THE EFFECT OF WINE ON THE DENTAL HEALTH OF CONSUMERS

Dissertation submitted in partial requirement for the diploma of Cape Wine Master

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DECLARATION

I, Danielle le Roux declare that this dissertation is my own, unaided work. It is submitted in partial fulfilment of the requirements for the diploma of Cape Wine Master to the Cape Wine Academy. It has not been submitted before for qualification of examination in this or any other educational organization.

____________________
Signature

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Name in full

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Date
A sure sign of a serious wine taster will simply be stained teeth. You have surely been in the following situation:

“You and your peers sip and swirl a ‘flight’ of red wines. Then you turn to your companion, smile ...
and reveal a row of dark purple teeth that would do justice to Count Dracula” (http://www.wineloverspage.com).

If winetasting is part of your job, you have probably accepted your fate. This raises a few important questions for wine lovers: Does red wine pose any long-term concerns for your teeth? Can you do anything about it? Furthermore, to what extent could wine be beneficial to our dental health?

The manifestation of the effect of wine on dental health, apart from the obvious purple teeth, is much more than what the eye can see: namely, dental sensitivity and huge dentist bills! These symptoms all stem from the same cause: dental erosion.

This dissertation will focus on some important aspects of wine consumption and the dental consequences.

Very little information is available on the overall effect of wine on the status of dental health of adults. Most papers and articles on this subject have been written from a dental background. The highly technical explanations and terms used are very difficult to understand if you are not an expert in the field. In this CWM study, the author will attempt to gather all the available information on the effect of wine on the dental health of consumers, and try to assemble some facts and propose some solutions, with the view to disseminating the information in a more understandable fashion.

There is a large volume of papers and articles available on the beneficial effects of wine on our general health. Some current information also reports that wine might be beneficial to our dental health. This will also be addressed in this study.
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CHAPTER 1: INTRODUCTION, OBJECTIVES and DEFINITIONS

1.1 INTRODUCTION

The aim of this study was to assemble all the literature that is available on the influence of wine on our health, to interpret it, and to present it in an understandable, demystified format for winemakers, wine tasters and wine consumers. The consumer needs to understand how wine can be beneficial to our health, but also that wine can be detrimental to our health. My intention is not to be a ‘spoilsport’, but rather by contributing to a better understanding of the influence of wine, contribute to our solutions to possible health risks and maximize the enjoyment and benefits of wine.

The aims of this study were

- to identify the effect of wine on teeth, both beneficial and detrimental
- to identify the causes of these effects
- to interpret the available information and
- to propose some solutions to the negative effects of wine in order to maximize the enjoyment of wine.
1.2 DEFINITIONS

Different types of human teeth: Teeth morphology

There are four different types of teeth in the mouth of an adult human: canines, incisors, premolars, molars (see figure 1.1). The complete dentition of an adult person contains 32 teeth.

![Figure 1.1 Different types of human teeth:](AMERICAN MEDICAL ASSOCIATION, San Francisco, 2009)

Anatomy of the tooth

Teeth consist of two parts: (see figure 1.2)

- The *crown* is the part of the tooth we can see in our mouths.
- The *root* of the tooth is ‘planted’ into the jawbone to keep the tooth steady while it is doing its job.
Teeth consist of three layers: (see figure 1.2)

- Enamel, a hard protective outer layer covering the crown of the tooth.
- Dentine, a second protective layer covering the nerve of the tooth.
- Pulp (also called the nerve), the soft middle of the tooth that has a blood supply and nerve endings. (Goss and Lyons, 2006)

![Figure 1.2 Anatomy of the tooth.](AMERICAN MEDICAL ASSOCIATION, San Francisco, 2009)

The following definitions are also relevant to discussions on teeth.

**Incisors/cutting teeth**

The very front human teeth with rather flat surfaces, a straight sharp horizontal edge for cutting and biting the food and one long single, conical root (DENTAL GLOSSARY, 2006)

**Canine teeth**

Very strong pointed corner teeth for tearing and shredding, placed laterally to each lateral incisor. They are larger and stronger than incisors. The upper canine teeth are sometimes called eyeteeth. (DENTAL GLOSSARY, 2006)

**Premolars/bicuspid teeth**

Used for chewing food, placed lateral to and behind the canine teeth, with a flat upper surface of 1-2 roots. Their crown has two pyramidal eminences or cusps. (DENTAL GLOSSARY, 2006)
**Molars/ molar teeth**
Back teeth. Molar teeth have a much different tooth morphology with large and flat upper surface and 2-4 roots. Used for final chewing and grinding of food before swallowing. The third molars are also known as wisdom teeth. (DENTAL GLOSSARY, 2006)

**Anterior teeth**
The six upper and six lower front teeth (DENTAL GLOSSARY, 2006)

**Cariogenesis**
The process during which cavities develop in teeth (DENTAL GLOSSARY, 2006)

**Dental caries**
An infectious disease caused by the interaction of bacteria (which reside in plaque on the surface of the teeth) with retained food particles, especially carbohydrates. This interaction produces organic acids, attacking the enamel. (DENTAL GLOSSARY, 2006)

**Dental erosion**
The irreversible loss of dental hard tissue (enamel, cementum, or dentine) resulting primarily from a non-bacterial, chemical attack and usually involving acid substances. According to correspondence between Louis Mandel and John Rhicard (Mandel, 2005b), the term “erosion” should be deleted from the dental lexicon and supplanted by “corrosion” to denote chemical dissolution of teeth. Erosion is the loss of solid matter due to the mechanical action of fluids. Corrosion is the more accurate description of the acid effect of wine on tooth structure. For the purpose of this thesis, the term erosion will be used throughout.

**Hydroxyapatite**
A mineral compound of the general formula $3\text{Ca}_3 (\text{PO}_4)_2\text{Ca (OH)}_2$, which is the principal inorganic component of bone, teeth, and dental calculus. (DENTAL GLOSSARY, 2006)

**Labial**
Pertaining around the lip (DENTAL GLOSSARY, 2006)
Lingual
Pertaining to or around the tongue surface of the tooth, directed toward the tongue; opposite of facial (DENTAL GLOSSARY, 2006)

Mandible
The lower jaw (DENTAL GLOSSARY, 2006)

Maxilla
Upper jaw (DENTAL GLOSSARY, 2006)

Pathogenesis
The origin and development of a disease. More specifically, it is the way a microbe (bacteria, virus, etc.) causes disease in its host (DENTAL GLOSSARY, 2006).

Pharyngitis
Sore throat, also called pharyngitis, is a painful inflammation of the mucous membranes lining the pharynx. It is a symptom of many conditions, but most often is associated with colds. Sore throat may be caused by either viral or bacterial infections or environmental conditions. Most sore throats heal without complications, but they should not be ignored because some develop into serious illnesses. (DENTAL GLOSSARY, 2006)

Salivary pellicle
An organic biofilm formed by the physisorption of proteins and carbohydrates onto the surface of dental enamel exposed to the oral environment. The pellicle has several key roles in oral physiology including lubrication and reduction of friction between teeth as well as chemical protection of the enamel against acidic solutions (Dickinson and Mann, 2006).

In the next chapter we will have a closer look at the literature review, and background on wine. Focussing on health issues as well as the historic relation of wine and health.
1.3 OBJECTIVES

This thesis focuses on the effects of wine consumption on dental health. Both the negative and positive effects are discussed, and some solutions recommended to minimize the negative effects of wine on dental health.
CHAPTER 2: LITERATURE REVIEW

2.1 CHANGES IN WINE PRODUCTION, CONSUMPTION AND TRENDS

South Africa's wine industry has a 350-year history. Today it is a developed, technologically sophisticated, and fully modern industry. Generally, the level of viticultural and oenological practices and research are equal to any wine producing nation. According to SAWIS (South African Wine Industry Information & Systems), 1.3 million tons of grapes were crushed in 2007, and 730 million litres of wine (excluding wine for brandy, distilling wine and grape juice) were produced in 2007 (SAWIS, 2008).

The South African wine industry continues to see a positive performance on the export and domestic markets, with exports at the end of 2007, exceeding 300 million cases for the first time- a goal the industry did not envisage achieving before at least 2010. In the first quarter of 2008 global exports are up 35% and exports to the UK were up 17% from January to April 2008, when compared to the same period in 2007 (WINES OF SOUTH AFRICA,2008).

With 209 million litres of wine being exported from South Africa alone, one comes to the realisation that many experts/employees are needed to produce such volumes of wines, assess the quality, taste the wines, and to pass information on to the public in general. With wine consumption becoming a lifestyle trend, the number of consumers is also constantly growing. The wine industry also supports employment opportunities for 256 908 people in 2003 (including tourism). The wine industry directly and indirectly supports 197 579 (excluding tourism) job opportunities throughout the economy in 2003. (SAWIS, 2008).

Over the past years, wine consumption has dramatically increased across most markets and wine sectors. According to the latest report by Global Industry analysts, Inc. (WINEMARKETER, 2008), consumption in the global wine market is projected to exceed 26.6 billion liters by the year 2010. Wine consumption is growing at a compounded annual rate of 1.26%.
The reasons for the growth in consumption, according to Global industry Analysts, Inc., (WINEMARKETER, 2008) are:

- Recent medical research findings which confirm that wine minimizes/modulates heart diseases, cancer, Alzheimer’s disease, muscular degeneration
- Increasing disposable incomes
- Increasing affluence and sophistication, and resultant consumer shift towards consumption of premium alcoholic beverages
- Developing countries like China; India expected to drive future growth
- Changing lifestyles in developing countries like China and India
- Growing base of younger consumers exhibiting preference for wine over other alcoholic beverages
- Advertising and marketing campaigns
- Increasing use of internet and on-line sales of wines.

The lifestyle (worldwide), has also changed dramatically in the past years – today a healthy lifestyle is more intensely promoted. Consumers are more aware of their health now than ever before, and especially the Mediterranean diet is advocated worldwide. This diet consists mostly of grains, fruits, beans and vegetables. It includes little meat, and plenty of olive oil. Another item commonly found in Mediterranean dishes is garlic. The Mediterranean diet also includes moderate amounts of wine. Some researchers think this may account for the Mediterranean's healthy hearts. Furthermore, several recent research findings claim that wine has a beneficial effect on health (preventing heart disease, cancer, Alzheimer’s disease).

With wineries trying to keep up with preferences and trying to make their wines more appealing to consumers, a growing percentage of wines nowadays also have higher sugar content. Because bacteria in plaque use sugar as a source of energy, sugar increases the risk of dental erosion.

With the continuously growing number of wine consumers and the huge impact of the wine industry on global society, much more research needs to be done on the influence of wine on all aspects of our health.
2.2 MORE FOCUS ON DENTAL EROSION

As the problem of dental erosion in winemakers apparently not very well documented, no appropriate management systems have been established.

It is surprising that so few authors have considered the importance of wine as a factor in dental erosion, considering that wine has been drunk for thousands of years (Wiktorsson et al., 1997). Non-carious destruction of teeth has also been observed in archaeological material from various parts of the world and clearly pre-dates the first appearance of dental caries (Holbrook et al., 2003).

Although Miller (Miller, 1907), as long ago as 1907, concluded that all acids have the capacity to cause erosion, including acids in wine, it was only during the 1990s that some attention was first paid to the erosive potential of wine.

Several factors have recently placed the focus on dental erosion due to wine consumption:

- Wine has gradually become a part of our society’s diet.
- More emphasis is now placed on environmental health hazards that employees face.
- More research is being carried out into health benefiting and detrimental substances.
- The consumer wants to know more and is more informed, than in the past.
- More knowledge is available on the components of wine.
- In earlier days, in severe situations, a damaged tooth was extracted as there was no other option. With modern dentistry, and for aesthetical reasons, such a tooth can nowadays be saved and restored (at a cost).
2.3 EXPENSES ASSOCIATED WITH DENTAL CARE

Health insurance and dental treatment is not a luxury- it is a necessity. With the increase in health insurance costs, most people can only afford a basic level of insurance, which usually excludes dental expenses. In 2009 the most basic health plan will have a monthly contribution of about R1200 per month for a family of two - husband and wife. (DISCOVERY, 2009) Any dentist bills have to be paid by the individual him/herself. An ordinary 6-monthly oral examination and a necessary cleanse and polish at a dental hygienist will cost about R600. A porcelain crown will cost you about R3000 and repairing the posterior resin surface of a filling will cost you R1400 (DENTIST SOUTH AFRICA, 2008). Dental treatment is often required as a result of regular dental exposure to acids, as in the case of winemakers and professional wine tasters.

2.4 WINE: AN OCCUPATIONAL HAZARD?

In the early 1900s there were calls for the improvement of working conditions and the protection of workers from sickness, disease and injury arising from employment. Tools were created to protect people and communities’ health, through the promotion of health and quality of life, by preventing and controlling disease, injury and disability and preparedness for threats. Thus much emphasis was placed onto a safe environment for employees.

The employee has rights, and any substance that the employee may come in to contact with that may endanger the employee’s health is an occupational hazard. Several studies have demonstrated that regular and large consumption of wine is associated with increased risk of tooth erosion (Chikte et al., 2005a). With excess exposure, wine may become harmful as it decreases the micro hardness of tooth enamel significantly. Since the incidence of such harmful attack on dental health happens at work, more research should be carried out into the effect of wine on dental health and possible preventative measures that can be taken. Inclusion of the cost of 6-monthly visits to the dentist in the employee’s remuneration package could be considered as preventative measure taken by the employer.
2.5 BENEFICIAL EFFECTS OF WINE ON GENERAL HEALTH

2.5.1 Antioxidant properties

The antioxidant content of red wine, and flavonoids in particular, has often been cited when discussing the health-promoting characteristics of moderate wine consumption. Red wines have a higher phenol concentration than white wines. This is due to greater grape skin contact time and higher fermentation temperatures (Singleton and Trousdale, 1992).

Flavanoids make up the bulk of the phenol content of wine and are powerful antioxidants. Flavonoids in the diet are inversely associated with deaths from heart disease. In one study, the relative risk of coronary heart disease (CHD) was reduced by 68% in the highest vs. the lowest intake of flavonoids (Hertog, 1993). In various countries there exist a significant inverse association between wine consumption and heart disease mortality (St. Léger, 1979).

Polyphenolics in grapes and red wine act as radical scavengers and antioxidants.

The oxidation process can be described as follows. A neutral atom consists of a positively charged nucleus surrounded by a cloud of negatively charged electrons; the total charge on the electrons is equal to that on the nucleus. If an electron is removed from the atom, the atom is said to have been oxidized. If we continue to remove the electrons from the atom, each step is a further oxidation (Hewitt and Troup, 2005). The atom/molecule receiving the electron is said to have been reduced.

The reactive form of oxygen is called a free radical. Most of the oxygen molecules in our cells join with hydrogen molecules already in our body to form water, but not all of the oxygen molecules are used this way — some form free radicals. These molecules are different from a normal oxygen molecule because they are unstable — they are missing an electron that the hydrogen molecule would have provided (Stieber, 2002). A free radical is thus an atom or group of atoms that has at least one unpaired electron and is therefore unstable and highly reactive. There are good and bad free radicals in our bodies. The radicals found in wine are essentially permanently stable. When a molecule such as tannin from wine (a good free radical) meets a very reactive radical (a bad free radical), the bad radical is converted to the more stable (less reactive) form, and the tannin is converted into one of the very stable (unreactive) free radicals.
In this way the bad radicals are converted into good (harmless) radicals, and chemicals not harmful to our bodies. Such a molecule is called a radical scavenger or an antioxidant (Hewitt and Troup, 2005).

2.5.2 Wine reduces the incidence of coronary heart disease

Above mentioned molecules (antioxidants) are proposed to protect cholesterol in the low density lipoprotein, (LDL) species from oxidation. The oxidation of the LDL leads to a product that clogs arterial walls, and leads to heart disease and atherosclerosis (Hewitt and Troup, 2005). Frankel was the first to show that red wine protected LDL from oxidation (Frankel, 1993).

It has been shown that moderate but frequent consumption of wine reduces the incidence of CHD. Alcohol raises High-density lipoproteins (HDL) subfractions which have been found to be protective against CHD (Kannel and Curtis Ellison, 1995). In most countries, a high intake of saturated fat is positively related to high mortality from CHD. However, the situation in France is paradoxical. The strikingly low incidence of CHD in France, despite an intake of a high-fat diet, has been attributed to the consumption of red wine (Sun et al., 2002).

2.5.3 Wine prevents clotting

Wine prevents clotting and clotting mechanisms that may cause heart attacks, strokes and vein thrombosis. Alcohol acts as a blood thinner that prevents clots from forming in already narrowed coronary arteries, which is the initial event in most heart attacks (Kannel, 1971).

2.5.4 Wine provides social pleasure and benefits.

The benefits of moderate wine consumption also need to be adequately recognized. Findings from a recent series of Danish studies suggest that moderate wine drinkers are healthier than those who drink other alcoholic beverages or those who abstain. Data demonstrate that wine drinking is a general indicator of optimal social, cognitive, and personality development in Denmark (Mortensen et al., 2001).

Wine touches almost every aspect of history, culture, science, and commerce and understanding its benefits better enables all of us to experience and share more of the social, psychological, interpersonal and health benefits that wine offers.
The following properties cause the beneficial effect of red wine:

- **Resveratrol** (a phenolic substance in grape skin and wines) is a phytoalexin involved in grey mold resistance and acts as an anti-fungal agent in grapes. Dr Edwin Frankel (Frankel, 1993) has shown that these antioxidants are 5 times more potent than vitamin E. Researchers have found that resveratrol caused human neural cells to grow extensions that enable them to connect to neighbouring nerve cells. This helps to explain why wine drinkers have less neuron-degenerative diseases such as Alzheimer and Parkinson’s: it is due to the resveratrol in wine helping the nerve cells in the brain to grow and connect. Red and white wines possess antimicrobial (antibacterial) properties (Weisse, 1995). In an investigation into the antimicrobial activity of Chilean red wines against strains of Helicobacter pylori, the main active compound was found to be resveratrol. Resveratrol was also active against bacteria and dermatophytes, which are major etiologic agents in human skin infections (Chan, 2002). Natural effective antimicrobial agents against oral pathogens (Streptococcus mutans) could play an important role in preventing dental caries (Daglia et al., 2007).

- **Quercetin** inhibits the oxidation of LDL (De Whalley, 1990) Quercetin may also lower blood pressure by reducing the tension in blood vessel walls. Some studies have shown that it is also a natural antihistamine and an anti-inflammatory, and an antiviral agent. It may also boost immune systems and help to maintain mental performance.

- Indications are that wine consumption is more beneficial than the consumption of other alcoholic beverages. In a finding that counters conventional thinking about the relationship between alcohol use and colorectal cancer, drinking at least one glass of wine per week may protect against the development of the disease, whereas beer or mixed drinks do not (SCIENCE DAILY, 2000). In 2000, more than 56,000 Americans died from the disease and more than 130,000 new cases were diagnosed that year. The protective influence of wine is thus a very interesting and important finding.
2.6 NEGATIVE EFFECTS OF WINE ON CONSUMER HEALTH

The negative effects of wine on general health and dental health are discussed here.

2.6.1 GENERAL HEALTH

- **Haematopoiesis** (from Ancient Greek: *haima* blood; *poiesis* to make) is the formation of blood cellular components. All of the cellular components of the blood are derived from haematopoietic stem cells. (WIKIPEDIA, 2009). Alcohol is toxic to Haematopoiesis and functions of the brain.

- **Korsakoff's psychosis**. This is a brain disorder caused by the lack of thiamine (vitamin B₁) in the brain. Conditions resulting in this vitamin deficiency include chronic alcoholism and severe malnutrition. Alcoholism is often an indicator of poor nutrition, which in addition to inflammation of the stomach lining, causes thiamine deficiency.

- **Heart disease, diabetes and stroke**. High triglycerides levels are associated with health problems that increase the risk for these common conditions.

- **Breast Cancer**: Studies have shown alcohol can increase oestrogen levels, leading to an increase in tumor progression in women.

- **Migraines**. Wine is often a significant trigger of migraine for people who suffer with migraine headaches.

- **Weight Gain**. Alcohol contains "empty calories"—calories that lack nutrients — and can lead to weight gain.

- **Alcoholism / alcohol addiction**. Alcohol abuse becomes alcohol dependence when drinkers begin to experience a craving for alcohol, a loss of control of their drinking, withdrawal symptoms when they are not drinking, and an increased tolerance to alcohol so that they have to drink more to achieve the same effect. Alcohol dependence is a chronic and often progressive disease that includes a strong need to drink despite repeated problems. Historically, wine farm workers were paid a proportion of their wages in wine (the 'dop' system), which has resulted in a culture of alcohol misuse and the associated community problems, specifically in the Western Cape.

- **Foetal Alcohol Syndrome (FAS)**. FAS is a pattern of mental and physical defects that develops in some unborn babies when the mother drinks "too much" alcohol during pregnancy. South Africa has the highest number of children born with FAS worldwide.
• **Cirrhosis of the liver.** Scar tissue replaces normal, healthy tissue, blocking the flow of blood through the liver and preventing it from functioning as it should. Cirrhosis is the twelfth leading cause of death by disease: about 26,000 people die annually from this disease (LIVER FOUNDATION, 2007).

2.6.2 **DENTAL HEALTH**

• dental erosion
• Tooth discoloration
• Dentin hypersensitivity
• **Oral leukoplakia.** Wine may play a role here. Leukoplakia is the most common premalignant or potentially malignant lesion of the oral mucosa. This can result in oral cancer (oral mucosa).

Although ethanol itself has not been found to be carcinogenic, many alcoholic drinks contain carcinogens (Elwood et al., 1984). Alcohol seems to mediate or transport carcinogens through the epithelium (tissue composed of layers of cells, which lines the inside of the mouth cavity’s mucous membranes).

Various factors may contribute to the development of alcohol-associated cancer, including the actions of acetaldehyde, the first and most toxic metabolite of alcohol metabolism. The main enzymes involved in alcohol and acetaldehyde metabolism are alcohol dehydrogenase (ADH) and aldehyde dehydrogenase (ALDH). Several mechanisms may contribute to alcohol-related cancer development. Acetaldehyde itself is a cancer-causing substance in experimental animals and reacts with DNA to form cancer-promoting compounds. In addition, highly reactive, oxygen-containing molecules that are generated during certain pathways of alcohol metabolism can damage the DNA, thus also inducing tumor development. (Seitz and Becker, 2007).
2.7 HISTORY OF HEALTH BENEFITS OF WINE

The medical profession has long recognized the healthy properties of wine — it has done so for thousands of years. Hippocrates himself recommended specific wines to purge fever, disinfect and dress wounds or for nutritional supplements (PROFESSIONAL FRIENDS OF WINE, 2000). “Is it possible that wine may indeed be one of the world’s oldest medicines?” (Chikte, 2005a).

Documentary sources from the Anglo-Saxon period in England (from the early fifth century AD to the time of the Norman Conquest – in 1066 AD) reveal that toothache was a frequent problem, and wine formed a very important part of their remedies (Anderson, 2004a).

In the "Leechbooks of Bald" (Anderson, 2004a), the following remedies for toothache are proposed:

“...chew pepper often with the teeth, it will soon be better for him. Again boil henbane’s root (Hyoscyamus niger) in strong vinegar or wine, set it on the sore tooth, and let him chew it with the sore tooth sometimes; he will be hale…”

“take...betonica (Stachys betonica), and boil in old wine or vinegar to a third, it heals wonderfully pain and swelling of the teeth…”

“take henbane root (Hyoscyamus niger), boil in strong wine, let him sip it thus warm and let him take hold of it in his mouth, soon it will heal the pain of the teeth…”

In the medieval period (12th – 14th century), medical literature suggest remedies for care of the teeth (Anderson, 2004b). The Chirurgia of Roger Frugard was written in Latin (1180 AD):

“then the gums should be washed in wine and after three days, rubbed with alum. Then apply a lotion made from wine and honey infused with roots of mullein (Verbascum Thapsus); honeysuckle (Lonicera periclymenum); pomegranate; pellitory and ginger.”

“Take a cupful of wine or claret, and a sprig of rosemary, boiling them together, put in a piece as big as a nut of frankincense; a spoonful of honey, and two of water, mixing them well together. Wash the mouth frequently and it will be cured.”
A French doctor also wrote the earliest known printed book about wine around 1410 AD.

Could the above all be meaningful facts, or just arising from thousands of years of trial and error? Why was wine part of so many of the remedies for teeth problems as well as general health problems? Could there be any truth in the fact that wine can cure health problems?

Until the 18th century, wine played an integral role in medical practice. Not only was it safer to drink than most available water but its alcohol, antioxidant and acid content inhibited the growth of many spoilage and pathogenic organisms.

In the 20th century, the outlook on wine consumption changed in a dramatically negative way, and health campaigners demanded warning labels on wine. On the other hand, much of the medical evidence accumulated in the 1990s indicated that moderate consumption of especially red wine could reduce the incidence of CHD (Armstrong, 2001).

Renewed interest in wine consumption has arisen from the dietary anomaly commonly referred to as the French Paradox. This phenomena refers to an association between a high fat diet and a lower incidence of CHD, particularly found in Mediterranean countries, which contrasts with a higher incidence of CHD among most Western cultures. The French eat 30% more fat, smoke more and exercise less than Americans, and yet have fewer heart attacks (Renaud and Lorgeril, 1993).

Regular, moderate wine drinking was discovered to be the one consistency in Mediterranean countries. Studies found the occurrence of CHD to be much higher in heavy or binge drinkers, and even higher in abstainers. (PROFESSIONAL FRIENDS OF WINE, 2000). Europeans generally drink wine and water with their meals daily. The American culture is that of binge drinking alcohol over the weekends, and not daily during the week. The key to the beneficial aspects of wine drinking are regularity and moderation.

Much more research needs to be done on the relationship between wine and dental health. Since ancient times, this drink has been simultaneously touted for its health benefits and blamed for its tortuous side effects (Cox, 2008).

The next chapter will focus on dental erosion and its causes.
CHAPTER 3: CAUSES OF DENTAL EROSION

3.1 ENDOGENOUS EROSION CAUSED BY INTRINSIC FACTORS

Endogenous dental erosion manifest in the dissolution of enamel and dentine from the palatal (side of the tooth adjacent to the palate) and lingual (side of the tooth adjacent to the tongue) surfaces of the dentition with subsequent thinning of the maxillary (upper jaw) incisal (direction towards the biting edge of anterior teeth) edges (Lupi-Pegurier et al., 2003).

The following intrinsic factors can cause endogenous erosion:

- Chronic vomiting, such as in eating disorders like anorexia nervosa and bulimia, where erosion is caused by propulsion of gastric content into the mouth.
- Gastrointestinal and psychogenic disorders.
- Low unstimulated salivary flow rates, with insufficient buffering and rinsing of acids, are believed to be additional factors in the development of dental erosion (Wöltgens, 1985).

3.2 EXOGENOUS EROSION CAUSED BY EXTRINSIC FACTORS

Exogenous dental erosion manifests in lesions that are usually bilateral, affecting mostly the labial (side of tooth adjacent to inside of lip) and buccal surfaces (side of tooth adjacent to inside of cheek) of incisors (front teeth), canines and premolars adjacent to the gingival (neck of the tooth) margin. Approximal and occlusal (biting) surfaces may be involved too (Lupi-Pegurier et al., 2003).

The following extrinsic factors can cause exogenous erosion:

- Acidic foods with demineralizing potential, such as citrus fruits and acidic beverages (such as wines).
- Occupational factors, such as exposure to acidic environments at work, e.g. sulfuric acid in battery manufacturing factories and hydrochloric acid where galvanizing is performed.
- Exposure to high levels of hydrochloric acid in improperly maintained chlorinated swimming pools. (Mandel, 2005a).
• Prolonged oral retention of medications such as hydrochloric acid tablets, aspirin and Vitamin C (ascorbic acid).

3.3 OTHER CAUSES

Tooth enamel erosion occurs only in susceptible individuals regardless of food and beverage consumption patterns. (Moss, 1998). Susceptibility is highly variable from person to person and further research is needed to determine why susceptibility to erosion differs so widely from person to person.

Several other factors have been proved to contribute to the risk of dental erosion over time.

• Geographic factors, which includes low fluoride content in drinking water. The use of fluoride has resulted in a substantial decline in the incidence and prevalence of dental decay and has improved the quality of life for millions of people (FDI statement, 2000).
• Genetic factors. Our genetic heritage can override our habits and leave a person prone to oral problems. Low resistance of enamel to erosion and low salivary flow can increase susceptibility to dental erosion.
• Population specific factors. Malnutrition is caused by a deficiency, excess or imbalance in proteins and other nutrients, and the condition may result in bad teeth. (E.g. During World War Two an entire population of children had dental problems due to malnutrition during the War.)

Having discussed the main causes of dental erosion, I will now focus on the role of acidic foods/beverages, and the specific role of wine, in dental erosion.
CHAPTER 4: THE IMPORTANT ROLE OF WINE IN DENTAL EROSION

Various records state that wine can cause dental erosion (Chikte et al., 2003). Acid is one of the main ingredients in wine that causes dental erosion. The degree of erosion caused by acids is determined by several factors, like the type of acid involved, the form in which the acid exists, what food type accompanies the acidic beverage, the frequency of intake, the duration of the contact of the acidic beverage with teeth, and the amount of acid involved.

4.1 CHEMICAL COMPONENTS OF WINE THAT CAUSE TO DENTAL EROSION

The capability of any drink (e.g. wine) to erode (demineralise) dental enamel will depend on many factors, such as the pH, total acid concentration, acid strength, buffering capacity, dissolution rate of acids, and specifically the calcium, phosphorous and fluoride concentrations, because these elements form the building blocks of hydroxy- and fluoroapatite.

Particularly the calcium, phosphate and fluoride content could counteract the effect of low pH and make beverage less harmful than if only the pH was taken into consideration. The pH of South African white wine is around 3.2 to 3.5: red wines have a pH of 3.5 to 4, and sparkling wines a pH of 2.9 to 3.1 (Chikte et al., 2005b). The critical point at which enamel dissolves is reported to be pH 5 to 5.7 (Touyz, 1994). Any solution with a pH value around this value and lower may cause significant erosion and thus wine can play a significant role in dental erosion, particularly if the exposure is of long duration and repeated over time.

The salivary concentration of calcium and phosphate is normally supersaturated in relation to enamel hydroxyapatite (a mineral compound which is the principal inorganic component of teeth). An acid challenge results in undersaturation of these salivary salts, and tooth demineralization and softening of dental enamel occur (Mandel et al., 2005a). The altered enamel now becomes susceptible to wearing away by masticatory (chewing) forces and tooth brushing.

The main acid constituents of wine are malic and tartaric acids, with a joint concentration of 5-8 g/L. The ratio of each depends on the degree of malolactic fermentation. Small quantities of succinic and citric acid are present. In a study done by Rytömaa et al. (1988) it was found that
lactic acid does not cause significant erosion compared to citric acid. The drinks with phosphoric and citric acid were very erosive.

Holloway (1958) found that the addition of sucrose, fructose or invert sugar to a 0.5% citric acid solution led to greater dental erosion. This fact is very relevant in the present situation as more and more clients and supermarkets demand higher sugar levels in wines. The effect of a combination of high acid and high sugar in wines still needs to be investigated.

4.2 HABITS ASSOCIATED WITH WINETASTING

4.2.1 Daily Consumption

Professsional wine tasters sample 5 to 50 wines each day, and hold the wine in their mouth from 15 to 60 seconds (Mok, 2001), which is sufficient time for widespread erosion of all teeth to occur. Winemakers are generally exposed to 12-60 tastings per day, depending on the season (Chikte et al., 2005b). During the fermentation of the wines, above statistics increase significantly. Each tank/batch is tasted repeatedly during the various stages of winemaking in order to make critical decisions. For example, during fermentation and aeration of a red wine the wine must be tasted several times to determine when the skins should be removed (pressed), and while the wine is pressed it must also be tasted to determine where the cut-off will be of the wine pressed at lower pressure and the fraction pressed at higher pressure. Winemakers have to taste young wines constantly while in the making, as well as numerous times in the wine’s lifetime to determine additions and make decisions on the handling of the wine.

It has been reported that a Master of Wine can routinely taste 200 wines per week and as many as 100 in a 2.5 hour period (Chaudhry et al., 1997). For professionals tasting wine for the Department of Agriculture (based in Stellenbosch South Africa), a flight of up to 100+ wines can be tasted in an hour. Swedish wine tasters working for Vin & Spirit AB (state-owned company) in 1994, also have normal sessions of more than an hour during which they tasted 20-50 wines (Wiktorsson et al., 1997). Each year they also made a number of trips to wine districts and participate in several wine tasting sessions daily. Wine judges are at a great risk of dental erosion as they may taste up to 200 wines a day for 4 consecutive days, several times a year (Mok, 2001).
This frequency is drastically decreased in the case of a consumer. Data show big differences in wine consumption in different countries. A consumer in France would drink about 55 litres per year (1 litre per week). A consumer in South Africa drinks about 8,4 litres per year (160 ml per week) (THE WINE INSTITUTE, 2006). The worldwide per capita wine consumption is currently 3.6 liters per person (70 ml per week) (Arora, 2008). This is about half a unit per week. Of course, this is the average taken of the entire population of a country. If you take into account that about 50% of young people (21-31 y) in France never drink wine (Macle, 2008), then the number of units per individual (that do drink wine) increases.

4.2.2 Contact of wine with teeth

During wine tasting, wine is swirled around the mouth to stimulate the taste buds and to reach the sides and base of the tongue, while inhaling mouthfuls of air to aerate the wine, before the wine is expectorated. This ritual might take about 15 seconds at a time. Thus the wine covers all areas of the mouth for an extended period. During sipping and holding the wine in the mouth, the occlusal (biting surfaces) aspects of the posterior teeth (at the back of the mouth) are contacted, and readily affected, and the enamel loss will be extensive. This frequent and long exposure to an acid pH makes the teeth more likely to be eroded than if the person rapidly swallowed the wine. In the case of an everyday consumer, this situation of swirling and prolonged retention of the wine in the mouth does not prevail, and hence the danger of erosion is reduced.

4.2.3 Wine and contact with food

In the case of serious wine tasting no food is taken, as food alters the taste and smell of the wine. In the case of consumption of wine by average consumers, food is often taken with wine. Food increases the salivary production and acts as physical detergent. This reduces the wine’s dental contact time and also reduces the posed danger to dental erosion. Thus the manner and timing of wine drinking is the key to an individual’s susceptibility to dental erosion (Mandel, 2005a). The differences in the manner of wine tasting between a consumer and a professional wine taster, makes all the difference in the danger that wine poses to teeth enamel and thus dental health.
4.2.4 Salivary stimulation

Sodium, potassium, calcium, magnesium, phosphate and bicarbonate ions are present in saliva. Saliva is supersaturated with calcium phosphate, which (in theory) prevents demineralization of teeth (Chikte et al., 2005b). The pH of saliva is in the range 6.2 - 8. Sorvari and Ryтомaa (1991) showed that a low flow rate of unstimulated saliva increased the risk of tooth erosion fivefold. In studies by Wiktorsson et al. (1997), all subjects with severe erosion had abnormally low unstimulated salivary flow rates. Saliva, with its buffering capacity and its ability to form a protective enamel pellicle, can control dental decalcification. But this physiological protection fails when saliva is overwhelmed by large quantities of substance with a low pH or when decreased salivary production occurs (Mandel, 2005a).

A possible reason for the low prevalence of erosion on the posterior (back), maxillary (upper), labial (side of tooth adjacent to the lip), and the lingual (side of tooth adjacent to the tongue), may be the proximity of the major salivary ducts discharging saliva in the vicinity of these tooth surfaces. The normal volume of salivary secretion in an adult male varies from 1000 - 1500 ml/24 h. Lower saliva flow levels in consumers and professional wine tasters will lead to increase in the risk of dental erosion.

4.3 DIFFERENCES IN CORROSIVENESS OF DIFFERENT WINE STYLES

Winemakers believe that sparkling wines are usually most damaging to teeth, and red wines least damaging, in terms of erosion. The longer maturation periods required for red wines may result in the greater production of potential inhibitors of erosion.

Red wines are however known to cause considerable problems with severe staining of teeth. In a study done by Mok (2001), continuous exposure of enamel and root surface cementum to samples of Rieslings and champagne-style wines and claret showed that red wine was the least erosive. The white wines resulted in the deepest erosion. Sparkling wine, which is usually the most erosive of wines, in this case resulted in the same level of erosion as white wine.

The figures below show how white wine erodes enamel more that red wine. The SEM image of the tooth surface exposed to red wine shows less signs of erosion (Figure 4.2) compared to the tooth surface exposed to white wine (Figure 4.1).
Figure 4.1 Scanning electron micrograph (SEM) showing eroded enamel surface and characteristic honeycomb structure after 30-min immersion in dry white wine (Meurman and Vesterinen, 2000).

Figure 4.2 Scanning electron micrograph (SEM) showing eroded enamel surface and characteristic honeycomb structure after 30-min immersion in dry red wine. (Meurman and Vesterinen, 2000).
The following table (Table 4.1) shows the analysis of three different wine samples in terms of acid content. The three selected wine samples represent the greatest diversity in terms of acid content and pH (Chikte et al., 2003).

Table 4.1  Analysis of three different wine samples (Chikte et al., 2003)

<table>
<thead>
<tr>
<th>Wine</th>
<th>Citric acid (g/l)</th>
<th>Acetic acid (g/l)</th>
<th>Malic acid (g/l)</th>
<th>Lactic acid (g/l)</th>
<th>TA (g/l)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.42</td>
<td>2</td>
<td>2.36</td>
<td>0.15</td>
<td>7</td>
<td>3.2</td>
</tr>
<tr>
<td>2</td>
<td>0.38</td>
<td>1.16</td>
<td>1.32</td>
<td>1.18</td>
<td>3.6</td>
<td>3.7</td>
</tr>
<tr>
<td>3</td>
<td>0.37</td>
<td>1.15</td>
<td>0.59</td>
<td>3.84</td>
<td>6.1</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Chikte, et al. (2003) investigated the severity of erosion caused by different styles of wine. All three wines eroded dental enamel, mainly due to the very low pH and high total acid (TA). Wine 2 (Table 4.1) had the severest influence on the hardness of the teeth. Looking at the pH values alone, it is expected that Wine 1 with the lowest pH would be responsible for the highest degree of demineralization, but this was found not to be the case. If the TA content was the major factor, then again Wine 1 should be the most damaging and Wine 2 the least damaging, which was not the case. Furthermore, the concentrations of different types of acid found in the two different wine samples also gave no reason for the fact that Wine 2 was responsible for the highest degree of demineralization. It was concluded that it is difficult to predict the relative erosion rate of different kinds of wines according to their chemical composition as dental erosion is affected by a large number of factors combined. However, from the results it is clear that drinks with a low pH value and a high TA concentration are erosive towards dental enamel. Thus according to Chikte et al., (2003), the reasons why Wine 2 was found to be the most damaging was due to other factors, such as the dissolution rate, concentration of undissociated acids and the diffusion rate.

Gray et al. (1966) reported that dissolution rate of buffer acids (formic, lactic and acetic acids) is controlled by rate of diffusion of the undissociated acids into the enamel and, to a lesser extent, by pH and acid strength.
Featherstone and Rogers (1981) reported that the rate of lesion progress (demineralization) is a function of calculated un-ionized acid concentration and the acid dissociation constants. They emphasized the importance of acid type and concentration rather than pH alone.

Mok (2001) also found no correlation between the pH and the depth of enamel dissolved. Erosion was found to be a function of the acid dissociation constant, the calculated un-ionized acid concentration and the concentration of demineralization inhibiting agents. Thus the demineralization process, the type of acid and concentration, are more important than the pH alone.

The next chapter will focus on the manifestations of dental erosion.
CHAPTER 5: MANIFESTATIONS OF DENTAL EROSION

5.1 DENTAL SENSITIVITY

Erosion of tooth tissue can have catastrophic consequences for oral health. Tissue loss can result in increased sensitivity and pain from exposed dentine. One may feel a twinge of pain when one consumes hot, cold or sweet foods and drinks.

5.2 ORAL MUCOSAL REACTIONS

Erosive oral lichen planus is an inflammatory skin disease of the outer pink membrane lining the inside of the oral cavity (oral mucosa). It presents itself in the form of lesions or rashes. It can be caused by allergic reactions to medications for high blood pressure and heart disease. Some case studies suggest that wine might also contribute.

Oral lichen planus may become complicated by acquisition of fungal micro-organisms (usually Candida albicans). C. albicans is normally present as a yeast (non-pathogenic state) and will, under favourable conditions, transform into a pathogenic (disease causing) form. This might lead to superimposed candidiasis, resulting in mild “burning” discomfort of the affected mucosa (Kalmar, 2007).

5.3 LOSS OF TOOTH SUBSTANCE/ENAMEL

Erosion attacks the enamel surface. Acids find their way to the pits and pores in the enamel and cause prism destruction in subsurface layers (Downer, 1995). Ultrasonic in vitro studies (Meurman et al., 1991) have demonstrated the progression of erosion in prismatic and aprismatic enamel. Ultrasonic studies have shown that erosive lesions are to be seen in prismatic enamel as characteristic demineralization patterns where either the prism cores or interprismatic areas dissolve, leading to a honeycomb structure.
The following remarks from Mandel (2005a) describe the characteristic patterns of tooth erosion:

- Cupping (a “peephole” in the enamel, often at a molar cusp tip): hollowed-out area that develops when softer exposed dentin dissolves faster than the surrounding enamel
- Frosty white rim of decalcified enamel encircling the exposed occlusal dentin—see image of an example of a frosty white rim (enamel) in Figure 5.1.

Figure 5.1: Mandibular left side. Loss of occlusal enamel – presence of white enamel rim (Mandel, 2005a).

- Irregular enamel loss, most advanced on the occlusal (biting surfaces/contact surfaces of opposing teeth) aspects of the premolars and molars, where masticatory (chewing) contact is pronounced
- Increased yellow hue of the buccogingival (near cheek and gums) aspects of the posterior (at the back of the mouth), most marked in the mandibular (lower jaw) teeth—derived from enamel loss, which makes the underlying yellow dentin more visible as it will be closer to the surface
• Gravity plays a role through the increased wine contact with mandibular teeth compared with the maxillary (upper jaw) teeth

The following remarks from Chaudry et al. (1997) describe more characteristic patterns of tooth erosion

• Shallow wear facets, shiny and smooth saucer-shaped cavities
• Thinning of maxillary incisal edges
• Absence of staining
• Extrusion of anterior amalgam restorations – dental hard tissue loss adjacent to the restorations — see image of extruded restorations in Figure 5.2.

Figure 5.2: Mandibular right side. Loss of occlusal enamel – amalgam projection results from loss of adjacent dental structure (Mandel, 2005a).
5.3.1 **Classification of erosion**

Based on visual examination, the following classes of severity of erosion have been proposed (Eccles’ classification- Eccles, 1979).

- **Class 1**
  Earliest stage of clinically detectable erosive change is loss of surface characteristics of the enamel, leaving it smooth and lacklustre (matt), mainly on labial (around lip) surfaces of maxillary (upper jaw) anterior (front) teeth. Teeth may have a rounded or “sandblasted” look.

- **Class 2**
  Lesions may involve labial surfaces of any teeth but are most commonly observed on the anterior (front) teeth, mandibular (lower jaw) as well as maxillary (upper jaw). There are two types of lesions:
  - Lesions in the cervical region (neck of tooth), concave in cross section.
  - Lesions on the labial surface - irregular in contour and stamped-out appearance.

- **Class 3a**
  Lesions with more extensive destruction of dentin on labial surfaces of teeth, particularly the maxillary and mandibular anteriors.

- **Class 3b**
  Lesions have extended into the dentin and occur mainly on the lingual surfaces, more frequently on the maxillary than the mandibular teeth.

- **Class 3c**
  Lesions involving the dentin of the incisal edge and the occlusal surfaces, often in combination with lesions on other surfaces.

- **Class 3d**
  Lesions seen in very severely damaged teeth, involving both labial and lingual surfaces and occasionally even the approximal surfaces. The teeth are shortened, and resemble preparations for shoulderless jacket crowns.
Chikte et al. (2005) use codes to measure tooth surface loss, in grades:

- **grade 0** - no clinical evidence of tooth surface loss
- **grade 1** - loss of enamel surface, giving a smooth glazed surface with no dentine involvement
- **grade 2** - involvement of dentine in less than one third of the area of the tooth surface
- **grade 3** - involvement of the dentine in more than one third of the area of the tooth surface.

The loss of tooth substance can sometimes occur unnoticeably. Only in severe cases will it be clear to the eye to see, and result in poor appearance.

### 5.4 POOR APPEARANCE

As the loss of enamel and dentine becomes more severe, the teeth become disfigured and lose their original shape and size, which can lead to the loss of the affected teeth (Chikte et al., 2005b). Many patients with dental erosion do not report deterioration in appearance until there has been sufficient loss of tooth tissue, particularly on the palatal surfaces (side of tooth adjacent to the palate) of maxillary (upper jaw) incisors (front teeth), to cause the thinned incisal edges to fracture. At this point expensive dental restorative treatment is required.

### 5.5 DISCOLORATION

Discoloration is an increased yellow hue of the buccogingival (near cheek and gums) aspects of the posterior teeth (at the back of the mouth), most marked in the mandibular (lower jaw) teeth. It is derived from enamel loss, which makes the underlying yellow dentin more visible as it will be closer to the surface.

All of the above describes the wider aspects of the resulting effect of dental erosion. Numerous studies have been carried out, the research of which support the above facts. Specific evidence of the erosive effect of wine (case reports) will be discussed in the next chapter.
CHAPTER 6: SPECIFIC EVIDENCE OF THE ERROSIVE EFFECT OF WINE

While evidence does exists to prove the existence of dental erosion in winemakers and others in the wine trade who are required to taste wines frequently, there is very little formal documentation on the topic. Some of the available documented case reports, and the results of a Laboratory investigation are now mentioned.

6.1 CASE REPORTS

- A 52 year old male complained of a burning sensation particularly affecting the cheeks. He had professionally tasted wine for a period of 23 years: 30 wines a day on average, and 245 000 acidic exposures over this period. Very little further erosion has taken place since retirement. (Chaudry et al., 1997). He had no previous history of bruxism, chronic vomiting or acid regurgitation. Dietary analysis showed he had not consumed excessive quantities of carbonated beverages, fruit juices or citrus fruits. The pattern of the toothwear was characteristic of tooth erosion. The key message of Chaudry was that individuals in the wine business are potentially exposed to a large amount of exogenous acid and are therefore at risk of developing some degree of dental erosion.

- A 56 year old woman was referred to Columbia University's Salivary Gland Centre because her dentist noted excessive loss of tooth structure (enamel). Irregular enamel loss was most advanced on the occlusal aspects of premolars and molars, where masticatory contact (chewing) was pronounced. The patient had been drinking a full bottle of white wine each evening for the past 34 years. She had the habit of sipping the wine over a period of 3 hours after dinner and then retiring without cleaning her mouth. This inevitably points to a diagnosis of dental erosion caused by the acidity of wine (Mandel, 2005a).

- A case of widespread dental erosion was reported in an individual who had worked in the wine industry for ten years (Gray et al., 1998). This occupation involved daily tasting of at least 20 wines or more. The erosion manifested as dental sensitivity, and the presentation of cervical erosion, occlusal pitting, and loss of enamel around restorations.
• Nineteen qualified Swedish wine tasters employed by Vin & Spirit AB were intra-orally examined. These winetasters tasted on average 20-50 different wines nearly 5 days a week. The pH of the wines ranges from 3 to 3.6, and thus they pose a potential risk for tooth erosion. Fourteen of the subjects had tooth erosion, ranging from mild to extreme. The severity of the erosion tended to increase with the number of years of occupational exposure. Fourteen subjects also had low, unstimulated salivary flow rates. It was concluded here that full-time winetasting is an occupation associated with an increased risk for tooth erosion (Wiktorsson et al., 1997).

• In a study done in South Africa (Chikte et al., 2005b), 36 persons: 21 winemakers (exposed to wine) and 15 of their spouses (unexposed) participated. In general, winemakers are exposed to 50-150 tastings per day, according to the season. In this study it was possible to show that the occurrence of tooth surface loss among the winemakers was highly likely due to the frequent exposure of the teeth to wine. This frequent exposure is deleterious to enamel and constitutes an occupational hazard.

6.2 LABORATORY INVESTIGATION

• In an SEM study carried out by Gray (Gray et al., 1998), freshly-extracted teeth were placed in 50 ml white wine (pH 3.3) at 37 °Celsius for 24 h. Some teeth were also placed in de-ionized water under otherwise identical conditions. After incubation, the samples was rinsed and examined by SEM. The electron micrographs of the water-only exposed specimens (Figure 6.1) depicted the typical appearance of the ends of enamel rods whilst those of the wine specimens (Figure 6.2), showed irregular areas of erosion.
Figure 6.1 Scanning electron micrograph of an unerupted tooth that had been placed in de-ionized water for 24 hours. The enamel rods are visible on the surface. (Gray et al., 1998)
Chikte et al. (2003), embedded 21 extracted human incisor teeth in epoxy resin, of which seven were immersed in each of three different wine samples for various time periods. The Knoop hardness of each tooth, after different immersion periods in different wines was determined as a measure of the degree of enamel erosion (demineralization). The finding was that all three wines eroded enamel (softer enamel) probably due to their very low pH values (3.2; 3.7; 3.8) and their high total acid content.

The microhardness test was performed with a Leitz Wetzlar microhardness tester (South Africa), with a load of 100 g applied for 30 sec. From the depth of each diamond indentation the Knoop hardness values (enamel micro-hardness) were calculated using the standard tables supplied with the apparatus. The enamel microhardness (EMH) is directly related to mineral loss and indicates the degree of enamel erosion (demineralization).
Microhardness tests are suitable for determining the small changes in surface microhardness that demonstrates the effect of acids on enamel and therefore attack by erosion (Lupi-Pegurier et al., 2003).

- Lupi-Pegurier et al. (2003) tested the effect of Bordeaux red wine on enamel by measuring the changes in Vickers microhardness. Thirty premolars were used, and microhardness tests were performed on buccal areas before and after 10, 30, 90 and 120 sec immersion in the wine (pH 3.9). After 90 sec immersion in red wine there was no overall statistically significant decrease in microhardness of the tooth surface. It was only longer exposure of 120 sec that resulted in a statistically significant decrease in enamel microhardness. For patients with reduced salivary flow, the harmless exposure time to the wine would be lower.

- Two demineralization test methods can be used to analyze the erosive potential of beverages. Namely, the iodide permeability (Ip) test (shows changes in porosity) and surface microhardness test (measuring the indention length at different sites). Both methods are able to detect the very early stages of enamel demineralization (Lussi et al., 1993).

Results of most of the above experiments have included warnings about the detrimental effect of wine on teeth. The following chapter will discuss, on the other hand, the beneficial effects of wine on dental health.
CHAPTER 7: BENEFICIAL EFFECTS OF WINE ON ORAL HEALTH

Grapes are one of the world’s largest and most economically important fruit crops, most of which is used for winemaking. A total of 1.35 million tons were crushed in 2007 in South Africa alone (SAWIS, 2008). South Africa’s wine industry is of crucial importance to the country’s economy.

Wine grapes are rich sources of flavonols, anthocyanins, proanthocyanidins, catechins, and other phenolic compounds (Thimothe et al., 2007). These contribute to the overall beneficial effects of wine on health.

7.1 ANTIBACTERIAL AGENT AGAINST ORAL STREPTOCOCCI

Streptococcus mutans can colonize tooth surfaces and is regarded as a primary microbial agent in the pathogenesis of dental caries. It can initiate plaque formation. This bacterium has at least two specific virulence traits that are involved in the formation of cariogenic biofilms on the tooth surface (Thimothe et al., 2007):

- Synthesis of extracellular polysaccharides (mainly water-insoluble glucans) from sucrose, using glucosyltransferase (Hamilton-Miller, 2001)
- Ability to produce and tolerate acids.

The acid production by S. mutans results in low pH values in the plaque matrix, which contributes to the demineralization of tooth enamel and the selection of acid-tolerant organisms, such as mutans streptococci. By aiming to disrupt the ability of S. mutans to utilize sucrose to form glucans and acids on the tooth surface, therapeutic approaches to reducing the formation of cariogenic biofilms could be precise and selective (Thimothe et al., 2007).

Several studies have shown that wine extracts and the phenolic compounds in wine exhibit antibacterial activities against oral pathogens, including S. mutans (Yanagida et al., 2000). Grape phenolic extracts exhibit biological activity against S. mutans by disrupting essential virulence traits like glucosyltransferases (GTF) activity of this ubiquitous oral pathogen involved in the formation and acidogenicity of dental biofilms, without affecting bacterial viability.
Grape extracts may harbour specific compounds that may be useful for pathogenic biofilm control (Thimothe et al., 2007). Fermented pomace is a promising and feasible source of compounds that can be extracted and isolated for prevention of oral diseases, such as dental caries.

Daglia et al. (2007) found that wine can act as an effective antimicrobial agent against the tested pathogenic oral streptococci and might be active in caries and upper respiratory tract pathologies prevention. Succinic, malic, lactic, tartaric, citric, and acetic acids also exhibited antibacterial and postcontact activities and can therefore be collectively considered responsible for these preventative properties.

7.2 EFFECTIVENESS OF WINE AGAINST S. PYOGNENES

In a study done by Daglia et al. (2007) it was found that both red and white wines proved to exert in vitro antibacterial activity against S. pyogenes (responsible for pharyngitis). The symptoms of pharyngitis are a sore throat, headache, fever, swollen lymph nodes and difficulty in swallowing. Most cases are caused by a virus, or bacteria like Group A streptococcus.

7.3 LOWER CARIES ACTIVITY (PLAQUE/ORDONTOPATHOGENS)

In a study done by Signoretto in 2006 (Signoretto et al., 2006), it was proved that wine can lower caries activity. Total bacteria, total streptococci, S. mutans and lactobacilli counts in both saliva and dental plaque were determined in cultures. The highest bacterial titres (number of molecules of a substance in a given volume) were recorded for the control population while for the wine-drinking group the counts were roughly one log lower than the controls. As far as dental plaque was concerned, a significant decrease was observed in those subjects drinking wine when mutans streptococci and lactobacilli were evaluated. In several cases a more than one log decrease was observed. Plaque indices were also determined, and a significant reduction in values was recorded in the subjects in the wine-drinking group compared to the control group.
### 7.4 BENEFICIAL EFFECT OF WINE ON GUMS

A component found in red wine can help to prevent and treat periodontitis (BRITISH DENTAL JOURNAL, 2006). Periodontitis is a gum disease: it manifests as inflammation around the tooth, affecting the gums and bone that surrounds and support the teeth, often causing tooth movement and it can lead to permanent tooth loss (SENIORJOURNAL, 2006). The health benefits of wine are believed to arise from a broad range of compounds in wine, collectively known as polyphenols (BRITISH DENTAL JOURNAL, 2006). Recent studies have shown that red wine, and particularly grape seeds, possesses anti-inflammatory and anti-tumor properties. Scientists from the Université Laval (Canada) conducted a study to investigate the role of polyphenols, including those from red wine, in scavenging free radicals released by immune cells stimulated with components of bacteria causing periodontal diseases (Houde, 2006). Free radicals are generated by immune cells during periodontitis and hence it is critical that low levels of free radicals be maintained to ensure healthy gums. The results of the study indicated that red wine polyphenols significantly modulate several inflammatory components released by macrophages in response to bacterial stimuli. Specifically, polyphenols efficiently scavenged and inhibited free-radical generation by immune cells by controlling intra-cellular proteins involved in their release. These antioxidant properties of red wine polyphenols could be useful in the prevention and treatment of inflammatory periodontal diseases.

### 7.5 CONCLUSION

Earlier evidence mainly focuses on the beneficial effects of wine on our general health. The information in this chapter emphasize that wine can also be beneficial to our dental health. Wine can act as antibacterial agent against oral streptococci and S. pyogenes. Wine can lower caries activity and can help to prevent periodontitis.

Nonetheless, for winemakers and employees in the wine industry, the consumption of wine will always be a part of our daily chores. It is therefore important to highlight and discuss possible solutions for, and treatments of dental erosion. This is done in the following chapter.
CHAPTER 8: SOLUTIONS TO DENTAL EROSION AND TREATMENT OF DENTAL EROSION

8.1 CONSIDERATION OF METHOD AND DURATION OF WINETASTING
The method by which wine tasting is executed is one of the factors that enhances erosion due to the prolonged time of contact with the teeth. The time of the day that the tasting is executed is also important. For example, if wine is consumed just before sleeping (that means no further beverages will follow the wine), the acid environment in one’s mouth will also extend for a longer time, and thus dental erosion will be more severe.

The following solutions are proposed:

- Wine consumption should be restricted to only during meals, if possible.

- Do not rinse every sip of wine as this will lengthen the contact period as well as enlarge the contact area with your teeth, and will reduce the buffering effect of saliva (by reducing the saliva pH value) (Chikte et al., 2003).

- It is advisable to drink through a straw (although not practical in wine tasting circumstances) to decrease the contact area. This would not be applicable to serious wine tasting.

8.2 CONSIDERATION OF VOLUME CONSUMED DURING WINE TASTING
Naturally, the more wine that is consumed the more acid will be exposed to one’s teeth. Therefore if one could reduce the frequency and severity of the acidic challenge, by consuming less wine, the danger of acid erosion would be diminished. Wine consumers could be advised to reduce number of wines tasted daily, if possible.

8.3 RE-HARDENING OF DENTAL ENAMEL

- Gray et al., (1998) recommended the following: Use fluoride mouth rinse to reduce the enamel solubility. Use of topical applications (fluorides) such as mouthrinses or dentifrices is reported to affect the repair of carious enamel lesions through remineralization (Gedalia et al., 1992). The enhancement of the process of
remineralization is currently considered to be an important part of the mechanism of the action of fluoride (White, 1987). Use of a daily rinse of a 0.05% sodium fluoride solution (alkaline mouth rinse) is advocated.

- Use fluoride enriched toothpastes.

- Use fluoride gels: Elmex gel contains a high concentration of fluoride and a weekly application is useful in rehardening enamel.

- Remineralizing toothpaste (Enamelon) has been shown in in-vitro studies to increase the hardness of acid-treated teeth significantly more than conventional fluoride toothpastes (Holbrook et al., 2003). Enamelon is an “over-the-counter” oral care product that helps to rebuild and renew tooth enamel, and can repair acid damage to tooth enamel. Research done by Enamelon, Inc. showed significant reductions in surface roughness and improvement in surface gloss in subjects who used Enamelon toothpaste for 3 months (Business Wire, 1999).

- The relationship of hard cheeses to surface enamel re-hardening has been discussed (Thomson, 1988). The mechanism has been related to the mineralization potential of casein—calcium phosphate components of the cheese and to its textural – or flavour influences which stimulate saliva (Jensen et al., 1984).

### 8.4 THE POSITIVE EFFECT OF SALIVA AND SALIVARY PELLICLE

There is an increasing awareness of the importance of saliva in maintaining oral and dental health (Imfeld et al., 1995). Attempts have consequently been made to improve salivary flow, and alkalinity of saliva by mechanical or gustatory stimulation or by adding various neutralizing agents to chewing gum formulations, such as dicalcium, monophosphate, sodium bicarbonate, and diammonium phosphate (Imfeld et al., 1995). Another approach to neutralize intraoral acid is to incorporate urea (carbamide) into sugarless chewing gums to stimulate salivary flow and to enhance remineralization. Urea has an alkalinising effect within saliva. Two gums containing urea hydrogen peroxide have been marketed, namely V6/Endekay and Caroxin.
Regular sugar-containing gums are cariogenic as they lead to elevated levels of sucrose in the saliva for more than 30 minutes. Topical preparations (like Profylin and Xerodent) are available to promote salivation for those who may not be willing to chew gum.

According to Michelle E. Dickinson (Dickinson et al., 2008), salivary pellicle is an organic biofilm formed by the physisorption of proteins and carbohydrates onto the surface of dental enamel exposed to the oral environment. The pellicle plays several key roles in oral physiology, including lubrication and reduction of friction between teeth, as well as chemical protection of the enamel against acidic solutions. This salivary pellicle can resist acidic action to some extend and provides protection to the underlying enamel surface against the erosive destruction caused by short-term action of acids (Hannig and Balz, 1999).

Hannig and Balz (1999) assessed the protective effect of salivary pellicle formed in vivo over 24 hours or 7 days against demineralization of bovine enamel caused by acid. They found that the acquired salivary pellicle provides protection of the enamel surface only after certain maturation and completion processes have taken place (Figure 8.1).

Saliva is known to have many properties offering protection against enamel erosion (Zero, 1996), e.g. buffering and neutralization of dietary acids, dilution and clearance of erosive agents, as well as the formation of acquired salivary pellicle with its ability to protect enamel surface against demineralization from dietary acids.
Figure 8.1  Erosive enamel alterations at the enamel surfaces without pellicle (a,d,g), with 24 hour pellicle (b,e,h), and 7 day pellicle (c,f,i) under the influence of 0.1% citric acid. Exposure times to acid were 30 s (a,b,c), 60 s (d,e,f), and 300 s (g,h,i) (Hannig and Balz, 1999).
8.5 PREVENTING ABRASION OF TOOTH SURFACE

A recent survey by the British Dental Health Foundation revealed that only one in eight patients are aware that brushing teeth after eating fruit/drinking fruit juices/wine can permanently damage your teeth (BRITISH DENTAL JOURNAL TRADE NEWS, 2002).

As mentioned above, the salivary pellicle has a limited protective effect against demineralization of the enamel surface caused by acids (present in wine). Removing the acquired salivary pellicle during tooth brushing may increase the susceptibility of the enamel surface to acid erosion. Thus tooth brushing before acid exposure should be avoided. Do not brush excessively, and use soft-bristled nylon toothbrush if brushing does occur. When tooth enamel has been weakened by contact with acid, the brushing will worsen the erosive effect by removing more enamel. After exposure to acidic food, brushing should be delayed for at least an hour so that tooth re-mineralization – a salivary function can occur. (Mandel, 2005a) It has been shown that resistance to this abrasion develops in the mouth (Attin et al., 2000), but that at least 60 minutes should elapse after an acid challenge to the teeth before brushing.

8.6 INCREASE SALIVARY PH (BUFFER CAPACITY)

When acidic beverages are consumed, the pH environment in the mouth is at the critical stage at which erosion commences. There is increasing awareness of the important role of saliva, as it can increase the pH of the dental environment. The following attempts should be made to increase salivary pH.

- Rinse the mouth between tasting samples with mouthfuls of water.
- The use of an alkaline mouth rinse after each tasting may alter taste, so this approach will not be practical, but rinsing the mouth at the end of a tasting session with alkaline mouth rinse will be of benefit.
- Chew gum that contains carbamide (urea) as it has been shown to rapidly increase salivary pH (Holbrook et al., 2003). This may contribute to reducing the erosive effect of acid in the mouth.
• Increase milk consumption. Much research evidence has proved the protective action of milk products on enamel (Moynihan et al., 1999). This includes protection of enamel by casein phosphor-peptides, stimulation of salivation by flavoured cheeses, reduction of plaque formation by milk lipids, and enhancement of plaque calcium levels. By opposing enamel dissolution, reduced demineralization and enhanced remineralisation can be achieved. After the consumption of wine it is possible to re-mineralise damaged enamel by drinking milk or eating hard cheese.

The potential of cow’s milk to protect the teeth against cariogenic challenges has been documented in a variety of case studies. Weiss and Bibby (1966) showed that bovine enamel exposed previously to cow’s milk was 20% less soluble in acetic acid buffer than control enamel. Adsorbed milk proteins and milk fat could have contributed to the protection of enamel against demineralization. Rehardening effects following milk consumption were evident from the significant microhardness increases. Morphologically fewer erosion centers on teeth were visible after exposures to milk. Gedalia et al. (Gedalia et al., 1991) showed that the enamel surface structure of a tooth had fewer erosion centres visible after exposure to milk or saliva (Figure 8.3), than before the exposure to milk or saliva (Figure 8.2).
Figure 8.2  Softened enamel surface. Erosion areas visible. (Gedalia et al., 1991)

Figure 8.3  Rehardening of enamel after milk/saliva exposure. Coatings on the enamel surfaces are observed. (Gedalia et al., 1991)
8.7 PREVENTITIVE MEASURES AND MANAGEMENT

With the problem of dental erosion in winemakers apparently not very well documented to date, no appropriate management regimes have been established. It is surprising that so few authors have considered the importance of wine as a factor in dental erosion, considering that wine has been drunk for thousands of years (Wiktorsson et al., 1997). Non-carious destruction of teeth has also been observed in archaeological material from various parts of the world and clearly pre-dates the first appearance of dental caries (Holbrook et al., 2003). Although Miller, as long ago as 1907, concluded that all acids have the capacity to cause erosion, including acids in wine, it was first during the 1990s that the erosive potential of wine was paid some attention.

Because wine gradually has become part of society’s diet and because dentists are in the key position to note the dental damage it can cause, dentists should be alerted to the fact that wine is a cause of erosion. It is crucial that the dental profession assist those patients involved in the wine industry or amateur wine tasters, by providing both protection and advice to how erosion can be minimized (Mok, 2001). A good starting point for consumers would be to attend regular 6-monthly reviews with their dentist for the early detection of problems.

In order to prevent or reduce the non-carious destruction of tooth substance it is important to first: (Holbrook et al., 2003)

- Recognize that the problem is present. This involves careful observation by the dentist or oral hygienist at a routine visit
- Grade the severity of the problem. The dental practitioner should note the tooth wear as being in the enamel only, into the dentine, or severely affecting the tooth or series of teeth, for example as frequently seen erosion of the palatal surfaces of the four maxillary incisor teeth.
- Diagnose the likely causes
- Obtain advice on preventative measures and treatment
- Monitor progress of the disease in order to determine the success, if any, of recommended preventative measures.
Another preventative element is mechanical protection. This takes the form of the use of sealants and varnishes that are applied to the teeth. Three types are mentioned here.

8.8.1 Fissure sealant
A fissure sealant is a material that is placed in the pits and fissures (grooves) of teeth in order to prevent or arrest the development of dental caries or erosion. In a study done by Mok (2001), no erosion was observed in crowns coated with a fissure sealant. The use of a fissure sealant might be considered the morning of a wine tasting.

8.8.2 Fluoride varnishes
Fluoride varnishes consist of high concentration fluoride in fast drying, alcohol based solutions. They are sticky pastes that are professionally applied on teeth at a frequency of 2 to 4 times a year. Calcium fluoride formed after application acts as a long-term reservoir of fluoride. These reservoirs gradually release fluoride into dental plaque, saliva and tooth structure when the pH drops. However, as varnish solvent (ethyl acetate) will possibly affect taste for some time following its application, the fluoride varnish would need to be applied professionally at least a day before any prolonged period of wine tasting.

8.8.3 Phosphate fluoride gel- APF gel
Fluoride gels contain levels of 12300 ppm F compared to 1100ppm in regular toothpaste. APF gel is more protective, with more frequent application. Neutral NaF gels are recommended above acidulated phosphate fluoride gels because it is chemically more stable and does not discolor teeth.

Wine assessors must be careful not to ingest/apply anything that will alter their taste perception for at least a few hours prior to tasting. Hence, any protective method must be applicable some hours at least before tasting begins. (Mok, 2001)
8.9 REDUCTION OF SENSITIVITY

The following methods can be used to reduce dental sensitivity.

- Use a fluoride mouth rinse, like Listerine with fluoride.
- Use desensitizing toothpaste with a high fluoride level, like Sensodyne.
- Use a low abrasive toothpaste, like Colgate Sensitive.
- A desensitizing gel like Sensigel can be applied to a tray, for prolonged contact with teeth while sleeping. This tray is specially made to cover one’s teeth, by having impression moulds made of one’s teeth.

8.10 MODIFICATION OF DRINKS

The method of adding fluoride to sports drinks and soft drinks has contributed to reducing the erosive effect. Amaechi et al (1998b), has shown in in-vitro studies that xylitol and fluoride have an additive effect in reducing the erosive potential of orange juice. Larson and Richards, (2002) report, however, that the protective effect against erosion of fluoride added to soft drinks is minimal. Below pH 2.9 the depth of lesions was unaffected by the high fluoride concentration (fluoride > 0.9 mmol/L). However, from pH 3 and above the lesions induced by the drinks saturated with calcium fluoride were consistently less deep than those induced by the fluoride-free controls (fluoride < 0.001 mmol/L). It should be emphasized that toxicological considerations prohibit the use of a very high concentration of fluoride in any drink (Larson and Richards, 2002). One of the most successful examples of drink modification is the development of the “Ribena tooth kind”. This low pH blackcurrant drink (Ribena) has been modified with the addition of calcium, and has been shown to be less erosive than blackcurrant drinks without added calcium (Holbrook et al., 2003).

More research is clearly required in this area to resolve these differences. Whether or not the modification of acidic drinks (to make them less erosive) will prove possible, or even acceptable, remains to be seen (Holbrook et al, 2003). Altering the smell and taste of wine obviously excludes this option.
Professional tasters/winemakers should take careful note of all of the above suggestions proposed to prevent permanent damage to their teeth. By adopting these simple routines, dental erosion can be minimized.
CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

The aim of this dissertation was not to add any new research data (be it in vitro, or in vivo), but rather to gather all information currently available on the effect of wine on the consumers’ dental health (with special reference to employees in the wine industry), summarise it and present it in a concise and clear format.

Wine has been a part of our diet for thousands of years, but the effect of wine on our dental health has only been investigated in recent years. A stronger focus on occupational health, increased wine consumption, high dental care expenses and as well as increased consumer involvement have lately lead to an increased interest in the effects of wine on dental health.

The beneficial effects of wine on our general health are well documented. Evidence presented suggests that an average consumption of wine (especially red) reduces the incidence of coronary heart disease and coronary artery disease and, that it is the polyphenols in red wine that act as radical scavengers and antioxidants. An average consumption of red wine also reduces the clotting mechanisms in the blood and subsequently helps prevent thrombosis in the heart and brain.

Some lesser known beneficial effects on our dental health are that grape phenolic extracts act as antibacterial agents against oral streptococci, which is the primary cause of dental caries. Therefore, wine can reduce the incidence of dental caries. Wine is also good for the gums and can help prevent and treat periodontitis.

However, the daily intake of alcohol exceeding the recommended amount can lead to several types of health problems, not only cardiovascular ailments, but also liver and neurological problems. The low pH and high acid content are some of the factors that results in dental erosion—dental erosion is the major negative visible manifestation of wine on dental health.

Due to the fact that regular wine tasting is an integral part of the job description of an employee in the wine industry, reducing the number of wines tasted, or changing the method of tasting is not an option. In my opinion, the general health benefits of the responsible consumption of wine
outweigh the negative effect on dental health. With the dental health benefits of wine only recently being investigated, it is possible many more benefits (or problems) will be discovered.

One of the most critical factors to keep in mind is that wine softens the dental enamel, which means that any abrasion will add to dental erosion. By neutralising the acidity level in the mouth, the erosion effect can be moderated.

It is important to note that the consumer needs to be educated and made aware of the effects of wine on our general and dental health. By employing the simple practices mentioned (Chapter 8), one can minimize the negative impact of wine on dental health, and maximize the beneficial aspects of wine consumption.

The enjoyment of wine affords intellectual and sensory pleasure, bringing people together in friendship and affection, especially over good food. If we can remember to enjoy wine in moderation, using common sense, then the treasure that is wine can safely continue to be part of our daily lives.
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