Wine as a digestive aid: comparative antimicrobial effects of bismuth salicylate and red and white wine

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Abstract

***Objective*—To test whether red and white wines are as potent as bismuth salicylate against the bacteria responsible for traveller's diarrhoea to try to explain wine's legendary reputation as a digestive aid.**

***Design*—Red and white wine, bismuth salicylate, two solutions containing ethanol (diluted absolute ethanol and tequila), and sterilised water were tested against suspensions of salmonella, shigella, and *Escherichia coli* to determine relative antibacterial activity. Suspensions of 10^7 colony forming units of shigella, salmonella, and *E coli* were added to the test solutions and plated on standard nutrient agar at 0, 10, 20, 30, 60, and 120 minutes and 24 hours. Dilutions of wine and bismuth salicylate were then tested with *E coli* as the test bacterium, and the experiment repeated.**

***Main outcome measures*—Exposure times necessary for eradication of organisms for the different solutions; decreases in colony counts at the different exposure times for dilutions of wine and bismuth salicylates.**

***Results*—Undiluted wine and bismuth salicylate were both effective in reducing the number of viable organisms (by 10^5-10^6 colony forming units) after 20-30 minutes. Dilutions of wine were much more effective in decreasing colony counts than were similar dilutions of bismuth salicylate.**

***Conclusion*—The antibacterial property of wine is largely responsible for wine's reputation as a digestive aid.**

Introduction

Wine has an ancient reputation for being a digestive aid, but to our knowledge, no convincing mechanism for this benefit has yet been elucidated. Wine may have an antibacterial effect on ingested pathogens, similar to the effect that bismuth salicylate has on enteropathogens in preventing traveller's diarrhoea. Bismuth salicylate treatment is effective prophylaxis against traveller's diarrhoea when taken with meals and at bedtime,[1,2] and its efficacy is at least partly due to its antibacterial properties.[3-5] We hypothesised that wine may be as efficacious as bismuth salicylate in eradicating the bacteria responsible for traveller's diarrhoea. To test our hypothesis we measured the in vitro antibacterial activity of red and white wine, bismuth salicylate, and solutions containing ethanol.

Materials and methods

The organisms studied included *Escherichia coli* (American type culture collection 25922), *Salmonella enteriditis* serotype *typhimurium* (American type culture collection 14028), and *Shigella sonnei* (American type culture collection 25931). The solutions containing ethanol were a two year old bottle of California white wine (Chardonnay, 11% ethanol); a bottle of Portuguese red table wine (9% ethanol); absolute ethanol diluted to 10% with sterilised tap water; and tequila diluted to 10% ethanol with sterilised tap water. A solution of bismuth salicylate (35 mg/l; Pepto-Bismol) was also tested, and sterilised tap water was used as a control.

The first phase of the study was to determine the relative antibacterial activity of each of the solutions against the three test bacteria. An 18 hour growth of bacteria was suspended in sterilised tap water to a density of 10^7 colony forming units/ml. An aliquot of the bacterial suspension (0·2 μl) was then added to 3·8 ml of the various test solutions. The suspension was mixed with a vortex mixer and plated on to trypticase soy broth with agar containing 5% sheep's blood (Baltimore Biologic Laboratory, Cockeysville, MD) after incubation at ambient temperature for 0, 10, 20, 30, 60, and 120 minutes and 24 hours. Inoculation was performed in duplicate with two calibrated wire loops (0·001 ml and 0·1 ml) and a pipette (0·1 ml). Plates were incubated for 18 to 24 hours at 35°C in 5% carbon dioxide. If little or no growth was noted at 24 hours the plates were reincubated and bacterial growth assessed at 48 hours. Bacterial growth was measured as the number of colonies seen with the naked eye, and the results of the duplicate plates were averaged. In all cases the initial concentration of bacteria in the mixtures was 10^5-10^6 colony forming units/ml; the lower limit of detection of bacteria on the plates was 10 colony forming units/ml.

The second phase of the study compared the antibacterial effects of dilutions of bismuth salicylate, red wine, and white wine against *E coli* as the test organism. Bacterial suspensions were prepared as indicated above and diluted to a concentration of 10^5-10^6 colony forming units/ml. Aliquots of wine and bismuth salicylate were mixed with increasing volumes of the bacterial suspension in the proportions of 1:1, 1:2, 1:4, and 1:8 (volume for volume). A mixture of equal parts of the bacterial suspension and sterilised tap water served as a control. Specimens were handled as described above.

Results

Red and white wine proved superior to all other solutions against the three bacteria tested. Both samples of wine decreased the bacteria count from 10^5-10^6 colony forming units/ml (no growth detected) within 20 minutes (fig 1). Bismuth salicylate was the next most effective antibacterial agent, reducing *E coli* by 10^4 colony forming units at 20 minutes, but requiring 60 and 120 minutes to reduce *S enteriditis* and *Sh sonnei* respectively to undetectable concentrations. Bismuth salicylate was substantially superior to the tequila solution except against *Sh sonnei*, in which it was only marginally superior. Diluted ethanol showed

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no significant reduction in the colony counts when compared with sterilised tap water.

The dilutions of white wine reduced the number of test organisms more rapidly than did the dilutions of red wine, and both were superior to dilutions of bismuth salicylate (table). Within 30 minutes a 1:1 dilution of white wine reduced colony counts by 10^4 and red wine by 10^2, while bismuth salicylate had no effect. At this dilution, white wine took 60 minutes to reduce *E coli* counts to ≤ 10 colony forming units/ml, red wine 120 minutes, and bismuth salicylate 24 hours (fig 2). Red and white wine also decreased the bacteria count from 10^5-10^6 colony forming units/ml to ≤ 10 colony forming units/ml at the 1:2 and 1:4 dilutions whereas bismuth salicylate did not. Red and white wine were equally effective at the 1:8 dilution, with counts being reduced by 10^3, but bismuth salicylate had only a negligible effect.

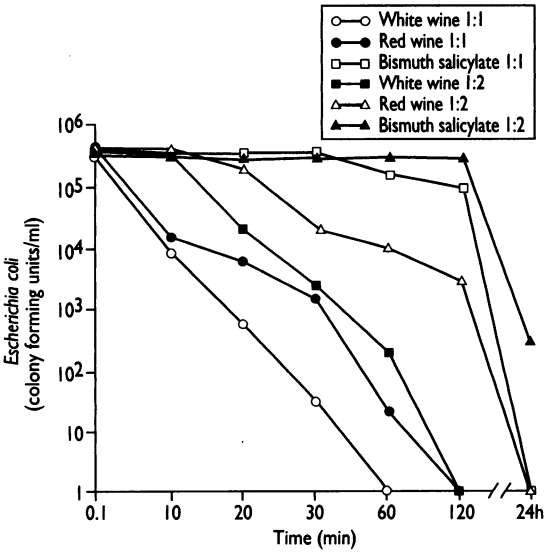

Fig 2—*Activity of dilutions of wine and bismuth salicylate against Escherichia coli*

Discussion

Wine has been used as an appetite stimulant and digestive aid at least since the 17th century in Europe,[6] and it was mixed with water and used as the drink at the main meal in ancient Greece.[7,8] Drinking wine with a meal is still widely thought to aid digestion, especially in France and Italy. Studies of the effect of alcoholic drinks on digestion have shown that only wine and beer increase gastrin production.[9] In addition, beer, but not wine, increases concentrations of cholecystokinin, stimulating release of pancreatic enzymes.[10] No other beneficial physiological effects on digestion have been attributed to wine in healthy adults, and it is unclear whether the increased gastrin concentrations are beneficial for digestion or would lead only to postprandial heartburn. Wine stimulates the appetite in cachetic adults, but the mechanism has not been elucidated.[6]

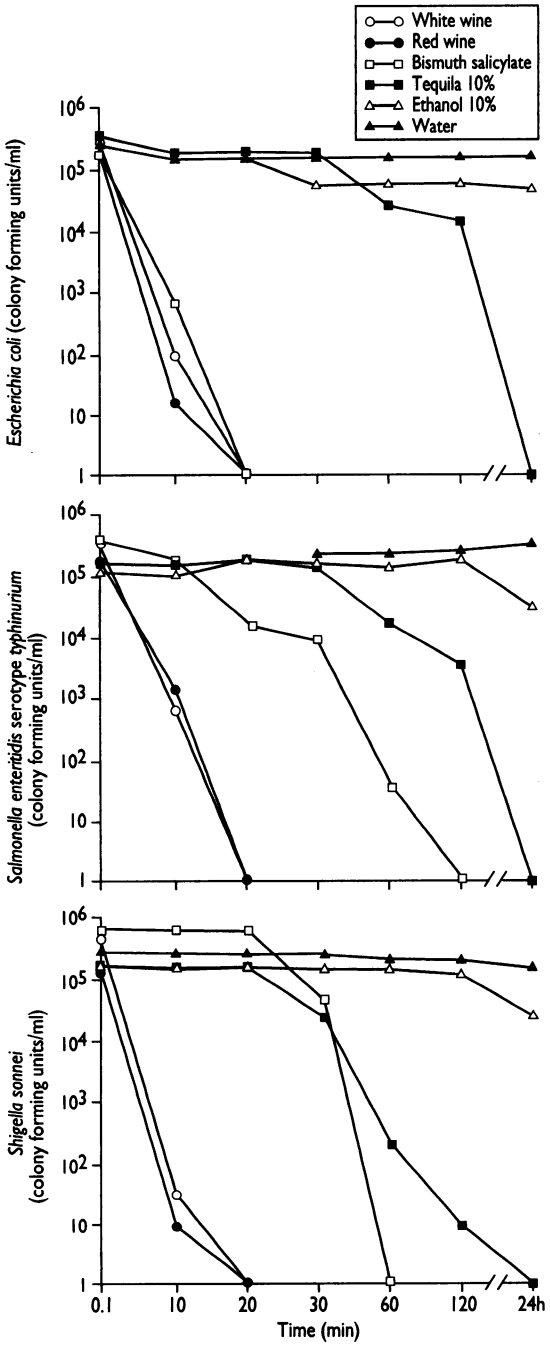

Fig 1—*Survival of the three test organisms in the five test solutions and in water (control)*

WINE AS A DIGESTIVE AID

One explanation for wine's reputation as a digestive aid is that it may, like bismuth salicylate, prevent diarrhoea due to ingested enteropathogens. Bismuth salicylate is effective prophylaxis against traveller's diarrhoea,[1,2] and its efficacy is at least partly due to its antibacterial properties.[3-5] Foods likely to cause traveller's diarrhoea contain about 10^3 colony forming units of bacteria per gram,[11] so a meal of 1 kg of food may contain $\geq 10^6$ organisms. As it takes 10^8 organisms of *E coli* or *Vibrio cholerae*, 10^5 of salmonella, and 10-10^2 of shigella to cause disease,[12] the decrease in colony counts that even diluted wine can effect in 30 minutes may be enough to protect someone from the adverse effects of these organisms. The increased gastrin secretion noted above and the resulting rise in gastric acid production enhance the antibacterial activity.[12]

Wine has been recorded in history as preventing infection, particularly infectious diarrhoea. Greek peasants drank wine mixed with three parts water as a daily drink, especially at the main meal,[7,8] presumably for this reason

In 1721 "four condemned criminals were recruited to bury the dead during a terrible plague in Marseilles. The gravediggers proved to be immune to the disease. Their secret was a concoction they drank consisting of macerated garlic in wine, which immediately became famous as *vinaigre des quatre voleurs* (four thieves' vinegar). It is still available in France today."[13] This anecdote has been used to emphasise the health benefits of garlic, although the wine probably protected them as much as the garlic did.

During the cholera epidemic in Paris in the late 19th century wine drinkers were observed to be spared. Based on these observations, Dr Alois Pick undertook some experiments in which he added

Decrease in Escherichia coli (number of colony forming units/ml) by serial dilutions of white wine, red wine, and bismuth salicylate

	Dilution											
	1:1			1:2			1:4			1:8		
	White wine	Red wine	Bismuth salicylate	White wine	Red wine	Bismuth salicylate	White wine	Red wine	Bismuth salicylate	White wine	Red wine	Bismuth salicylate
10 min	10-10^2	10	0	0-10	0	0	0	0	0	0	0	0
20 min	10^2-10^3	10-10^2	0	10	0-10	0	0	0-10	0	0	0	0
30 min	10^4	10^2	0	10^2	10	0	0-10	0-10	0	0	0	0
60 min	10^5	10^4	0-10	10^3	10-10^2	0-10	10-10^2	0-10	0	0-10	0	0
120 min	—	10^5	0-10	10^5	10^2	0-10	10-10^5	10-100	0	10	0-10	0
24 h	—	—	10^5	—	10^6	10^3	10^6	10^6	10^2	10^3	10^3	0-10

cholera bacilli to wineskins containing wine (red or white), water, or wine diluted with an equal volume of water. The bacteria thrived in the water, but the neat and diluted wine killed the cholera vibrios within 15 minutes.[14]

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Wine: a good accompaniment to meals for more reasons than one. "The Toast" by Peter Baumgarten (1834-1911)

MECHANISM OF ACTION

It is not the alcohol in wine that makes it bactericidal as 10% ethanol only marginally inhibited the bacteria compared with the controls. Nor is it the pH alone as solutions with comparable pH (cola pH 2·4; sour mix, a carbonated soft drink used as a mixer with American whiskey, pH 3·1) decrease viable enterotoxigenic *E coli*, salmonella, and *Sh sonnei* by only a tenth in four hours; over the same time wine (pH 3·0) decreases counts by 10^6-10^7.[15] Similarly, simulated gastric juice (pH 3·0) has slow antibacterial activity against *E coli*, causing numbers to decrease by less than a tenth in two hours.[3] The combination of 10% ethanol and low pH may be important. We found that wine (pH 3·0) was substantially better than the tequila solution (pH 4·0) and that 10% ethanol (pH 7·5) had virtually no antimicrobial effect.

The antimicrobial agent in wine seems to be a polyphenol that is liberated during fermentation and is active against bacteria at an acid pH.[16] Although polyphenol concentrations have not been measured in wine aged for different lengths of time, the antimicrobial properties of wine increase with age to a certain point, peak antimicrobial activity being observed in 10 year old wine, and activity decreases as wine is aged further.[14]

Whatever the active antimicrobial agent in wine, we found that wine was a better antibacterial agent than bismuth salicylate against the most common genera of bacteria that cause traveller's diarrhoea. This superiority was especially notable when the solutions were diluted.

LIMITATIONS

An argument against the validity of our study is that the acid environment of the stomach is quite different from the flasks filled with sterilised tap water that we used. Sox *et al* found that the antimicrobial effect of bismuth salicylate in simulated gastric juice (pH 3·0) was greater than that at neutral pH, and they reported similar results to ours for the antimicrobial effect of diluted wine against *E coli*.[3] This would not argue against wine's efficacy, but it is additional evidence that bismuth salicylate works by an antibacterial effect.

Another argument is that bismuth salicylate prevents diarrhoea by binding the toxins of enterotoxigenic organisms, so that comparing the antibacterial activity of wine to that of bismuth salicylate is irrelevant. Though bismuth salicylate certainly binds toxins,[17] it also prevents diarrhoea due to salmonella and shigella. In a study of 128 American students visiting Mexico, 62 were randomly allocated prophylactic treatment with bismuth salicylate and 66 placebo. Although nearly the same number of symptom free students in each group shed these organisms, only two taking bismuth salicylate became ill with salmonella or shigella compared with 12 taking placebo (two tailed Fisher's exact test, $P<0·01$).[1] Protection from these non-toxin mediated causes of diarrhoea implies a decrease in the colony count below the number necessary to cause disease. This direct antibacterial effect in vivo has also been demonstrated in vitro.[3-5]

CONCLUSION

In conclusion, the antibacterial activity of red and white wine against enteropathogens may protect against bacterial diarrhoea in a similar way to bismuth salicylate. This protective effect helps explain wine's legendary reputation as a digestive aid.

Key messages

- Wine has a legendary reputation for being a digestive aid, but no mechanism has been elucidated
- Non-antibiotic substances such as bismuth salicylate can be effective prophylaxis against the bacteria of traveller's diarrhoea
- Wine is more active than bismuth salicylate against enteropathogens in vitro
- This antibacterial activity against enteropathogens helps explain wine's reputation as a digestive aid

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Cardiac chest pain: does body language help the diagnosis?

W M Edmondstone

The pain of cardiac ischaemia is characteristically crushing, gripping, or tight in nature. When describing their chest pain many patients will use movements of the hands to illustrate their symptoms. A clenched fist to the centre of the sternum conveys the gripping quality of the pain (Levine's sign; fig 1) while a flat hand describes the sensation of crushing heaviness (fig 2).[1] Tight band-like chest pain may be represented by a movement of the palmar surfaces of both hands laterally from the centre of the chest (fig 3). Patients with non-cardiac pain may use other actions to illustrate their pain, such as movement of the fingertips up and down the sternum (oesophageal pain) or pointing to one spot (chest wall pain).

In response to the request "show me where your pain is and tell me what it feels like" virtually all the patients I have seen used their hands not only to show the location of the pain but also to convey its quality. It is often assumed that Levine's sign and its variants are good markers for ischaemic cardiac pain but their value has not been assessed objectively. This study aimed to measure the sensitivity, specificity, and predictive value of these signs in patients admitted to the coronary care unit with chest pain.

Fig 2—*Flat of hand to centre of chest*

Patients, methods, and results

During their initial clerking patients admitted to the coronary care unit with chest pain were asked to "show

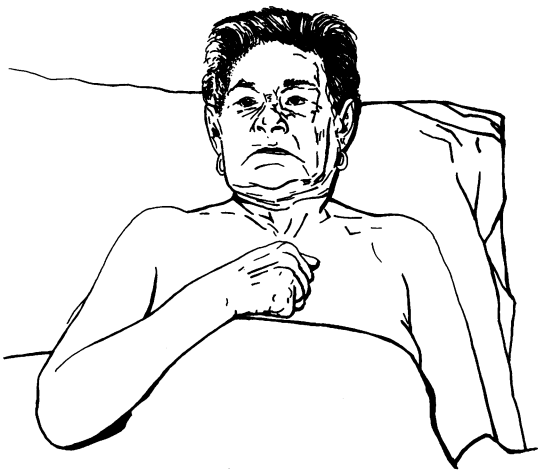

Fig 1—*Levine's sign: clenched fist to middle of chest*

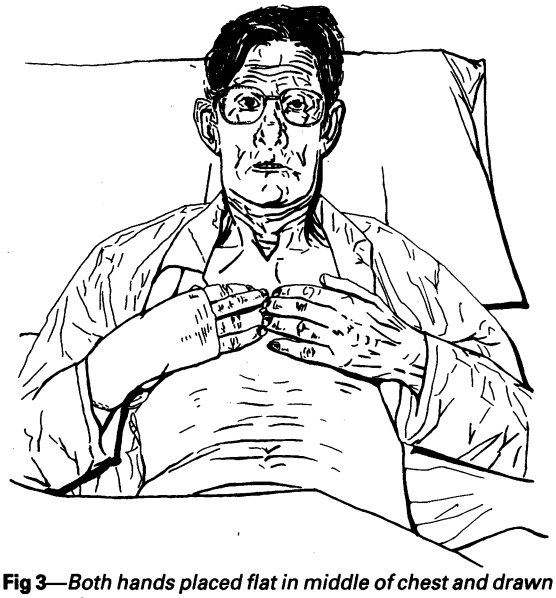

Fig 3—*Both hands placed flat in middle of chest and drawn outwards*

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