SCHOOL OF MATERIALS AND MINERAL RESOURCES ENGINEERING

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FABRICATION AND CHARACTERIZATION OF DENTURE ADHESIVE FILLED STARCHES CONTAINING ANTIMICROBIAL AGENTS

By

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DECLARATION

I hereby that I have conducted, completed the research work and written the dissertation entitled “Fabrication and Characterization of Denture Adhesive Filled Starches containing Antimicrobial agents. I also declare that it has not previously submitted for the award or any degree or diploma or other similar title of this for any examining body of University.

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Date:

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LIST OF ABBREVIATION

PEO	Polyethylene Oxide
CMC	Carboxymethylcellulose
FTIR	Fourier Transform Infrared Spectroscopy
TPA	Texture Profile Analysis
SEM	Scanning Electron Microscopy
TTO	Tea Tree Oil
CNO	Coconut Oil
EO	Essential Oil
MCTs	Medium Chain Triglycerides
ASTM	American Society for Testing and Materials
FDA	Food and Drug Administration
UTM	Universal Testing Method
TBD	Tensile Bond Strength
N	Newton
MPa	Mega Pascal
rpm	Revolution per minute
g	Gram
ml	Milliliter
mm	Millimeter

LIST OF SYMBOLS

%	Percentage
℃	Degree Celcius
(v/v) %	Volume per volume percent

FABRIKASI DAN PENCIRIAN PELEKAT GIGI PALSU DENGAN PENGISI KANJI UBI KAYU YANG MENGANDUNGI AGEN ANTIMIKROBIAL

ABSTRAK

Pelekat gigi palsu digunakan secara meluas bagi pemakai gigi palsu untuk meningkatkan pengekalan gigi, kestabilan dan fungsi terutamanya semasa pengunyahan. Pelekat memainkan peranan penting dalam pelekatan gigi palsu, untuk meningkatkan pengekalan dan memberikan keyakinan psikologi yang lebih kepada pesakit. Objektif kajian ini adalah untuk menghasilkan dan mencirikan pelekat gigi palsu yang mengandungi agen antimikrobial. Kanji ubi kayu dipilih sebagai pengisi untuk melekat lebih baik kerana telah terbukti ia mempunyai kekuatan pelekatan. Beberapa kajian telah menyatakan minyak pati seperti minyak "Peppermint", Minyak Pokok Teh (TTO) dan Minyak Kelapa (CNO) mempunyai keberkesanan bagi merencatkan bakteria *Candida albicans*. Oleh itu, minyak-minyak pati ini dipilih untuk kajian ini. Terdapat beberapa pencirian dan ujian yang telah dijalankan seperti Fourier Transform Spectroscopy Inframerah (FTIR), Analisis Profil Tekstur (TPA), Kekuatan Ikatan Tegangan (TBD), ujian kekuatan ricih, ujian pH, ujian antimikrob dan kajian morfologi menggunakan Mikroskopi Pengimbasan Elektron (SEM), kelarutan dan ujian pembengkakkan. Pelekat gigi palsu dengan pemuatan pengisi 10% mempamerkan komposisi kanji optimum kerana ia menunjukkan pelekatan tertinggi, kekuatan ricih dan pemanjangan takat putus. Walau bagaimanapun, untuk kekuatan dan kekuatan ikatan tegangan tiada trend yang ketara diperhatikan. Minyak pati tulen; minyak Peppermint dan minyak pokok Teh terbukti dapat menghalang pertumbuhan bakteria, tetapi minyak kelapa tidak menunjukkan apa-apa zon perencatan. Agen antimikrobial dalam pelekat gigi palsu juga kehilangan aktiviti mereka kerana kepekatan rendah atau pelekat gigi palsu menyahaktifkan reaksi molekul imun semula jadi dalam agen antimikrob.

FABRICATION AND CHARACTERIZATION OF DENTURE ADHESIVE FILLED STARCHES CONTAINING ANTIMICROBIAL AGENTS

ABSTRACT

Nowadays, denture adhesive is widely used for denture wearers in order to improve the denture's retention, stability and function especially during mastication. Adhesiveness plays an important role in denture adhesive, to enhance retention and gives more psychological confidence for the patient. The objective of this study is to fabricate and characterize the denture adhesive filled starches and containing antimicrobial agents. Tapioca starch is chosen as filler as it has proven to exhibit excellent adhesiveness. Several studies have been reported essential oils such as Peppermint oil, Tea Tree oil (TTO) and Coconut Oil (CNO) have effectiveness against *Candida albicans*. Therefore, these essential oils were chosen in this research. There are several characterization and test were conducted such as Fourier Transform Infrared Spectroscopy (FTIR), Texture Profile Analysis (TPA), Tensile Bond Strength (TBD), Shear strength test, pH test, antimicrobial test and morphology study for Scanning Electron Microscopy (SEM), solubility and swelling test. Denture adhesive with 10% filler loading exhibits the optimum starch composition as it shows highest adhesiveness, shear strength and elongation at break. However, for tensile bond strength and hardness no significant trend is observed. Pure essential oils; Peppermint oil and Tea tree oil are proven to inhibit the bacterial growth, but Coconut oil does not show any zone of inhibition. Antimicrobial agents in denture adhesive also loss their activity due to low concentration or denture adhesive deactivate the reaction innate immune molecules in antimicrobial agents.

CHAPTER 1

INTRODUCTION

1.1 Research background

Dentures are usually used by older people and about more than 600 million people are 60 years or older all around the world. Almost more than 80% of this community are living in developing nations. Most elderly population failed to maintain their natural teeth and cannot avoid to use dentures. (Fallahi, Khadivi et al. 2017)

Denture adhesives are extensively used worldwide, to enhance the comfort and benefit of dentures wearers by developing their retention and stability. It has been reported that currently up to 30% of denture wearers had regular used denture adhesive. Many researcher presented that by using denture adhesives, can have a lot of benefit such as increased fit, comfort, chewing ability and confidence denture wearers.(Harada-Hada, Mimura et al. 2017)

There are several benefits that denture wearers experience by using denture adhesive by offering stability and comfort. People who had wear dentures should consider using denture adhesives, in order to stabilize and reduce movements of dentures. (Harada-Hada, Mimura et al. 2017)

Denture adhesive can come in various form such as paste form, powder form, strip form or as a sticky adhesive and is applied on the bottom of the between dentures and oral mucosa for providing sufficient adhesion. Moreover, denture adhesive can keep dentures in a place, preventing slippage during chewing and as a seal to keep food from being trapped under dentures. Dentists have been suggested that cream type is the most recommended for denture adhesive because easy to apply. (Yegin, Akpinar et al. 2017)

The composition of the commercial brands of denture adhesive such as shown in Table 1.1, poly vinyl ether methyl cellulose, poly methyl vinyl ether/maleic anhydride (PVMMA), tragacanth, karaya gum, and synthetic polymers like acrylamides, acetic, polyvinyl and poly ethylene oxide (PEO) as adhesive agents. Synthetic antimicrobial agents such as sodium tetraborate, ethanol and hexachlorophene and flavoring agents like peppermint oil, wintergreen oil or aroma. (Sampaio-Maia, Figueiral et al. 2012, Yegin, Akpinar et al. 2017)

Table 1.1 : The composition of the commercial brands of denture adhesive. (Sampaio-Maia, Figueiral et al. 2012)

Denture adhesives	**Composition**
Corega cream	Poly(methylvinylether/maleic acid) sodium/magnesium/zinc mixed partial salt, petrolatum,cellulose gum, paraffinum, aroma, silica and Cl 45430.
Kukident cream	Calcium and zinc PVM-MA copolymer, paraffinum liquidum, petrolatum,cellulose gum, menthol, silica, menthyl lactate, peppermint powder, Cl 16185 and Cl 75470.
Novafix cream	Vinyl copolymer and CMC
Polident cream	Poly(methylvinylether/maleic acid) sodium/calcium partial salt, paraffinum liquidum, petrolatum,cellulose gum, flavour, propylparaben and Cl 45430.
Protefix cream	Poly(methylvinylether/maleic acid) sodium/calcium partial salt, CMC, paraffinum liquidum, vaseline, silica, menthol, azorubin and p-hydroxybenzoic acid methyl ester.
Steradent cream	Calcium and sodium PVM-MA copolymer, cellulose gum/H, cellulose gum/M, petrolatum, polyethylene, menthe piperita, menthol and Cl 454301.
Aderyn powder	Karaya gum and aroma
Corega ultra powder	Poly(methylvinylether/maleic acid) sodium/calcium mixed partial salt, cellulose gum and aroma

Denture wearers who use removable prosthetic devices probability have oral health problems if they do not maintain sufficient hygiene rules. Normally in the oral mucosa area covered by the denture high probability have infection and soreness on that area. There are several research reported that denture wearers have potency to suffer from denture stomatitis. (Baygar, Ugur et al. 2017)

The oral cavity consist of several types of pathogen such as fungi, bacteria, parasites, viruses or other microbes into dental plaque. These microorganisms are capable to have resistant to mechanical stress and medical treatment such as antibiotic. Furthermore, pathogen on the oral cavity give an important roles to enhance caries and periodontal diseases. (Baygar, Ugur et al. 2017)

Some studies have been reported that denture adhesive enhance microbial growth in oral. One i*n vitro* study had been determined that several denture adhesives promoted microorganisms called *Candida albicans* growth. The reaction of microbial between denture adhesive and oral cavity have been conducted, but the results obtained not consistent. (Sampaio-Maia, Figueiral et al. 2012)

Nowadays there are various type of natural antibacterial compounds such as essential oil and extracts of several species of edible and medicinal plants, herbs. Essential oils have therapeutic properties to inhibit bacteria without having to experience potentially severe side effects that come with antibiotics. Generally much safer than taking a prescription antibiotic and have been used as natural ingredients food preservation due to the exhibition of antimicrobial properties. (Rahman, Sultana et al. 2017)

An overview of the published data on the antibacterial activity of those Essential Oils, Tea tree oil (TTO) and their components that could be considered suitable for application in human body or on foods, and to describe their possible modes of action. The current knowledge on potential antagonists and synergists is presented, legal and safety aspects are discussed and areas for future research are proposed. Tea tree oil (TTO) is the essential oil steam-distilled from Melaleuca alternifolia, an Australian native plant. There are several resulted of the awareness of a range of bacteria, yeasts, and fungi to the antimicrobial properties of TTO that support the increasing popularity of TTO as an antimicrobial agent for the treatment of conditions such as tinea pedis and acne. (Lee, Chen et al. 2013)

This research was to improved properties of denture adhesive by adding starch as filler containing tea tree oil and coconut oil as antimicrobial agent. Starch is recommended by researchers as a biodegradable polymer, non-toxic, harmless and most abundant natural with lower cost bio-resource, which has been generally used in various application such as food, medicine, textile, paper, pharmacy and agriculture. (Zhao, Peng et al. 2017) It is generally known that starch can be used as an adhesive in a wide range of products, including binders, glues, pastes, and sizing material. (Li, Wang et al. 2015)

Natural carbohydrate polymers have been derived into various adhesives. Nowadays, plant-derived gums mostly are replaced by synthetic polymers. Gums are used as adhesives, detergents, textiles, pharmaceuticals, cosmetics and many industrial purposes. Several polymers have adhesives characteristic that can be utilized. Anyhow, natural carbohydrate polymers are mostly used as modifiers for highly costs synthetic resin such as thickeners, colloidal stabilizers and flow controllers. Natural gums used as adhesive in many applications especially in pharmaceuticals and denture adhesives. (Zhao, Peng et al. 2017)

According (Zhao, Cheng et al. 2004) in the vivo conditions to determine the clinical effect of pH and bonding strength. Denture adhesives should have a neutral pH. Secondly, bonding load test was conducted between acrylic resin as denture base on a universal testing machine. Commercial product, Polident, was used as a control as shown in Figure 1.1.

Figure 1.1: Commercially available denture adhesive, Polident

1.2 Problem statement

Most of the commercial brands denture adhesive enhance denture stability, retention and function. Several studies have been reported that some commercially brands available denture adhesives showed microbial contamination.

The aim of this study to evaluate the properties of a denture adhesive filled native Tapioca starch containing antimicrobial agent. Starch is a renewable plant polymer that has been used for a long time in many different applications especially as adhesives in order to improve the properties of denture adhesive and study the effect of denture adhesive on microbial in oral, *Candida albicans*.

Antimicrobial agent was formulated into a denture adhesive to control inflammation from bacteria contamination. By adding antimicrobial agent in denture adhesive will inhibit the bacteria in the mouth. In this research, we used Tapioca starch as adhesive agents and Tea tree oil as anti-microbial agents.

1.3 Objectives

The objectives of this project are:

1. To prepare and characterize a natural polymer based denture adhesive filled starches.
2. To identify the effect of native starch at different filler loading using Tapioca starch on the denture adhesive properties.
3. To evaluate the effect of properties Tea Tree Oil, Coconut Oil as Antimicrobial agent on the denture adhesive properties.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Denture Adhesive

The first usage of denture adhesives was the late 18th century. Denture adhesives have been used worldwide for denture wearers especially effectiveness and biocompatibility in the ingredients. (Koronis, Pizatos et al. 2011)

Nowadays, improvement in denture adhesives make denture wearers more confidence while using denture adhesives to reinforce retention, function and stability. Application of denture adhesives required standardized guidelines for use and removal of denture adhesives, provide denture wearers more confident, comfort and increase chewing ability of their dentures. (Chen, Mao et al. 2014)

Denture adhesives need to be biocompatible, nontoxic, non-irritating and give cushioning effect to the oral mucosa. The adhesives also prefer lack of taste, odourless and easy to apply and remove from the denture. Properties of the denture adhesives must can be retained more than 12hour, maintained the neutral pH and against the microbial growth. (Sampaio-Maia, Figueiral et al. 2011)

Denture adhesives commonly are supplied in variable as a paste, powder or cream for soluble adhesives and cushions or strips for insoluble materials. Based on previous studies, about 30% denture wearers have used denture adhesives. (Koronis, Pizatos et al. 2011)

2.2 Characteristic of Denture Adhesive

New adaptation of the denture adhesives is improved by increasing the surface contact area between tissue and mucosa within the formation of compression. The compression of denture adhesives is occur during the denture base is applied to the mucosa, combination of the adhesive and the presence of saliva become swelling to prevent the denture to dislodgement. (Fallahi, Khadivi et al. 2017)

The clinical procedures for denture adhesives demanding adhesives that provide fixation to the denture base within the aggressive environment and effective the removability of denture adhesives. Fundamental consideration also for oral care applications such as sensitive mucosa patients, provides a cushion between surface of implants and denture to reduce irritation such as ulcers and inflammation that usually from compression. Therefore important in controlling the stability and failure of the denture adhesives. (Fallahi, Khadivi et al. 2017)

Denture adhesives have been produced in variety form such as pastes, powders, creams or strips as shown in Figure 2.1.(Harada-Hada, Mimura et al. 2017)The important characteristic of denture adhesives, the ingredient materials that affect the strength and viscosity of the adhesive. Composition of the adhesives has to improve the efficacy by increasing retention and stability. (Sampaio-Maia, Figueiral et al. 2011)

Figure 2.1: Commercial types of denture adhesive in various form

In the glossary of prosthodontic terms, it has been defined denture adhesives consist material to the oral cavity with chemical and physical interactions. Ingredients of denture adhesive absorbing water from saliva become swelling then getting viscous and sticky to fill the gap between the denture and mucosa. Combination of the saliva, oral fluids and adhesive can improve the resistance of the denture to dislodgement. (Elif Yegin et al. 2017)

(Koronis, Pizatos et al. 2011) studied about the tending effect on maxillary dentures of several denture adhesives by applying an intraoral transducer. Retention of complete maxillary dentures were demonstrated for increase the desirable of denture adhesives. Users of denture adhesives recognize and more confidence and comfort when using denture adhesives because better stability, retention and reduced accumulation of food particles under the denture.

Felton, Cooper et al. (2011) further evaluated that by using denture adhesives during mastication promote better retention compared without denture adhesives. Chewing ability rates also found that increased by using a multichannel magnetometer tracking device when denture adhesives were applied.

(Ozkan, Uçankale et al. 2012)have reported dentistry have been concern in developing retention and stability for the denture wearers while dealing usage and removing dentures. Now, improving in denture fabrication and oral care required denture adhesives due to efficiency and achievement in formulation denture adhesives. Moreover, dentists and dental students have been investigated their knowledge and understanding.

2.3 Advantages of using Denture Adhesive

Denture adhesive can act as a denture relining material by providing cushioning effect and during mastication denture relining transferred the stress constantly distribute onto soft tissues. Denture wearers that have thin athrophic mucosa, normal mucosa with an atrophied ridge and a sharp alveolar ridge are suggested to use denture adhesive as denture relining due mucosa tissues show a low resistance to the stress applied. (Baygar, Ugur et al. 2017)

To prevent the undesirable movement and retention of dentures of the denture wearers, adhesives which are shear thinning pastes are usually used in dental application. Gum or denture adhesives can improve adhesiveness of oral mucosa and dentures. (Fallahi, Khadivi et al. 2017)

2.4 Compositions of Denture Adhesive

First formulated ingredients for denture adhesives, was initially introduced by a mixing of vegetable gums. A hydrophilic material was produced for absorbing moisture from saliva. The mixture had high absorbing material properties to prevent the viscous material from hydration and allowed the prosthesis stick to oral mucosa. Mostly, mechanism of action results creates a retentive force within the prosthesis and oral mucosa when increased contact between denture and the tissues. (de Oliveira da Rosa WL et al. 2015)

The major materials of denture adhesives are divided into three group. Adhesive agents such as Karaya gum, Tragacanth, gelatin, methyl cellulose, acacia, hydroxyl-methyl cellulose, pectin, sodium carboxyl-methyl cellulose and synthetic polymers like acrylamides, acetic polyvinyl and polyethylene oxide. Antimicrobial agents from synthetic polymer such as ethanol, hexachlorophene, sodium borate and sodium tetraborate. Inert component for plasticizing agents or flavouring agents like peppermint oil and wintergreen oil. (Ranjith Kumar et al. 2015)

The chemical properties of ingredients in denture adhesive that become viscous and sticky in the presence of water or saliva. The volume of the material that increase filling the spaces between the base of prosthesis and the supporting tissues. (Fallahi, Khadivi et al. 2017)

2.4.1 Polyethylene oxide (PEO)

Polyethylene oxide (PEO) a semi-crystalline synthetic polymer have high crystallinity degree because the uniformity of a linear structure unit. The chemical structure of PEO accommodate of polar group –O– that can react with the cations of metal salt. Furthermore, structural unit of PEO shown in Figure 2.2 has C–H, C–C, C–O bonds only make the reactivity of PEO very low. (Abdelrazek, Abdelghany et al. 2017)

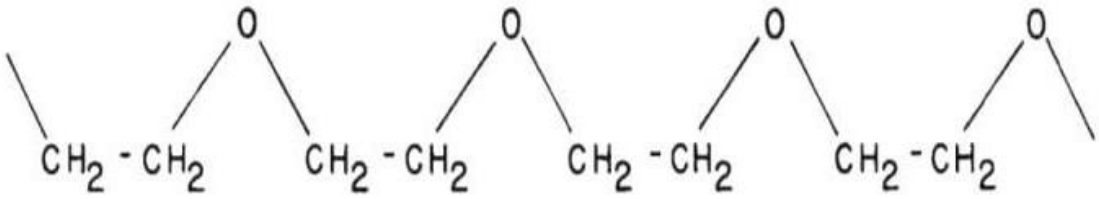

Figure 2.2: Molecular structure of Polyethylene Oxide or PEO

FDA has acclaimed that PEO can be used in various biomedical application such as tissue replacement, scaffold artificial skin, drug delivery systems, scaffolds for cell culture in tissue engineering, bone cements, implant and filling agents, and contact lenses and surface coating for the prohibit of protein. (Pereira, Paulino et al. 2011). PEO are commercially available and widely used, due its properties biocompatibility, low toxicity, low cost, chemical stability, and water solubility. (Alsabagh, Hassan et al. 2016)

The advancement in PEO to get better materials for biomedical devices, it can blend with starch due both are biodegradable and biocompatible polymers. Moreover, it can enhance the mechanical properties of the polysaccharide and give a semi-crystalline structure when blends with PEO.(Pereira, Paulino et al. 2011)

Denture adhesives usually contain poly vinyl ether methyl cellulose, polymethoxyethylene/maleic anhydride copolymer (PVMMA) and carboxy methyl cellulose (CMC) as viscosity modifier, Polyethylene oxide (PEO) as water soluble polymer that absorbs water to become a gel having adhesive characteristic, minerals oil or peppermint oil as flavouring agent, glycerin as levigating agent, silicone dioxide and calcium stearate as clumping powders. (Grasso 2004)

2.4.2 Carboxymethylcellulose (CMC)

Carboxymethyl cellulose (CMC), a natural polysaccharideis derivative from cellulose, consist of a high number of carboxymethyl group in the cellulose bound to the hydroxyl groups of the glucose unit polymer structural chain. (Mansur, de Carvalho et al. 2017)

Due to its low cost, high viscosity, non-toxicity, non-allergic character (Mansur, de Carvalho et al. 2017) water solubility, high availability, biological and environmental compatibilities. Moreover, properties of CMC noticeable can swell in the presence of fluid. (Mohamed 2012)

CMC are one of the polysaccharides that comes from natural ingredients derive from sodium salt shown in Figure 2.3. Advantages of CMC biocompatibility, biodegradability, chemical stability and solubility in physiological environment. CMC broadly used in various application such as medical application, cosmetics and textile industry. (Mansur, de Carvalho et al. 2017)

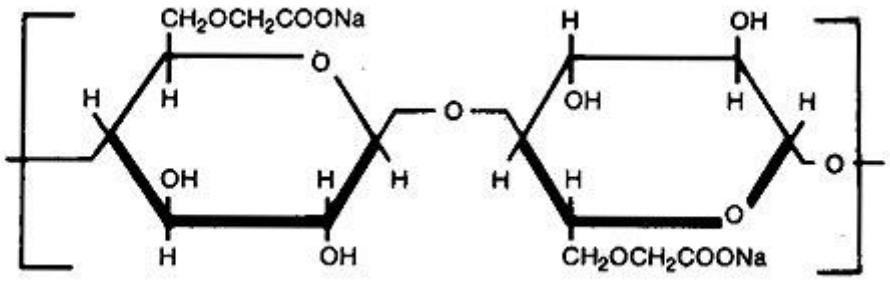

Figure 2.3: Unit structure of Carboxymethyl cellulose or CMC

(Fallahi, Khadivi et al. 2017) found that in their studies the presence of water or saliva, the ingredients in denture adhesives become viscous and sticky due to swelling water is absorbed by carboxyl groups. Carboxy methyl cellulose (CMC) at different levels of solubility that affect initial activation process because high levels of carboxy groups as hydrophilic compound.

While for hydrophobic compound such as mineral oils and petrolatum prevent excessive absorbing of hydrophilic compound to maintain the dissolution of the paste. CMC compound provide a strong initial strength because is naturally derived while PVMMA salts is a synthetic copolymer having lower solubility compared to CMC compound. (Fallahi, Khadivi et al. 2017)

2.4.3 Glycerol

Glycerol is a known as glycerine or propane- 1,2,3-triol as shown in Figure 2.4, colourless, odourless liquid with a sweet taste found in lipids known as triglycerides. Naturally carbohydrate usually used in chemical, food and chemical industries. It is widely used as a humectant, sweetener in food, drug and cosmetic industries. (Monteiro, Kugelmeier et al. 2018)

Nowadays, glycerol as a versatile biodegradable are attracting increased attention due to the diversity potential into various application, commonly used in production of plastics. Glycerol commonly used in the cosmetic industry as a moisturizer, to retain water and prevent the product from drying out. Its ability can retain moisture and prevent the product from drying or freezing make glycerol as popular ingredient in moisturizing formulations. (Monteiro, Kugelmeier et al. 2018)

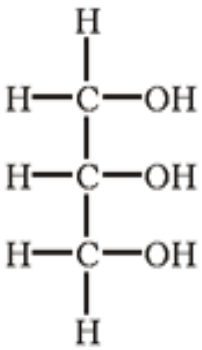

Figure 2.4: Structure of glycerol

2.5 Starch as Biomaterials

2.5.1 Starch as filler

Starch is polymeric carbohydrate extracted from biomaterials because it is renewable and biodegradable. Starch have been used in various applications such as food, chemical, industrial and etc. The starch molecule consists of two polymers of glucose; amylose and amylopectin as shown in Figure 2.5 joined by glycosidic bonds. Amylose is an unbranched or linear structure homo-polysaccharide formed by about 5-600 glucose units and linked by α-1,4 glycosidic bonds. Amylopectin is highly branched polysaccharides formed by up to 5000 of glucose units and joined by α-1,6 glycosidic bonds. Usually starches are composed about 20% amylose and 80% amylopectin while for high amylose starches are composed of 50% to 80% amylose and 20% to 50% amylopectin. (Torres, Troncoso et al. 2013)

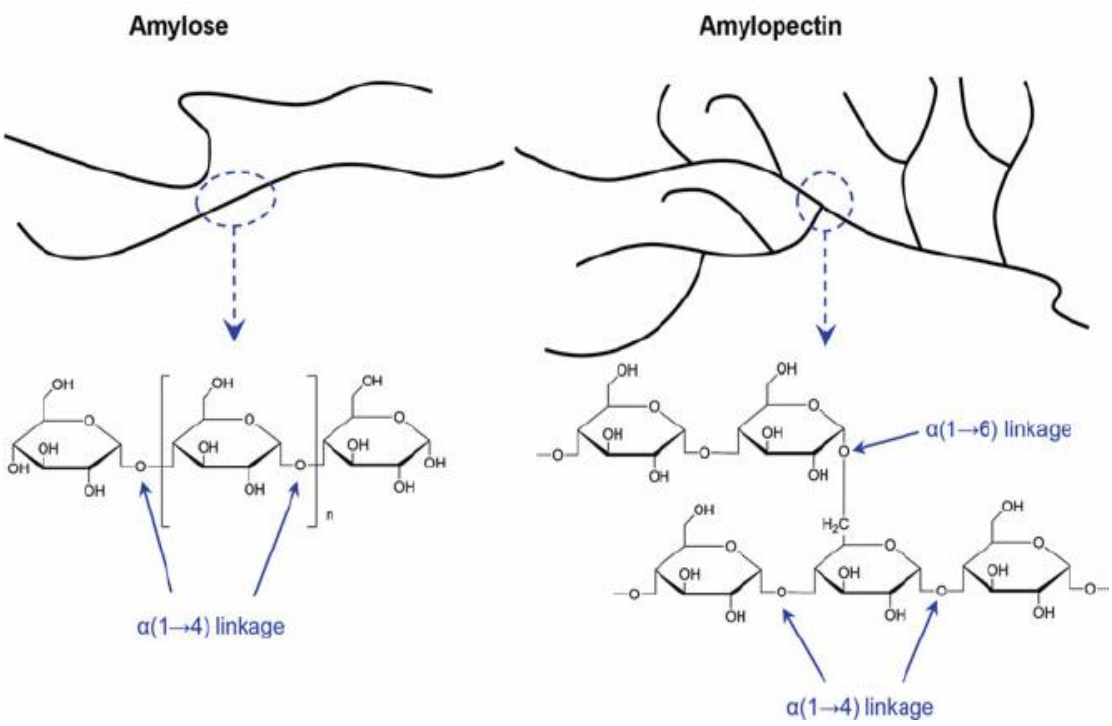

Figure 2.5: Chemical structures of amylose and amylopectin molecules of starch.

Native starch is the granules is semicrystaline and insoluble in water at ambient temperature. Starch can obtain in various shape and size usually composed by amylose and amylopectin depending on botanical origin. The form of starch can be oval, round and elliptical. Starch therefore described in plant source as corn starch, potato starch, cassava starch and tapioca starch. It is used as a thickening agent and stabilizer. (Mohammadi Nafchi, Alias et al. 2013)

Major benefits of starch as natural carbohydrate polymers due to its availability, plenty and low cost compared with synthetic polymeric materials. Starch has two circumstances; first starch contains hydroxyl groups that enhance hydrophilic properties. Amylose dissolve in and amylopectin absorb and swells in the presence of water. (Mohammadi Nafchi, Alias et al. 2013)

2.5.2 Tapioca starch

Tapioca starch obtained from the root of the cassava plant. It has cohesive paste bland and neutral taste. Disadvantages for native tapioca starch; thermal decomposition and low heat and shear resistance. (Wongsagonsup et. al 2014)There are several type of starch from multiple resources, tapioca starch generally known have strong tendency of intermolecular forces between starch chains. (Kim, Choi et al. 2015)

Potato and cassava starch contains typical large oval spherical granules ranging in size between 15 and 100 μm diameter. Corn starch has an average diameter about 10 μm and Sago starch contain a wide size range 10 and 50 μm diameter. (Mohammadi Nafchi, Alias et al. 2013)

2.6 Microorganisms in oral cavity

Pathogenic organisms such as bacteria, fungi, parasites, viruses or other microbes when enter the body, begin to grow and causes infection diseases and consequently it is give high impact on health. Disease occurs when the cells in body are damaged as a result of infection and signs and symptoms of an illness appear. In Nigeria, there are information of invasive bacterial infections with Gram-positive Staphylococcus aureus, Gram-negative Escherichia coli, and other Gram-negative bacteria which are enteric in nature. (Bello, Ibitoye et al. 2017)

Denture adhesives would have to be not harmful to denture wearers especially who suffer from denture stomatitis. Nowadays, antimicrobial additives in denture adhesives are important element to inhibit the growth of organisms in the mouth. *Candida albican* is one of the microorganisms that isolated in human oral cavity. Evolution properties in formulation of denture adhesives to prevent attachment of bacteria or food, so it can be retained for more than 12 hours. The material of the denture adhesives also must maintained the pH value. (Sampaio-Maia, Figueiral et al. 2011)

Candida albican is one of the microorganisms that isolated in human oral cavity. For the denture wearers Candida probability increasing about 60% to 100%. (Sampaio-Maia, Figueiral et al. 2011)*Candida albicans* are adequate of colonizing and persisting in the mucosa of the oral cavity, gastrointestinal system, and genitourinary tract in healthy humans. Moreover, about half from population have carries, this organism in gastrointestinal tract. Based on the situation, *candida albicans* also known as a dimorphic microorganism that can survive as typical budding yeast cells (type Y) and as mycelium cells forming hyphae (type M).(Masłyk, Janeczko et al. 2018)

2.7 Antimicrobial agents in Denture Adhesive

Synthetic antimicrobials agents that most commonly used in denture adhesives such as amphotericin, hexachloroprene, methyl salicylate, sodium borate and sodium tetraborate. But several studies carried out that synthetic antimicrobials agents cannot be used for a long-term due to enhance bacterial growth. Denture adhesives without antimicrobial agents probability supporting the growth of organisms such as *Candida albican* as seen in Figure 2.6 (Koronis, Pizatos et al. 2011)

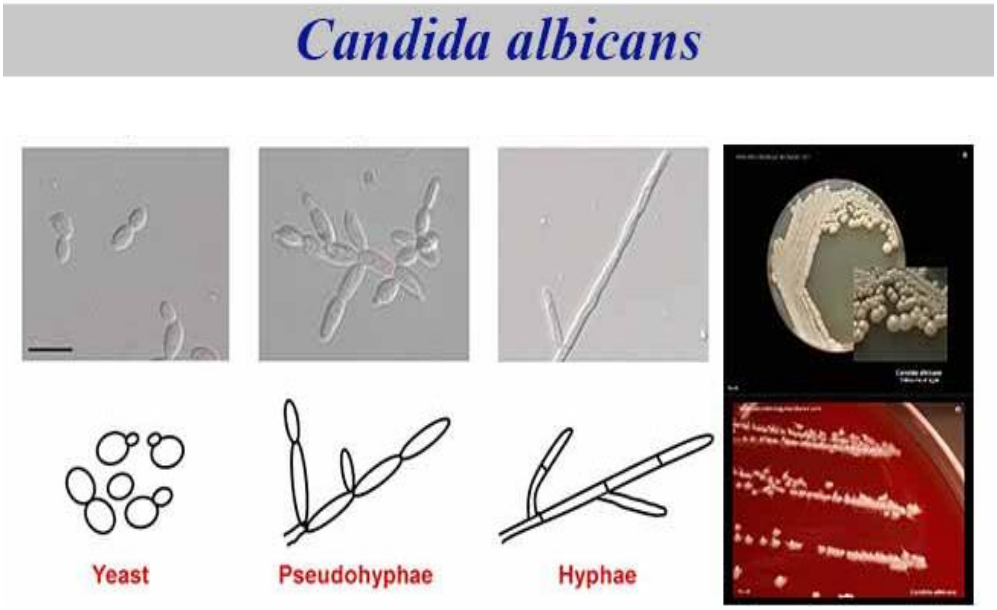

Figure 2.6: Morphology of antimicrobial *Candida Albican.* (Rahman, Sultana Shanta et al. 2016)

There are a lot of virus microorganisms such as *Sarcina lutea, Bacillus subtilis, Escherichia coli* (Figure 2.7), *Staphylococcus aureus* (Figure 2.8), *Klebsiella pneumoniae, Pseudomonas sp.* and *Xanthomonas campestries* have been determined as infection in human diseases. Several type chemical and synthetic compounds have been tested as antimicrobial agents to kill bacteria. Due to request for natural antimicrobials, researchers start to study the

persuasive of inhibitory substances such as essential oils from extracts plants. (Rahman, Sultana Shanta et al. 2016)

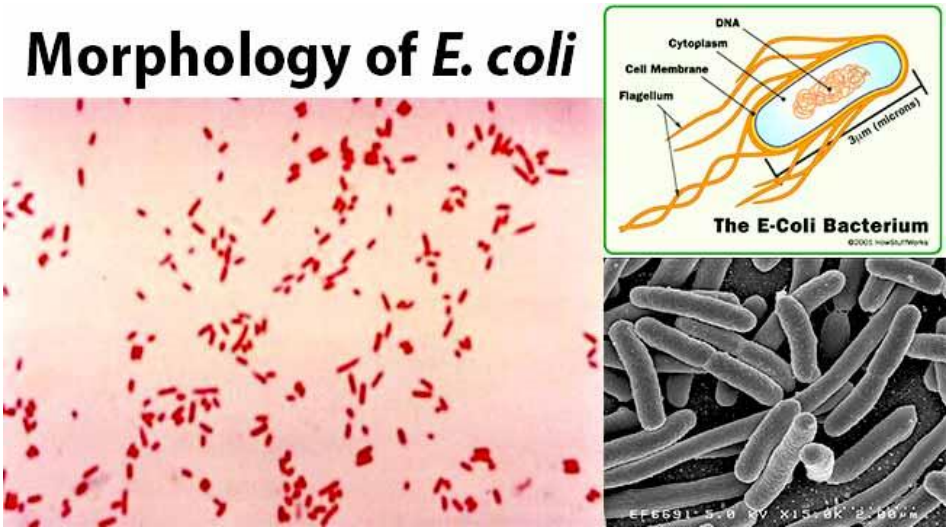

Figure 2.7: Morphology of antimicrobial *Escherichia coli.* (Rahman, Sultana Shanta et al. 2016)

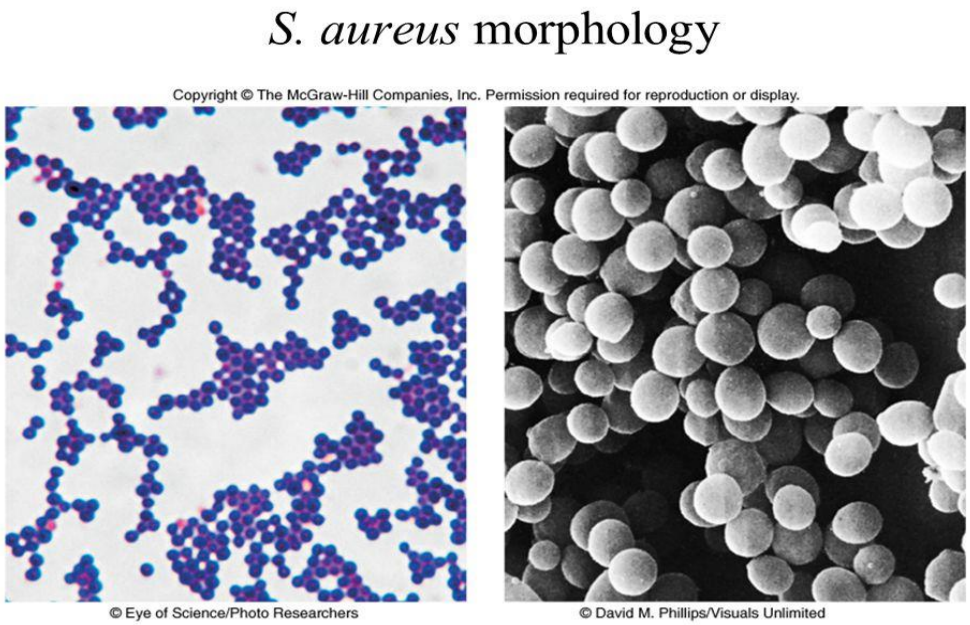

Figure 2.8: Morphology of antimicrobial *Staphylococcus aureus.* (Rahman, Sultana Shanta et al. 2016)

Essential oils, a type of plant secondary metabolites complex mixtures of volatiles molecules have widely recognized for their healing and aromatherapy properties. There are several reports have been evaluated to inhibit antimicrobial, antifungal, anticancer and antiviruses. (Lee, Chen et al. 2013) These precious essential oils not just counter infection into body but it can restraint from illness, cure skin infection and defeat antibacterial from spread.

The properties of essential oils and its component have been proved widely used in medical application. Essential oils can improve or maintain the quality food and preserve our body from microorganisms such as bacteria.(Rahman, Sultana Shanta et al. 2016)

Essential oils also known as complex combination of substances, corresponding oxygenated derivatives and mainly monoterpenes from natural ingredients. A wide spectrum in research of antimicrobial activities of essential oil, it have been used as flavouring agents and food preservatives. The usage of essential oil are not harmful due to natural antimicrobial agents from plant extracts widely used in applications such as food, pharmaceutical and agro industries for preserves from microorganisms such as bacteria and fungi. (Rahman, Sultana Shanta et al. 2016)

Mostly, plant derived essential oils are labelled as non-phytotoxic compounds and highly sufficient against microorganisms. It has been proven in case essential oil are inadequately used can be harmful to people such as skin irritation, headache and nausea. Highly precautions step need to be considered if essential oils are to be used internally or used on food application. (Rahman, Sultana et al. 2017)The antibacterial characteristic of essential oils and their ingredients are exposed in commercial products as dental root canal sealers and antiseptics.(Burt 2004)

Table 2.1: Effect of Plant oils against Candida Albican. (Agarwal, Lal et al. 2010)

Group	**Botanical name**	**Plant oils**	**ZOI (mm)**
Most effective (0.05-0.15%)	*Eucalyptus globulus*	Eucalyptus	26.7
	Mentha piperita	Peppermint	22.2
Moderately effective	*Cympopogan martini*	Ginger grass	16.0
(0.15-1.00%)	*Eugenia caryophyllus*	Clove	13.8
	Ocimun sanctum	Tulsi	11.3
	Melaleuca alternifolia	Tea Tree	11.0
Less effective (> 1.00%)	*Ocimun basilisum*	Ocimun	9.8
	Ricinus Communis	Castor	7.8
	Juniperus Chinensis	Juniper	5.6
	C. anthelminticum	Malkangni	5.3
	Cocos nucifera	Coconut	4.0
	Psoralea corylifolia	Babchi	3.4
	Madhuca indica	Mahua	3.2
	Z. officinalis	Ginger	2.6
	Brassica juncea	Mustard	2.3
	R. officinalis	Rose	2.1
	Jasminum nudiflorum	Jasmine	1.4
	Lavandula angustifolia	Lavender	1.2
Non-effective	*Linum usitatissimum*	Alsi	0
	Azadirachta indica	Neem	0
	Matricaria chamomilla	Babuna	0
	Sesamun indicum	Til	0
	Celastrus paniculata	Jyotishmati	0
	Simmondsia chinensis	Jojoba	0
	Juglans regia	Walnut	0
	Prunus glandulosa	Almond	0
	Triticum vulgare	Wheatgerm	0
	Vetveria zizanoides	Khus	0
	Juniperus oxycedrus	Cade	0

2.7.1 Tea tree oil

Tea tree oil (TTO) is an aboriginal Australian traditional medicine usually used for skin infection because of its ability to kill parasites and fungal infection. In 1920, TTO was rediscovered as a Topical antiseptic because more effective action compared phenol. TTO is the essential oil steam distilled from Melaleuca alternifolia, a species of northern New South Wales, Australia. (Calcabrini, Stringaro et al. 2004)

Australian tea tree oil (TTO) invaded from *Melaleuca alternifolia L* known as excellent essential oil compared the other essential oil especially in oral, airway, vagina and skin infection. There are several research antibacterial and antifungal activities of TTO have been published. (Lee, Chen et al. 2013)

Table 2.2: Reference reviews of the antibacterial activity of Tea Tree Oil (TTO) (Lee, Chen et al. 2013)

Bacterial species	**MIC %(v/v)**	**MBC %(v/v)**
Gram-positive		
Actinomyces visciosus	0.6	>0.6
Bacillus cereus	0.3	-
Enterococcus faecalis	>8	>8
Staphylococcus aureus	0.5	2
Staphylococcus marcescens	0.25	0.25
Gram-negative		
Acinetobacter baumannii	1	1
Fusobacterium nucleatum	0.06	0.06
Klebsiella pneumoniae	0.25	0.25
Pseudomonas aeruginosa	3	3
Mollicutes		
Mycoplasma hominis	0.12	-
Mycoplasma fermentans	0.03	-

*MIC = minimun inhibitory concentration; MBC = minimun bactericidal concentrations

Table 2.3: Reference reviews of the antifungal activity of Tea Tree Oil (TTO) (Lee, Chen et al. 2013)

Fungal species	**MIC %(v/v)**	**MBC %(v/v)**
Aspergillus niger	0.02	0.05
Candida species	0.03	0.05
C. albicans	0.25-0.50	-
C. glabrata	0.25-1.00	-
Madurella mycetomatis	0.25	-

*MIC = minimun inhibitory concentration; MFC = minimun fungicidal concentrations

Tea tree oil is recognized as not harmful, non-poisonous, friendly odour and usually used as wound care and skin infection. Verifiable truth from several researchers that the skin can permit the oil and suitable used as medicine and curing agent of fungal mucosal and cutaneous infections. (Calcabrini, Stringaro et al. 2004)