

Do weak stationary magnetic fields affect the perceived astringency of red wine?

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Abstract

To investigate claims that products containing weak stationary magnets can reduce the astringency of tannic red wine, a double-blind randomized trial was carried out, in which 96 paired tastings were conducted of magnetized and non-magnetized samples of a young Nebbiolo. The data showed no association between reported differences in astringency and actual difference in the magnetic treatments given to the wine ($\chi^2=0.135$, degrees of freedom=1, $P=0.71$). This study confirms an earlier work that magnets have no observable effect on red wine.

Introduction

There is a range of commercially available wine magnets which make various claims to enhance the palatability of red wine. Having reviewed the experimental research of Rubin *et al.*¹ into the efficacy of magnets on *improving* cheap wines, a replication study was designed with a more specific focus on the effects of weak magnetic fields on the *astringent properties* of highly tannic red wine. In their experiment, Rubin and his team used The Perfect Sommelier™, which consists of a magnetic coaster and stopper. In this experiment, the Wine Clip™ was used, which consists of a collar made up of six bar magnets placed around the neck of the bottle, through which the wine is poured.

The magnetic properties of the Wine Clip™

A Magnaprobe was used to determine the direction of the field lines, which were found to form tightly packed longitudinal lines along the central axis of the device. The lines emerged from the ends of the clip and formed a bar magnet-like arrangement around the exterior, as shown in Figure 1. The maximum field strength measured within the clip was determined using a Vernier Magnetic Field Sensor set to Low amplification (x10). Within the clip along

the longitudinal axis, along which the wine would flow, a maximum range of 13.8 mT±0.1 mT was recorded.

The claims of the manufacturer

The manufacturer claims that the Wine Clip™ results in: i) A smoother, more balanced flavour; softer tannins. ii) An effect that is most noticeable on highly tannic red wines. (<http://www.thewineclip.com/how-it-works/>, accessed 15th Jan 2018).

The proposed mechanism of action of the Wine Clip™

The manufacturer claims that these effects occur because: i) passing a conductive fluid through a properly designed magnetic field has an effect on the polar molecules in the fluid; ii) the large, polymerized tannins in wine that normally result in a high degree of astringency are affected in a way that results in a less astringent, softer flavor; iii) (it) accelerates aeration, by drawing higher concentrations of oxygen to the wine as it is being poured. In contrast with most gases, oxygen is highly magnetically susceptible, and is attracted to a magnetic field.

Evaluating the claims of the mechanism of action

Grissom² states that *few areas are as controversial as research into the biological effects of magnetic fields*; indeed, the literature is full of contradictory reports, with few successful replication studies coupled with a lack of plausible biophysical mechanisms.³ Therefore, there is a strong tendency for scientists to approach such claims with a high level of initial skepticism. However, the aim of this paper is to approach the matter with an open mind, and to evaluate each claim on its own merits according to accepted scientific theory and peer-reviewed research.

Claim 1 states that *passing a conductive fluid through a magnetic field has an effect on the polar molecules in the fluid*. There has been considerable research into the effects of magnetic devices on flowing water in pipes, in particular on the effects of such fields on calcium and magnesium ions in solution. Zamora *et al.*⁴ investigated claims that a static magnetic field can affect the pH, conductivity, hardness and surface tension of drinking water, and found no significant change in any of these variables. This finding is consistent with the work of Amiri and Dadkhah,⁵ who conducted over 200 experiments and could find no effect of magnetic fields on the surface tension of water.

On the other hand, in 2007 Holysz *et*

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*al.*⁶ reported that a 15mT magnetic field *did* have a measurable effect the conductivity of ionic solutions, and attributed these findings to changes in the hydration shells around the ions brought about by the magnetic field somehow interacting with hydrogen bonds between water molecules and the ions. Szcześ *et al.*⁷ also claim to have detected an increase in conductivity and evaporation rate when distilled water was passed through a 15mT stationary magnetic field, hypothesizing that this was due to a strengthening of the hydrogen bond network between the water molecules. Similar conclusions were drawn by Ibrahim⁸ and Cai *et al.*⁹ albeit with much stronger magnetic fields, postulating that larger clusters of water molecules are formed in magnetic fields as a result of stronger hydrogen bond formation. Toledo *et al.*¹⁰ theorized that such clusters of water molecules would in fact be smaller, but more numerous, in water exposed to magnetic fields. Iwasaka and Ueno¹¹ also found experimental evidence that magnetic fields can affect hydrogen bonds between water molecules, and hydration shells of solvent molecules, although once again in very strong fields of 14T.

Water is a diamagnetic substance, and is repelled by magnetic fields. Most explanations for how magnetic fields might affect hydrogen bonding derive from the field of spin chemistry, and indeed there is a body of evidence that magnetic fields *can alter the rate, yield, or product distribution of chemical reactions*;¹² indeed, many magnet-

ic field effects are known on reactions occurring in solids or the interior of proteins.¹² It is, therefore, not outside of the bounds of plausibility that a weak magnetic field could have some effect on the hydrogen bonds between the myriad molecules in wine, however slight.

Claim 2 states that, when exposed to the magnetic field in the Wine Clip™ the large, polymerized tannins in wine that normally result in a high degree of astringency are

affected in a way that results in a less astringent, 'softer' flavor.

Tannins are a diverse group of phenolic compounds found in grape skins, a subset of which, known as flavanols or proanthocyanadins, are responsible for the astringent organoleptic oral sensation associated with red wine, tea, and others.¹³ These molecules may exist as monomers or polymers of up to 80 units, and produce the sensation of astringency by interacting with and deacti-

vating the salivary proteins responsible for lubrication of the buccal cavity. The degree of astringency is positively correlated with the degree of flavanol polymerization,¹⁴⁻¹⁶ and with a higher degree of salivary protein complex formation.¹⁷ In summary, larger tannin polymers react with a greater number of salivary protein molecules, resulting in greater perceived astringency.

Therefore, for claim 2 to be true, the magnetic field must either reduce the size of

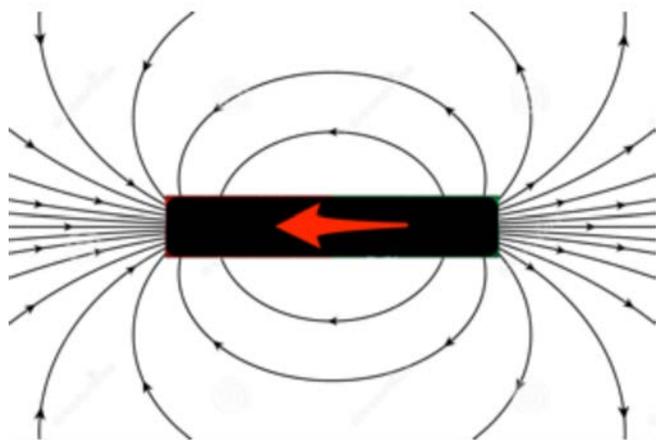


Figure 1. The magnetic field lines around the Wine Clip™, the direction of flow of wine shown by the red arrow.

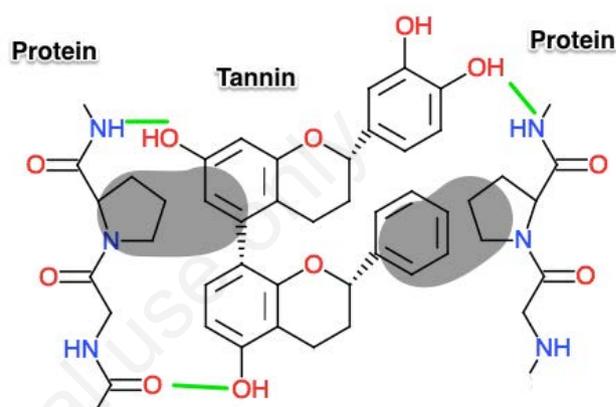


Figure 2. Protein-Tannin interactions. The grey areas show the hydrophobic interactions; the green lines indicate hydrogen bonds. Based on the work of Santos *et al.*¹⁶

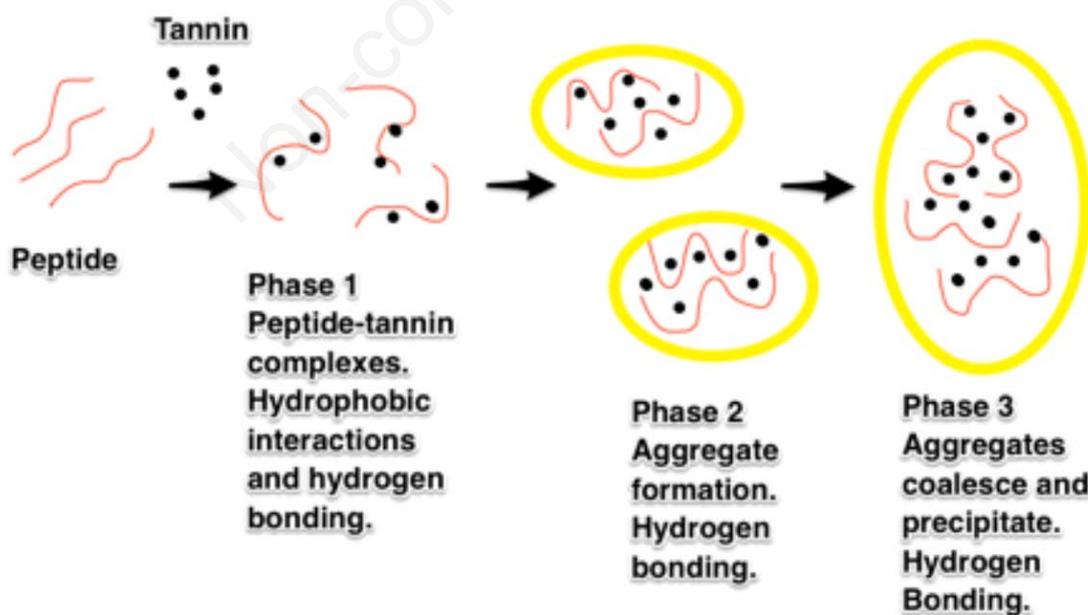


Figure 3. The formation of peptide-tannin complexes as a wine ages. Based on the work of McRae *et al.*²⁴

the tannin polymers by increasing the rate of hydrolysis of the bonds between the monomers, or reduce the degree to which tannins interact with salivary proteins. It has been well established that any effect of a static magnetic field on a chemical system would have to be kinetic, rather than thermodynamic, in nature,¹⁸ and therefore the first possibility may be rejected – it is energetically impossible that a weak magnetic field could break the covalent bonds between flavanol monomers. However, the possibility remains that the magnetic field could reduce the degree to which tannins interact with salivary proteins, and a mechanism by which this might occur is discussed below.

Astringency is defined as a *drying and puckering sensation in the mouth* and derives from a *tactile sensation caused by a loss of lubricity in oral saliva*.¹⁹ Cala *et al.*²⁰ used 3D molecular modeling software to determine that salivary proteins rich in the amino acid proline have three binding sites to which tannins may adhere with high affinity, causing a precipitation of these lubricating proteins from the salivary solution and resultant sensation of roughness in the mouth. Such tannin-protein interactions are thought to be governed by hydrogen bonding between carbonyl groups on the proline residues of salivary proteins and phenol and catechol OH groups on tannin molecules.²¹ There is also evidence that hydrophobic interactions are important in forming and stabilizing tannin-protein interactions.²² The nature of both interactions are shown in Figure 2.

Proline rich proteins are often found in red wine itself, particularly in Cabernet Sauvignon and Italian grape varieties.²³ McRae *et al.*²⁴ have shown that increased interactions between tannins and proline-rich wine proteins over time may explain the reduction in wine astringency that occurs naturally in a bottle as a wine ages, by the formation and eventual precipitation of protein-tannin complexes in the wine, as shown in Figure 3. Therefore, a hypothesis can be made that, when a wine passes through the Wine Clip™, the magnetic field strengthens, stabilizes or increases the number of hydrogen bonds between the proline-rich wine proteins and the tannins, giving rise to an increase in either the stability or the number of tannin-protein complexes. This would reduce the number of protein-tannin complexes formed between wine tannins and salivary proteins when the wine is tasted, hence reducing the perceived astringency of the wine.

Claim 3 states that the magnetic field

draws *higher concentrations of oxygen to the wine (because) oxygen is highly magnetically susceptible, and is attracted to a magnetic field*. It is true that oxygen is paramagnetic gas, attracted to magnetic fields, and it is also true that oxygenation is known to reduce tannin molecular mass and astringency.²⁵ However, Kitazawa *et al.*²⁶ found that significant effects on the solubility of oxygen in water occur only in magnetic fields well above 1T, three orders of magnitude stronger than the 15mT fields in the Wine Clip™. It therefore seems highly unlikely that any significant increase in oxygenation of the wine occurs in such a weak field, and so this claim seems highly improbable.

Materials and Methods

A double blind randomized trial was carried out, in which participants were asked to taste four paired samples of wine and report whether they could detect a difference between the astringency in each of the pairs. As the manufacturer claimed that the *effect that is most noticeable on highly tannic red wines*, a red wine was selected that is known for its high tannins and astringency, a young Sordo Nebbiolo d'Alba 2014.²⁷

Magnetizing the wine

The first 375mL of each bottle of wine was decanted into a standard 1-litre carafe. The magnet was then attached to the neck of the bottle and the remaining 375mL of wine was immediately poured into an identical second carafe, to ensure that no magnetized wine would contaminate the non-magnetized wine by backflow. Using half of the same bottle of wine in this way also avoids the possibility that pre-existing differences between bottles of the same wine may mask the effect of the magnet, as suggested by Rubin *et al.*¹ in their discussion as a weakness of their own method. A further modification to their method was to add control pairings for false positive and false negative results, where both samples of wine were either magnetized or non-magnetized.

Controlled variables: i) Participants were comparing identical wine – from the same bottle – the only difference being the presence or absence of the magnetic field; ii) The wine pairs were served at the same temperature; iii) Participants compared identical volumes of wine (20mL); iv) The wine treatments had been exposed to oxygen for the same duration in the carafes; v)

All participants were university-educated adults with some experience in wine tasting.

Randomizing the trials

There were four pairing treatments, shown in Table 1.

Rubin *et al.*¹ added questions to their survey to determine the wine tasting proficiency of their participants, based on the work of Hughson and Boakes.²⁸ These questions were omitted from the design of this experiment, as Rubin and co-workers found that wine-tasting proficiency had no statistically significant effect on their results.

Each participant was given a tray with four pairing treatments, which were allocated using the random number generator function in Microsoft Excel. Table 2 shows the results of the randomization, and Table 3 (for clarity) shows an example of the pairings for Tray 1.

Double blinding

One experimenter (SR) assembled the trays in the preparation room, behind closed doors from the tasting room. Once a tray was ready, the second experimenter (RH) was summoned into the room to bring the tray to the participant in the tasting room. Thus, neither the participants nor the experimenter who gave them the tray had any knowledge of the treatments. Furthermore, only SR had access to Table 2 or Table 3.

Collecting data

Participants were given the following instructions and information: i) Astringency is a property of wine that results in a drying and puckering sensation in the mouth; a roughness similar to that which you feel when you drink cold tea; ii) Please taste each pair of glasses of wine in turn and decide whether there is a difference in the astringency you feel between glass A and B, for each of the four rows; iii) Circle *yes* on the form provided (Table 4) if you feel that there is a difference, and *no* if the astringency of the two wines feels the same.

Table 1. Pairing treatments and glasses.

Pairing Treatment	Glass A	Glass B
1	Magnetized	Magnetized
2	Non-magnetized	Non-magnetized
3	Magnetized	Non-magnetized
4	Non-magnetized	Magnetized

Results and Discussion

These results (Tables 5 and 6) show that the majority of participants reported no discernible difference in the astringency of the wines, whatever the treatment (61/94). Moreover, fewer participants reported a difference in astringency when the wines had received a different magnetic treatment (16/33), compared to when the wines had received the same treatment (17/33). Finally, more participants reported detecting no difference in the astringency of the wines when they wines had received different magnetic treatments (32/61) than when the treatments had received the same treatment (29/61). These results seem to suggest that the effects of the magnetic treatment on astringency were not detected by the participants, and the results appear to be as a result of random chance alone.

Chi-Squared test

Chi-square statistic=0.1354; P-value=0.713 – result is not significant; P>0.05.

The Chi-squared test confirms what the data seem to show – that there was no statistically significant association between magnetization treatments and perceived astringency of the wine.

Evaluation and recommendations for further research

This experiments replicates, builds upon and confirms the findings of earlier research by Rubin *et al.*¹ Only one variety of wine was used in this experiment, and further research could investigate whether other wines, for example with lower tannin concentrations or with different blends of tannin molecules, or higher proline-rich protein concentrations, might behave differently in magnetic fields.

The human senses may be a limitation to this experiment. It would be interesting to run samples of magnetized and non-magnetized wine (or indeed purified solutions of tannin molecules and proline-rich proteins) through mass-spectrometry to determine whether the size of tannin-protein aggregations does in fact change as a result of a magnetic field, in a method suggested by the work of Perez-Gregorio *et al.*²⁹ Alternatively, Horne *et al.*³⁰ describe a method of quantifying interactions between tannins and salivary proteins by the measurement of turbidity, which could also be a viable alternative method for data collection.

Conclusions

Having reviewed the published literature and suggested a possible causative mechanism by which astringency of red wine could be reduced by magnetic fields, this experiment found no empirical evi-

dence that human subjects can detect such an effect, if it exists. It seems reasonable to conclude, therefore, that either tannin molecules in red wine are not affected at all by such magnetic fields, or that any effects on the astringency of a tannic young Nebbiolo are too subtle to be detected by the human

Table 2. Result of the randomization process of allocating pairings to trays.

Tray	Pairing Treatment by Row			
	Row 1	Row 2	Row 3	Row 4
1	3	2	1	4
2	3	3	3	2
3	2	4	4	2
4	3	4	4	3
5	3	2	2	4
6	2	4	4	4
7	1	1	4	4
8	4	4	2	2
9	2	4	2	1
10	4	2	4	2
11	1	2	1	2
12	2	3	3	1
13	2	4	3	3
14	1	3	1	1
15	2	2	3	3
16	1	3	3	3
17	3	1	1	3
18	4	2	2	4
19	1	2	4	3
20	1	1	2	1
21	4	2	4	3
22	2	3	1	1
23	3	1	3	3

Table 3. The pairings for Tray 1.

Row	Glass A	Glass B
1	Magnetized	Non-magnetized
2	Non-magnetized	Non-magnetized
3	Magnetized	Magnetized
4	Non-magnetized	Magnetized

Table 4. Response form.

Did you notice a difference in the astringency between wines A and B?		
Row 1	YES	NO
Row 2	YES	NO
Row 3	YES	NO
Row 4	YES	NO

Table 5. Raw data; total number of responses by pairing treatment.

Treatment	Number of Responses	
	Yes	No
1	8	13
2	9	16
3	8	15
4	8	17

Table 6. Processed data; total number of responses, pairing treatments grouped according to whether the wines were both magnetised or non-magnetised (Same) or one magnetized and the other non-magnetized (Different).

Treatment	Number of Responses		
	Yes	No	Total
Same (1/2)	17	29	46
Different (3/4)	16	32	48
Total	33	61	94

palate. In either case, this study provides more evidence that the extravagant claims made by wine magnet manufacturers should be treated with the utmost skepticism by the consumer. The reported efficacy of the device in consumer reviews is most likely a result of the placebo effect resulting from the taster seeing the wine magnet on the bottle; it has been found that, for sighted judgment, 95% of a wine's quality rating may be attributed to the extrinsic visual cues of price and region.³¹

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