and 30 mg/L sulfur dioxide was added to each. Following 45 days of storage, the biodynamically and organically grown wines were racked into four 19-L glass carboys per experimental group. Unlike commercial red wines, there was no contact with oak and little oxidative action on the wines. Just prior to bottling, the four glass carboys of each type were

combined into a single biodynamic lot and a single organic lot. The wines were then evaluated for percent alcohol, residual sugar, volatile acidity, total acid, pH, free SO_2 and malic acid using standard protocols (Iland *et al.*, 2004). The wines were bottled and wine yield was 626 to 668 L/1000 kg grapes. Wines of four vintages, 2001 through 2004, were used for sensory evaluation.

Materials

Unsalted-top saltine crackers were purchased at a local grocery in Pullman, WA. Deionized water was filtered over a Milli-Q Reagent Water System (Millipore, Bedford, MA) containing carbon, deionizing, and trace organic scavenger filters.

Sensory Evaluation

The sensory panel for triangle testing was conducted using 48 panelists (2001 and 2002) or 72 panelists (2003 and 2004). For all panels, panelists ranged in age from 21 to 76 and from the demographic questionnaire, panelists consumed wine at least once per week. Panelists were recruited from the Washington State University community. A minimum amount of information on the nature of the study was provided in order to reduce potential bias. All test sessions were conducted in the sensory laboratory equipped with eight individual sensory booths, under red lights to mask possible color differences. The computer software, Compusense®*five* software (release 4.6, Compusense Inc., Guelph, ON), was used to gather sensory data. All wine samples were presented in random order in a balanced block design. Twenty-five ml. aliquots of red wine were served at room temperature in ISO/INAO wine glasses, with glasses covered with a small petri dish. Each panelist was provided with deionized filtered water and unsalted crackers for cleansing the palate.

Initially, four flights of triangle tests with 48 panelists (one flight per vintage) were carried out to determine if there were sensory differences among the four vintages of organically and biodynamically grown wine. For the 2003 and 2004 vintages, another triangle test was conducted using an additional 24 panelists. Specifically, the triangle tests were conducted over three days. On Day 1, panelists were presented with two flights, the 2001 and 2002 vintages. On Day 2, panelists were presented with two flights, the 2003 and 2004 vintages. On Day 3, panelists were presented with two flights, 2003 and 2004. Each flight, consisting of three coded wine samples (two biodynamic and one organic, or two organic and one biodynamic), was presented to each panelist. Panelists were asked to select which sample they felt was different from the other two. Each flight represented the comparison between biodynamically and organically grown wine for a specific vintage.

A directional paired difference test was conducted to further explore if sensory differences existed between the 2003 and 2004 biodynamically and organically grown wines. This directional paired difference test was selected as it has an increased likelihood of identifying differences between samples compared to the triangle test. It is also generally more efficient and powerful to use a directional paired comparison test specifying the sensory attribute in which the samples may possibly differ than to ask the panelists to identify the different sample (Lawless and Heymann, 1998).

A directional paired difference test was performed for aroma, flavor and taste attributes of the 2003 and 2004 vintages. The panel was composed of 48 panelists, ranging

in age from 21 to 62. The sensory evaluation session for each vintage was conducted on a separate day, thus the data were collected over two days.

To develop a list of aroma and flavor descriptors for the directional paired difference test, the wines were initially evaluated by a panel of six experienced tasters. Comments from panelists who correctly identified the different sample in the previously conducted triangle tests were also considered. For the directional paired difference testing, the aroma attributes studied were herbaceous/green, floral/sweet and musty/earthy (Table 1). The flavor and mouthfeel attributes were herbaceous/green, musty/earthy, astringent, bitter and finish (Table 1). Overall preference for both aroma and flavor/taste was also evaluated.

During the directional paired difference test, panelists were provided with a list of attribute definitions to clarify descriptive terms (Table 1) and were asked to choose which of two coded samples imparted more of a specific aroma or flavor attribute. Each sample pair consisted of an organically grown wine and a biodynamically grown wine from the same vintage. Panelists were instructed to evaluate the first two sample pairs for aroma differences only, refreshing olfactory senses by smelling the cup of water between samplings. Flavor/taste evaluations were reserved for the third and fourth sample pairs. Panelists were instructed to rinse their palate with water and crackers between flavor samplings. Following the attribute questions, panelists were asked to indicate which wine they preferred and comment on why.

Data Analysis

Data were collected and statistically analyzed using Compusense®*five* software (release 4.6, Compusense Inc., Guelph, ON) according to the method of Roessler *et al.* (1978). Level of significance for treatment differences was established at $p < 0.1$ or $p < 0.05$.

Power calculations for the triangle test were made using the Test Sensitivity Analyzer from Meilgaard *et al.* (1999). For all vintages, the probability of a correct guess was held at 0.33 and the proportion of distinguishers was maintained at 0.25. For 2001 and 2002, the number of panelists was 48 and number of correct responses was 22 (Roessler *et al.*, 1978). In 2003 and 2004, the number of panelists was 72 and the number of correct responses was 32 (Roessler *et al.*, 1978).

Table 1. Attributes and descriptions used in the paired attribute difference testing of the 2003 and 2004 biodynamically and organically grown wines. These definitions were provided in-booth to the panelists participating in the paired comparison test of wine attributes

Sensory attribute	Definition
Aroma:	
Floral/fruity	Aroma of fresh flowers; dried leaves
Musty/earthy	Aroma of damp potting soil; wet leaves
Herbaceous/green	Aroma of canned asparagus; green pepper; freshly cut grass
Flavor/taste:	
Herbaceous/green	Flavor of bell pepper, green beans
Musty/earthy	Bark; wet leaves
Astringent	Drying, puckering sensation in the mouth
Bitter	Lingering, sensed toward the back of the tongue; the bitterness in grapefruit
Finish	Length of aftertaste

Results and Discussion

Triangle test results indicated no significant differences at $p < 0.05$ between the 2001, 2002, 2003, and 2004 biodynamically and organically grown Merlot wines (Table 2). For the 2004 vintage, a notable difference ($p < 0.1$) was found between the two wines. Comments from panelists who responded correctly in the triangle test indicated the organically grown wine had a more intense flavor, was more sour, and more astringent compared to the biodynamically grown wine.

Results of the directional paired difference test showed a significant difference in musty/earthy aroma, which was higher in the 2003 biodynamically grown wine compared to the 2003 organically grown wine (Table 3). For the 2004 vintage, the musty/earthy aroma was significantly higher in the organically grown wine compared to biodynamically grown wine. No differences in aroma preference were observed between the wines.

With regard to flavor/mouthfeel, the 2003 and 2004 organically grown wines had a significantly higher musty/earthy flavor compared to the same vintage biodynamically grown wines (Table 4). The 2004 organically grown wine had a significantly longer finish ($p < 0.05$) and notably higher perceived astringency ($p < 0.1$) compared to the 2004 biodynamically grown wine. Perceived bitterness varied between the two vintages, with the 2003 biodynamically grown wine notably higher ($p < 0.1$) in bitterness compared to the 2003 organically grown wine, and the 2004 organically grown wine notably higher ($p < 0.1$) in bitterness than the corresponding 2004 biodynamic wine. When examining overall flavor/mouthfeel preference of the wines, the 2003 organically grown wine was notably more preferred ($p < 0.1$) than the 2003 biodynamically grown wine. The increased preference of the organically grown wine may be related to its increased musty/earthy flavor or decreased perceived bitterness compared to the 2003 biodynamically grown wine. The difference in preference may also have been due to the presence or absence of other attributes that were not evaluated in the present study. Interestingly, the higher astringency and bitterness of the 2004 organically grown wine may have been balanced by its higher musty/earthy flavor and longer finish, resulting in no overall difference in preference between the 2004 organically and biodynamically grown wines. Another issue which may be used to explain these results is the halo effect. With the halo effect, the evaluation of one attribute of a sample tends to influence the rating of another attribute. For example, if the product is generally accepted, all of its individual attributes will tend to be rated favorably (Meilgaard *et al.*, 1999). To minimize this effect in the present study, a separate set of samples with a new set of three-digit codes was presented for each attributes under evaluation. However, panelists may have remembered the previous sample.

Table 2. Results of triangle difference test of biodynamically vs organically grown Merlot for four vintages ($n = 48$ for 2001, 2002; $n = 72$ for 2003, 2004). Results are expressed as the number of correct responses per session

	Number of correct responses			
	Vintage			
	2001	2002	2003	2004
Biodynamically vs organically grown wine	12/48	15/48	19/72	31/72*

* $p < 0.1$.

Table 3. Aroma results for the directional paired comparison tests of biodynamically vs organically grown Merlot over the 2003 and 2004 vintage. Results are expressed as the number of responses indicating a higher intensity of the specific attribute in the sample ($n = 48$)

		Floral/sweet	Herbaceous	Musty/earthy	Preferred
Vintage	Treatment				
2003	Biodynamic	21	27	33*	22
2003	Organic	27	21	15	26
2004	Biodynamic	24	21	17	24
2004	Organic	24	27	31**	24

* $p < 0.05$.

Table 4. Flavor/mouthfeel results for the directional paired comparison tests of biodynamically vs organically grown Merlot over the 2003 and 2004 vintage. Results are expressed as the number of responses indicating a higher intensity of the specific attribute in the sample ($n = 48$)

		Herbaceous	Musty/earthy	Astringent	Bitter	Finish	Preferred
Vintage	Treatment						
2003	Biodynamic	25	17	20	29*	22	18
2003	Organic	23	31**	28	19	26	30*
2004	Biodynamic	23	17	18	18	16	24
2004	Organic	25	31**	30*	30*	32**	24

* $p < 0.1$, ** $p < 0.05$.

In the study by Reeve *et al.* (2005) on the same wine grapes, wine grape analysis showed significantly higher Brix levels ($p < 0.05$) and notably higher phenols and anthocyanins ($p < 0.1$) in the biodynamically grown wine grapes from the 2003 vintage compared to the organically grown wine grapes in the same year. However, these differences did not translate into sensory differences in the 2003 vintage, or these differences are not yet apparent.

Other studies have explored differences in sensory properties between organically and conventionally grown foods with mixed results. Using a triangle difference test, a panel of 18 consumers failed to discriminate between organically and conventionally grown carrots (Oude Ophuis, 1988), while a trained panel failed to discriminate between organically and conventionally grown spinach (Maga *et al.*, 1976). In contrast, Basker (1992) reported sensory differences between organically and conventionally grown spinach and grapes, but not grapefruit or sweet corn. Using descriptive analysis, studies have failed to produce consistent results, with some studies showing differences in specific attributes between organically and conventionally grown apples (DeEll and Prange, 1992; Reganold *et al.*, 2001) and tomatoes (Johansson *et al.*, 1999; Porretta, 1994; Vogtmann *et al.*, 1993).

In examining preference between organically and conventionally grown produce, results are equally mixed. No differences were found in ratings of liking between organically and conventionally grown lettuce or green beans using a consumer group (Schutz and Lorenz, 1976). Similar results were reported in grapefruit, grapes, corn,

spinach, carrots, and tomatoes (Basker, 1992). However, preferences for organically grown bananas were expressed (Basker, 1992), as well as preference for one variety of organically grown tomato (Johansson *et al.*, 1999).

Because few perceptible sensory differences were found in this study between the organic and biodynamic treatments using the triangle test, it is important to address the issue of power. Using the test sensitivity analyzer (Meilgaard *et al.*, 1999), the power of the triangle tests for the 2001 and 2002 vintages was calculated as 75%. In 2003 and 2004, the power was 85%. While the power of the triangle tests for the 2001 and 2002 vintages was lower than 2003 and 2004, we still felt the power was adequate to determine if differences were present.

The biodynamically and organically grown wines were not made in the traditional commercial or Bonterra red wine style, in which Bonterra red wines are usually aged in oak for at least 14 months. We avoided contact with oak for aging the wine because oak barrels can introduce additional variability into the wines through the addition of different flavors and aromas. By transferring the wine in glass carboys directly to bottles and avoiding the oak barrels in between, we also lost the effect of microoxygenation, the controlled process of oak-barrel aging where wine is allowed to interact very slowly with a miniscule amount of air penetrating through the barrel. In addition to the flavors and tannins imparted by the wood, wines aged in oak barrels exhibit more complexity than wines aged in glass containers or stainless tanks primarily because of microoxygenation. Therefore, our wines in this study lacked the complexity typical of good commercial wines. By forgoing the oak-barrel aging process, our study design facilitated greater scientific control in measuring differences in aroma and flavor between biodynamically and organically grown wines.

Conclusions

Using a triangle test, we found no major sensory differences, except one notable difference in 2004, between four vintages (2001 – 2004) of biodynamically and organically grown Merlot wines. When the 2003 and 2004 wines were evaluated using the directional paired comparison tests, the organically grown wine was significantly higher in musty/earthy aroma (2004) and musty/earthy flavor (2003 and 2004). The 2003 biodynamically grown wine was significantly higher in musty/earthy aroma compared to the 2003 organically grown wine. The 2004 organically grown wine also had a significantly longer finish and notably higher perceived astringency and bitter taste compared to the 2004 biodynamically grown wine; however, the 2003 biodynamically grown wine was notably higher in bitterness. When examining overall flavor/mouthfeel preference of the wines, the 2003 organically grown wine was notably more preferred than the 2003 biodynamically grown wine.

These findings provide support to the alternative hypothesis that perceptible sensory differences existed between biodynamically and organically grown wines in the 2003 and 2004 vintages.

Acknowledgments

Bonterra Vineyards, Jim Fetzer, and the Department of Crop and Soil Sciences at Washington State University supported this research. Special thanks go to Chad Boardman and Dave Koball at Bonterra Vineyards and Alan York at Wholistic Estate Management.

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