Establishing and Maintaining Oral Homeostasis: The Role of Arginine in Modulating the Oral Environment

A Peer-Reviewed Publication
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Abstract
Regardless of the mechanism, neutralizing oral acid is a primary goal for preventing or treating caries, erosion, and candidiasis infections. Caries and erosion are classified as pH-mediated conditions. Repeated acid attacks eventually damage enamel, dentin, and cementsum. Acidic pH also sets the stage for the development of oral fungal infections. A variety of situations allow the oral pH to become acidic: frequent intake of acidic foods and beverages or fermentable carbohydrates, medical conditions involving regurgitation, acidic stomach acid vapors, insufficient salivary flow, poor-quality saliva, xerostomia, and high numbers of acid-producing microbes.

Educational Objectives
At the conclusion of this educational activity participants will be able to:
1. Understand developmental differences between caries and erosion
2. Appreciate the role of dry mouth syndrome in oral disease
3. Learn how dietary habits and food composition affect oral health
4. Discover how acidogenic and aciduric microbes are involved in oral disease
5. Understand how arginine and arginine-based compounds contribute to a neutral oral pH
6. Learn about the antimicrobial properties of arginine

Author Profile
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**Abstract**
Regardless of the mechanism, neutralizing oral acid is a primary goal for preventing or treating caries, erosion, and candidiasis infections. Caries and erosion are classified as pH-mediated conditions. Repeated acid attacks eventually damage enamel, dentin, and cementum. Acidic pH also sets the stage for the development of oral fungal infections. A variety of situations allow the oral pH to become acidic: frequent intake of acidic foods and beverages or fermentable carbohydrates, medical conditions involving regurgitation, acidic stomach acid vapors, insufficient salivary flow, poor-quality saliva, xerostomia, and high numbers of acid-producing microbes.

Dry mouth, now recognized as one of the most important factors in the development of oral disease, is a highly complex condition experienced by 30% of the population and is more common in women and older adults. Environmental, lifestyle, and health factors further complicate dry mouth issues. Acid-producing microbes favor dry conditions. Healthy saliva, in sufficient quantities, neutralizes acids, cleanses the oral cavity, and supports the intake of nutritious foods that must be chewed. Digestion begins with saliva since salivary enzymes assist in the breakdown of many foods. Adequate salivary flow maintains soft tissue comfort, which facilitates effective personal oral hygiene habits.

Traditional culturing techniques have identified a handful of microbes involved in caries and periodontal disease. Both diseases are highly complex, and recent advances in molecular techniques and genomics demonstrate that caries and periodontal disease involve a more diverse range of microbial species than previously thought. These findings further weaken the goal to design a vaccine to target specific pathogens. Newer research models focus on creating an oral environment that discourages the growth of acid-producing pathogens, favoring the establishment and proliferation of commensal microbes associated with homeostasis.

Human saliva naturally contains small amounts of the amino acid arginine. Salivary arginolytic microbes metabolize arginine. Ammonia is the metabolic end product. Consistent arginine metabolism results in sustained neutral pH levels in the oral cavity. Over the last four decades, multiple laboratory and human-subject studies have demonstrated the critical role of arginine metabolism in achieving and sustaining neutral pH levels. A continuous, stabilized neutral pH provides a favorable environment for arginolytic microbes and supports an ecological microbial shift that results in oral homeostasis.

Regular use of products that contain an arginine bicarbonate/calcium carbonate complex can lead to a neutral pH and promote the establishment of an oral environment rich with arginolytic microbes. Supplementing the oral cavity with arginine bicarbonate/calcium carbonate compounds provides a reliable source of mineral necessary for caries prevention and remineralization. Products that contain arginine chemistry provide an effective desensitizing strategy. In the presence of a neutral pH, calcium and phosphorus readily plug open dentinal tubules. Arginine also has a negative effect on Candida albicans growth, destabilizes biofilm extracellular polysaccharide integrity, and interferes with biofilm adhesion on hard tooth structures. Arginine-based products are now available for use in the clinical setting, as well as for use on a daily basis to supplement and support neutral oral pH values and provide a foundation for a healthy oral ecology.

**Introduction**
Homeostasis is a basic tenet for wellness. When the pH of the oral cavity is maintained in the neutral range of 7, there is balance and the potential to maintain health. As the oral pH falls below 5.5, the acidic environment increases the risk for caries, erosion, dental hypersensitivity, and candidiasis.

In order to serve patients at an optimal level, it is important to understand how low pH levels contribute to oral disease and which factors initiate or accelerate the development of an acidic oral environment. Research over the last 40 years clearly demonstrates the unique role of arginine in reversing low pH levels. Recent studies validate how arginine, in combination with other ingredients, can support and maintain oral homeostasis.

**Caries and erosion – similarities and differences**
Caries and erosion have similarities. Both are widespread disease in their effects: Caries is the most widespread disease in the world that affects hard tooth structure. Erosion is one of the leading causes of dental hypersensitivity. Both are classified as pH-mediated conditions.

The resting pH of healthy saliva falls between 6.8 and 7.2, a range that supports oral balance. Critical pH is a dynamic number, dependent on salivary levels of calcium and phosphorus. Oral stability is maintained as long as the pH remains above 6.5. As the pH level drops below 5.5, tooth structure begins to lose calcium and phosphorus. Repeated acid attacks on enamel, dentin, and cementum eventually result in damaged tooth structure.
Despite the role of pH in both caries and erosion, there are distinct differences in the etiology of the two conditions. Caries, a microbial infection involving hard tooth structures, is a two-stage process. Initially, tooth structure degrades in the presence of excess concentrated acids. The caries process continues if there is insufficient alkali to counteract the acid attack and an inadequate mineral source to initiate remineralization. In early stages, it is possible to reverse the damage to the tooth. Erosion is defined as the progressive weakening and loss of hard tooth structure via repeated acid attacks. Unlike caries, erosion lacks a microbial component. Acids involved in the erosive process come from either extrinsic or intrinsic sources that include both dietary intake and medical conditions. Despite the lack of microbial activity, erosion can have a profound impact on tooth structure. Neutralizing oral acid, regardless of the source, is a primary goal for treating or preventing caries or erosion.

The microbiology of caries
Caries infections are categorized by the location of the lesion on the tooth: occlusal, root, cusp tip, or interproximal. However, these terms do little more than describe the physical location of the carious lesion. New research demonstrates that caries is a poly-microbial, biofilm-based disease, with dozens of microbes now implicated in the caries process. Different bacteria favor specific tooth surfaces, and certain microbes are found in differing proportions on primary and permanent dentition. For many years, caries research focused on acid-producing bacteria that were easy to culture. Early research targeted specific caries pathogens, a goal supported by traditional culturing techniques. The role of Streptococcus mutans and Lactobacillus species in the development of caries has been studied extensively. Caries research no longer has to rely on traditional culturing techniques. Advances in molecular science and genomics demonstrate that caries is a highly complex condition, involving a greater number of microbial species than previously identified. However, only half of these species can actually be grown.

Acid-producing microbes are classified as either acidogenic or acetic, a classification system that describes when and how acid production is initiated. Acidogenic microbes naturally favor low pH environments, initiate the initial pH drop, and produce large quantities of acid, lowering oral and biofilm pH levels. In contrast, aciduric microbes do not contribute to the initial pH change. However, they can readily change gene expression to survive lower pH levels. Once adapted, aciduric microbes begin producing acid, a modification that increases the overall acid load.

Candida albicans, an aggressive, acid-producing fungal organism is often found in conjunction with known caries microbes. C. Albicans can be a predominate member of the microbial community in those with early childhood caries.

Dietary habits – multiple risks for oral disease
Dietary habits create an enormous challenge from several standpoints. Both consumption behaviors and food composition directly affect oral health. The primary source of extrinsic acids comes from food and beverages. Exposure to these acids has grown significantly since 1971. Fewer meals are now prepared at home. Food and beverages are more readily available in all social settings, from workspaces to schools. It is not uncommon for people to sip beverages throughout the day or snack frequently, a habit referred to as “grazing.” Many meals are now consumed away from home—a social shift over the last 50 years.

Most modern beverages are very acidic, with pH levels ranging from 2 to 4. These levels are low enough to cause significant loss of both calcium and phosphorus in teeth. Erosive beverages include traditional soda pop, energy drinks, sports drinks, flavored waters, fruit-infused waters, fruit juices, flavor-enhancing drops and powders, citrus and fruit-based teas, wine, and beer. While low pH beverages that are sugar-free can cause significant damage, drinks that contain either natural or added sugars, increase the risk to the tooth structure even more. This is because bacterial metabolism of fermentable carbohydrates creates additional acid. Many commercially available beverages, promoted as healthy nutritional supplements, also damage valuable tooth structures, restorative materials, and cements.

Milk, considered “liquid food,” has a pH of 6.5, bathes the teeth in calcium and contains protein that can neutralize acids. Milk consumption among children and teens has declined steadily since the 1970s, whereas there is a well-documented increase in carbonated beverages, fruit-flavored drinks, and fruit juices among all age groups. Many commercially available beverages are marketed as healthy nutritional supplements. Oral medications create additional acid. Effervescent preparations as natural approaches for combating digestive maladies or weight control. Sites focused on improving digestive health espouse either apple cider vinegar or kombucha (a sweetened, lightly effervescent fermented tea). Drinking lemon juice and warm water is often recommended to enhance weight loss.

Contributing health conditions
Certain health conditions expose tooth structures to intrinsic acid attacks. Regurgitation is a side effect or symptom of a wide variety of medical conditions. Thirty percent of all adolescents experience weekly regurgitation disease (GERD), and up to 40% of the general population in the United States report symptoms of GERD. Infants, young children, and adolescents can also experience GERD. Over 8% of all adolescents experience weekly regurgitation
from GERD. Frequent use of both prescribed or over-the-counter antacid preparations or acid-reducing medications, such as proton pump inhibitors, can serve as a clue for undiagnosed reflux. Vomiting can be a complication of pregnancy, gastritis, peptic ulcers, alcohol intake, chemotherapy, or a drug side effect.

Self-induced vomiting is a classic symptom of two well-known eating disorders: anorexia and bulimia. Bulimic patients regularly purge in an attempt to reach or maintain a normal weight level. Close to one-half of all who suffer from anorexia fall into the binge and purge subcategory to maintain a suboptimal weight level. Research indicates those with eating disorders consume large quantities of acidic beverages and fresh fruit, and are often treated with antidepressants that cause dry mouth.

The role of saliva – a more complex situation

Xerostomia, or dry mouth, creates a further challenge. Whereas only a small percentage of patients report symptoms of dry mouth, dry mouth affects roughly one in three. Females have higher rates of dry mouth than males. Many over the age of 50 experience xerostomia, but only 10% in their early 30s may also have dry mouth issues. A variety of symptoms can indicate progressive or chronic dry mouth issues. Patients with dry mouth can experience difficulty in talking, chewing, and swallowing, in addition to alterations in taste or a burning sensation.

Healthy saliva provides bicarbonate ions and proteins that can buffer acids. Insufficient salivary flow compromises the body’s natural acid-neutralizing ability. Both acidogenic and aciduric microbes favor a dry mouth. The microbes proliferate, the stage is set for oral pH values to remain low over a protracted period of time. Those with low salivary flow rates typically have a more acidic salivary pH. Oral mucosa is meant to be moist, and saliva keeps food from sticking to both hard and soft tissues, helping clear food debris from the oral cavity. As the soft tissue becomes more uncomfortable in those that suffer from a dry mouth, typically oral hygiene practices are less effective.

Dental professionals are on the front line for recognizing dry mouth and providing valuable guidance. Dry mouth may be a vague symptom, but it is not a life inconvenience. It is a significant factor in the development of dental disease. The etiology of dry mouth can be very complex and often takes years to get an accurate diagnosis. Dry mouth is now a well-recognized complication for numerous medical conditions and a direct side effect for many prescribed and over-the-counter medications.

Seniors have an increased risk for dry mouth due to complex medical conditions, higher rates of autoimmune disorders, polypharmacy, and a natural decrease in salivary flow associated with aging. Environmental, behavioral, and dietary factors can also accelerate dry mouth symptoms, creating an additive effect. Mouth breathing, sodium intake, diuretic beverages, and humidity levels each contribute to dry mouth.

Salivary arginine

Early caries research focused on controlling a few known pathogens. Caries is a polymicrobial, biofilm-based disease, not a classic infectious disease caused by a singular pathogen. Recent advances in oral biofilm microbiology suggest targeting specific pathogens is a nearly impossible goal, especially since key pathogens may not have been identified at this point. Newer research models focus on creating an oral environment that discourages the growth of acid-producing pathogens. Environmental changes, such as modifying oral pH levels, favor the establishment or proliferation of commensal microbes associated with homeostasis.

Studies over the last four decades support the unique role of arginine in creating neutral oral pH levels. Arginine, one of 20 basic amino acids necessary for human life, is a building block of proteins. Long chains of proteins are known as polypeptides. Human saliva contains small amounts of both urea and arginine. Arginine plays a significant role in modulating plaque biofilm pH levels. Ammonia is the primary metabolic byproduct for both the breakdown of urea and arginine in the oral cavity. Several bacterial species employ urease to break down urea; however, numerous microbes utilize the Arginine Diaminase System (ADS), a three-enzyme pathway, to break down arginine. Regardless of the source, ammonia production has the potential to create and support a neutral oral pH.

Arginolytic bacterial species metabolize arginine to varying degrees. These variations in metabolic activity are directly related to environmental pH, oxygen levels, and the availability of carbohydrates and arginine. As proteins and polypeptides are broken down, additional arginine is released in the oral cavity. The overall level of ammonia produced by the ADS is greater than that of urea for two reasons: (1) a greater number of arginolytic bacteria and (2) a more abundant supply of arginine.

Both the initiation and progression of caries activity is influenced by acid/base formation in the oral cavity. Caries-free subjects have much higher levels of oral ammonia and a potentially different oral ecology than those who are caries active or caries experienced. Caries-free subjects consistently have higher ADS activity levels in both plaque biofilm and saliva and also have higher levels of urease activity. Conversely, those at high risk for caries tend to have lower ADS activity levels.

Differences in ADS activity can also be found within a subject’s mouth. In a recent study of 100 children, Nascimento et al. determined that plaque located on non-carious tooth surfaces had higher ADS activity than plaque samples obtained from caries lesions. Another study showed caries-active subjects had significantly higher levels of salivary and plaque biofilm S. mutans in saliva and plaque biofilm. S. mutans is a well-known acid producer in both saliva and plaque.
Reversing demineralization and inhibiting caries – arginine-based chemistry

Kleinberg’s early research laid the foundation for oral pH modification-strategies to prevent or alter caries activity and erosion. Arginolytic bacteria have a different effect on oral biofilm pH than ureolytic microbes, and arginine degradation is optimal when the pH is closer to neutral. These two key findings supported Kleinberg’s postulate that creating and supporting a neutral oral pH provides an unfavorable range environment for acidogenic and aciduric microbes.

Based on the growing body of research, a novel anti-caries dentifrice was developed in 2002. The proprietary formula, known as Cavistat (Ortek Therapeutics) contained arginine bicarbonate, ingredients required to initiate arginolytic activity and neutralize acid and calcium carbonate for remineralization. Cavistat was shown to be effective in both inhibiting caries onset and progression. Preliminary research demonstrated the novel formula, containing 1.5% arginine bicarbonate and calcium carbonate, was both clinically and statistically more effective in preventing and stopping the caries process in children as compared to a group using a 1,100 ppm fluoride dentifrice. Similar anti-caries results were reported for children in a randomized trial who chewed a mint confection formulated with 1.5% arginine bicarbonate and calcium carbonate, the original Cavistat technology.

Recent studies continue to substantiate the benefits derived from using commercially available arginine bicarbonate calcium carbonate formula toothpaste. Wolf’s research demonstrated the dentifrice modulated plaque biofilm metabolism by increasing ammonia production and decreasing lactate production, resulting in a neutral oral environment. Nascimento demonstrated caries-active subjects had increased ADS activity and a change in microbial composition mirroring that of the caries-free participants, suggesting the creation of healthier biofilm ecology. A study by Hu and colleagues concluded that a 1.5% arginine calcium fluoride dentifrice is effective in arresting and reversing root caries by producing clinically harder tooth surfaces. Six thousand children, classified as low to moderate risk for decay, were evaluated at the end of a two-year, double blind, randomized trial. In this study, children using either of the two arginine calcium-based fluoride paste product formulations had a 16.5% lower DMFS score as compared to the control group that used a 1,450 ppm toothpaste. Both groups using toothpastes with arginine exhibited significant reductions in DMFS, as well as overall DMFT scores. To date, arginine calcium-based fluoride toothpaste is readily available in most retail markets outside of the United States.

Dental hypersensitivity – the role of arginine technologies

An 8% arginine calcium carbonate paste, known as Colgate Sensitive Pre-Procedural Desensitizing Paste (Colgate Oral Pharmaceuticals), is available for professional application. Typically the professional paste is applied to sensitive tooth surfaces using a slowly rotating polishing cup. Numerous studies report the positive benefits. Subjects report statistically significant reductions in sensitivity using tactile and air-blast tests, both immediately after application and at post-treatment examinations 4 and 12 weeks later. Periodontal patients had a statistically significant reduction in dentinal hypersensitivity one month after the application over subjects treated with a 1.23% NaF gel.

Arginine-based toothpastes are useful in controlling dentinal hypersensitivity. A randomized 100-subject, six-month trial evaluated the effectiveness of using arginine-calcium toothpaste twice daily for four weeks after an in-office professional application of the 8% arginine desensitizing paste. Subjects in the control group received a professional polishing using a fluoride prophylaxis paste, followed by a twice daily brushing with a non-desensitizing toothpaste. The arginine-calcium toothpaste test group had significantly less dentinal hypersensitivity immediately post treatment, and at 8 and 24 weeks, and maintained a statistically significant reduction in sensitivity.

Arginine – a new antimicrobial weapon

Emerging research indicates that arginine-calcium carbonate compounds may inhibit bacterial adhesion on tooth surfaces, reduce biofilm thickness, and reduce the density of biofilm extracellular matrix, the slimy substance that protects these unique microbial communities. A recent in vitro study concluded the combination of fluoride and arginine had a more pronounced anti-caries affect on a multispecies biofilm than fluoride alone by suppressing S. mutans levels and P. gingivalis growth, while favoring the proliferation of S. sanguinis, a microbe known to inhabit a healthy oral microbiome. Another study found arginine supplementation suppressed the growth of the acid-producing fungal organism, C. albicans and facilitated microbial resistance to an acidic environment, supporting the stability of the oral microbial community.

New products with arginine bicarbonate – calcium carbonate technology

The benefits of arginine bicarbonate combined with calcium carbonate are well substantiated. The combination of ingredients is known to create and support a neutral salivary pH, reduce the risk of tooth demineralization, attenuate the caries process, and treat dentinal hypersensitivity. Despite the scientific advances, until recently, there have been no products available for direct purchase by patients in the United States. However, two commercial products that target different oral challenges are now available.

The Colgate Sensitive Relief Pen (Colgate Oral Pharmaceuticals) is a unique, unit-dose delivery technique designed to treat dentinal hypersensitivity. The pen delivery system utilizes...
a glycerin-based gel, formulated with arginine bicarbonate and calcium carbonate for self-treatment of localized hypersensitivity. The gel can supplement benefits derived from the professional application of a desensitizing agent such as Colgate Sensitive Pro-Procedure Desensitizing Paste. The Sensitive Relief Pen is available at retail outlets that sell over-the-counter products that treat dentinal hypersensitivity.

BasicBites® (Ortek Therapeutics) is a unit-dose, soft-chew confection that contains that contains the essential ingredients, arginine bicarbonate and calcium carbonate (the AlkaGen Technology). The BasicBites formulation, based on Kleinberg’s pioneering research in salivary and oral microbial chemistry, provides a ready source of arginine to the arginolytic bacteria, supporting sustained alkaline generation to help neutralize plaque acids. Just as in saliva, the calcium carbonate in the chew is available to augment the remineralization process in a neutral oral pH environment. The bicarbonate component enhances the buffering and remineralizing activities of arginine and calcium.

BasicBites hold great promise for those who suffer oral disease effects from dry mouth; have a high consumption of fermentable carbohydrates; or have health-related, low oral pH conditions. A recent laboratory study demonstrated the chews sustain a neutral oral pH that can last for more than 20 hours after a glucose challenge in the presence of salivary microbes.76 The latest in vitro study demonstrated BasicBites soft-chew chemistry occluded the orifices of the dentinal tubules after a single fingertip application, resulting in a significant reduction of tubular fluid mobility.77

BasicBites are a chocolate-flavored, non-cariogenic confection sweetened with maltitol, isomalt, and xylitol. The chews contain 20 calories, are kosher and gluten free, deliver 20% of the recommended daily amount of calcium, and are available online. The chews should be used both in the morning and at night after routine oral hygiene procedures, and should be allowed to soften naturally in the mouth. BasicBites are designed so that the essential nutrients are retained on tooth surfaces after chewing.

**Conclusion**

Research over the last 40 years clearly demonstrates the unique role of arginine in reversing low pH levels. Multiple studies have investigated the impact of arginine on caries, erosion, dentinal hypersensitivity, candidiasis, and periodontal pathogen activity. Arginine has the potential to either modulate oral disease activity or significantly reduce the risk for a number of oral conditions; when combined with calcium and fluoride, the outcome can be even more significant.

Both acidogenic and aciduric microbes are not metabolically active in a neutral pH environment, and some species cannot survive the higher pH level. A neutral pH range, however, creates an ideal environment for the proliferation of non-pathogenic microbes. Over time, the metabolic activity of arginolytic microbes supports the reestablishment of a homeostatic microbial community that is consistent with oral health. Recent studies validate how arginine, in combination with other ingredients, can support and maintain oral homeostasis when consistent levels of arginine are available on a regular basis.

**References**

2. Lussi A, Schlatter N, Rahnamallouhi E, Ganss C. Dental erosion—a overview with emphasis on chemical and histopathological aspects. *Caries Res*. 2011;45.
1. Critical pH in the oral cavity is:
   a. Acidic
   b. Dependent on the salivary levels of calcium and phosphorous
   c. An accurate measure of periodontal disease activity
   d. An indicator of frequent snacking

2. Caries is caused by erosion. Erosion rarely leads to dentinal hypersensitivity.
   a. Both statements are true
   b. The first statement is true and the second is false
   c. Both statements are false
   d. The first statement is false and the second is true

3. Caries is considered a multifactorial disease. Which statement regarding caries is true?
   a. Caries can affect any age group
   b. Dry mouth increases the risk of caries
   c. Caries is accelerated by drinking low pH beverages
   d. A, B, and C are all true

   4. Neutralizing oral acid is:
      a. An endpoint that can’t be achieved
      b. An important factor in controlling caries activity
      c. Easily accomplished by rinsing with water every two hours
      d. A benefit of daily brushing

5. An oral pH below 5.5 affects all of the following except:
   a. Increasing risk for caries
   b. Contributing to tooth erosion
   c. Favoring the growth of acidogenic microbes
   d. Eliminating the need for flossing

6. Acidogenic microbes initially tolerate acidic pH levels and then begin producing acids. Acidogenic microbes are not involved in the caries process.
   a. Both statements are true
   b. The first statement is true and the second is false
   c. Both statements are false
   d. The first statement is false and the second is true

7. Which statement is true about erosion lesions?
   a. Patients who suffer from dry mouth are at low risk for erosion
   b. Primary teeth are not at risk for erosion
   c. Erosion occurs at all pH levels
   d. Regular consumption of energy and sports drinks contributes to erosion

8. Which statement is true about caries?
   a. Strep mutans and lactobacillus sp. are the only bacteria involved in caries
   b. Drinking milk daily will prevent caries
   c. Acidogenic microbes are responsible for the initial drop in pH
   d. Caries is not an infection

9. Which statement about Candida albicans is incorrect?
   a. It is a fungal organism
   b. It is a known acid producer
   c. It is not an oral pathogen
   d. It is found in many cases of early childhood caries

10. Which statement about dry mouth is false?
    a. It reduces the risk for erosion
    b. It accelerates the caries process
    c. It sets the stage for demineralization
    d. It is an uncommon problem

11. Which of the following factors contributes to dry mouth?
    a. Emotional stress
    b. Eating fresh fruit every day
    c. Cigarette smoking
    d. Both A and C

12. Dry mouth can be a side effect of:
    a. An autoimmune disorder
    b. Living in a low humidity climate
    c. Eating foods high in sodium
    d. All of the above

13. Which is not true about Strept mutans?
    a. It initiates the pH drop
    b. It is the only microbe responsible for caries
    c. It has been studied extensively
    d. It is not affected by the pH level

14. Which of the following beverages does not have an acid pH?
    a. Fruit juices
    b. Energy drinks
    c. Low-fat milk
    d. Citrus-based tea

15. Sugar-free drinks do not have the potential to erode teeth. All sugar-sweetened beverages can contribute to the development of a caries lesion.
    a. Both statements are true
    b. The first statement is false and the second is true
    c. The first statement is true and the second is false
    d. Both statements are false

16. Highly processed snacks can contribute to erosion for the following reasons.
    a. Contain high levels of sugar and starch
    b. Many are sticky and retained on tooth surfaces
    c. Both A and B
    d. Do not contribute to erosion

17. Regurgitation is a frequent complication of many medical conditions. Which condition does not belong in this category?
    a. Anorexia and bulimia
    b. Osteoarthritis
    c. Gastric esophageal reflux disease
    d. Pregnancy

18. Xerostomia is a common problem that affects quality of life. People with dry mouth frequently experience:
    a. Difficulty chewing
    b. Problems with swallowing
    c. Alterations in taste
    d. All of the above

19. Healthy saliva performs the following functions.
    a. Buffers oral acids
    b. Improves the taste of food
    c. Helps clear food from the oral cavity
    d. All of the above

20. Low salivary flow rates create a multitude of issues. Which situation is not a direct result of insufficient saliva?
    a. Less effective oral hygiene
    b. Regurgitation
    c. Halitosis
    d. Caries

21. Which factor is true about the amino acid, arginine?
    a. A naturally occurring amino acid
    b. Not found in saliva
    c. An effective buffer
    d. A key factor in the development of an erosive lesion

22. Salivary arginine can be metabolized by:
    a. Brushing with a fluoride tooth paste
    b. All oral microbes
    c. Only arginolytic bacteria
    d. A combination of A. albicans and S. mutans

23. Current research demonstrates that caries free subjects typically have all but one of the following:
    a. Higher levels of ADS activity
    b. Lower levels of oral ammonia
    c. Greater numbers of arginolytic bacteria
    d. Lower levels of S. mutans

24. Which is not true about arginolytic microbes?
    a. Produce ammonia from metabolizing arginine
    b. Use the ADS enzyme pathway to metabolize arginine
    c. Favor a neutral pH
    d. All statements are true

25. Arginine degradation is optimal when the pH is neutral. While ammonia is the metabolic byproduct, a greater number of oral microbial species can breakdown arginine than urea.
    a. Both statements are true
    b. The first statement is true and the second is false
    c. Both statements are false
    d. The first statement is false and the second is true

26. Dentifrices that contain a 1.5% arginine/bicarbonate complex can:
    a. Inhibit caries onset
    b. Support a neutral pH biofilm ecology
    c. Arrest root caries lesions
    d. All of the above

27. A professionally applied 8% arginine calcium desensitizing paste:
    a. Provides immediate relief of dentinal hypersensitivity
    b. Creates relief than can last for up to 12 weeks
    c. Is applied with a slowly rotating polishing cup
    d. All of the above

28. Arginine calcium carbonate compounds may decrease bacterial adhesion to tooth surfaces and the biofilm density. Arginine supplementation does not affect the growth of A. albicans, an acid-producing fungal organism.
    a. The first statement is true and the second is false
    b. Both statements are true
    c. Both statements are false
    d. The first statement is false and the second is true

29. Confections that contain arginine/bicarbonate-calcium carbonate support the following functions in the oral cavity:
    a. Supply calcium for remineralization
    b. Neutralize oral acids
    c. Support arginolytic activity for up to 20 hours
    d. All of the above

30. Which statement is not true about chews formulated with arginine bicarbonate-calcium carbonate?
    a. Can help reverse a low oral pH
    b. Are useful for those with dry mouth/xerostomia
    c. Should be used every hour
    d. Supply valuable nutrients to support oral health
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4. Discover how acidogenic and aciduric microbes are involved in oral disease
5. Understand how arginine and arginine-based compounds contribute to a neutral oral pH
6. Learn about the antimicrobial properties of arginine

Course Evaluation

1. Were the individual course objectives met?
   Objective #1: Yes No
   Objective #2: Yes No
   Objective #3: Yes No
   Objective #4: Yes No
   Objective #5: Yes No
   Objective #6: Yes No

2. To what extent were the course objectives accomplished overall?  5 4 3 2 1 0
3. Please rate your personal mastery of the course objectives.  5 4 3 2 1 0
4. How would you rate the objectives and educational methods?  5 4 3 2 1 0
5. How do you rate the author(s) grasp of the topic?  5 4 3 2 1 0
6. Please rate the instructor's effectiveness.  5 4 3 2 1 0
7. Was the overall administration of the course effective?  5 4 3 2 1 0
8. Please rate the usefulness and clinical applicability of this course.  5 4 3 2 1 0
9. Please rate the usefulness of the supplemental webography.  5 4 3 2 1 0
10. Do you feel that the references were adequate?  Yes No
11. Would you participate in a similar program on a different topic?  Yes No
12. If any of the continuing education questions were unclear or ambiguous, please list them.

13. Was there any subject matter you found confusing? Please describe.

14. How long did it take you to complete this course?

15. What additional continuing dental education topics would you like to see?

PLEASE PHOTOCOPY ANSWER SHEET FOR ADDITIONAL PARTICIPANTS.

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