Antibacterial Efficacy of Epigallocatechin-3-gallate against *Streptococcus mutans*: A Systematic Review

**Eficacia antibacteriana de la epigallocatequina-3-galato contra el Streptococcus mutans:**

**Revisión Sistemática**

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ABSTRACT

Background: Green tea, obtained from the *Camellia sinensis*, is one of the most popular drinks worldwide and has recently been in the focus of scientific research due to its beneficial effects on general health. Several studies suggest that, among the polyphenols found on green tea, epigallocatechin-3-gallate (EGCG) is the most bioactive compound and is responsible for its antibacterial activity. Purpose: To conduct a qualitative systematic review of literature evaluating
the antibacterial efficacy of EGCG against *Streptococcus mutans* (*S. mutans*). **Methods:** Relevant published studies included in the Pubmed (1966- June 2015), Scopus (1960- June 2015), Web of Science (1900- June 2015), and Google Scholar databases were identified. Publications of *in vitro* studies, which studied EGCG antibacterial efficacy against *S. mutans*, were extracted and pooled in a table. The evaluation included inhibition zone measures, reduction of the number of microorganisms, and biofilm formation. **Results:** Twelve studies were selected to compose this systematic review. Eleven of them showed that EGCG has antibacterial efficacy against *S. mutans*. **Conclusions:** *In vitro* evidence available confirms the antibacterial activity of EGCG against *S. mutans*.

**KEYWORDS**
Antimicrobial Agents; *Camellia sinensis*; Dental Caries, Epigallocatechin-3-gallate

**THEMATIC FIELDS**
Cariology; Catechins; Microbiology

**RESUMEN**
**Antecedentes:** El té verde, obtenido de la *Camellia sinensis*, es una de las bebidas más populares en el mundo y ha estado recientemente en el foco de atención de la investigación científica por sus efectos benéficos en la salud general. Varios estudios sugieren que, entre los polifenoles encontrados en el té verde, la epigalocatequina-3-galato (EGCG) es el compuesto más bioactivo y es el responsable de su actividad antimicrobiana. **Objetivo:** Realizar una revisión sistemática cualitativa de la literatura donde se evalúe la actividad antibacteriana de la EGCG contra el
Streptococcus mutans (S. mutans). **Métodos:** Se identificaron estudios relevantes incluidos en las bases de datos bibliográficas Pubmed (1966- junio 2015), Scopus (1960- junio 2015), Web of Science (1900- junio 2015) y Google Académico. Los datos de estudios in vitro que investigaron la eficacia antibacterial de la EGCG contra el S. mutans se seleccionaron y organizaron en una tabla. La evaluación de los estudios incluyó los criterios: medidas de las zonas de inhibición, reducción del número de microorganismos y formación de biopelícula. **Resultados:** Se seleccionaron 12 estudios para la revisión sistemática. Once de ellos comprobaron la eficacia antibacteriana de la EGCG contra el S. mutans. **Conclusiones:** La evidencia in vitro disponible confirma que la EGCG tiene un efecto antibacteriano contra el S. mutans.

**PALABRAS CLAVE**
agentes antimicrobianos; Camellia sinensis; caries dental; epigallocatequina-3-galato

**ÁREAS TEMÁTICAS**
cariología; catequinas; microbiología

**INTRODUCTION**

The green tea, originating from the Camellia sinensis plant, is one of the most popular drinks and has received special attention by presenting known effects on general health (1,2). Among the components of this tea, Epigallocatechin-3-gallate (EGCG) is the substance found in greater amounts, constitutes about 59% of total substances and the most bioactive component (3).
In addition to these properties, can be highlight the antimicrobial action, several studies have reported the inhibitory effects of EGCG on both Gram-positive and Gram-negative bacteria, such as *Enterococcus* spp., *Staphylococcus aureus*, *Streptococcus* spp., *Salmonella* spp., and *E. coli* (1,2,4-6). In Dentistry, this substance was proposed in toothpaste (7), because it presents a broad spectrum of action against *Streptococcus mutans* (*S. mutans*) and *Streptococcus sobrinus* (*S. sobrinus*). The action of catechin occurs preventing bacterial adhesion to the tooth surface by inhibiting glucosyltransferase enzyme and bacterial amylase (1, 2, 8).

The primary role of *S. mutans* in the pathogenesis of dental caries resides with it is ability to assemble an insoluble polymeric matrix (9). This microorganism is considered the main and predominant etiologic agent of dental caries and contributes significantly to the virulence of the biofilm, especially in the presence of sucrose (10). There are many studies regarding the use of EGCG in medicine, however few and recent studies have been conducted on the use of EGCG in Dentistry, since this substance is found in a very popular drink that contacts the oral mucosa, it may have antimicrobial efficacy and play an anticariogenic role. The research question behind this systematic review was: Does EGCG have antibacterial efficacy against *S. mutans*? The hypothesis of this study was: EGCG performs an antibacterial efficacy against the microorganisms *S. mutans*. This systematic review evaluated the antibacterial efficacy of the EGCG against *S. mutans*.

**METHODS**

Originals *in vitro* studies that investigated the EGCG as an antibacterial agent were included, as well as those who evaluated the antibacterial activity of this substance against *S. mutans*, which
have been published in the English language.

*In vivo, ex vivo, in situ*, animals, clinical studies, letters to the editor, case reports, case series, review and studies with explicit convenience sample (institutionalized/hospitalized individuals, vulnerable population, sample selection performed according to the researcher interest) were excluded, as well as patents, conferences, studies evaluating other extracts of green tea, other microorganisms and other studies that have been published in non-English language.

Electronic searches were conducted to identify the published literature in the Pubmed Medline (1966- Feb 2016), SciVerse Scopus (1960- Feb 2016), Web of Science (1900- Feb 2016) and Google Scholar databases. The Google Scholar was used as a program aimed at the international literature.

The search strategy was based on the following Medical Subject Heading terms (MeSH) and free terms: (“epigallocatechin-3-gallate” [MeSH] OR “EGCG” [MeSH] OR “Camellia sinensis” [MeSH] OR “green tea” [all]) AND (“Streptococcus mutans” [MeSH] OR “S. mutans” [all] OR “Mutans streptococci” [all]). Data was extracted and pooled in a table, to facilitate the visualization of information.

All papers were managed using the software EndNote X7 (Thomson Reuters, New York, NY, US). Duplicate papers were excluded. Titles and abstracts were screened independently by two reviewers based on the criteria mentioned above, (DCAF and SAFP). When there was some sort of disagreement, a third examiner was requested (ECK). After initial screening of titles and
abstracts, full articles were evaluated by the same two reviewers. Structured data collection worksheets were employed for the assessment of each publication.

RESULTS

The Figure 1 presents a flow diagram, describing the process of selection of the studies about antimicrobial activity of EGCG against *S. mutans*. In Pubmed Medline database 40 studies were found, in Scopus database 48 studies were found, in Web of Science 109 studies were found, and finally 340 studies were found in the Google Scholar database.

Studies were compared across all database and the studies in duplicate were excluded (91 studies). The remaining studies were analyzed and those, which did not meet the inclusion criteria, were excluded (434 studies). At the end, 12 studies were included in the full-text analysis and all were selected for inclusion in the systematic review. Table 1 (at the bottom of the manuscript) shows the characteristics of the selected studies. The results demonstrated that EGCG present a considerable efficacy against *S. mutans*, by using different methods to analyze the antibacterial activity against this microorganism. Of the 12 studies evaluated, 11 demonstrated that EGCG showed efficacy against the lineage of microorganisms in question. However, 2 of them presented low efficacy, verifying interference in the formation of the biofilm, without causing the total inhibition. Only 1 study showed that EGCG is not an effective agent against *S. mutans*.

**Figure 1.**
Flow diagram showing the process of selection of the studies
Dental caries is the most common oral disease and is an irreversible infectious disease of multifactorial origin, which leads to the destruction of dental hard tissue (10). The biofilm plays an important role in the cause of tooth decay, the cariogenic microorganisms such as *Streptococcus mutans*, *Streptococcus sanguis*, *Streptococcus salivarius*, *Streptococcus mitis*, *Streptococcus oralis* and *Lactobacillus acidophilus* play a vital role in the etiology of the dental caries (11). *Streptococcus mutans* is the major causative agent of dental caries and plays an important role in
cariogenic biofilm formation (12, 13). It has been demonstrated that S. mutans are the primary etiological agent of caries (12).

Medicinal plants have been used for therapeutic purposes for thousands of years and although their use has been popularly propagated between generations or described in pharmacopoeias, it has also aroused the interest of the current scientific community. Teas generally are rich in biologically active compounds such as flavonoids, catechins, polyphenols, alkaloids, vitamins and minerals that may contribute to the prevention and treatment of various diseases (14).

It is important to emphasize that this systematic review has shown that although the methods used in the included studies are different, the results clearly support the important role of EGCG as an antibacterial agent against S. mutans. The EGCG agent inhibits the formation of biofilm and prevents infections (15), it is effective in inhibiting the formation of fermentable carbohydrates involved in the caries formation, which explains it is antimicrobial role (16). Per the findings of this review, 11 studies showed favorable results for EGCG as an effective antibacterial agent against S. mutans in in vitro studies, acting both inhibiting the growth of the microorganism, as in the biofilm formation and in decreased acids production. Only one study found a negative result regarding the use of EGCG in the decontamination of infected dentin. This lack of effectiveness was justified in the study by the authors for perhaps be some interaction between EGCG with specific sites in collagen molecular structure (17).

Several antimicrobial agents have been suggested, but the agent considered the gold standard is chlorhexidine gluconate (CHX). CHX widely used antimicrobial in Dentistry (18), due to it is
strong antibacterial activity and ability to reduce the accumulation of oral biofilms (19). Its efficacy can be attributed to bactericidal and substantivity effects (20), broad spectrum against microorganism, both aerobic and anaerobic, and selectively suppress the growth of caries-associated *S. mutans* (21). CHX presents antimicrobial efficacy *in vitro* and *in vivo* (mouthwash) against salivary microbiota cariogenic and has a role in preventing the development of gingivitis (22). Some studies compared EGCG with CHX (17, 23-26). The results of the comparison between CHX and EGCG showed that both substances were effective in inhibiting microbial the growth and biofilm formation. Other studies (26-31) used as negative control the absence of EGCG and in these situations; it was observed that there was a marked growth of microorganisms compared to the experimental group. One study compared the antimicrobial activity of EGCG whit black, oolong and Pu-erh tea against growth of *S. mutans* (32) and another study had no control group (33).

Different methods have been used to evaluate the efficacy of EGCG against microorganisms, such as inhibition zone measurement, counting colonies forming units, counting of microorganisms and biofilm formation. In addition, different forms of manipulation of the EGCG, in some studies the solution was used (29-31), others incorporated into dental materials (24, 27, 28), and even as specific formula (26). Despite all these variety in the method and material handling, the results suggested that it is a stable substance and with antimicrobial properties and able to inactivate the *S. mutans*, and thus inhibit the formation of biofilm. This systematic review demonstrates a clear efficacy of EGCG against *S. mutans* in *in vitro* studies. However, clinical studies are needed to determine this substance as a potential agent for the prevention of dental caries.
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REFERENCES


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<td>Assis et al.</td>
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<td>Anita et al.</td>
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<td>Shumi et al.</td>
<td>To investigate the inhibitory effect of EGCG on SM biofilm formation</td>
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<td>Low efficacy</td>
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<td>Du et al.</td>
<td>To evaluate the antimicrobial potential of a dental adhesive incorporated with EGCG</td>
<td>Dental adhesive</td>
<td>Spatial distribution and architecture of biofilm using SEM</td>
<td>Incorporation of EGCG showed growth inhibition of SM</td>
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<td>Xu et al.</td>
<td>EGCG suppresses glucosyltransferase genes in SM</td>
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<td>EGCG inhibited the in vitro growth of SM</td>
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<td>Effective</td>
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<td>Xu et al.</td>
<td>EGCG contributes to the suppression of virulence factors of SM</td>
<td>Medium without EGCG</td>
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<td>EGCG inhibited the in vitro growth of SM and biofilm formation.</td>
<td>Acidity and the virulence factors of SM at the transcriptional and enzymatic levels was suppressed</td>
<td>Effective</td>
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<tr>
<td>Saito et al.</td>
<td>To assess the antibacterial efficacy of incorporating catechins into resin against SM</td>
<td>Resin without EGCG</td>
<td>Count forming units of bacteria colonies</td>
<td>EGCG incorporated into resin showed growth inhibition of SM.</td>
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<td>Effective</td>
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<tr>
<td>Tamura et al.</td>
<td>To evaluate the antimicrobial activities of gel-entrapped catechin on oral microorganisms in vitro</td>
<td>-Gel-entrapped catechin (GEC) -Gel-entrapped EGCG (GEEG) -Gel containing 0.03% CHX (CHX-gel)</td>
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<td>To compare the antimicrobial activities of extracts of various teas leaves on SM</td>
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<td>—</td>
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</tr>
<tr>
<td>Sakanaka et al.</td>
<td>To determine EGCG mode of inhibition of microbial growth</td>
<td>—</td>
<td>Count forming units of bacteria colonies</td>
<td>EGCG showed growth inhibition of SM.</td>
<td>—</td>
<td>Effective</td>
</tr>
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Note: Bold form indicates the EGCG superiority against the control. GIC means glass ionomer cement; SEM means scanning electron microscopy; CHX means chlorhexidine; SM means Streptococcus mutans.