

**Natural plant products: an alternative to oral dog care?**

**Produtos naturais de plantas: uma alternativa ao cuidado oral para cães?**

**Productos vegetales naturales: ¿una alternativa al cuidado oral del perro?**

Received: 09/12/2020 | Reviewed: 09/12/2020 | Accept: 09/15/2020 | Published: 09/17/2020

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**Abstract**

Periodontal disease is one of the most common and prevalent oral diseases in dogs. With the increasing closeness between man and the animals of company, the care with the health and well-being of those animals also increase. Being the bacterial plaque the main cause of periodontal disease, oral care performed by dog owners are essential for the prevention and control of this disease. There are a lot of alternatives, developed exclusively for animal use, which assist in oral hygiene. There are data on the use of active natural products in the prevention of halitosis, dental plaque and calculus, in the form of antiseptic substances, but the volume of information is still scarce. Natural substances, used since immemorial times for treatment of diseases, have the potential to integrate oral care products, such as main or adjuvant active agent in the formulation of the most varied compounds. This is the result of desirable actions in oral and dental therapies, as anti-inflammatory, healing and antimicrobial. This article reviews the information available on the subject and seeks to indicate what is

possible to do overcome the gap between research and application of these products on a day-to-day basis.

**Keywords:** Bioactive products; Plaque; Companion animals; Animal well-being.

### **Resumo**

A doença periodontal é uma das doenças bucais mais comuns e prevalentes em cães. Com a crescente proximidade entre o homem e os animais de companhia, os cuidados com a saúde e o bem-estar desses animais também aumentam. Sendo a placa bacteriana a principal causa da doença periodontal, os cuidados bucais realizados pelos donos de cães são essenciais para a prevenção e controle desta doença. São muitas as alternativas, desenvolvidas exclusivamente para uso animal, que auxiliam na higiene bucal. Existem dados sobre a utilização de produtos naturais ativos na prevenção da halitose, placa bacteriana e cálculo, na forma de substâncias anti-sépticas, mas o volume de informações ainda é escasso. Substâncias naturais, utilizadas desde tempos imemoriais para tratamento de doenças, têm potencial para integrar produtos de higiene bucal, como agente ativo principal ou adjuvante, na formulação dos mais diversos compostos. Este é o resultado de ações desejáveis em terapias orais e odontológicas, como anti-inflamatórias, cicatrizantes e antimicrobianas. Este artigo revisa as informações disponíveis sobre o assunto e busca indicar o que é possível fazer para superar a lacuna entre a pesquisa e a aplicação desses produtos no dia a dia.

**Palavras-chave:** Produtos bioativos; Placa; Animais de companhia; Bem-estar animal.

### **Resumen**

La enfermedad periodontal es una de las enfermedades bucales más comunes y prevalentes en los perros. Con la creciente cercanía entre el hombre y los animales de compañía, también aumenta el cuidado con la salud y el bienestar de esos animales. Siendo la placa bacteriana la principal causa de enfermedad periodontal, los cuidados bucales que realizan los dueños de perros son fundamentales para la prevención y control de esta enfermedad. Existen muchas alternativas, desarrolladas exclusivamente para uso animal, que ayudan en la higiene bucal. Existen datos sobre el uso de productos naturales activos en la prevención de halitosis, placa dental y cálculos, en forma de sustancias antisépticas, pero el volumen de información aún es escaso. Las sustancias naturales, utilizadas desde tiempos inmemoriales para el tratamiento de enfermedades, tienen el potencial de integrar productos de higiene bucal, como agente activo principal o adjuvante en la formulación de los más variados compuestos. Este es el resultado de acciones deseables en terapias bucodentales, como anti-inflamatorias, cicatrizantes y

antimicrobianas. Este artículo revisa la información disponible sobre el tema y busca indicar qué es posible hacer para superar la brecha entre la investigación y la aplicación de estos productos en el día a día.

**Palabras clave:** Productos bioactivos; Placa; Animales de compañía; Bienestar animal.

## 1. Introduction

The relationship between people and animals has been narrowed increasingly, and reflects their importance in the current society. The number of companion animals has increased and there is still growth projection for the coming years. According to data from Brazilian Institute of Geography and Statistics (IBGE), the population of pets in Brazil reached 132 million in 2013, nearly 40% were dogs (ABINPET, 2013). Dogs and cats have lived intimately with the man for thousands of years, and this contact generates numerous benefits for the physical and psychological health and promoting the well-being of both (Grisolio et al., 2017).

Dental care are essential to the quality of life of wild and domestic animals, and due to the damage that the oral diseases can cause to health, a growing number of professionals have been dedicated to veterinary dentistry, which has evolved a lot in Brazil (Ciffoni & Pachaly, 2001).

The periodontal disease, mainly caused by the buildup of bacterial plaque, is one of the most common oral diseases in dogs, and it presents a progressive framework with two stages: gingivitis, reversible, and periodontitis, irreversible, but generally manageable (Ford & Mazzaferro, 2007; Pieri et al., 2012). Age, dental care, breed and genetic factors predispose to the development of periodontal disease, but the severity of manifestations may vary according to local immunity and the barriers of protection (Menezes et al., 2004). The fact is that without proper care, the disorder may result in consequences ranging from tooth loss to systemic diseases, diminish the quality of life and survival of the animal (Santos et al., 2012).

Being prevention the best way to prevent the installation of periodontal disease, a good oral hygiene is paramount to maintain the animals' health. In addition to veterinary follow-up, dog owners can make use of various products for dogs' oral care, such as dentifrices for brushing, mouthwash and oral chewable products that promote mechanical cleaning or have active components with antimicrobial activity (Lima et al., 2004; Gallagher, 2013; Moshkelani et al., 2014).

With time and observation, humans were able to identify the therapeutic effects of natural resources available for treatment and prevention of pathological states (Betancourt et al., 2015). Thus, the presence of natural products in dentistry is not a novelty once that compounds such as agar-agar, citric acid, eugenol and thymol have been part of the clinical routine for some time. Considering that a single plant may have several biological activities of interest in the dental-stomatological area, such as anti-inflammatory, antibacterial action, antifungal activity, etc., the incorporation of natural plant products to dental practice is promising (Hotwani et al., 2014).

Thus, the objective of this article is to perform a thorough literature review about the use of natural products used in oral care in dogs, with emphasis on those of plant origin.

## **2. Methodology**

Qualitative literature review research was carried out as defined by Pereira et al. (2018).

The search was based on articles available on the Google Scholar online platform and on the PubMed database, in December 2018.

The keywords were used: "dog", "oral disease", "plant", "antimicrobial", "bacteria", "natural product" and "bacterial plaque" in Portuguese and in English.

As an inclusion criterion, articles related to oral care / problems of dogs and products of natural origin were selected in studies conducted in vitro and in dogs. Articles that were not available in full were excluded.

## **3. Periodontal Disease and Oral Care**

Periodontium is a set of tissues that surround the teeth, whose function is to protect and support them. It is composed of periodontal ligament, cementum, gingiva and alveolar bone structures that form a system that allows the food to be torn and crushed without fracture of the teeth or bone where they are inserted. The gingiva fibrous tissue provides protection to the bone, which otherwise would be worn by abrasion during mastication. The rapid renewal of gingival tissues allows the bone to remain healthy even when compressed by frequent chewing activity (Harvey, 1998).

Periodontal disease is a multifactorial process being influenced by agents such as bacterial plaque, immune status, amount of saliva, race, age, prophylactic cleaning routine and

type of food ingested. The primary etiologic agent is the plaque that modifies itself according to the disease evolution. At the beginning of the infection, there is a predominance of gram-positive, aerobic and immovable bacteria, passing gradually to anaerobic, gram-negative and mobile bacteria, which predominate in the later stages of infection (Harvey & Emily, 1993; Mitchell & Messonnier, 2005; Gioso, 2007).

The bacterial plaque is characterized by a biofilm adhered to the teeth surface, originated from waste food, saliva, extracellular polysaccharides, cellular remnants, leukocytes, macrophages, lipids, carbohydrates and bacteria (DuPont, 1998). Its onset occurs a few hours after thorough surface cleaning of the teeth and its presence by itself is not a disease, but its accumulation is the cause of periodontal disease (DuPont, 1997; Harvey, 1998).

The buildup of plaque on the tooth surface results in gingival inflammation and, if not contained, can generate tissue destruction which, not being treated, can lead to systemic problems, jeopardizing health and well-being (DuPont, 1998; Harvey, 1998).

Being one of the oral diseases of higher incidence, periodontal disease can affect up to 80% of the dogs between four and eight years of age (Gioso, 2003). It is responsible for various degrees of inflammation and infection of the oral cavity tissues, causing pain, with eventual tooth loss and even mandibular or fractures in alveolar bones. In addition, it can cause systemic disorders capable of compromising vital organs such as heart, liver and kidneys, and also joints (Santos et al., 2012).

The identification of the disease occurs by the identification of clinical signs such as halitosis, thick salivation, oral bleeding, dental mobility, calculus and gingivitis. The basis for the treatment is the complete plaque removal and, when necessary, scraping the calculus, root flattening or smoothing of hard surfaces (Gioso, 2003).

So that the periodontal tissues remain healthy throughout life, it is necessary good oral hygiene, as well as proper alignment of the teeth, good systemic health, diet that provides adequate nutrition and abrasive food to the teeth mechanical cleaning and functional stimulus for periodontal and gingiva ligament. If one or more of these factors are not in equilibrium, there is a buildup of plaque and subsequent injury to tissues, resulting in periodontal disease (Harvey, 1998).

According to Menezes et al., (2004), the severity of these alterations varies according to the animal's immunity and with the local barriers of defense, constituted by the antimicrobial action of saliva and oral blood supply. The predisposition to periodontal diseases varies according to age, oral care, and the breed and genetic factors.

Once the plaque is the main trigger factor for this disease, it is important to raise awareness about the need of toothbrushing in dogs. Performed periodically, the brushing acts by destroying the biofilm by means of friction (DuPont, 1998), and the frequency may vary depending on the breed, the presence or absence of active periodontal disease, the animal's cooperation and the dog owners' availability (Gioso, 2007).

Lima et al., (2004) compared the efficiency of brushing in dogs of different breeds and ages through the plate quantification. Dental brush and rubber or silicone fingerstall were equally efficient in removing plaque, concluding that choice of instrument should be guided by the ease of handling by the dog owners. Watanabe et al., (2016) found that brushing significantly reduced the number of oral bacteria either alone or with use and toothpaste, in relation to the non-brushed group. Dentifrice was effective in the bacteria inhibition, but not exceeding the brushing, being its application advantageous and easy for the dogs' oral care (Watanabe et al., 2016)

A good brushing technique may be associated with the use of dentifrice and oral antiseptic agents aiming to expand the oral hygiene benefits. However, the fluoridated toothpaste commonly used by people is not suitable for dogs, because it can cause toxicity, since the animals ingest product during brushing, instead of spitting it (Gorrel et al., 2007).

The agents commonly employed in dogs toothpastes are zinc, which has antimicrobial action and consequently reduces plaque formation and calculus, chlorhexidine, which has bactericidal or bacteriostatic action, causing cell lysis of microorganisms (Souza et al., 2013). In spite of great efficiency of chlorhexidine in plaque control, it should not be prolonged use, because it can cause dark stains on the teeth, in addition to its bitter taste cause difficulties of acceptance by animals (Gioso, 2003).

Another component of dentifrices, sodium hexametaphosphate acts as a chelating agent of calcium in the saliva, preventing the plaque mineralization and the calculus formation (Bellows, 2000; Santos et al., 2012). There are also enzymatic systems that combine hydrogen peroxide and thiocyanate, forming products which interfere in the metabolism and microbial growth (Rosin et al., 2001).

#### **4. Natural Products as Adjuncts of Oral Hygiene**

Natural products have been used for a long time in treatment of diseases, and are increasingly studied as sources of new class of therapeutic agents. Due to having several biological activities, they have therapeutic potential in situations such as cancer, hypertension,

inflammation and diseases of microbial, parasitic and viral origin. The mentioned areas were those when more medicines were approved originated from natural sources between 1981 and 2006 (Newman & Cragg, 2007).

Obviously, due to the most varied purposes covered by natural products, they have also been applied in the care and treatment related to oral health (Cordeiro et al., 2006) and as adjuncts to oral hygiene, in the form of toothpastes components, mouthwash, oral gels and stain removers, among others (Ledder et al., 2014).

**Apitherapy:** Honey, propolis and royal jelly products are obtained from the beekeeping. All are important not only for the nutritional properties, but also due to functional and biological properties. They have antioxidant, anti-inflammatory, antibacterial, antiviral and anti-ulcerative activities, and also the capacity of inhibition of dental darkening of enzymatic origin. These actions are attributed mainly to the phenolic compounds, such as the flavonoids (Viuda-Martos et al., 2008).

Propolis is a complex mixture, formed by resinous and balsamic material. Its use has been explored in dentistry in the treatment against caries and plaque, in chronic periodontitis, oral candidiasis and pulp therapy, and seems to be a promising alternative for the oral diseases control, in terms of antimicrobial response and lower associated risks (Ahuja & Ahuja, 2011). In a study conducted with mixed breed healthy dogs, Darweesh et al., (2014) observed that propolis was a good means of teeth storing before the reimplantation, which increased the success rate of the procedure. It is worth noting that these compounds inhibit the connection of bacteria to the tooth surface, so that their antibacterial activity would not induce bacterial resistance, which emphasizes their potential as an oral antiseptic (Ilewicz et al., 1979; Betancourt et al., 2015).

Honey is a liquid and sweet substance, produced by bees from the nectar collected from flowers and stored for their feeding. In dentistry, it has clinical significance in oral infections, ulcers, periodontal disease, stomatitis, halitosis and anticariogenic activity. Its antibacterial activity is already well established, but there is still need for further studies (Ahuja & Ahuja, 2010). In the periodontitis treatment, for example, the main practical difficulty is its application in the gingival margins, but due to being a natural product, honey has advantage of reducing effects and risks of antimicrobial resistance (Thomas, 2014).

**Chitosan:** Obtained essentially from the carapace of crustaceans, chitosan is a polysaccharide originated from the chitin deacetylation of chitin. It has antioxidant, antimicrobial, anti-inflammatory, healing properties and inhibit the biofilms formation, which makes its application particularly interesting in dentistry (Tavaria et al., 2009; Tavaria

et al., 2013). The use of a non-woven membrane of chitosan was tested in bone regeneration in Beagle dogs, showing beneficial effects on the regeneration of periodontal tissues, indicated by the increase of new cementum (Yeo et al., 2005). In another publication, the combination of thermosensitive hydrogel of chitosan with basic factor of fibroblasts growth showed potential for the delivery of drugs and tissue scaffold, effectively increasing new tissue of periodontal support in dogs (Ji et al., 2010).

**Probiotics:** According to the World Health Organization and the United Nations Organization for Food and Agriculture (2001) probiotics are "live microorganisms which when administered in adequate amounts in people and animals, have beneficial effects on the health of the host". With the increase in the incidence of resistance to antibiotics, probiotics can be a promising area of research with respect to the prevention of caries and periodontal diseases (Koduganti et al., 2011). Within this definition, the species of *Lactobacillus*, *Streptococcus* and *Bifidobacterium* are the most used (Zambori et al., 2014).

Teughels et al., (2011) carried out a review on the influence of probiotics in the microbiota and periodontal health, commenting that their effects may be originating from three modes of action: the host's defenses modulation, production of antimicrobial substances against periodontopathogens and competitive exclusion mechanisms. When analyzing studies carried out in animals and people, it was observed that there is an effect on oral microbiota, but clinical periodontal effects are limited, perhaps due to lack of corroboration in advance of the *in vitro* strains activity (Teughels et al., 2011). In more recent studies, the beneficial effects of probiotics in oral cavity diseases were reaffirmed. According to the authors, it is recommended the periodic use of probiotics, since they may not permanently colonize the oral cavity, but the use in immunocompromised patients should be done with caution. Strains capable of fermenting sugars and reducing the pH of the oral cavity should be the focus of future research in the area (Zambori et al., 2014).

Research highlights the potential of products of natural origin in promoting and restoring oral health, whether in the control of microorganisms to more invasive applications such as implants or tissue regeneration. However, its use in clinical practice still seems to depend on more studies to prove these activities. Despite this, the antibacterial activity of natural products of animal or bacterial origin has great relevance in the current scenario, where several microorganisms are resistant to the available synthetic antimicrobials and treatment and control alternatives are necessary.

## 5. Natural Plant Products Against Oral Microorganisms

Nowadays, many people have sought a healthier lifestyle and sought more information on the composition and the form of production of the products they consume. This increased consumer awareness contributes to the growth of the natural products popularity. The number of studies increases which evaluate the medicinal plants, having as objective the formulation of products with greater biocompatibility and therapeutic activity, and lower cost and toxicity (Francisco, 2010; Pinheiro et al., 2012; Pinto et al., 2013).

Considering that the majority of oral diseases has microbial origin, herbal medicines have been widely tested in dentistry, and may present themselves as formulations obtained and developed from the active principle of one or more plants or natural products. These substances have effects on caries, periodontal diseases and candidiasis, and have been associated with dentifrices, with the curative and preventive objective (Pinto et al., 2013).

To the extent that the studies in dentistry are advancing and the emergence of bacterial strains resistant to conventional antimicrobials increases, the number of investigated plants also grows as to potential use in the treatment, care and oral hygiene products. There are studies on the use of green tea (*Camellia sinensis*) before the biofilms of *Streptococcus mutans* (Kawarai et al., 2016); antibacterial effect of chamomile (*Matricaria chamomilla*) on the representative microbiota of saliva (Modesto et al., 2003); antimicrobial activity of plant products such as oils of green tea, cloves, neem, ginger, tea tree, ginger, garlic, cinnamon, eucalyptus and saffron on microorganisms isolated from decayed teeth (Kanth et al., 2016); antibacterial activity of the extract of rosemary (*Rosmarinus officinalis*) on *Streptococcus mutans*, *Streptococcus oralis* and *Lactobacillus rhamnosus* (Valones et al., 2016), among others. There is also mention of the *in vitro* antibacterial activity of commercial herbal-based toothpaste (Pinto et al., 2013; Ledder et al., 2014; Camargo Smolarek et al., 2015) and *in vivo* antiplaque activity (Rubido et al., 2014).

In a survey on the popular use of plants in oral diseases, Vieira et al., (2014) evaluated thirty-four publications where forty-seven botanical families were referred with the highest number of citations to Anacardiaceae (16), Compositae (11), Meliaceae (08), Lamiaceae (06), Solanaceae (06) and Zingiberaceae (06). Among the studies conducted in Brazil, diversity of plant species was observed, predominantly *Anacardium occidentale* and *Punica granatum*. According to the authors, several plant species popularly used with therapeutic purpose in oral diseases, were subjected to *in vitro* antimicrobial assessment aiming to search for new complementary therapies for oral health.

Menezes et al., (2004) evaluated the antimicrobial activity of garlic extracts (*Allium sativum*), *espinheira-santa* (*Maytenus ilicifolia*), guava leaves (*Psidium guava*) and the copaiba oil (*Copaifera officinalis*) on bacteria in the oral cavity of dogs. The extracts were able to inhibit bacterial growth facing the strains of *Staphylococcus aureus*, *Streptococcus mitis*, *Streptococcus oralis* and *Streptococcus mutans*, compared to extracts containing honey, propolis, ginger and pomegranate, which were not able to inhibit bacterial growth by the tested method (Menezes et al., 2004).

Corroborating the data in the literature, Ravi & Divyashree (2014) also observed that guava presents potential for the treatment of periodontal disease acting as antiplaque, anti-inflammatory, antioxidant and healing agent. This plant has great medicinal value, because it has tannins, phenolic compounds, flavonoids, essential oils, sesquiterpene and triterpene alcohols (Ravi & Divyashree, 2014). The potential use of copaiba oil in the prevention of periodontal disease was also confirmed by Pieri et al., (2010) upon evaluating the plaque in 18 mixed-breed dogs. The solution of copaiba oil showed positive results compared to the negative control, presenting media of bacterial inhibition *in vitro* and *in vivo*. Regarding the inhibitory activity of microbial adherence (*Streptococcus mutans*), desirable characteristic to an oral antiplaque solution, copaiba oil showed better results than the other solutions (water and chlorhexidine) in the *in vitro* assay, arising as a candidate to replace the chlorhexidine in the oral antimicrobial therapy (Pieri et al., 2010).

The ethanolic extract of pomegranate (*Punica granatum*) has been incorporated into the oral hygiene products, showing clear activity before the oral biofilm. Pereira et al., (2005) demonstrated its efficiency in the form of toothpaste on biofilm microorganisms, *in vitro* and clinically (*in vivo*). The activity on the biofilm was observed by the reduction in the number of *Streptococcus mutans* and consequent reduction in the rate of bleeding (Pereira et al., 2005). Recently, the hydro alcoholic extract of pomegranate was evaluated as prophylactic treatment for oral health problems of dogs, and *in vitro* assessment it was possible to observe that the pomegranate extract showed inhibitory activity on the oral microbiota of dogs. After this screening, the extract was used in the herbal-based preparation of dental gel and mouthwash in spray for the hygiene of the oral cavity of mixed-breed adult dogs, and the results were promising, because the extract showed activity on dental biofilm microorganisms, and the use of dental gel reduced the halitosis (Carvalho Amorim et al., 2017).

Present in the Northeast of Brazil, the pepper-rosmarin (*Lippia sidoides*) is a plant whose essential oil is rich in thymol. German Shepherd dogs with gingivitis, were evaluated

for the use of an oral mouthwash prepared with this oil, and the treated group showed a reduction in the scores of plaque, calculus, gingivitis and inflammatory infiltrate, which did not occur in the placebo group (Girão et al., 2003).

Green tea contains bioactive compounds, such as for example, the catechins, with capacity to promote health benefits and to exert beneficial role in several diseases (Senger et al., 2010). Chang et al. (2009) evaluated the efficacy of green tea bags on the gingival index, plaque index, calculus index and depth of dental pockets, checking antibacterial potential in function of the reduction of the bacterial load.

The essential oil of basil (*Ocimum gratissimum*) embedded in a dentifrice was tested for plaque, bacterial load and dental calculus of dogs with periodontal disease. The dogs had their teeth brushed three times a week for a period of two months, being evaluated prior to the initiation of treatment and monthly. Although there is no reduction in the rate of plaque and in the calculus index between the treated and untreated groups, there was an expressive reduction in the load of anaerobic microorganisms before and after treatment, indicating bactericidal activity of the essential oil of basil on the animals' oral microbiota (Souza et al., 2013). The antibacterial activity of the essential oil of *O. gratissimum* is attributed to its high percentage of eugenol (Nakamura et al., 1999).

An alternative to the use of extracts and oils is the application of isolated compounds, which do not have the variations in the composition presented by the entire plant and, consequently, for their products. Some of these compounds were tested against the bacterial growth and the synthesis of glucans (polysaccharides strongly associated to the cariogenic potential), and among the assessed items, the tannic acid was the most effective in inhibiting bacterial growth (Li & Liu, 2008). Cnidium, barbaloin, caryophyllene and piperine showed inhibitory effect of 40% in the synthesis of glucan soluble, while eugenol and piperine were effective in inhibiting the synthesis of glucan soluble and insoluble of *S. sobrinus*, making them desirable agents in oral care products.

To potentiate the activities that the compounds present separately, a strategy may be the association of different products. A mouth washing product containing a mixture of extracts of chamomile, common myrtle (*Myrtus communis*) and Echinacea (*Echinacea Purpurea*) presented a favorable effect, reducing gingivitis and halitosis in dogs. The product showed higher efficiency than the chlorhexidine at 0.1% (Torkan, 2015). Therefore, the combination of green tea and microbial enzymes isolated from plants attenuated the formation of dental plaque in dogs with periodontal disease, when consumed daily with potable water (Lindinger, 2016).

Research involving conventional antibiotics associated with medicinal plants evidence that this combination may have synergistic effects before bacteria of clinical interest, especially veterinarian. Maia et al., (2017) found that the extract of chamomile potentiated the effect of norfloxacin and cefalexin against isolates of *Staphylococcus aureus*.

Feeding plays a fundamental role in the development and maintenance of the teeth, gums and oral tissues integrity, bone efficiency and in the prevention and treatment of the oral cavity diseases. Thus, it is interesting to use the textures of own food to offer dental benefits to companion animals, providing effective mechanical cleaning for dental plaque control (Logan, 2006). Gallagher (2013) found that raw bones, vegan chewable strips and sticks of chewable meat reduced the bacteria from the dogs' teeth at levels comparable to those of the brushing, expanding the dog owners' options regarding oral care.

Table 1 (prepared by the authors) presents a compilation of works carried out exclusively with microorganisms from the oral cavity of dogs that involve plants, pointing out the main objective, method by which the product was tested and which microorganisms are of interest, in publications in the researched period. Among the studies analyzed, the activity of plants is directly observed in bacteria and also in the formulation of various oral care products. Thus, it is possible to verify once again the relevance of products of natural origin in relation to the control of microorganisms.

## 6. Conclusions

The plants, which have long been used due to their biological activities, may act also as active components or adjuvants to promote dogs' oral health, with effect on the quantity of microorganisms, especially those that comprise the bacterial plaque, acting accordingly in the prevention and control of periodontal disease. Just as shown in Table 1, the studies with plant origin products are concentrated mainly in *in vitro* antibacterial activity of plant extracts and essential oils using isolated microbiota directly from the dogs' oral cavity or reference strains. Among the most varied sources of these bioactives, *Copaifera officinalis* and *Punica granatum* stand out due to promising results both *in vitro* and *in vivo*. There are countless possibilities for advancement in this area of Pharmacology and Therapeutics, with the capacity to generate effective exploitation of these plants in oral products and treatments. This includes the careful planning of experiments, contemplating tests on the microorganisms in culture media and in the oral cavity, and also tests of oral mucosa irritation, enamel abrasion, as well as stability and toxicity of natural products of plant origin. The association of

compounds to the potentiation of the action and the reduction of adverse effects is also a point to be developed. The availability of food and snacks for oral hygiene using only plant origin ingredients is already a reality in the pet industry, but these ingredients still have a lot to develop in the canine dentifrices area.

Therefore, future studies should go beyond demonstrating biological activity. The challenge is to create viable and safe alternatives for the use of products of natural origin in the day-to-day oral care of dogs, requiring different experimental approaches and greater knowledge of natural active compounds.

**Table 1.** Survey of studies with plant products made exclusively in dogs or in samples isolated from the dogs' oral cavity.

Plant Product	Goal	Methods	Microorganism	Reference
<i>Lippia sidoides</i> essential oil	Mouth washing effect on the dogs' oral health with marginal gingivitis.	Application on the dogs' teeth every 2 days for 2 weeks. Clinical evaluation on days 0 and 15.	Not applicable.	(Girão et al., 2003)
Extracts of pomegranate; composed of honey, propolis and ginger; composed of honey, propolis and ginger and pomegranate; <i>Allium sativum</i> , <i>Maytenus ilicifolia</i> , <i>Psidium guava</i> and oil of <i>Copaifera officinalis</i>	Sensitivity of bacterial species commonly found in the oral cavity, before commercial extracts of plants.	Disk diffusion (Mueller Hinton agar).	<i>Staphylococcus aureus</i> (ATCC 25923), <i>Streptococcus mitis</i> (ATCC 903), <i>Streptococcus oralis</i> (ATCC 10557) and <i>Streptococcus mutans</i> (ATCC 25175), <i>Streptococcus oralis</i> and <i>Streptococcus mitis</i> isolated from the dogs' oral cavity <i>Streptococcus mutans</i> , NCTC Ingbritt, <i>Streptococcus sobrinus</i>	(Menezes et al., 2004)
Twenty-one compounds isolated from plants.	Inhibitory effects of herbal extracts in the bacteria associated with caries and glucans of dental plaque <i>in vitro</i> .	Broth microdilution. Inhibition of glucans synthesis by <i>Streptococcus sobrinus</i> by colorimetric method.	ATCC 6715, <i>Actinomyces viscosus</i> ATCC 19246 and <i>Lactobacillus acidophilus</i> ATCC 4356.	(Li & Liu, 2008)
Green tea	Effect on the reduction of oral bacteria and gingival index, plaque index, calculus index, and depth of periodontal pockets.	Clinical assessment. Counting of colonies after use.	Isolated microorganisms of the oral cavity.	(Chang et al., 2009)
<i>Copaifera officinalis</i> oil	Action of a solution of oil of copaiba in plaque forming bacteria in comparison to chlorhexidine.	Diffusion in agar. Inhibition of adherence of <i>Streptococcus mutans</i> . Clinical assessment. Disclosure of bacterial plaque with basic fuchsine solution.	<i>Streptococcus mutans</i> (ATCC 25175), <i>Streptococcus salivarius</i> (CDC 262), <i>Streptococcus pyogenes</i> (ATCC 19615) and <i>Enterococcus faecalis</i> (ATCC 19433).	(Pieri et al., 2010).
<i>Ocimum gratissimum</i> essential oil	Effect of a dentifrice containing essential oil on bacterial load, plaque and calculus.	Brushing three times a week during two months. Clinical assessment. Counting the colony forming units.	Aerobic and anaerobic bacteria isolated from gingival biofilm and gingival sulcus.	(Souza et al., 2013)
<i>Psidium guajava</i>	Review of the <i>P. guajava</i> potential in the	Consulting the Internet databases, PubMed	Not applicable.	(Ravi & Divyashree, 2014)

	treatment of periodontal disease.	and Google Scholar. The most relevant articles were considered.		
Mixture of extracts of <i>Myrtus communis</i> , <i>Matricaria recutita</i> and <i>Echinacea purpurea</i>	Mouth washing effects with herbs compared to those of chlorhexidine in the dogs' oral microbiota.	Clinical assessment. Treatment in animals with periodontal disease for 65 days. Bacteria collection and counting.	Oral microbiota bacteria.	(Torkan, 2015)
Hydro alcoholic extract of <i>Punica granatum</i>	Promote alternative methods in the oral hygiene of company animals.	Disk diffusion. Dental gel spray formulation. Use by dog owners twice a week.	Oral cavity microbiota.	(Carvalho Amorim et al., 2017)
Green tea	Effect of the combination of green tea and microbial enzymes isolated from plants in the formation of dental plaque of dogs without periodontal disease.	Mix the product in water of dogs for 28 days. Temporal evaluation of the index of plaque, plaque thickness, gingivitis and health general assessment.	Not applicable.	(Lindinger, 2016)

Source: The authors.

## Acknowledgements

The authors are grateful to University of Paraná State (UNIPAR) for funding this research, and e Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for granting PNPB scholarship.

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