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Antimicrobial Activity Of Selected Essential Oils Against Food Borne Bacteria To Extend Shelf Life Of Labneh (Concentrated Yoghurt)

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Thesis Approval

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Jerusalem-Palestine

1438 / 2016

This Thesis is dedicated to my family

My great father

And to my wonderful mother

Who have raised me to be the person I am today ……

And gratitude to my beautiful wife

Declaration

I certify that this thesis submitted for the degree of master is the result of my own research, except where otherwise acknowledges, and that this thesis (or any part of the same) has not been submitted for the higher degree to any other university or institute.

Signed……

Mohannad Nabil Al-ayobe

Date 21/12/2016

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Antimicrobial Activity of Selected Essential Oils Against Food Borne Bacteria To Extend shelf life of Labneh (concentrated yoghurt)

Abstract

The main method of producing labneh consists of straining whole milk yogurt in a cheese cloth bag to the desired total solid level; it's a critical step in labneh manufacturing, due to the sanitary problems usually associated with the cloth bags used, which increases microbial contamination. In this study, essential oils are used to increase the shelf life of labneh from 4 weeks to at least 6 weeks with decrease in the concentration of synthetic antimicrobial agent used. Measurement of the antimicrobial activity of essential oils is done using total plate count method, on mold, yeast, *Staphylococcus aureus*, coliforms, and *Escherichia coli O157:H7*.

The essential oils used in this study, are namely cinnamon, clove, rosemary, almond sweet, sesame, wheat germ, cedar wood and eucalyptus oil. They were added to (labneh), in the presence of synthetic preservative (first set of experimental) and alone without any synthetic preservative (another set of experimens). Essential oils were added at different concentrations (150, 200, 250, 300 and 350 µl\kg) in the presence of the only synthetic preservative used (potassium sorbate at 150 parts per million "ppm"). Additionally, essential oils were added at different concentrations (300, 400, 500 and 600 µl\kg) without addition of the synthetic preservative.

Total solids of labneh sample, treated with essential oils, were only slightly affected. Essential oils affect the pH. In the presence of synthetic preservative, in terms of influence a total bacterial viable count, the best three essential oils used were found to be cinnamon, clove and rosemary in the presence of synthetic preservative. For essential oils used in the absence of potassium sorbate, the best three essential oils were found to be clove, rosemary and eucalyptus. The mold count for essential oils, in the presence of synthetic preservative, the best three essential oils used were found to be cinnamon, clove and rosemary. However, for essential oils used in the absence of potassium sorbate, the best three essential oils used were found to be clove, rosemary and eucalyptus for inhibiting molds at 400 µl\kg oil. In the presence of synthetic preservative yeast decreased, where the best essential oils were found to

be cinnamon, clove, rosemary, almond sweet and cedar wood. However, for essential oils used in the absence of potassium sorbate, the best essential oils were found to be clove and eucalyptus at 600 µl\kg. In the presence of synthetic preservative cinnamon, clove, rosemary, almond sweet and cedar wood when added to labneh decreased significantly the growth of *S. aureus* and even better than positive control. However, for essential oils used in the absence of potassium sorbate the best essential oil that decreased significantly the growth of *S. aureus* was found to be rosemary at concentration of 600 µl\kg. No Coliforms or *E. coli* bacteria were detected in the treated labneh as well as in the positive control.

The most acceptable organoleptic properties of treated labneh was 150 µl\kg sesame and roseamry oils in the presence of the synthetic preservative (150 ppm potassium sorbate), and for essential oils in the absence of potassium sorbate was rosemary oil at 300 µl\kg followed by almond sweet at 500 µl\kg. Organoleptic properties in these groups were better than positive control.

In this study, it can be concluded that the addition of eucalyptus, rosemary, cinnamon and clove E.Os at (500, 600 µl\kg) in the absence of potassium sorbate, and addition of cinnamon, clove and rosemary E.Os at (300, 350 µl\kg) with 150 ppm of potassium sorbate, could be increase the shelf life of labneh for up to 6 weeks instead of 4 week.

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List of Acronyms

µl: Microliter

kg: Kilogram

gm: gram

ppm: parts per million

P.S: potassium sorbate

T.S: Total Solids

E.Os: Essential Oils

Min: Minute

H: hour

^{o}C: Degrees Celsius

V/V: Volume/Volume

MIC: Minimum Inhibitory Concentration

MBC: Minimum Bactericidal Concentration

ML: Milliliter

E. Coli: Escherichia coli

S. aureus: Staphylococcus aureus

TVC: Total viable counts

Cfu: Colony forming units

+ve: positive, –ve: Negative

S.D: Standard Deviation

Con.: concentration

CHAPTER ONE
INTRODUCTION

1.1. Background

Many food products are perishable by nature and require protection from spoilage during their preparation, storage, and distribution to give them desired shelf life, especially dairy product. Food products can be subjected to contamination by bacteria and fungi. Many of these microorganisms can cause undesirable reactions that deteriorate flavour, odour, colour, sensory, and textural properties of food. Illness can be caused as a result of the consumption of foods contaminated with pathogens such as *Staphylococcus aureus*, *Escherichia coli O157*, *Salmonella*, *Fecal coliform*, *Total coliform*, *yeast and mold.* To prevent growth of spoilage and pathogenic microorganisms in foods, several preservation techniques, such as heat treatment, salting, acidification, and drying have been used in the food industry (Davidson and Taylor, 2007; Farkas, 2007). In addition, a chemical method can be used which involved the use of chemical preservatives and artificial antimicrobials to inactivate or inhibit growth of spoilage and pathogenic micro-organisms (Arques, Rodriguez, Nunez, & Medina, 2008; Aslim & Yucel, 2007). Numerous efforts are conducted to find natural alternatives to prevent bacterial and fungal growth in foods. In recent years, because of the great consumer awareness and concern regarding synthetic chemical additives, foods preserved with natural additives have become very popular. To inhibit growth of undesirable microorganisms in food, the antimicrobials can be directly added into the product formulation, coated on its surface or incorporated into the packaging material. Direct incorporation of active agents into food results in an immediate but short-term reduction of bacterial populations, while the antimicrobial films can maintain their activity for a long period of time (Appendini and Hotchkiss, 2002; Hanušová et al., 2009).

Natural antimicrobials are derived from animal, plant and microbial sources. There is considerable potential for utilization of natural antimicrobials in food. However, methods and mechanisms of action, as well as the toxicological and sensory effects of natural antimicrobials, are not completely understood (Burt, 2004; Ponce et al.). Main natural compounds are essential oils derived from plants (e.g., cinnamon, clove, rosemary , almond sweet, sesame, wheat germ, sandal wood, basil, thyme, eucalyptus and oregano), enzymes obtained from animal sources (e.g., lysozyme, lactoferrin), bacteriocins from microbial

sources (nisin, natamycin), organic acids (e.g., sorbic, propionic, citric acid, benzoic), and naturally occurring polymers (chitosan).

Most plant essential oils are gaining a wide interest in food industry for their potential as decontaminating agents, as they are Generally Recognized as Safe (GRAS). The active components are commonly found in the essential oil fractions and it is well established that most of them have a wide spectrum of antimicrobial activity, against food-borne pathogens and spoilage bacteria (Gutierrez et al., 2008, 2009).

The antimicrobial activity of plant essential oils is due to their chemical structure, in particular to the presence of hydrophilic functional groups, such as hydroxyl groups of phenolic components and/or lipophilicity of some essential oil components (Dorman and Deans, 2000). Usually, the compounds with phenolic groups such as oils of clove, oregano, rosemary, thyme, sage, and vanillin are the most effective (Skandamis et al., 2002). They are more inhibitory against Gram-positive than Gram-negative bacteria, (Mangena and Muyima, 1999; Marino et al., 2001).

Many reviews focus on the use of natural compounds to control microbiological and physicochemical shelf life of main food categories, such as meat, fish, dairy products, minimally processed fruit and vegetables and cereal-based goods. The information is mostly based on case-studies dealing with application of active compounds to prevent microbial proliferation occurring in packaged food during storage.

Essential oils (E.Os) are very interesting natural plant products and among other qualities they possess various biological properties. The term “biological” comprises all activities that these mixtures of volatile compounds (mainly mono-and sesquiterpenoids, benzenoids, phenylpropanoids, etc.) exert on humans, animals, and other plants (Burt, 2004; Ponce et al.).

Milk the main component of labneh, (a concentrated fermented yogurt), is a good media for many bacterial growth including pathogens. Labneh is a semisolid food that results from the concentration of yogurt using different methods; the most important is the use of cloth bags and draining the yogurt for 14 hours. The total solid of the resulting labneh is approximately 23 g/100g and the product has a cream white colour and a flavour that is slightly acidic, the texture is soft and smooth. The high microbial load of labneh, coupled with the packaging and

storage conditions, result in the formation of off-flavour s and undesirable physicochemical changes that eventually lead to rejection of the product (Muir and Banks, 2000). One of the most accepted methods to extend the shelf life of perishable food products is through the use of bio-preservatives (Burt, 2004; Draughon, 2004).

1.2. Manufacturing of labneh (concentrated yoghurt)

Concentrated yogurt is popularly known as labneh in the Middle East or as strained yogurt in Greece, and the rest of Europe, or as Suzme yogurt in Turkey. Labaneh is a semisolid fermented dairy food produced by removing part of the whey from yogurt to reach total solid levels between 23 and 25 g/100 g. (Thabet. etal, 2014)

Labneh was manufactured according to Robinson and Tamime (1994). Fresh cow's milk (3% fat) was heated at 90^{o}C for 20 min, cooled to 45^{o}C and then inoculated with 2% of the yoghurt starter culture (*S. thermophilus and L. bulgaricus*). The milk was agitated, dispensed in glass containers and incubated at 40^{o}C for 3 h until it was completely coagulated. The resultant coagulant was mixed thoroughly with 0.5% NaCl. The mixtures were then put into cheese cloth bags, which were hung in the refrigerator room at 5 ± 1^{o}C for 18 h, to allow drainage of the whey. (A.Y.Tamime and R.K.Robinson, 2007)

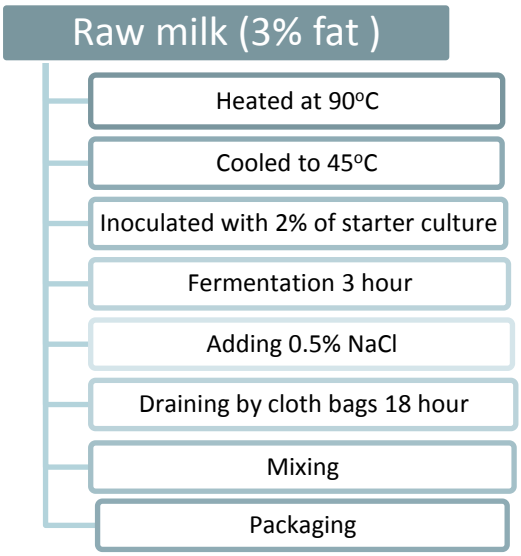


Figure (1.1): Production flowchart for labneh

1.3. Chemistry of Essential Oils

Essential oils are not simple compounds or even simple mixtures of several individual compounds. They may contain up to approximately 100 components, although many contain about 20 to 60 .The compounds found in essential oils are from a variety of chemical classes, predominantly terpenes, but phenylpropanoids and other compounds also occur although at a lesser frequency and often, but not always, in smaller proportions. They are all hydrocarbons and their oxygenated derivatives, and they may also contain nitrogen or sulfur. They are generally low-molecular-weight compounds with limited solubility in water (Husnu. K, and G.Buchbauer, 2010).

The classification and nomenclature of essential oil compounds is complicated by the fact that many were isolated and studied before the instigation of systematic chemical nomenclature. Consequently, many are known by nonsystematic or trivial or common names. These are sometimes but not always based on their source, such as eucalyptol, limonene, pinene and thymol, names which hint at historical botanical origins of these compounds.
In terms of shedding light on their chemistry, the long history and widespread use of these nonsystematic names further obfuscates the chemical nature and characteristics of essential oils and their components. (Obst, J.R, 1998)

1.3.1. Chemical components present in Essential oils and (Bioactive compounds)

Essential oils are a group of terpenoids, sesquiterpenes and possibly diterpenes with different groups of aliphatic hydrocarbons, acids, alcohols, aldehydes, acyclic esters or lactones (Fisher & Phillips, 2006). E.Os and other plant extracts are principally responsible for antimicrobial activities in plants, herbs and spices. These extracts can be obtained from plants and spices by various methods, such as steam, cold, dry and vacuum distillation. These plant compounds, including glucosides, saponins, tannins, alkaloids, E.Os, organic acids and others, are present as parts of the original plant defense system against microbial infection (Bajpai, Rahman, & Kang, 2008; Ceylan & Fung, 2004). Generally, phenolic compounds of E.Os such as citrus oils extracted from lemon, olive oil (oleuropein) and tea-tree oil (terpenoids), orange and bergamot have broader antimicrobial effects and are not categorized as spices. Meanwhile,

there are increasing reports of nonphenolic compounds of oils, which are effective against both Gram-positive and Gram-negative groupso of bacteria, from oregano, clove, cinnamon, citral, garlic, coriander, rosemary, parsley, lemongrass, purple (cultivar Ison) and bronze (cultivar Carlos) muscadine seeds and sage (Angioni et al., 2004; Daferera et al., 2000; Davidson & Naidu, 2000).

[Table 1.1] shows the Major components of selected E.Os that exhibit antibacterial properties- S. Burt / International Journal of Food Microbiology 94 (2004) 223–253.

[Table 1.1.A] Major components of selected E.Os that exhibit antibacterial properties

Common name of E.O	**Latin name of plant source**	**Major components**	**Approximate % composition**	**References**
Eucalyptus	*Coriandrum sativum (immature leaves)*	1, 8-cineole Limonene	70% .05-15%	(Rammanee and Hongpattarakere,2011)
Coriander (seeds)	*Coriandrum sativum (seeds)*	Linalool E-2-decanal	70% ---	(Delaquis et al., 2002)
Cinnamon	*Cinnamomum zeylandicum*	Trans-cinnamaldehyde	65%	(Lens-Lisbonne et al., 1987)
Oregano	*Origanum vulgare*	Carvacrol Thymol Terpinene p-Cymene	Trace-80% Trace-64% 2 –52% Trace-52%	(Lawrence, 1984; Prudent et al., 1995; Charai et al., 1996; Sivropoulou et al., 1996;)
Rosemary	*Rosmarinus officinalis*	a-pinene Bornyl acetate Camphor 1,8-cineole	2 –25% 0 –17% 2 –14% 3 –89%	(Daferera et al., 2000, 2003; Pintore et al., 2002)
Sage	*Salvia officinalis.L*	Camphor a-Pinene h-pinene 1,8-cineole a-tujone	6 –15% 4 – 5% 2 –10% 6 –14% 20–42%	(Marino et al., 2001)

[Table 1.1.B] Major components of selected E.Os that exhibit antibacterial properties

Clove (bud)	*Syzygium aromaticum*	Eugenol Eugenyl acetate	75–85% 8 –15%	(Bauer et al., 2001)
Thyme	*Thymus vulgaris*	Thymol Carvacrol g-Terpinene p-Cymene	10–64% 2 – 11% 2 –31% 10–56%	(Lens-Lisbonne et al., 1987; McGimpsey et al., 1994; Cosentino et al., 1999; Marino et al., 1999;)

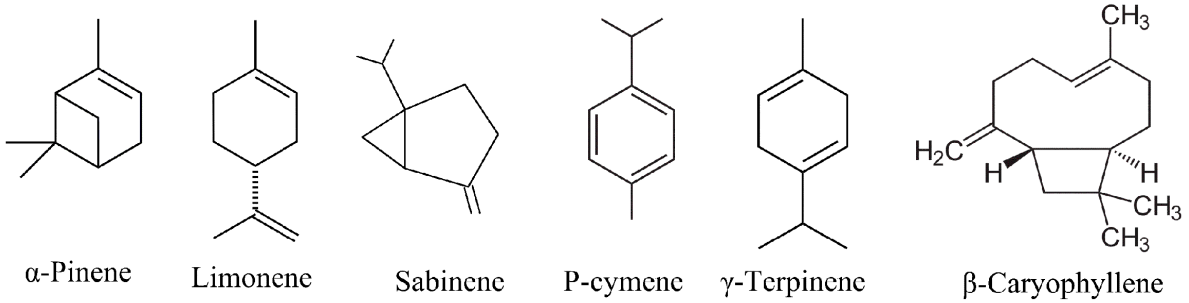
Little information is available on interaction among constituents in Essential oils (Almond sweet, Sesame, Wheat germ, Eucalyptus, Sandal wood) and the effects they have on antimicrobial activity.

Phenolic components are responsible for antimicrobial action and other constituents are believed to have little activity. Dependability of Essential oils as antimicrobials could be improved if their content of active agents should be standardized by distillation (Delaquis *et al.* 2002).

Terpenes

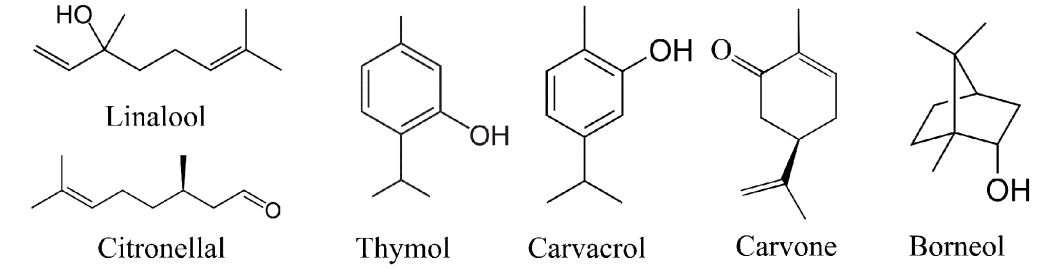
Monoterpenes

Sesquiterpenes

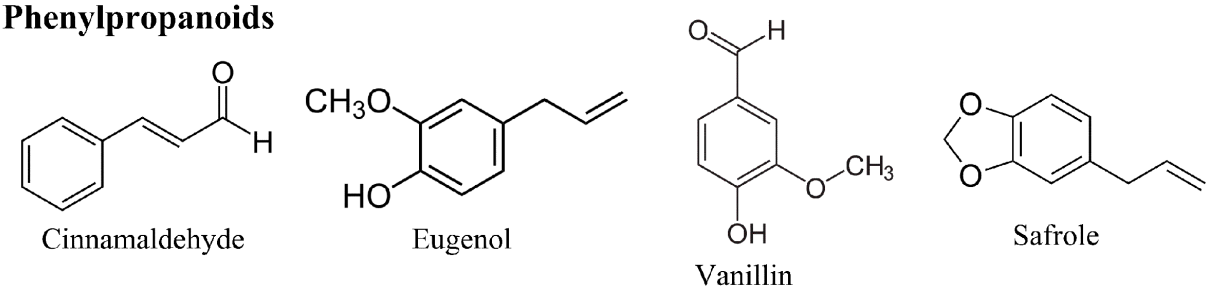


Terpenoids

Monoterpenoids



Phenylpropanoids



Others

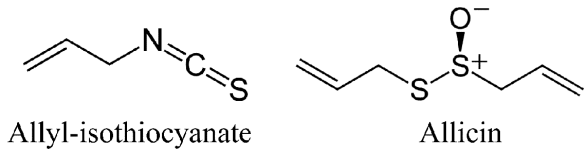


Figure (1.2): Chemical structures of selected essential oil constituents.

(Morten Hyldgaard,Tina Mygind, 2012)

1.4. Mechanism of action (Mode of antibacterial action for Essential oils)

It has been demonstrated that the antimicrobial effects of the essential oils acts by causing structural and functional damages to the bacterial cell membrane. It is also indicated that the optimum range of hydrophobicity is involved in the toxicity of the E.Os (Goni et al., 2009).
Spices and herbs are mostly used in the range of 0.05–0.1% (500–1000 ppm) in food systems. Some spices have stronger antimicrobial activity than others and can be effective at 1000ppm. However, some spices require higher concentrations (Ceylan & Fung, 2004).

The stereochemistry, lipophilicity and other factors affected the biological activity of these compounds which might be altered positively or negatively by slight modifications. It has been shown that plant substances affect microbial cells by various antimicrobial mechanisms, including attacking the phospholipid bilayer of the cell membrane, disrupting enzyme systems, compromising the genetic material of bacteria, and forming fatty acid hydroperoxidase caused by oxygenation of unsaturated fatty acids (Arques et al., 2008; Burt et al., 2007).
Although the antimicrobial properties of essential oils and their components have been reviewed in the past, the mechanism of action has not been studied in great detail (Lambert et al., 2001).

Considering the large number of different groups of chemical compounds present in E.Os, it is most likely that their antibacterial activity is not attributable to one specific mechanism but that there are several targets in the cell (Skandamis et al., 2001; Carson et al., 2002).
An important characteristic of E.Os and their components is their hydrophobicity, which enables them to partition in the lipids of the bacterial cell membrane and mitochondria, disturbing the structures and rendering them more permeable (Knobloch et al., 1986; Sikkema et al., 1994).
Leakage of ions and other cell contents can then occur. Although a certain amount of leakage from bacterial cells may be tolerated without loss of viability, extensive loss of cell contents or the exit of critical molecules and ions will lead to death (Denyer and Hugo, 1991). There is

some evidence from studies with tea tree oil and *E. coli* that cell death may occur before lysis (Gustafson et al., 1998).

Generally, the E.Os possessing the strongest antibacterial properties against food borne pathogens contain a high percentage of phenolic compounds such as carvacrol, eugenol (2-methoxy-4-(2- ropenyl) phenol) and thymol (Farag et al., 1989; Thoroski et al).
It seems reasonable that their mechanism of action would therefore be similar to other phenolics; this is generally considered to be the disturbance of the cytoplasmic membrane, disrupting the proton motive force (PMF), electron flow, active transport and coagulation of cell contents (Denyer and Hugo, 1991b; Sikkema et al., 1995; Davidson, 1997).

The chemical structure of the individual E.O components affects their precise mode of action and antibacterial activity, The importance of the presence of the hydroxyl group in phenolic compounds such as carvacrol and thymol has been confirmed, The relative position of the hydroxyl group on the phenolic ring does not appear strongly to influence the degree of antibacterial activity; the action of thymol against *B.cereus*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* appears to be comparable to that of carvacrol, for example (Lambert et al., 2001; Ultee et al., 2002). However, in one study carvacrol and thymol were found to act differently against gram-positive and gram-negative species (Dorman and Deans, 2000).
The significance of the phenolic ring itself (destabilised electrons) is demonstrated by the lack of activity of menthol compared to carvacrol (Ultee et al., 2002). In one study the addition of an acetate moiety to the molecule appeared to increase the antibacterial activity; geranyl acetate was more active against a range of gram-positive and negative species than geraniol (Dorman and Deans, 2000). As far as non-phenolic components of E.Os are concerned, the type of alkyl group has been found to influence activity (alkenyl>alkyl). For example, limonene (1-methyl-4-(1-methylethenyl) - cyclohexene) is more active than p-cymene (Dorman and Deans, 2000).
Component of E.O also appear to act on cell proteins embedded in the cytoplasmic membrane (Knobloch et al., 1989). Enzymes such as ATPases are known to be located in the cytoplasmic membrane and to be bordered by lipid molecules. Two possible mechanisms have been suggested whereby cyclic hydrocarbons could act on these. Lipophilic hydrocarbon molecules

could accumulate in the lipid bilayer and distort the lipid–protein interaction; alternatively, direct interaction of the lipophilic compounds with hydrophobic parts of the protein is possible (Juven et al., 1994; Sikkema et al., 1995). Some E.Os have been found to stimulate the growth of pseudomycelia (a series of cells adhering end-to end as a result of incomplete separation of newly formed cells) in certain yeasts. This could be an indication that E.Os act on the enzymes involved in the energy regulation or synthesis of structural components cinnamon oil and its components have been shown to inhibit amino acid decarboxylases in *Enterobacter aerogenes* (Conner and Beuchat, 1984).

The mechanism of action was thought to be the binding of proteins, indications that E.O components may act on proteins were also obtained from studies using milk containing different protein levels (Pol et al., 2001).

The apparent antimicrobial efficacy of plant origin antimicrobials depends on factors such as the method of extracting E.Os from plant material, the volume of inoculums, growth phase, culture medium used, and intrinsic or extrinsic properties of the food such as pH, fat, protein, water content, antioxidants, preservatives, incubation time/temperature, packaging procedure, and physical structure of food (Brandi et al., 2006; Burt, 2004).

The mechanism of action has not been studied in great detail (Lambert et al., 2001). Considering the large number of different groups of chemical compounds present in E.Os, it is most likely that their antibacterial activity is not attributable to one specific mechanism but that there are several targets in the cell.

Another important parameter regarding effects of food preservatives is ability to reduce the pH level inside the bacterial cell pH It has been shown that pH of both E. coli and *Salmonella* has been reduced by the effect of mustard's E.Os (Turgis et al., 2009).

An important characteristic of E.Os and their components is their hydrophobicity, which enables them to partition in the lipids of the bacterial cell membrane, disturbing the structures and rendering them more permeable. Leakage of ions and other cell contents can then occur.

In fact, the mechanisms of action of the EOs include the degradation of the cell wall, damaging the cytoplasmic membrane, cytoplasm coagulation, damaging the membrane proteins, increased permeability leading to leakage of the cell contents, reducing the proton

motive force, reducing the intracellular ATP pool via decreased ATP synthesis and augmented hydrolysis that is separate from the increased membrane permeability and reducing the membrane potential via increased membrane permeability.

The locations or mechanisms in the bacterial cell thought to be sites of action for E.O components are indicated in [Fig.1.3].

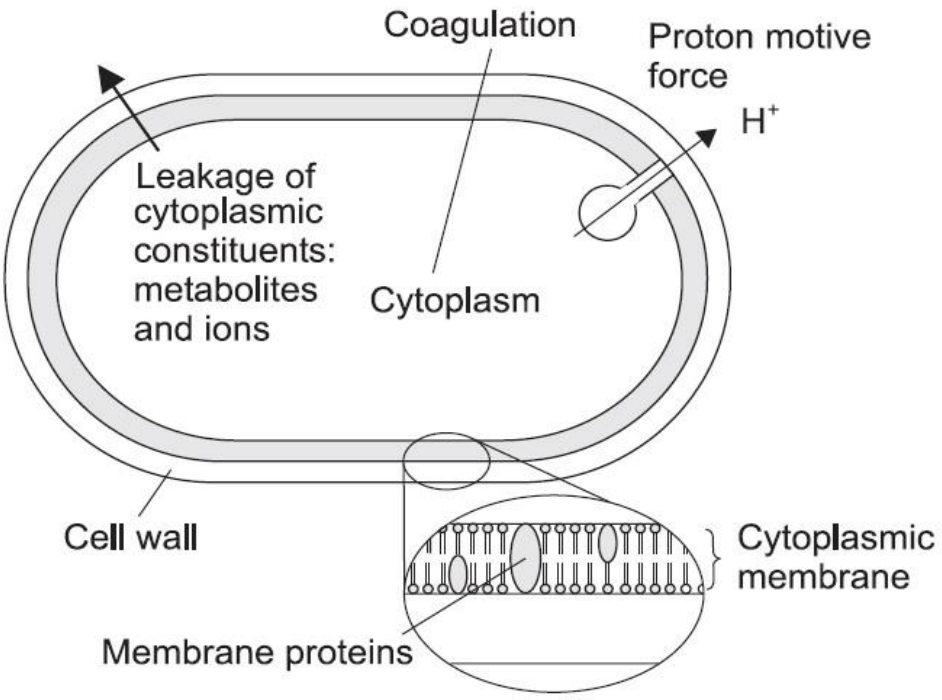


Fig. (1.3.) Locations and mechanisms of action of E.O on bacterial cell

Degradation of the cell wall, damage to cytoplasmic membrane, damage to membrane proteins, leakage of cell contents, coagulation of cytoplasm, and depletion of the proton motive force (Burt, 2004).

1.5. Antibacterial and Antifungal Activities of Essential Oils

Great variation exists amongst antimicrobial essential oils in terms of both the diversity of plants from which they may be derived and the chemical composition of each essential oil.

Despite this diversity, there are a number of generalizations that can be made about their antimicrobial activity. For example, most essential oils are inhibitory at concentrations well

below 5% (v/v) and exhibit dose-dependent activity, with greater activity seen at higher oil concentrations.

Essential oils tend to be bactericidal in action, meaning that organisms are inhibited and killed at approximately the same concentration. In contrast, bacteriostatic agents inhibit growth but do not kill (Halldor, 2011).

Many essential oils also have a relatively rapid antimicrobial action, with significant cell death occurring at concentrations equivalent to or greater than the minimum bactericidal or fungicidal concentrations. The majority of oils are broad-spectrum in activity, meaning that they are active against a wide range of bacteria and fungi.

Most essential oils possess at least some degree of antibacterial activity. However, those attracting the most attention are the ones which inhibit or kill bacteria. Oregano (*Origanum spp*.), tea-tree (*Melaleuca alternifolia*), lemongrass (*Cymbopogon citratus*), lemon-myrtle (*Backhousia citriodora*) and clove (*Syzigium aromaticum*) oils are examples of essential oils that have activity against a wide range of Gram-positive and Gram-negative bacteria (Halldor, 2011).

Essential oils and components also exhibit activity against fungi, activity that is becoming increasingly well described. A wide range of human, animal and agricultural fungal pathogens have been shown to be inhibited and/or killed by essential oils, heightening interest in their therapeutic or industrial application. There has been particular interest in the activity of essential oils and their components against food-spoilage fungi and essential oils and their components have been shown to inhibit the growth of many of them, including species of *Aspergillus, Microsproum, Mucor, Penicillium, Eurotium, Debaryomyces, Pichia, Zygosaccharomyces* and *Candida*. However, one of the key issues with agents intended to preserve food is maintenance of the aroma, taste, colour and texture of the food (Leistner, L. (2000) Basic aspects of food preservation by hurdle technology).

Table 1.2 shows that the Inhibitory activities of plant-origin antimicrobials against pathogenic bacteria, protein toxins and fungi – representative studies conducted within the last 10 years. (M.M. Tajkarimi et al. / Food Control 21 (2010) 1199–1218).

Table 1.2 Inhibitory activities of plant-origin antimicrobials against pathogenic bacteria, protein toxins and fungi - M.M. Tajkarimi et al. / Food Control 21 (2010) 1199–1218.

Organism	Adverse effects	Some Inhibitors
Escherichia coli	Food poisoning; diarrhea	Cinnamon, oregano oil (*Oreganum vulgare*), pure essential oils, leaf olatile oil, eugenol, bark volatile oil, bark oleoresin, E-cinnamaldehyde, carvacrol, oregano oil, citra, lemongrass oil, cinnamaldehyde, cinnamon oil , clove (*Eugenia caryophyllata*),
Listeria monocytogenes	Food poisoning; listeriosis	cinnamon bark, cinnamon leaf, and clove
Salmonella spp.	Food poisoning; Salmonellosis	oregano (*Origanum vulgare*), and cinnamon (*Cinnamomum zeylanicum*), lemongrass, thyme (*Thymus vulgaris*), carvacrol, cinnamaldehyde, and thymol
Staphylococcus aureus	Food poisoning; infection	cinnamon, oregano (*Origanum vulgare*), clove, mustard , rosemary (*Rosmarinus officinalis*)
Molds	Mycotoxicosis	Pure essential oils, leaf oleoresin, leaf volatile oil, eugenol, bark volatile oil, bark oleoresin, Ecinnamaldehyde .

[Table 1.3] Shows some studies regarding application of E.Os or their components in food (Dairy product) studies conducted in the past 10 years - M.M. Tajkarimi et al. / Food Control.

[Table 1.3] some studies regarding application of E.Os

Food group	E.O or component	Bacterial species	Inhibitory effect
Mozzarella cheese	Clove oil	*Listeria monocytogenes*	Yes
Soft cheese	DMC Base Natural preservative comprising 50% E.Os of rosemary, sage and citrus	*Listeria monocytogenes*	Yes
Yoghurt	Clove, cinnamon, cardamom, peppermint oil	*Streptococcus thermophilus* *Several species of bacteria*	Yes

1.6. Problems statement

1.6.1. Main problem

The shelf life of labneh (concentrated yoghurt) is short due to the processing methods used, characteristics, and chemical composition and also to the possibilities of cross contamination. There is a real need to increase the shelf of labneh for more than 3 months so as the Palestinian industry can be competitive and to be able to export this highly demanded product to the different Gulf countries and Europe.

The addition of Potassium sorbate is highly controlled in Palestine and the maximum admitted level is 300 ppm. Meanwhile in Lebanon it can reach 50 mg/kg (50 ppm) where as in many countries this is not allowed, because it's a chemical, may cause disease or may be carcinogenic, and there are many researches looking for uses of potassium sorbate and the allowable limit. Another solution that may be used to increase shelf life is heat treatment of labneh before packaging at 70°C for 35 seconds, or after packaging at 55°C for 15-30 minutes even though these methods increase the shelf life, it needs high investments and labneh maybe unstable and some of its characteristics changes such as appearance of grains of proteins and increase syneresis which is the collections of whey protein on the surface of labneh.

1.6.2. Sub- Specific problem

1. Use of natural preservatives instead of synthetic (chemical) preservatives, since they are more safe, and\or to find a good combination between natural preservatives and synthetic antimicrobials applied to labneh
2. Increase the shelf life of the labneh (which is one month in Palestine) to a maximum period.

1.7. Purpose of the present work

1.7.1. Hypothesis

1. Essential oils (cinnamon oil, clove oil, rosemary oil, almond sweet oil, sesame oil, wheat germ oil, cedar wood oil, eucalyptus oil) have antimicrobial activity on the growth of the labneh pathogenic and spoilage bacteria.
2. Antimicrobial active compounds of essential oils could substitute natamycin, sodium benzoate and potassium sorbate of effectiveness as antimicrobial.
3. The shelf life of labneh could be extended by using the hurdle effect which involves the combination of natural preservatives and synthetic preservatives, leading to better results using low concentration of synthetic antimicrobial agents.

1.7.2. Questions

1. Which of the studied essential oils have activity to reduce the harmful bacteria of labneh?
2. What is the time extension in the shelf life period of labneh?
3. What is the optimum ratio of the essential oils to synthetic preservative in labneh that give best results?

1.7.3. Objectives

1. To measure the antimicrobial activity of essential oils (cinnamon oil, clove oil, rosemary oil, almond sweet oil, sesame oil, wheat germ oil, cedar wood oil, eucalyptus oil), by plate count method on most common bacteria and fungi's found in labneh which are Total viable count, *Coliforms, Escherichia coli O157:H7, yeast, mold, Staphylococcus aureus*.
2. To substitute the use of Potassium sorbate by natural antimicrobial agents or to use it synergistically
3. To compare the antimicrobial activity of the natural preservatives and synthetic dairy antimicrobial; natamycin, sodium benzoate and potassium sorbate.
4. Extension shelf life of labneh for at least 3 months.

CHAPTER TWO

LITERATURE REVIEW

AND PREVIOUS STUDIES

Literature review and previous studies

2.1. Antibacterial Activity of Plant Essential Oils against Food Borne Bacteria

[A.Sheeladevi and N.Ramanathan – 2012, India]

This study determined the antibacterial activity of plant essential oils against five food borne bacteria. The antibacterial activities of cinnamon, clove, oregano, rosemary and thyme oils were investigated against *Campylobacter* sp., *Listeria* sp., *Yersinia* sp., *Salmonella* sp. and *Pseudomonas* sp. by agar well diffusion method, minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) method. Most of the essential oils showed a relatively high antibacterial activity against all the food borne bacteria. Of the essential oils studied, clove, cinnamon and thyme are the more inhibitory activity against all five food borne bacteria. The ranges of MIC of the essential oils were 50 – 60, 60 – 80 and 80 – 100 μl ml^{-1}, respectively, for clove, cinnamon and thyme. This work shows that essential oil is more effective against food borne pathogens and spoilage bacteria and could be used as natural antibacterial agents in food preservation.

The conclusion of this study showed that essential oils of clove, cinnamon, thyme, oregano and rosemary showed relatively high antibacterial activity against all the tested food borne bacteria. The present study suggests that the essential oil of clove, cinnamon and thyme is a potential source of natural antibacterial agents and to be used as food preservatives. After this screening experiment, phytochemical studies will be necessary to isolate the active constituents.

2.2. Improvement of the quality and shelf life of concentrated yoghurt (labneh) by the addition of some essential oils

[Mutlag Al.Otaibi, and Hassan El.Demerdash – 2008, Saudi Arabia]

Three essential oils, namely thyme, marjoram and sage, were added to concentrated yoghurt (labneh) at concentrations of 0.2, 0.5 and 1.0 parts per million (ppm). Subsequently, the

chemical, microbiological and organoleptic properties of freshly prepared labneh and of the labneh stored at 5°C ± 1 for up to 21 days were determined. Addition of essential oils affected the pH, soluble nitrogen-to-total nitrogen, total volatile fatty acid and acetaldehyde values of the prepared labneh.

On the other hand, total solids and fat-to-dry matter values were only slightly affected. Total viable counts, as well as counts of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus* in the treated labneh increased and reached a maximum after 7 days of storage where after it decreased until the end of the storage period. *Yeasts* and *moulds*, *coliform* bacteria and spore-forming bacteria were not detected in the treated labneh. Of the different treated labneh, labneh containing 0.2 ppm thyme, marjoram or sage oils were organoleptically the most acceptable, and it had a good body and texture that was similar to that of the untreated control. From the results of this study, it can be concluded that 0.2 ppm of thyme, marjoram or sage can be used in order to increase the shelf life of labneh for up to 21days.

2.3. Food applications of natural antimicrobial compounds

[Annalisa Lucera, Cristina Costa, Amalia Conte, Matteo A. Del Nobile - 2012, Italy]

In agreement with the current trend of giving value to natural and renewable resources, the use of natural antimicrobial compounds, particularly in food and biomedical applications, becomes very frequent.

The direct addition of natural compounds to food is the most common method of application, even if numerous efforts have been made to find alternative solutions to the aim of avoiding undesirable inactivation. Dipping, spraying, and coating treatment of food with active solutions are currently applied to product prior to packaging as valid option. The aim of the current work is to give an overview on the use of natural compounds in food sector. In particular, the review will gather numerous case studies of meat, fish, dairy products, minimally processed fruit and vegetables, and cereal based products where these compounds found application.

2.4. Food Preservation – A Bio-preservative Approach

[Iraj Rasooli - 2007, Iran]

Preservative agents are required to ensure that manufactured foods remain safe and unspoiled. Antimicrobial properties of essential oils (E.Os) reveal that Gram-positive bacteria are more vulnerable than Gram-negative bacteria. A number of E.O components have been identified as effective antibacterials, e.g. carvacrol, thymol, eugenol, cinnamaldehyde and cinnamic acid, having minimum inhibitory concentrations (MICs) at higher dilutions *in vitro*. E.Os comprise a large number of components and it is likely that their mode of action involves several targets in the bacterial cell.

The potency of naturally occurring antimicrobial agents or extracts from plants, ranges of microbial susceptibility and factors influencing antimicrobial action and their antioxidative properties, aimed at food preservation, are reviewed in this article. Methods employed for estimation of inhibitory activity, mode of action and synergistic and antagonistic effects are evaluated. The potential value of these agents as natural and biological preservatives is considered.

Some titles from this study for Future research:

1- The antimicrobial molecules in complex mixture of E.Os' compounds and their eventual interactions should be addressed. This will lead to increase in control of microbial growth, to minimize the impact of these substances on the flavour of food products and to avoid fluctuations in E.Os activity due to meteorological, seasonal and geographical factors, as well as different compositions due to the plant type.

2- The stability of E.Os during food processing will also need to be studied.

3- Standardization of test methods for testing antibacterial for use in food. This is a field where a selection of standard methods would accelerate the study of promising antibacterial components and their synergistic or antagonistic action with each other and with food ingredients.

4- Synergistic effects could be exploited so as to maximize the antibacterial activity of E.Os and to minimize the concentrations required to achieve a particular antibacterial effect. Antagonism between E.Os and food ingredients is undesirable and research is needed so it can be avoided in practical applications.

2.5. Antimicrobial herb and spice compounds in food -a review

[M.M. Tajkarimi, S.A. Ibrahim, D.O. Cliver - 2010, USA]

Herbs and spices containing essential oils (E.Os) in the range of 0.05–0.1% have demonstrated activity against pathogens, such as *Salmonella typhimurium, Escherichia coli O157:H7, Listeria monocytogenes, Bacillus cereus* and *Staphylococcus aureus,* in food systems. Application of herbs, spices and E.Os with antimicrobial effects comparable to synthetic additives is still remote for three major reasons: limited data about their effects in food, strong odour, and high cost. Combinations of techniques have been successfully applied in several in food and in vitro experiments. This paper aims to review recent in-food applications of E.Os and plant-origin natural antimicrobials and recent techniques for screening such compounds.

The conclusion of this study showed that Plant-origin antimicrobials are present in a variety of plants, spices and herbs. Spices and herbs are used for both flavour ing and preservation purposes. Spices and herbs, which were originally added for improving taste, can also naturally and safely improve shelf life of food products (Holley & Patel, 2005). Evaluation of new preservatives such as natural antimicrobials in food, evaluating food structure, composition and interaction between natural microflora and food-borne disease agents could be made much more precise by application of predictive models (Koutsoumanis et al., 1999).

Several studies have been focused on the application of individual E.Os derived from plants. Some studies showed whole E.Os have more antimicrobial activity compared to the mixture of major components (Burt, 2004). However, information on the effects of these natural compounds in combination and or as crude extracts against food-borne micro-organisms is limited (Ibrahim et al., 2009; Mandalari et al., 2007).

The future will see much-needed investigation of food applications of the naturally occurring antimicrobials, especially the effectiveness of E.Os, individually and in combination with other parts of plant extract, other effective E.Os and other food-processing techniques.

2.6. Essential oils: antibacterial properties and potential applications in foods – review

[Sara Burt - 2004, Netherlands]

A number of E.Os components have been identified as effective antibacterials, e.g. carvacrol, thymol, eugenol, perillaldehyde, cinnamaldehyde and cinnamic acid, having minimum inhibitory concentrations (MICs) of 0.05–5 μl ml^{-1}, E.Os comprises a large number of components and it is likely that their mode of action involves several targets in the bacterial cell. The hydrophobicity of E.Os enables them to partition in the lipids of the cell membrane and mitochondria, rendering them permeable and leading to leakage of cell contents. Physical conditions that improve the action of E.Os are low pH, low temperature and low oxygen levels.

In conclusion: this study shows that, the phenolic components are most active and appear to act principally as membrane permeabilizers. Gram-positive organisms are generally more sensitive to E.Os than gram-negative organisms.

2.7. Evaluation of the effects of some plant derived essential oils on shelf life extension of Labneh

[Habib M Thabet, Qais A Nogaim, Ali S Qasha, and Najib Alnsheme – 2014, Yemen]

Concentrated yogurt (labneh) was produced by straining cow milk set yogurt in cloth bags. Three plants derived essential oils cinnamon, cumin and mint oils, were added to final concentrations of 0.3, 0.5 and 0.8% each to extend the shelf life of labneh. The chemical, microbiological and organoleptic properties of the labneh stored at 6±1ºC for up to 24 days were determined. Addition of plant derived essential oils affected the pH and total volatile fatty acid values of the prepared labneh, while total solids and fat values were only slightly affected. Total therapeutic bacterial count, *Streptococcus thermophilus* and *Lactobacillus*

delbrueckii ssp. *Bulgaricus* in the treated labneh increased and reached a maximum after 8 days of storage where after it decreased until the end of the storage period. Coliform and *staphylococcus* bacteria were not detected, while yeasts and moulds were detected at insignificant in some treated labneh. Labneh containing 0.3% cinnamon, cumin or mint oils were organoleptically the most acceptable and it had a good body and texture that was similar to the untreated one. From the results of this study, it can be concluded that 0.3% of cinnamon can be used in order to increase the shelf life of labneh for up to 24 days, with higher level of total volatile free fatty acid and therapeutic bacteria counts and low level of total viable, molds and yeast count.

The conclusion of this study showed that the natural antimicrobial is wide and there are still a great number of possibilities to explore. The tested plant derived oils must be thoroughly described and identified in the future studies as food preservation. The results of the present study showed that, the addition of essential oils can be used to increase the shelf life of labneh, the cinnamon oil at 0.3% has shown to extend the shelf life for up to 24 day at $6 \pm 1^{o}C$ with acceptable taste, flavour and without any microbial spoilage.

CHAPTER THREE

MATERAILS AND METHODS

3.1. Materials

3.1.1. Essential oils

Different essential oils purchased from (Al-shams company, Nablus, Palestine), will be studied.

These essential oils are:

1. Cinnamon oil (*Cinnamomum zeylanicum*)
2. Clove oil (*Syzygiumarom aticum*)
3. Almond sweet oil (*Prunus dulcis*)
4. Rosemary oil (*Rosmarinus officinalis*)
5. Sesame oil (*Sesamum indicum)*
6. Wheat germ oil (*Triticum vulgare*)
7. Cedar wood oil (*Santalum album)*
8. Eucalyptus oil *(Eucalyptus Globu)*

All Essential oils were stored at cold temperature 5°C.

3.1.2. Fresh labneh

Labneh prepared from fresh and pasteurized milk.

3.1.3. Chemicals

Ethanol, Water, Microbiological media (Plate count agar for the detection viable bacterial growth in labneh, Violet Red Bile Agar recommended for the detection of coliforms in labneh, Eosin Methylene Blue for the detection of *E. Coli* in labneh, Oxytetra Glucose Yeast Agar base for the detection of yeast and mold in labneh, Baird–Parker agar for the detection of *Staphylococcus aureus* in labneh), peptone water.

3.1.4. Instruments

Oven, Scales, Incubator, Agar disc, Petri-dishes, Blender or Mixer, Colony counter, Refrigerator, Flame, pH meter, Autoclave, Microscope, Delicate scales, Forceps, Micropipette, moisture analyzer.

3.2 Methodology

3.2.1 Main method (Antimicrobial activities of essential oils)

The antimicrobial activity of eight Essential oils will be evaluated against major microorganisms that can be present in labneh such as Coliforms, *Escherichia coli O157:H7*, *yeast*, *mold*, *Staphylococcus aureus*, and total count bacteria.

Experiments will involve the evaluation of the effect of the addition of essential oils each type separately, cinnamon oil, rosemary oil, almond sweet oil, sesame oil, wheat germ oil, cedar wood oil, clove oil, Eucalyptus oil, at different concentrations, 600 µl\kg, 500 µl\kg, 400 µl\kg, 300 µl\kg, 350 µl\kg, 300 µl\kg, 250 µl\kg, 200 µl\kg, 150 µl\kg, on the microorganisms that present in labneh.

Additionally, the essential oils will be also tested in combination of potassium sorbate (synthetic preservative).

3.2.2 Addition of essential oils to labneh

Addition of essential oils to Labneh at two stages:

- First stage

Addition of one of the essential oils: cinnamon oil, rosemary oil, almond sweet oil, sesame oil, wheat germ oil, cedar wood oil and clove separately, to one kilogram of labneh sample at

different concentrations 150 µl\kg, 200 µl\kg, 250 µl\kg, 300 µl\kg, 350 µl\kg, with addition of synthetic preservative (Potassium Sorbate) at 150 ppm.

The resulting mixture is then mixed for 15 minutes and distributed to six packages of 200 gm, and stored in fridge at 5°C for 6 weeks.

- Second stage

Addition of one of the essential oils: cinnamon oil, rosemary oil, almond sweet oil, sesame oil, wheat germ oil, cedar wood oil, clove and eucalyptus oil separately, to one kilogram of labneh sample at different concentrations 300 µl\kg, 400 µl\kg, 500 µl\kg, 600 µl\kg, without addition of synthetic preservative (Potassium Sorbate). The resulting mixture is then mixed for 15 minutes and distributed to six packages of 200 gm, and stored in fridge at 5°C for 6 weeks.

Note: Eucalyptus oil was used in the second stage only, because it was not available at that time

3.2.3. Chemical analysis

The methodology reported by Ling (1963) was used to determine the total solid content, and pH of the different labneh samples.

3.2.4. Microbiological analysis

Evaluated antibacterial activity and properties against major labneh borne bacteria such as, *Coliforms* , *Escherichia coli O157:H7, yeast, mold, Staphylococcus aureus,* and total aerobic count bacteria by plate count method, (pouring plate method) is used for counting microorganisms in labneh.

A 1 g sample of labneh was diluted in 9 ml of peptone water yielding a 10^{-1} dilution. Serial dilutions were subsequently prepared and viable numbers were enumerated using the pour plate technique. Total viable counts (TVC) were determined according to Klose (1968), The agar plates were incubated at 30°C for 72 h. Mould and yeast counts were determined according to Harrigan and McConce (1966), while *coliform* bacteria were enumerated using the method described by the American Public Health Association (1978). The colony forming

units (cfu) were converted to log10 and the results are reported as the average from three replicates , Each colony can be counted and represents a single cell in the labneh . When labneh sample mixed with liquefied agar, then must be used dilution to obtain accurate quantitative analyses of cell number. In microbiological tests, every plate was repeated three times for each type of bacteria, and calculates the mean, then the standard deviation.

3.2.5. Organoleptic properties

All labneh Samples were sensory evaluated for flavour (50 points), body and texture (40 points), and appearance (10 points) according to Keating and Rand-white (1990).

All samples were evaluated by eight people, specialists in food science, and rated by percentage.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1. Effect of essential oils on microorganisms *(*total count of bacteria, mold, yeast, *Staphylococcus aureus, Coliforms and Escherichia coli O157:H7,*)

4.1.1. Effect of Almond sweet, Cedar wood, Cinnamon, Clove, Rosemary, Sesame and Wheat germ essential oils on labneh, in the presence of synthetic preservative (potassium sorbate at 150 ppm)

Different type of E,Os (almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils), with 150 ppm potassium sorbate were used as preservatives of labneh sample and compared to positive control samples (300 ppm p.s) as preservatives which used in labneh manufacturing in Palestine, and compared to negative control, no preservatives added to labneh sample. Some essential oils such as cinnamon, clove and rosemary, almond sweet and cedar wood showed a clear obvious effect with reduction in bacterial and mold and yeast count throughout the six weeks storage, and others such as sesame and wheat germ did not show obvious effects.

The total viable count (TVC) decreased in the presence of essential oils compared with the control samples. This is due to the antibacterial effect of essential oils, during storage period.
The results showed that the best three essential oils are cinnamon, clove and rosemary, where the total bacterial viable count decreased to reach 13.00×10^{1} cfu/g in the positive control sample. While the TVC at 200 µl\kg E.Os and 150 ppm potassium sorbate, it reached 5×10^{1}cfu/g in cinnamon labneh, 2×10^{1}cfu/g in clove labneh and in rosemary labneh 10.00×10^{1}cfu/g. while at 250 µl\kg and 150 ppm potassium sorbate TVC reached 12×10^{1} cfu/g in cinnamon labneh, 7.00×10^{1}cfu/g in clove labneh and 11×10^{1}cfu/g in rosemary. In the treated labneh the TVC at 300 µl\kg and 150 ppm potassium sorbate, was 10×10^{1} cfu/g in clove labneh and 4×10^{1}cfu/g in rosemary labneh. While in the treated labneh the TVC at 350 µl\kg and 150 ppm potassium sorbate were 9×10^{1} cfu/g in clove labneh reach and 11×10^{1} cfu/g in rosemary labneh. This activity is due to antimicrobial effects of essential oils in treatment labneh.

In other essential oils (Almond sweet oil, Cedar wood, Sesame and Wheat germ) there was no obvious effect on total viable count. Cinnamon oil, clove oil, rosemary oil, have good antiseptic, antibacterial and antifungal properties more than other oils that are used in this study, because of the phenols and monoterpene, alcohols, monoterpene, aldehydes esters and lactones. (K.Hüsnü¸ Buchbauer, 2010)

Quality and shelf life of labneh were also evaluated with mold and yeast counts. Molds were detected in small number in labneh containing clove oil, cinnamon oil and rosemary at 350, 300, 250, 200 µl\kg and 150 ppm potassium sorbate throughout the storage period. At the end of the storage period molds number reached 7.00×10^1 cfu/g in the positive control sample (300 ppm) potassium sorbate, While in the treated labneh the molds number at 200 µl\kg and 150 ppm potassium sorbate, reached 4.00×10^1cfu/g in cinnamon labneh, 2×10^1 cfu/g in clove labneh and 2.00×10^1cfu/g in rosemary labneh. While in the treated labneh at 250 µl\kg and 150 ppm potassium sorbate, the molds number reached 2.00×101 cfu/g in cinnamon labneh, 4.00 × 101 cfu/g in clove labneh and 5.00 × 101 cfu/g in rosemary labneh. In the treated labneh the molds number at 300 µl\kg and 150 ppm potassium sorbate reached 3.00×10^1 cfu/g in cinnamon labneh, 2.00×10^1 cfu/g in clove labneh and 1.00×10^1 cfu/g in rosemary labneh. While in the treated labneh the molds number at 350 µl\kg and 150 ppm potassium sorbate, in cinnamon labneh reach 4.00×10^1 cfu/g, in clove labneh reach 2.00×10^1 cfu/g and in rosemary labneh reach 2.00×10^1cfu/g. In other essential oils (Almond sweet oil, Cedar wood, Sesame and Wheat germ) there was no obvious effect on molds count.

Manso *et al.,* (2013) supported our results by demonstrating the influence of the substrate of several packaging materials containing cinnamon oil (*Cinnamomun zeylanicum*) on the antifungal activity against *A.flavus.*

Results of this work provide the best alternative to preserve labneh by using the essential oil instead of chemicals preservatives. Mihyar *et al.,* (1999) reported that more than 400 mg of sodium benzoate per Kg of labneh were needed to control the counts of yeast and mould such as *S.cerevisiae, Pichia farinose, candida blankii and Trichosporon brassicae* to 105 cfu/g after 14 days at 5^oC; while 150 and 300 mg of sodium benzoate per Kg of labneh were needed for *Geotrichum candidum* and *Trichosporon cutaneum,* respectively.

Yeast were detected at small number in labneh containing clove, cinnamon, rosemary, throughout storage period at 150, 200, 300 µl\kg and 350 ppm potassium sorbate, giving better effect than positive control.

At the end of the storage period yeast number reach 5×10^1cfu/g in the control sample, while in the treated labneh the yeast number at 200 µl\kg and 150 ppm potassium sorbate, in cinnamon labneh reached 2.00×10^1cfu/g, 2×10^1cfu/g in clove labneh and 4×10^1cfu/g in rosemary labneh. While at 300 µl\kg and 150 ppm potassium sorbate yeasts were 2×10^1 cfu/g in cinnamon labneh, 2×10^1 cfu/g in clove labneh and in rosemary labneh TVC reach 2×10^1 cfu/g. At 350 µl\kg and 150 ppm potassium sorbate yeasts reached 2×10^1 cfu/g in cinnamon labneh, 3×10^1 cfu/g in clove labneh and 2.00×10^1 cfu/g in rosemary labneh, while in labneh containing (Sesame and Wheat germ) obvious effect was observed.

The results obtained for *Staphylococcus aureus* indicated that use of clove, cinnamon, rosemary, almond sweet and cedar wood oil throughout and at the end the storage period, gives better effects than positive control.

At the end of the storage period *S. aureus* number reached 8.00×10^1 cfu/g in the control sample. The best three essential oils are cinnamon, clove, rosemary at 300, 250, 200 µl\kg and 150 ppm potassium sorbate. At 200 µl\kg and 150 ppm potassium sorbate, *S. aureus* reached 3×10^1cfu/g in cinnamon labneh, 3.00×10^1cfu/g in clove labneh and 5.00×10^1cfu/g in rosemary labneh. While at 250 µl\kg and 150 ppm potassium sorbate, *S. aureus* reached 5.00×10^1 cfu/g in cinnamon labneh to, 4×10^1 cfu/g in clove labneh. At 300 µl\kg and 150 ppm potassium sorbate *S. aureus* reached 6.00×10^1 cfu/g in cinnamon labneh, 4×10^1 cfu/g in clove labneh and 3.00×10^1 cfu/g in rosemary labneh. While at 350 µl\kg and 150 ppm potassium sorbate, *S. aureus* reached 4×10^1 cfu/g in cinnamon labneh, 4×10^1 cfu/g in clove labneh and 3.00×10^1 cfu/g in rosemary labneh. While in labneh containing Sesame and Wheat germ oils *S. aureus* were detected at high number more than control in the end of the storage period and throughout the storage period, and it didn't show any obvious effects.

Both coliform and *E. coli* were not detected in any of the labneh prepared by addition of the respective essential oils. This effect may be attributed to the effect of active compounds in the essential oils; Burt (2004) reported that essential oils contain phenolic compounds that are primarily responsible for their antimicrobial properties.

4.1.1.1. Total viable count in labneh at 150 µl\kg oil concentration and 150 ppm P.S

When comparing the positive control and negative control samples, with labneh samples at a concentration of 150 ppm potassium sorbate and 150 µl\kg E. Os, almond sweet oil showed an obvious decrease in bacterial count lower than the positive control during the storage period, with best inhibition growth at second and fourth week. (See table 4.1)

When cedar wood oil was used, results showed significant decrease in bacterial count in fifth and last week, indicating that the inhibitory effect needs time to be more effective. The bacterial count was always lower than the negative control. (See table 4.1)

Cinnamon oil results showed that there was obvious decrease in bacterial count lower than positive control during the storage period, except the first week which was slightly higher than positive control. (See table 4.1).

Clove oil didn't show obvious effect on the labneh sample compared to positive control in the first weeks of storage, but growth rate decreased significantly till the end of storage time, with results comparable to positive control. The bacterial count was lower than negative control during storage time

Concerning rosemary oil and wheat germ oil results there was obvious decrease in bacterial count lower than positive control during the storage period except the first week.

When using sesame oil, the results showed that there was obvious decrease in bacterial count lower than positive control during the storage period, with most efficient results at week four where reduction rate was of 100% (see table 4.1).

It is noteworthy to mention that all the essential oils at this concentration showed lower bacterial count compared to the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the bacterial count when it is used synergetically with the synthetic preservative potassium sorbate at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E.Os were compared, the best E.O to be used to control TVC was: sesame oil followed by cinnamon oil, almond sweet oil, wheat germ oil, rosemary oil, clove oil and finally cedar wood oil. (See table 4.1).

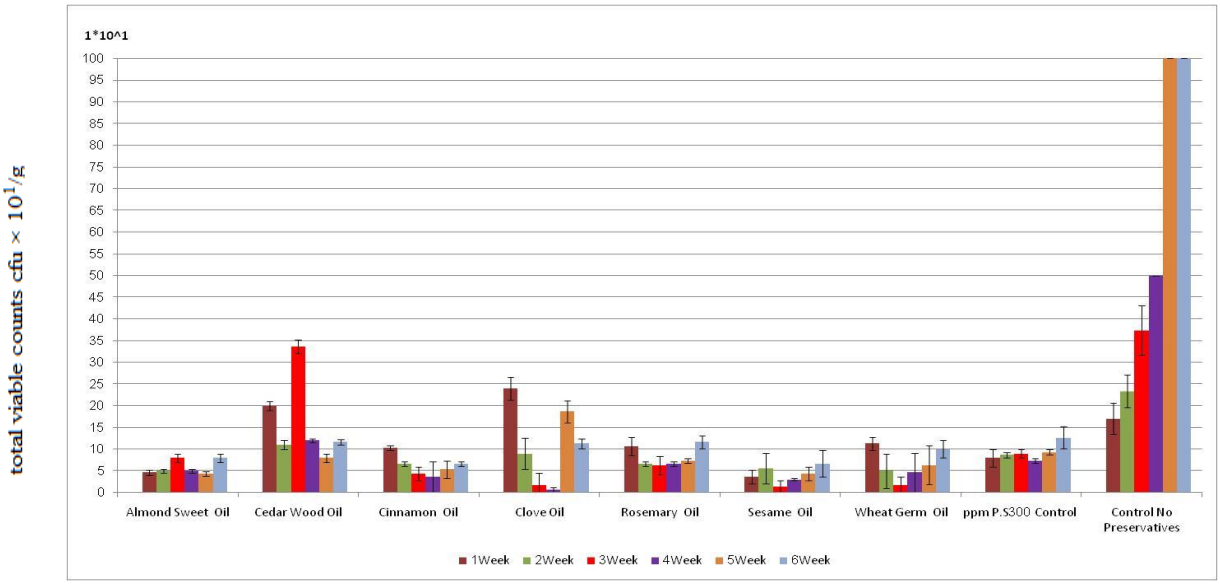


Figure 4.1: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 150 µl\kg oil concentration and150 ppm potassium sorbate on the counts of total viable counts.

Table 4.1: Microbiological analysis of total viable counts of labneh during 6 weeks at 150 µl\kg oil concentration and150 ppm p.s

T.V.C with 150 µl\kg oil Con.and 150 PPM P.S	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	5.00	0.58	5.00	0.58	8.00	1.00	5.00	0.58	4.00	0.58	8.00	1.00
Cedar Wood Oil	20.00	1.00	11.00	1.00	34.00	1.53	12.00	0.32	8.00	1.00	12.00	0.58
Cinnamon Oil	10.00	0.58	7.00	0.58	4.00	1.53	4.00	3.51	5.00	2.08	7.00	0.58
Clove Oil	24.00	2.65	9.00	3.61	2.00	2.89	1.00	0.58	19.00	2.52	12.00	1.15
Rosemary Oil	11.00	2.08	7.00	0.58	6.00	2.08	7.00	0.58	8.00	0.58	12.00	1.53
Sesame Oil	4.00	1.53	6.00	3.51	1.00	1.53	0.00	0.00	4.00	1.53	7.00	3.06
Wheat Germ Oil	12.00	1.53	5.00	4.00	2.00	2.08	5.00	4.51	6.00	4.51	10.00	2.00
Control 300 ppm P.S	8.00	2.00	9.00	0.58	9.00	1.00	8.00	0.58	9.00	0.58	13.00	2.52
Control No Preservatives	17.00	3.61	23.00	3.79	37.00	6.00	50.00	0.00	100.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.2. Total viable count in labneh at 200 µl\kg oil concentration and150 ppm P.S

When comparing the positive control and negative control, with labneh samples at a concentration of 150 ppm potassium sorbate and 200 µl\kg E.Os, almond sweet oil showed significant decrease in bacterial count till the third week, indicating that the inhibitory effect lasted until the fourth week, so there is no significant decrease in bacterial count compared to positive control. The bacterial count was always lower than negative control (see table 4.2).

When cedar wood oil was used, the bacteria count was a bit higher than positive control but this count was always lower than the negative control showing the effectiveness of the essential oil.

Concerning cinnamon oil, clove oil, and rosemary oil results showed that there was obvious decrease in bacterial count lower than positive control during the storage period (six weeks). This showed that these combinations of natural preservative with synthetic one is better than synthetic preservative. (See table 4.2).

Sesame oil results showed that there was obvious decrease in bacterial count lower than positive control during the storage period, except the fifth week which was slightly higher than positive control. (See table 4.2).

Wheat germ oil didn't show obvious effect on the labneh samples compared to positive control. The bacterial count was less than negative control. (See table 4.2).

It is noteworthy to mention that all the essential oils at this concentration showed bacterial count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the bacterial count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E,Os were compared, the best E,O to be used to control TVC was: clove oil followed by cinnamon oil, rosemary oil, sesame oil, cedar wood oil, almond sweet oil, and finally wheat germ oil. (See table 4.2).

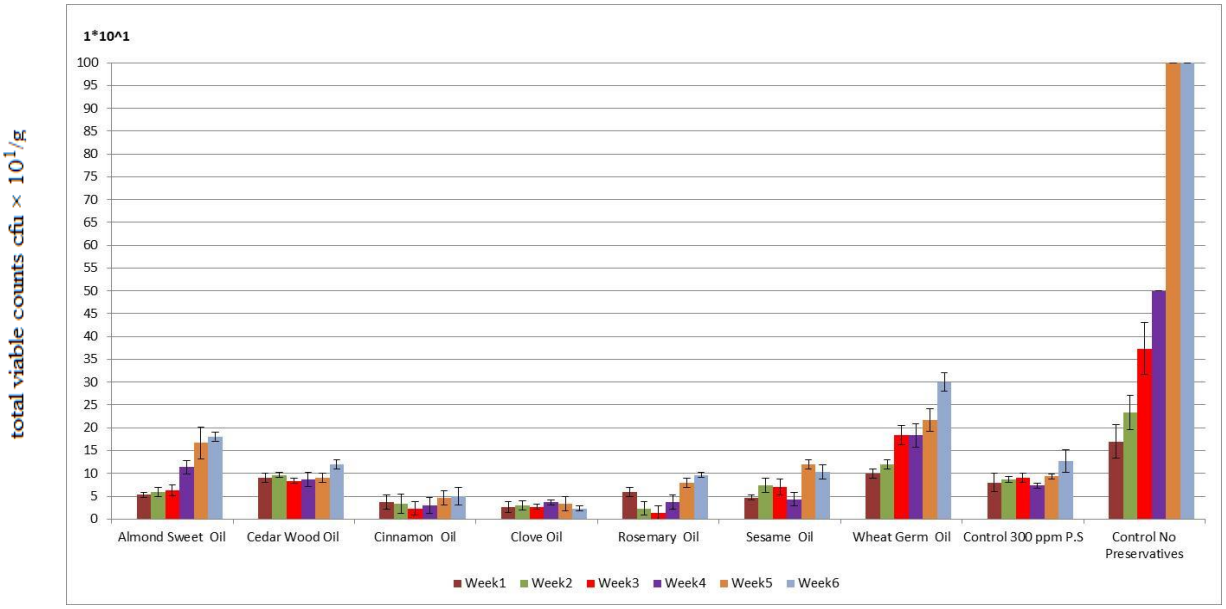


Figure 4.2: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 200 µl\kg oil concentration and150 ppm potassium sorbate on the counts of Total viable counts.
The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.2: Microbiological analysis of total viable counts of labneh during 6 weeks at 200 µl\kg oil concentration and 150 ppm p.s.

T.V.C with 200 µl\kg oil Con. and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	5.00	0.58	6.00	1.00	6.00	1.15	12.00	1.53	17.00	3.51	18.00	1.00
Cedar Wood Oil	9.00	1.00	10.00	0.58	8.00	0.58	9.00	1.53	9.00	1.00	12.00	1.00
Cinnamon Oil	4.00	1.53	3.00	2.08	2.00	1.53	3.00	1.73	5.00	1.53	5.00	2.00
Clove Oil	3.00	1.15	3.00	1.00	3.00	0.58	4.00	0.58	3.00	1.53	2.00	0.58
Rosemary Oil	6.00	1.00	2.00	1.53	1.00	1.53	4.00	1.53	8.00	1.00	10.00	0.58
Sesame Oil	5.00	0.58	8.00	1.53	7.00	1.73	4.00	1.53	12.00	1.00	10.00	1.53
Wheat Germ Oil	10.00	1.00	12.00	1.00	18.00	2.08	18.00	2.52	22.00	2.52	30.00	2.00
Control 300 ppm P.S	8.00	2.00	9.00	0.58	9.00	1.00	8.00	0.58	9.00	0.58	13.00	2.52
Control No Preservatives	17.00	3.61	23.00	3.79	37.00	6.00	50.00	0.00	100.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.3. Total viable count in labneh at 250 µl\kg oil concentration and150 ppm P.S

When comparing the positive control and negative control, with labneh samples at a concentration of 150 ppm potassium sorbate and 250 µl\kg E.Os, both almond sweet oil and cedar wood oil didn't show obvious effect on the labneh samples. (See table 4.3).

Cinnamon oil results showed that there was obvious decrease in bacterial count lower than positive control during the storage period, except fourth and fifth week bacterial count is a slightly higher than positive control. The count was always lower than the negative control showing the effectiveness of the essential oil. (See table 4.3).

When clove oil was used, the results showed that there was obvious decrease in bacterial count lower than positive control during the storage period, except in first and fifth week the bacteria count is a bit higher than positive control. This count was always lower than the negative control showing the effectiveness of the essential oil. (See table 4.3).

Concerning rosemary oil results showed that there was obvious decrease in bacterial count lower than positive control during the storage period.

Sesame oil didn't show obvious effect on the labneh sample compared to positive control. The bacterial count is less than negative control. (See table 4.3).

When wheat germ oil was used results showed that there was obvious decrease in bacterial count lower than positive control during the storage period, except first week. The bacterial count was always lower than the negative control showing the effectiveness of the essential oil. (See table 4.3).

It is noteworthy to mention that all the essential oils at this concentration showed bacterial count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the bacterial count when it is added with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E,Os were compared, the best E,O to be used to control TVC was: clove oil, cinnamon oil, rosemary oil, wheat germ oil, sesame oil, and finally almond sweet oil and cedar wood oil. (See table 4.3).

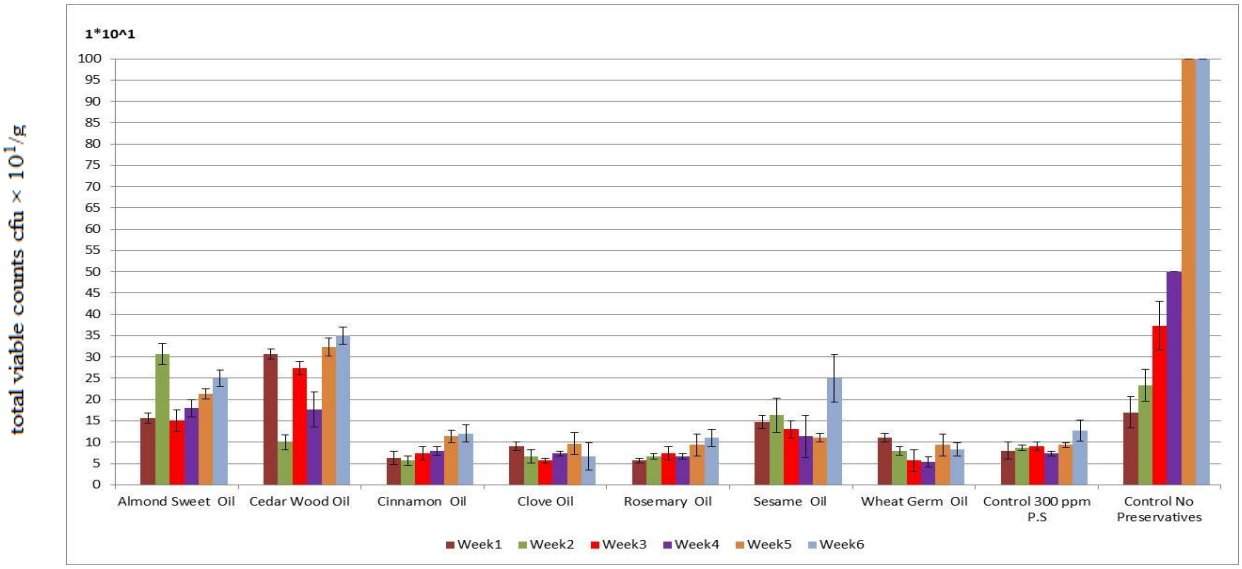


Figure 4.3: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 250 µl\kg oil concentration and150 ppm potassium sorbate on the counts of Total viable counts.

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.3: Microbiological analysis of total viable counts of labneh during 6 weeks at 250 µl\kg oil concentration and 150 ppm P.S.

T.V.C with 250 µl\kg oil Con. and 150 PPM p.s	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	16.00	1.15	31.00	2.52	15.00	2.65	18.00	2.00	21.00	1.15	25.00	2.00
Cedar Wood Oil	31.00	1.15	10.00	1.73	28.00	1.53	18.00	4.16	32.00	2.08	35.00	2.00
Cinnamon Oil	6.00	1.53	6.00	1.15	8.00	1.53	8.00	1.00	12.00	1.53	12.00	2.00
Clove Oil	9.00	1.00	7.00	1.53	6.00	0.58	8.00	0.58	10.00	2.52	7.00	3.21
Rosemary Oil	6.00	0.58	7.00	0.58	8.00	1.53	7.00	0.58	9.00	2.52	11.00	2.00
Sesame Oil	15.00	1.53	16.00	4.04	13.00	2.00	12.00	4.93	11.00	1.00	25.00	5.57
Wheat Germ Oil	11.00	1.00	8.00	1.00	6.00	2.52	5.00	1.15	9.00	2.52	8.00	1.53
Control 300 ppm P.S	8.00	2.00	9.00	0.58	9.00	1.00	8.00	0.58	9.00	0.58	13.00	2.52
Control No Preservatives	17.00	3.61	23.00	3.79	37.00	6.00	50.00	0.00	100.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.4. Total viable count in labneh at 300 µl\kg oil concentration and150 ppm P.S

When comparing the positive control and negative control, with labneh samples at a concentration of 150 ppm potassium sorbate and 300 µl\kg E.Os, both almond sweet oil and cedar wood oil both of them didn't show obvious effect on the labneh sample. The bacterial count was always lower than the negative control showing the effectiveness of the essential oil.

Concerning cinnamon oil results showed that there was obvious decrease in bacterial count lower than positive control during the storage period till the third week, while in fourth, fifth and last week the bacteria count is a bit higher than positive control. This count was always lower than the negative control showing the effectiveness of the essential oil. (See table 4.4).

When clove oil was used results showed that there was obvious decrease in bacterial count lower than positive control during the storage period.

Rosemary oil results showed a fluctuation in the number of bacteria till the fourth week, but in the last two weeks bacteria count was lower than positive control. The bacterial count was always lower than the negative control showing the effectiveness of the essential oil.

Sesame oil and wheat germ oil didn't show obvious effect on the labneh sample compared to positive control and negative control. (See table 4.4).

It is noteworthy to mention that all the essential oils except sesame oil and wheat germ oil at this concentration showed bacterial count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the bacterial count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E.Os was compared, the best E.O to be used to control TVC was: clove oil followed by rosemary oil, cinnamon oil, almond sweet oil and finally cedar wood oil. (See table 4.4).

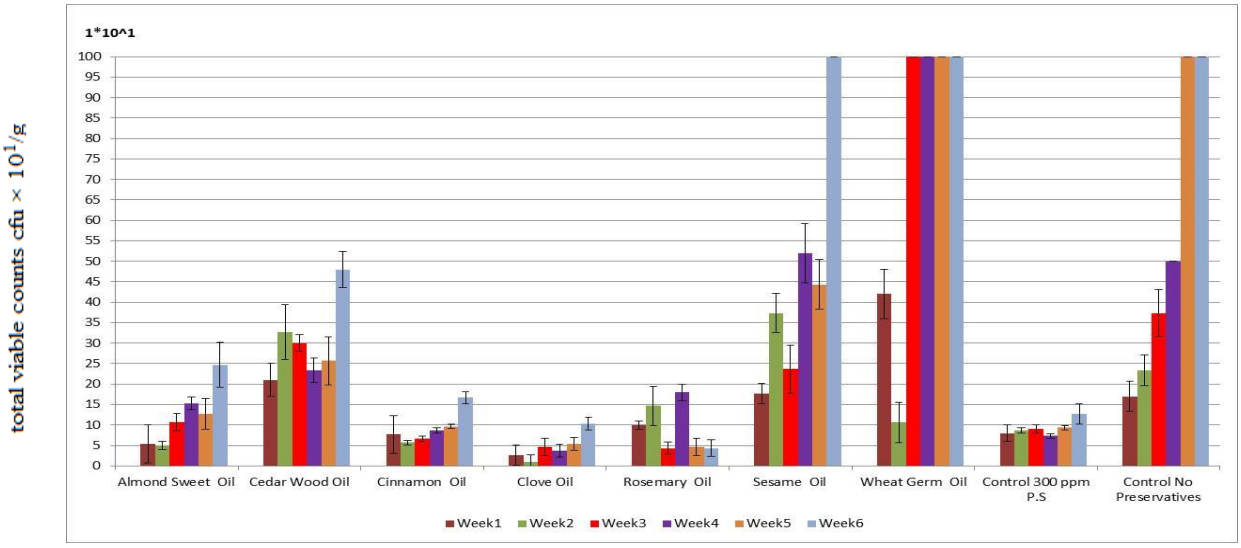


Figure 4.4: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 300 µl\kg oil concentration and150 ppm potassium sorbate on the counts of Total viable counts. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.4: Microbiological analysis of total viable counts of labneh during 6 weeks at 300 µl\kg oil concentration and 150 ppm p.s

T.V.C with 300 µl\kg oil Con. and 150 PPM p.s	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	5.00	5.00	5.00	1.00	11.00	2.08	15.00	1.53	13.00	3.79	25.00	5.51
Cedar Wood Oil	21.00	4.00	33.00	6.66	30.00	2.00	23.00	3.06	26.00	5.86	48.00	4.36
Cinnamon Oil	8.00	4.51	6.00	0.58	7.00	0.58	9.00	0.58	10.00	0.58	17.00	1.53
Clove Oil	3.00	2.52	1.00	1.73	5.00	2.08	4.00	1.53	5.00	1.53	10.00	1.53
Rosemary Oil	10.00	1.00	15.00	5.00	4.00	1.53	18.00	2.00	5.00	2.08	4.00	2.08
Sesame Oil	18.00	2.52	37.00	5.00	24.00	5.86	52.00	7.21	44.00	6.03	100.00	0.00
Wheat Germ Oil	42.00	6.00	11.00	4.93	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00
Control 300 ppm P.S	8.00	2.00	9.00	0.58	9.00	1.00	8.00	0.58	9.00	0.58	13.00	2.52
Control No Preservatives	17.00	3.61	23.00	3.79	37.00	6.00	50.00	0.00	100.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.5. Total viable count in labneh at 350 µl\kg oil concentration and150 ppm P.S

When comparing the positive control and negative control, with labneh samples at a concentration of 150 ppm potassium sorbate and 350 µl\kg E.O , almond sweet oil, cedar wood oil, wheat germ oil and cinnamon oil didn't show obvious effect on the labneh samples, The bacterial count is less than negative control.(See table 4.5).

When clove oil was the used result showed that there was obvious decrease in bacterial count lower than positive control during the storage period except in first week. There was a continuous effect untill the end of storage period due to the effect of oil, indicating that the inhibitory effect needs time to be more effective. (See table 4.5).

Rosemary oil showed fluctuation in the number of bacteria till the third week, rosemary affect on labneh sample in the last two weeks, indicating that the inhibitory effect needs time to be more effective. The bacterial count was always lower than the negative control showing the effectiveness of the essential oil. (See table 4.5).

Sesame oil didn't show obvious effect on the labneh sample, even increased during the six weeks, but was lower than negative control in first and second weeks, meanwhile bacteria number increased in the last four weeks.

It is noteworthy to mention that all the essential oils except sesame oil at this concentration showed bacterial count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the bacterial count when it present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

This shows the effect of essential oils in labneh preservation and these combinations of natural preservative with synthetic one is better than synthetic preservative alone

When E.Os were compared, the best E.O to be used to control TVC was: clove oil followed by rosemary oil, cinnamon oil, cedar wood oil and finally almond sweet oil and wheat germ oil. (See table 4.5).

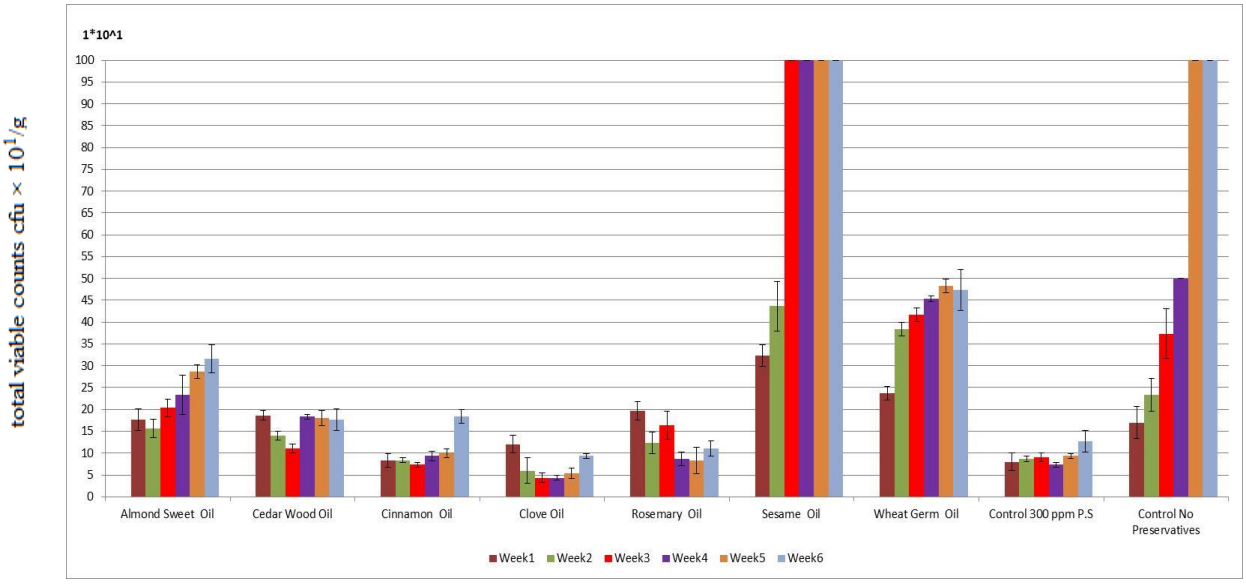


Figure 4.5: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 350 µl\kg oil concentration and150 ppm potassium sorbate on the counts of Total viable counts. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.5: Microbiological analysis of total viable counts of labneh during 6 weeks at 350 µl\kg oil concentration and 150 ppm p.s.

T.V.C with 350 µl\kg oil Con. and 150 PPM p.s	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	18.00	2.52	16.00	2.08	20.00	2.08	23.00	4.51	29.00	1.53	32.00	3.21
Cedar Wood Oil	19.00	1.15	14.00	1.00	11.00	1.00	18.00	0.58	18.00	1.73	18.00	2.52
Cinnamon Oil	8.00	1.53	8.00	0.58	8.00	0.58	9.00	1.15	10.00	1.00	18.00	1.53
Clove Oil	12.00	2.00	6.00	3.00	4.00	1.15	4.00	0.58	5.00	1.15	9.00	0.58
Rosemary Oil	110.00	2.08	12.00	2.52	16.00	3.21	9.00	1.53	8.00	3.06	11.00	1.73
Sesame Oil	32.00	2.52	44.00	6.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00
Wheat Germ Oil	24.00	1.53	38.00	1.53	42.00	1.53	45.00	0.58	48.00	1.53	48.00	5.00
Control 300 ppm P.S	8.00	2.00	9.00	0.58	9.00	1.00	8.00	0.58	9.00	0.58	13.00	2.52
Control No Preservatives	17.00	3.61	23.00	3.79	37.00	6.00	50.00	0.00	100.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.6. Mold content in labneh at 150 µl\kg oil concentration and150 ppm P.S

When comparing the positive control and negative control, with labneh samples at a concentration of 150 ppm potassium sorbate and 150 µl\kg E.Os, almond sweet oil and cedar wood oil, results showed that there was obvious decrease in mold content in labneh samples, except in the first three weeks, indicating that the inhibitory effect needs time to be more effective. The mold count was less than negative control in all weeks. (See table 4.6).

Cinnamon oil, rosemary oil, sesame oil and wheat germ didn't show obvious effect on the labneh sample compared to positive control. The mold count is less than negative control. (See table 4.6).

When clove oil was used, the results showed that there was relative reduction in mold number lower than positive control during the storage period.

It is noteworthy to mention that all the essential oils at this concentration showed mold count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the mold count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E.Os were compared, the best E.O to be used to control mold was: clove oil followed by rosemary oil, cinnamon oil, cedar wood oil and finally almond sweet oil, sesame oil and wheat germ oil. (See table 4.6).

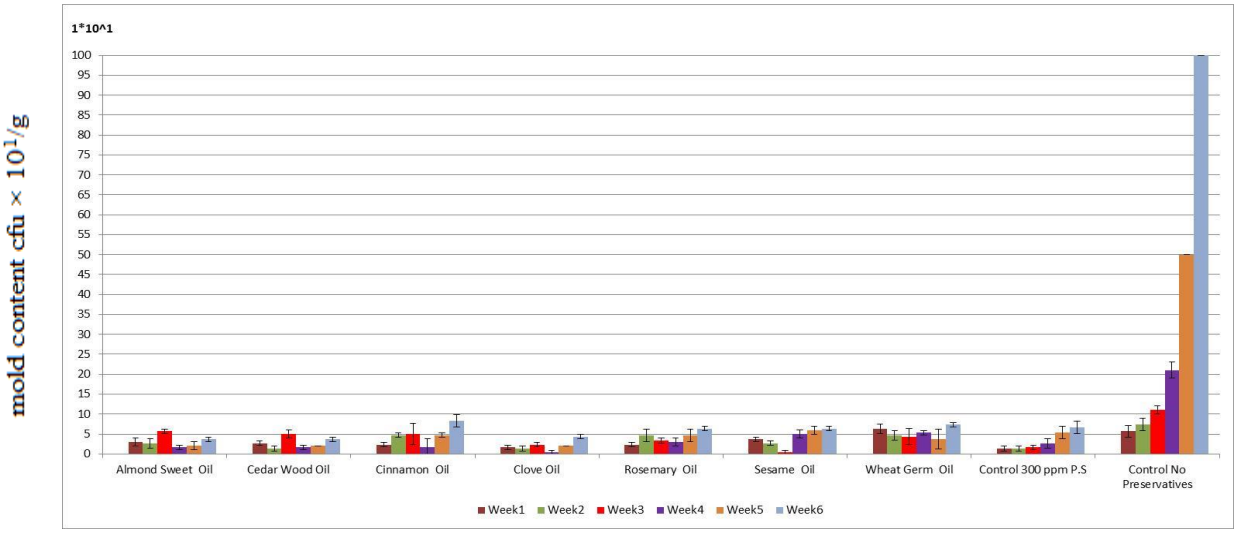


Figure 4.6: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 150 µl\kg oil concentration and150 ppm potassium sorbate on the counts of mold. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.6: Microbiological analysis of mold content of of labneh during 6 weeks at 150 µl\kg oil concentration and 150 ppm p.s

Mold with 150 µl\kg oil Con. and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	3.00	1.00	3.00	1.15	6.00	0.58	2.00	0.58	2.00	1.00	4.00	0.58
Cedar Wood Oil	3.00	0.58	1.00	0.58	5.00	1.00	2.00	0.58	2.00	0.00	4.00	0.58
Cinnamon Oil	2.00	0.58	5.00	0.58	5.00	2.65	2.00	2.08	5.00	0.58	8.00	1.53
Clove Oil	2.00	0.58	1.00	0.58	2.00	0.58	1.00	0.58	2.00	0.00	4.00	0.58
Rosemary Oil	2.00	0.58	5.00	1.53	3.00	0.58	3.00	1.00	5.00	1.53	6.00	0.58
Sesame Oil	4.00	0.58	3.00	0.58	1.00	0.58	5.00	1.00	6.00	1.00	6.00	0.58
Wheat Germ Oil	6.00	1.15	5.00	1.15	4.00	2.08	5.00	0.58	4.00	2.52	8.00	0.58
Control 300 ppm P.S	1.00	0.58	1.00	0.58	2.00	0.58	3.00	1.15	5.00	1.53	7.00	1.53
Control No Preservatives	6.00	1.53	8.00	1.53	11.00	1.00	21.00	2.00	50.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.7. Mold content in labnehat 200 µl\kg oil concentration and150 ppm P.S

When comparing the positive control and negative control, with labneh samples at a concentration of 150 ppm potassium sorbate and 200 µl\kg E.Os, almond sweet oil results showed that there was obvious decrease in mold content during the storage period of labneh sample (6weeks).(See table 4.7).

Concerning cedar wood oil, cinnamon oil and wheat germ oil didn't show obvious effect on the labneh sample. The mold count was less than negative control. (See table 4.7).

When clove oil and rosemary oil were used, results showed that there was obvious decrease in mold number to a lower level than positive control during the storage period with best inhibition growth at first week in clove, and at first week with most efficient results at week three where reduction rate was of 100% when rosemary oil was used. (See table 4.7).

Concerning sesame oil when compared with the positive control, results showed that there was obvious decrease in mold content during the storage except the third week mold content is a bit higher than positive control. The mold count was lower than the negative control showing the effectiveness of the essential oil. (See table 4.7).

It is noteworthy to mention that all the essential oils at this concentration showed mold count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the mold count when it is present with synthetic preservative (potassium sorbate) at half concentration (150ppm) compared to that usually used for labneh preservation.

When E.Os were compared, the best E.O to be used to control mold was: clove oil followed by rosemary and sesame oil. (See table 4.7).

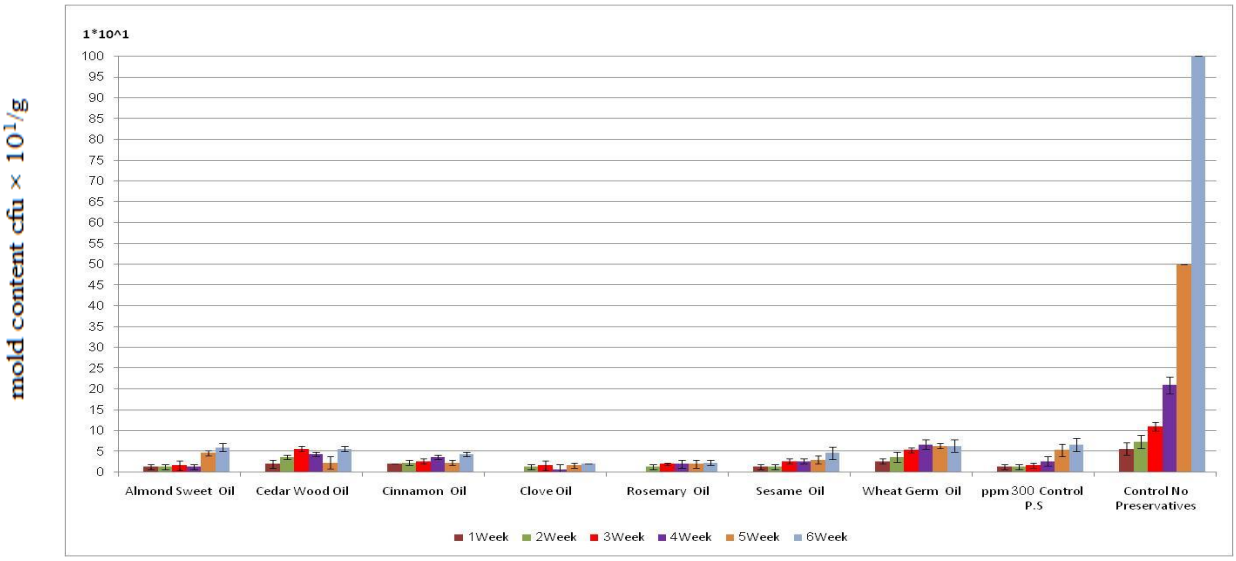


Figure 4.7: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 200 µl\kg oil concentration and150 ppm potassium sorbate on the counts of mold. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.7: Microbiological analysis of mold content of of labneh during 6 weeks at 200 µl\kg oil concentration and 150 ppm p.s.

Mold with 200 µl\kg oil Con. and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	1.00	0.58	1.00	0.58	2.00	1.15	1.00	0.58	5.00	0.58	6.00	1.00
Cedar Wood Oil	2.00	1.00	4.00	0.58	6.00	0.58	4.00	0.58	2.00	1.53	6.00	0.58
Cinnamon Oil	2.00	0.00	2.00	0.58	3.00	0.58	4.00	0.58	2.00	0.58	4.00	0.58
Clove Oil	<10	0.00	1.00	0.58	2.00	1.15	1.00	1.15	2.00	0.58	2.00	0.00
Rosemary Oil	<10	0.00	1.00	0.58	2.00	0.58	2.00	1.00	2.00	1.00	2.00	0.58
Sesame Oil	1.00	0.58	1.00	0.58	3.00	0.58	3.00	0.58	3.00	1.00	5.00	1.53
Wheat Germ Oil	3.00	0.58	4.00	1.15	5.00	0.58	7.00	1.15	6.00	0.58	6.00	1.53
Control 300 ppm P.S	1.00	0.58	1.00	0.58	2.00	0.58	3.00	1.15	5.00	1.53	7.00	1.53
Control No Preservatives	6.00	1.53	8.00	1.53	11.00	1.00	21.00	2.00	50.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.8. Mold content in labneh at 250 µl\kg oil concentration and150 ppm potassium sorbate

When comparing the positive Control and negative control, with labneh samples at a concentration of 150 ppm potassium sorbate and 250 µl\kg E.Os, almond sweet oil and cedar wood oil, clove oil, rosemary oil, sesame oil and wheat germ oil respectively, didn't show obvious effect on the labneh sample. The mold count was less than negative control. (See table 4.8).

Cinnamon oil results showed that there was obvious decrease in mold number and even lower than positive control during the storage period.

It is noteworthy to mention that all the essential oils at this concentration showed mold count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the mold count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E.Os were compared, the best E.O to be used to control mold was: cinnamon oil followed by clove oil, and rosemary oil. (See table 4.8).

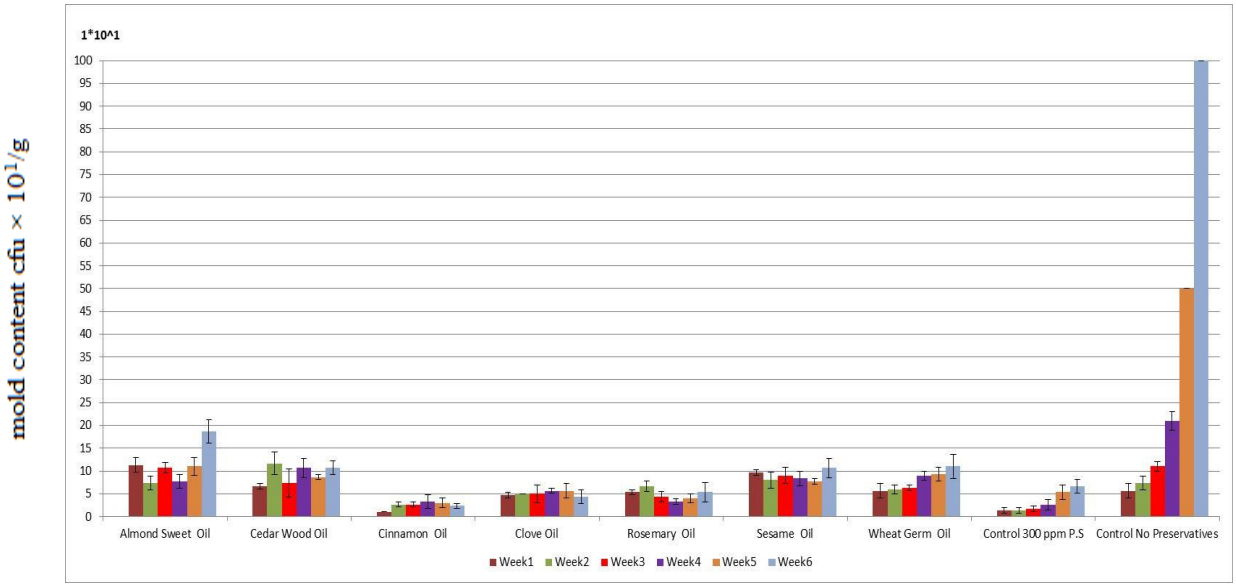


Figure 4.8: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 250 µl\kg oil concentration and150 ppm potassium sorbate on the counts of mold. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.8: Microbiological analysis of mold content of of labneh during 6 weeks at 250 µl\kg oil concentration and 150 ppm p.s.

Mold with 250 µl\kg oil Concentration and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	12.00	1.53	8.00	1.53	11.00	1.15	8.00	1.53	11.00	2.00	19.00	2.52
Cedar Wood Oil	7.00	0.58	12.00	2.52	8.00	3.06	11.00	2.08	9.00	0.58	11.00	1.53
Cinnamon Oil	1.00	0.00	3.00	0.58	3.00	0.58	3.00	1.53	3.00	1.00	2.00	0.58
Clove Oil	5.00	0.58	5.00	0.00	5.00	2.00	6.00	0.58	6.00	1.53	4.00	1.53
Rosemary Oil	5.00	0.58	7.00	1.15	4.00	1.15	3.00	0.58	4.00	1.00	5.00	2.08
Sesame Oil	10.00	0.58	8.00	1.73	9.00	1.73	8.00	1.53	8.00	0.58	11.00	2.08
Wheat Germ Oil	6.00	1.53	6.00	1.00	6.00	0.58	9.00	1.00	9.00	1.53	11.00	2.65
Control 300 ppm P.S	1.00	0.58	1.00	0.58	2.00	0.58	3.00	1.15	5.00	1.53	7.00	1.53
Control No Preservatives	6.00	1.53	8.00	1.53	11.00	1.00	21.00	2.00	50.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.9. Mold content in labneh at 300 µl\kg oil concentration and 150 ppm potassium sorbate

When comparing the positive control and negative control, with labneh samples at a concentration of 150 ppm potassium sorbate and 300 µl\kg E.Os, almond sweet oil and cedar wood didn't show obvious effect on the labneh sample. The mold count was always lower than the negative control showing the effectiveness of the essential oil. (See table 4.9).

Concerning cinnamon oil and clove oil when compared with the positive control, results showed that there was obvious decrease in mold number lower than positive control during the storage period, except in the third week where mold content higher than positive control when cinnanon oil is used. (See table 4.9).

Rosemary oil didn't show obvious effect on the labneh sample compared to positive control at first forur weeks, but growth rate decreased significantly till the end of storage time, with results comparable to positive control, indicating that the inhibitory effect needs time to be more effective. The mold count was always lower than the negative control showing the effectiveness of the essential oil. (See table 4.9).

Sesame oil didn't show obvious effect on the labneh sample compared to positive control with best inhibition growth at fourth week the mold content was lower than positive control. The mold count was less than negative control.

Wheat germ oil didn't showed obvious effect on the labneh sample and lower than negative control till fourth weeks, but in fifth and last week mold content increase as the increased in negative control. (See table 4.9).

It is noteworthy to mention that all the essential oils at this concentration showed mold count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the mold count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E.Os were compared, the best E.O to be used to control mold was: cinnamon oil and clove oil followed by rosemary oil. (See table 4.9).

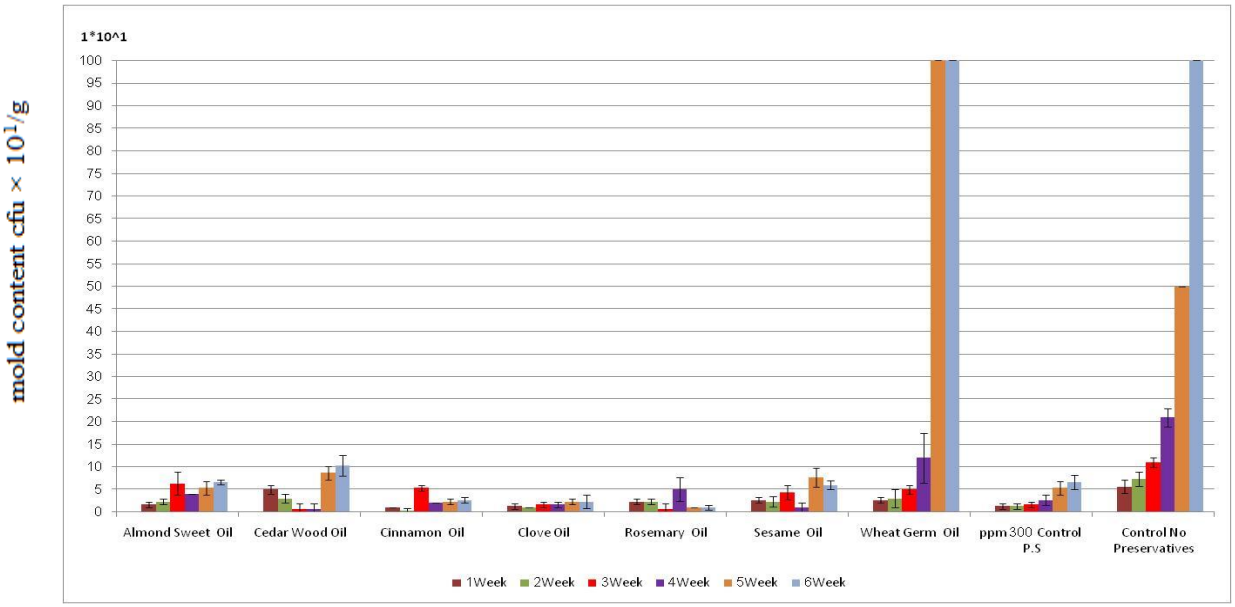


Figure 4.9: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 300µl\kg oil concentration and150 ppm potassium sorbate on the counts of mold. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.9: Microbiological analysis of mold content of labneh during 6 weeks at 300 µl\kg oil concentration and 150 ppm p.s.

Mold with 300 µl\kg oil Conc. and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	2.00	0.58	2.00	0.58	6.00	2.52	4.00	0.00	5.00	1.53	7.00	0.58
Cedar Wood Oil	5.00	1.00	3.00	1.00	1.00	1.15	1.00	1.15	9.00	1.53	10.00	2.31
Cinnamon Oil	1.00	0.00	1.00	0.58	5.00	0.58	2.00	0.00	2.00	0.58	3.00	0.58
Clove Oil	1.00	0.58	1.00	0.58	2.00	0.58	2.00	0.58	2.00	0.58	2.00	1.53
Rosemary Oil	2.00	0.58	2.00	0.58	1.00	1.15	5.00	2.65	1.00	0.00	1.00	0.58
Sesame Oil	3.00	0.58	2.00	1.15	4.00	1.53	1.00	1.00	8.00	2.08	6.00	1.00
Wheat Germ Oil	3.00	0.58	3.00	2.00	5.00	1.00	12.00	5.57	100.00	0.00	100.00	0.00
Control 300 ppm P.S	1.00	0.58	1.00	0.58	2.00	0.58	3.00	1.15	5.00	1.53	7.00	1.53
Control No Preservatives	6.00	1.53	8.00	1.53	11.00	1.00	21.00	2.00	50.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.10. Mold content in labnehat 350 µl\kg oil concentration and 150 ppm potassium sorbate

When comparing the positive control and negative control, with labneh samples at a concentration of 150 ppm potassium sorbate and 350 µl\kg E.Os, almond sweet oil and cedar wood oil, didn't show obvious effect on the labneh sample, except the sixth week comparatively lower than positive. (See table 4.10).

Concerning cinnamon oil when compared with the positive control results showed that there was obvious decrease in mold content in fifth and last week, thear was constant multiplication in the first four weeks then declining in the last two weeks. (See table 4.10).

When clove and rosemary oils were used results showed that there was obvious decrease in mold content lower than positive control during the storage period, the most efficient results showed in rosemary oil where reduction rate was of 100%, mold mold did not appears from first to fourth week. Mold grew only in fifth and sixth week even less than positive control.

Sesame oil and wheat germ oil when compared with the positive control didn't show obvious effect on the labneh sample. (See table 4.10).

It is noteworthy to mention that all the essential oils except sesame oil at this concentration showed mold count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the mold count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

This shows the effect of essential oils in labneh preservation and these combinations of natural preservative with synthetic one is better than synthetic preservative alone.

When E.Os were compared, the best E.O to be used to control mold were: rosemary oil and clove oil followed by cinnamon oil. (See table 4.10).

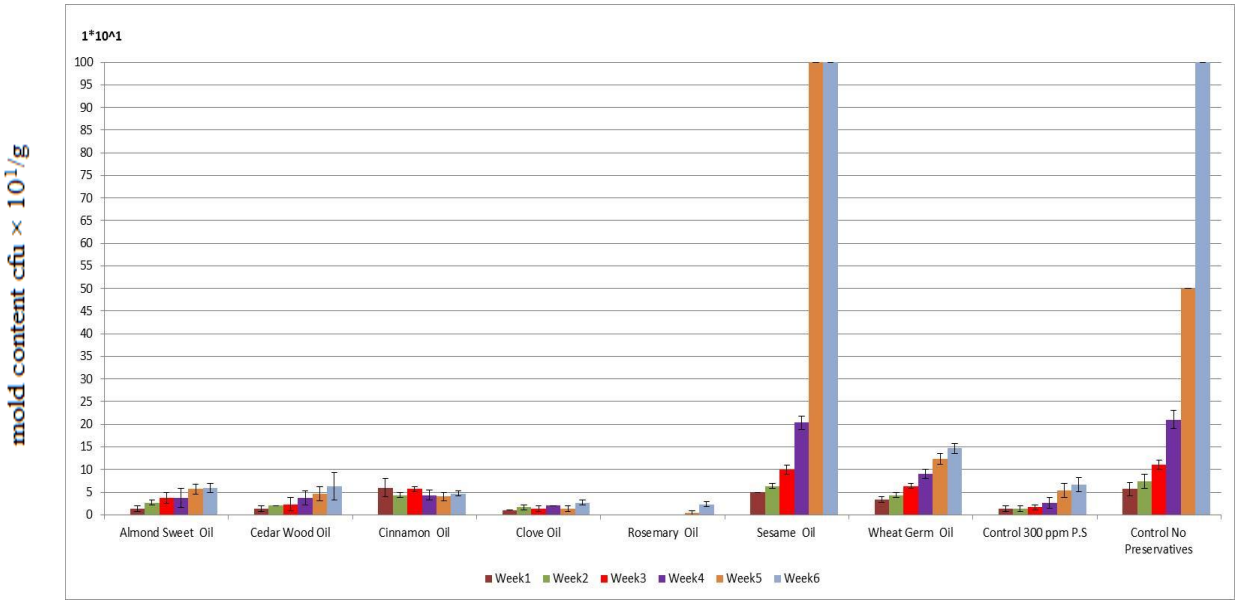


Figure 4.10: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 350µl\kg oil concentration and 150 ppm potassium sorbate on the counts of mold.
The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.10: Microbiological analysis of mold content of labneh during 6 weeks at 350 µl\kg oil concentration and 150 ppm p.s.

Mold with 350 µl\kg oil Con. and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	1.00	0.58	3.00	0.58	4.00	1.15	4.00	2.08	6.00	1.15	6.00	1.00
Cedar Wood Oil	1.00	0.58	2.00	0.00	2.00	1.53	4.00	1.53	5.00	1.53	6.00	3.06
Cinnamon Oil	6.00	2.00	4.00	0.58	6.00	0.58	4.00	1.15	4.00	1.00	4.00	0.58
Clove Oil	1.00	0.00	2.00	0.58	1.00	0.58	2.00	0.00	1.00	0.58	2.00	0.58
Rosemary Oil	<10	0.00	<10	0.00	<10	0.00	<10	0.00	1.00	0.58	2.00	0.58
Sesame Oil	5.00	0.00	6.00	0.58	10.00	1.00	20.00	1.53	100.00	0.00	100.00	0.00
Wheat Germ Oil	3.00	0.58	4.00	0.58	6.00	0.58	9.00	1.00	12.00	1.15	15.00	1.15
Control 300 ppm P.S	1.00	0.58	1.00	0.58	2.00	0.58	3.00	1.15	5.00	1.53	7.00	1.53
Control No Preservatives	6.00	1.53	8.00	1.53	11.00	1.00	21.00	2.00	50.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.11. Yeast content in labneh at 150 µl\kg oil concentration and 150 ppm potassium sorbate

When comparing the positive control and negative control, with labneh samples at a concentration of 150 ppm potassium sorbate and 150 µl\kg E.Os, almond sweet oil and cedar wood oil results showed that there was obvious decrease in yeast number lower than positive control during the storage period, almond sweet oil has the best inhibition growth at first, second, and third weeks. (See table 4.11).

Concerning cinnamon oil, clove, rosemary, sesame oil and wheat germ oil results showed that there was obvious decrease in yeast number lower than positive control during the storage period, except in cinnamon oil, second and third weeks, and in clove oil yeast didn't appear in first and second weeks, and in rosemary yeast did not appear in the first week, and in sesame oil yeast did not appear in first, fourth and fifth weeks, and in wheat germ oil yeast did not appear in the first week. (See table 4.11).

It is noteworthy to mention that all the essential oils at this concentration showed yeast count less than the negative control throughout the six weeks. This is a promising result show the effectiveness of essential oils on the yeast count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E.Os were compared, the best E.O to be used to control yeast was: clove oil followed by sesame oil, almond sweet oil, rosemary oil and finally cedar wood oil and wheat germ oil, respectively. (See table 4.11).

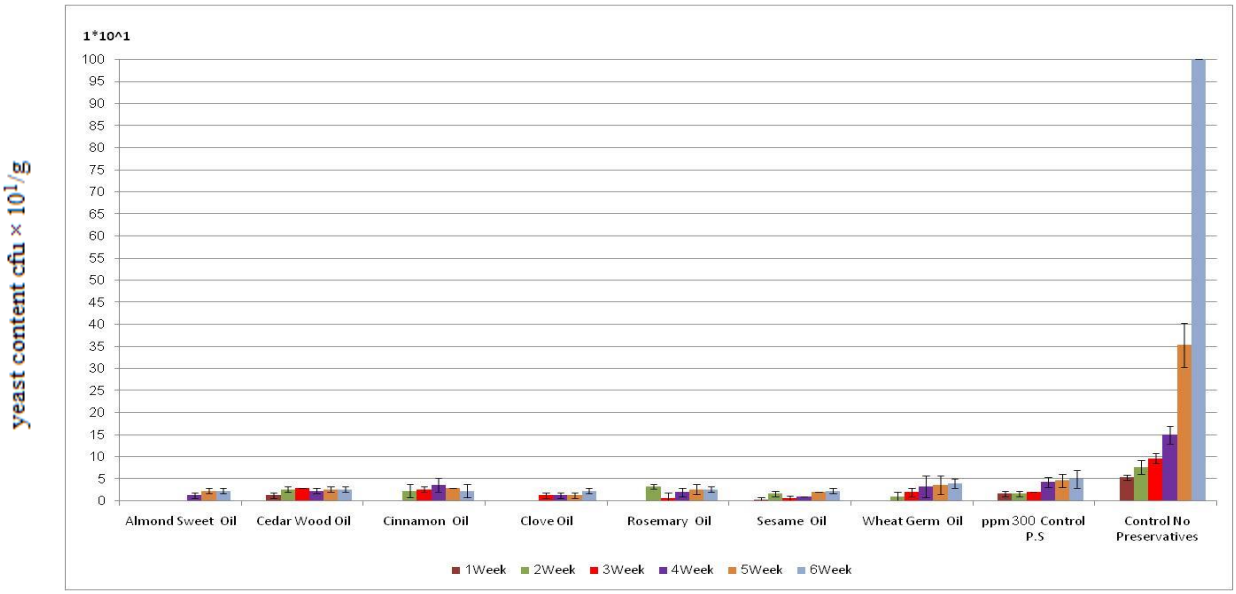


Figure 4.11: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 150 µl\kg oil concentration and150 ppm potassium sorbate on the counts of yeast. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.11: Microbiological analysis of yeast content of labneh during 6 weeks at 150 µl\kg oil concentration and 150 ppm p.s.

Yeast with 150 µl\kg oil Conc. and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	<10	0.00	<10	0.00	<10	0.00	1.00	0.58	2.00	0.58	2.00	0.58
Cedar Wood Oil	1.00	0.58	3.00	0.58	3.00	0.00	2.00	0.58	3.00	0.58	3.00	0.58
Cinnamon Oil	<10	0.00	2.00	1.53	3.00	0.58	4.00	1.53	3.00	0.00	2.00	1.53
Clove Oil	<10	0.00	<10	0.00	1.00	0.58	1.00	0.58	1.00	0.58	2.00	0.58
Rosemary Oil	<10	0.00	3.00	0.58	1.00	1.15	2.00	1.00	3.00	1.15	2.00	0.58
Sesame Oil	1.00	0.58	2.00	0.58	1.00	0.58	1.00	0.00	2.00	0.00	2.00	0.58
Wheat Germ Oil	<10	0.00	1.00	1.00	2.00	1.00	3.00	2.52	4.00	2.08	4.00	1.00
Control 300 ppm P.S	2.00	0.58	2.00	0.58	2.00	0.00	4.00	1.15	5.00	1.53	5.00	2.00
Control No Preservatives	5.00	0.58	8.00	1.53	10.00	1.15	15.00	2.00	35.00	5.03	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.12. Yeast content in labneh at 200 µl\kg oil concentration and 150 ppm potassium sorbate

When comparing the positive control and negative control, with labneh samples at a concentration of 150 ppm potassium sorbate and 200 µl\kg E.Os, when almond sweet oil was used results showed that there was relative decrease in yeast number; because the number of yeast in the sixth week in the labneh sample is similar to the number of yeast in the sixth week in the positive control, the effect of essential oil like positive control effect until the end of period. (See table 4.12).

Concerning cedar wood oil, cinnamon oil, clove oil, rosemary oil results showed that there was obvious decrease in yeast number, and even lower than positive control during the storage period, with most efficient results when used cinnamon oil at week three,four and five where reduction rate was of 100%. (See table 4.12).

Sesame oil when compared with the positive control didn't show obvious effect on the labneh sample compared to positive control in the first four weeks of storage, but growth rate decreased significantly till the end of storage time, with results comparable to positive control. (See table 4.12).

Wheat germ oil didn't show obvious effect on the labneh sample compared to positive control. The yeast count is less than negative control. (See table 4.12).

It is noteworthy to mention that all the essential oils at this concentration showed yeast count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the yeast count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E.Os were compared, the best E.O to be used to control yeast was: cinnamon oil followed by clove oil, cedar wood oil, rosemary oil and sesame oil finally almond sweet oil, respectively. (See table 4.12).

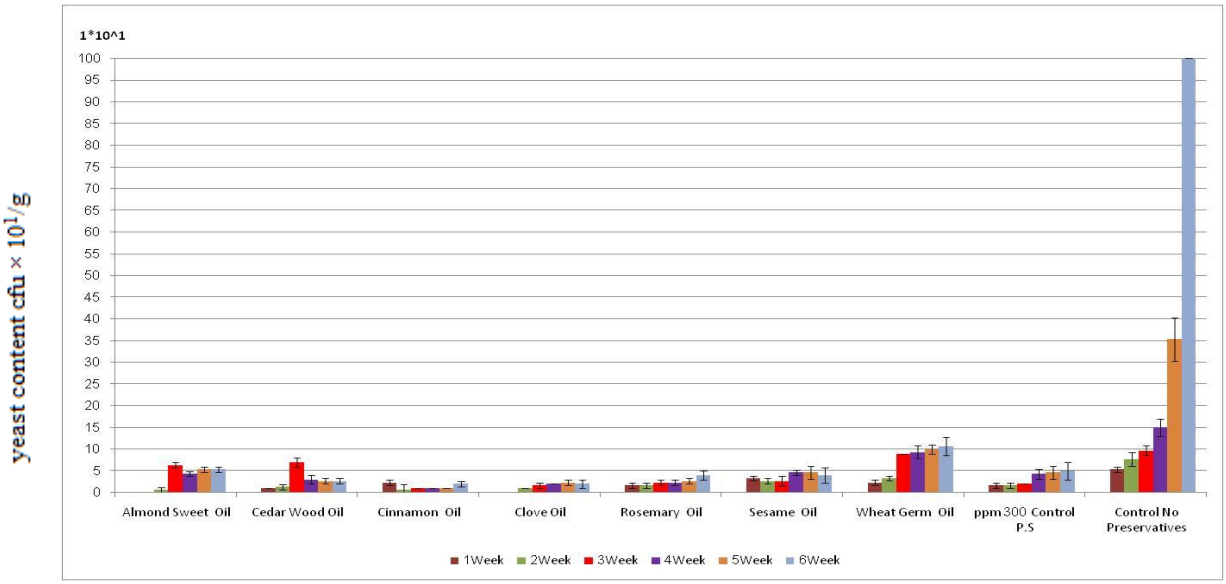


Figure 4.12: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 200 µl\kg oil concentration and150 ppm potassium sorbate on the counts of yeast.

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.12: Microbiological analysis of yeast content of labneh during 6 weeks at 200 µl\kg oil concentration and 150 ppm p.s.

Yeast with 200 µl\kg oil Con. and 150 PPM P.S	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	<10	0.00	1.00	0.58	6.00	0.58	4.00	0.58	5.00	0.58	5.00	0.58
Cedar Wood Oil	1.00	0.00	1.00	0.58	7.00	1.00	3.00	1.00	3.00	0.58	3.00	0.58
Cinnamon Oil	2.00	0.58	1.00	1.15	1.00	0.00	1.00	0.00	1.00	0.00	2.00	0.58
Clove Oil	<10	0.00	1.00	0.00	2.00	0.58	2.00	0.00	2.00	0.58	2.00	1.00
Rosemary Oil	2.00	0.58	2.00	0.58	2.00	0.58	2.00	0.58	3.00	0.58	4.00	1.00
Sesame Oil	3.00	0.58	3.00	0.58	3.00	1.15	5.00	0.58	5.00	1.53	4.00	1.73
Wheat Germ Oil	2.00	0.58	3.00	0.58	9.00	0.00	9.00	1.53	10.00	1.00	11.00	2.08
Control 300 ppm P.S	2.00	0.58	2.00	0.58	2.00	0.00	4.00	1.15	5.00	1.53	5.00	2.00
Control No Preservatives	5.00	0.58	8.00	1.53	10.00	1.15	15.00	2.00	35.00	5.03	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.13. Yeast content in labneh at 250 µl\kg oil concentration and 150 ppm potassium sorbate

When comparing the positive control and negative control, with labneh samples at concentration of 150 ppm potassium sorbate and 250 µl\kg E.Os, almond sweet oil, cedar wood oil and wheat germ oil didn't show obvious effect on the labneh sample compared to positive control. The yeast count was less than negative control. (See table 4.13).

Concerning cinnamon oil, clove oil and rosemary oil didn't show obvious effect on the labneh sample compared to positive control from first till fifth week of storage, but in last week there was relative effect by decreasing yeast number, because the number of yeast in the sixth week in the labneh samples was relatively similar to the sixth week in the positive control. The yeast count was always lower than the negative control showing the effectiveness of the essential oil.

When sesame oil and wheat germ were used no observable effect on yeast content, but it was lower than negative control throughout the six weeks. (See table 4.13).

It is noteworthy to mention that all the essential oils at this concentration showed yeast count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the yeast count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E.Os were compared, the best E.O to be used to control yeast was: cinnamon oil followed by almond sweet oil. (See table 4.13).

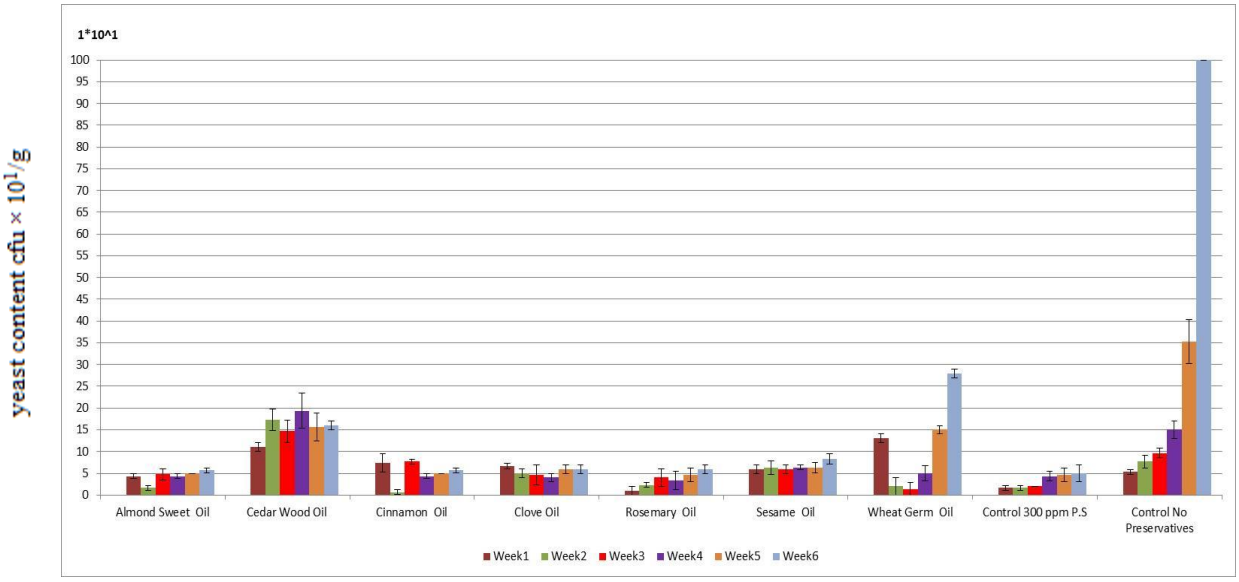


Figure 4.13: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 250 µl\kg oil concentration and150 ppm potassium sorbate on the counts of yeast. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.13: Microbiological analysis of yeast content of labneh during 6 weeks at 250 µl\kg oil concentration and 150 ppm p.s.

Yeast with 250 µl\kg oil Concentration and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	4.00	0.58	2.00	0.58	5.00	1.27	4.00	0.58	5.00	0.00	5.00	0.58
Cedar Wood Oil	11.00	1.00	18.00	2.52	15.00	2.52	19.00	4.04	16.00	3.21	16.00	1.00
Cinnamon Oil	8.00	2.08	1.00	0.58	8.00	0.58	4.00	0.58	5.00	0.00	5.00	0.58
Clove Oil	7.00	0.58	5.00	1.00	5.00	2.31	4.00	1.00	6.00	1.00	6.00	1.00
Rosemary Oil	1.00	1.00	2.00	0.58	4.00	2.00	3.00	2.08	5.00	1.53	6.00	1.00
Sesame Oil	6.00	1.00	6.00	1.53	6.00	1.00	6.00	0.58	6.00	1.15	8.00	1.15
Wheat Germ Oil	13.00	1.00	2.00	2.00	1.00	1.53	5.00	1.73	15.00	1.00	28.00	1.00
Control 300 ppm P.S	2.00	0.58	2.00	0.58	2.00	0.00	4.00	1.15	5.00	1.53	5.00	2.00
Control No Preservatives	5.00	0.58	8.00	1.53	10.00	1.15	15.00	2.00	35.00	5.03	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.14. Yeast content in labneh at 300 µl\kg oil concentration and 150 ppm potassium sorbate

When comparing the positive control and negative control, with labneh sample at concentration of 150 ppm potassium sorbate and 300 µl\kg E.Os, almond sweet oil, cedar wood oil results showed that there was obvious decrease in yeast number lower than positive control during the storage period, except in the first, second, and third weeks which was similar to positive control effect. (See table 4.14).

When cinnamon oil and clove oil were used results showed that there was obvious decrease in yeast number even lower than positive control during the storage period, except in the first and second weeks of storage wlen using cinnamon oil extract and with best inhibition growth at third, fourth and sixth week. The effect of cinnamon oil was similar to positive control sample. (See table 4.14).

Rosemary oil when compared with the positive control results showed that there was obvious decrease in yeast number, with best inhibition growth in the last of storage period at week six, this means that the yeast were killed in the last period due to the influence of oil and needs time to be more effective.

Sesame oil and wheat germ oil do not show obvious effect on the labneh sample compared to positive control. The yeast count is less than negative control. (See table 4.14).

It is noteworthy to mention that all the essential oils except wheat germ oil at this concentration showed yeast count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the yeast count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E.Os were compared, the best E.O to be used to control yeast was: cinnamon oil followed by clove oil, rosemary oil finally almond sweet oil and cedar wood oil, respectively. (See table 4.14).

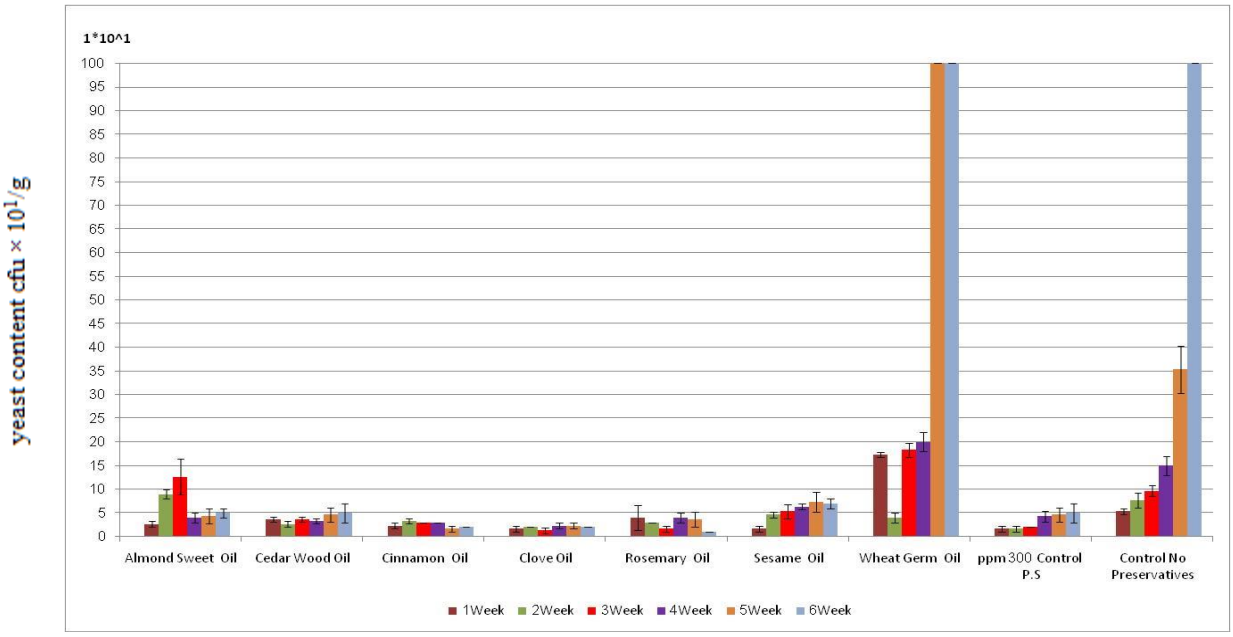


Figure 4.14: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 300 µl\kg oil concentration and150 ppm potassium sorbate on the counts of yeast. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.14: Microbiological analysis of yeast content of labneh during 6 weeks at 300 µl\kg oil concentration and 150 ppm p.s.

Yeast with 300 µl\kg oil Concentration and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	3.00	0.58	9.00	1.00	13.00	3.79	4.00	1.00	4.00	1.53	5.00	1.00
Cedar Wood Oil	4.00	0.58	3.00	0.58	4.00	0.58	3.00	0.58	5.00	1.53	5.00	2.00
Cinnamon Oil	2.00	0.58	3.00	0.58	3.00	0.00	3.00	0.00	2.00	0.58	2.00	0.00
Clove Oil	2.00	0.58	2.00	0.00	1.00	0.58	2.00	0.58	2.00	0.58	2.00	0.00
Rosemary Oil	4.00	2.65	3.00	0.00	2.00	0.58	4.00	1.00	4.00	1.53	2.00	0.00
Sesame Oil	2.00	0.58	5.00	0.58	5.00	1.53	6.00	0.58	8.00	2.08	7.00	1.00
Wheat Germ Oil	18.00	0.58	4.00	1.00	18.00	1.53	20.00	2.00	100.00	0.00	100.00	0.00
Control 300 ppm P.S	2.00	0.58	2.00	0.58	2.00	0.00	4.00	1.15	5.00	1.53	5.00	2.00
Control No Preservatives	5.00	0.58	8.00	1.53	10.00	1.15	15.00	2.00	35.00	5.03	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.15. Yeast content in labneh at 350 µl\kg oil concentration and 150 ppm potassium sorbate

When comparing the positive control and negative control, with labneh samples at a concentration of 150 ppm potassium sorbate and 350 µl\kg E.Os, almond sweet oil results showed that there was relative effect in decreasing yeast number, the yeast number in the last week was relatively similar to the positive control. (See table 4.15).

When cedar wood oil was used results showed that there was obvious decrease in yeast number lower than positive control during the storage period, except in third and fourth weeks which was slightly higher than positive control. (See table 4.15).

Concerning cinnamon oil, clove oil and rosemary oil when compared with the positive control results showed that there was obvious decrease in yeast number lower than positive control during the storage period, with most efficient results at week one and two when used cinnamon oil, at week one and three when used clove oil where reduction rate was of 100%. (See table 4.15).

Sesame oil and wheat germ oil both of them didn't show obvious effect on the labneh sample compared to positive control. The yeast count was less than negative control.

It is noteworthy to mention that all the essential oils except sesame oil at this concentration showed yeast count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the yeast count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E.Os were compared, the best E.O to be used to control yeast was: cinnamon oil and rosemary oil followed by clove oil, cedar wood oil and almond sweet oil, respectively. (See table 4.15).

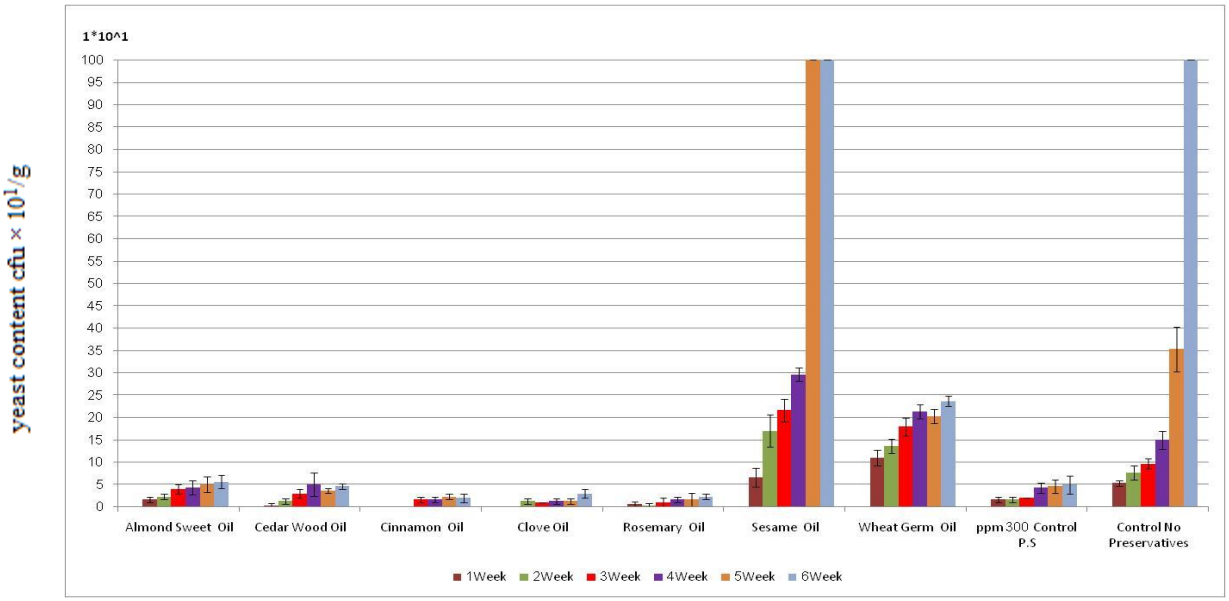


Figure 4.15: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 350 µl\kg oil concentration and150 ppm potassium sorbate on the counts of yeast.

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.15: Microbiological analysis of yeast content of labneh during 6 weeks at 350 µl\kg oil concentration and 150 ppm p.s.

Yeast with 350 µl\kg oil Conc. and 150 PPM P.S	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	2.00	0.58	2.00	0.58	4.00	1.00	4.00	1.53	5.00	1.73	6.00	1.53
Cedar Wood Oil	1.00	0.58	1.00	0.58	3.00	1.00	5.00	2.65	4.00	0.58	4.00	0.58
Cinnamon Oil	<10	0.00	<10	0.00	2.00	0.58	2.00	0.58	2.00	0.58	2.00	1.00
Clove Oil	<10	0.00	1.00	0.58	1.00	0.00	1.00	0.58	1.00	0.58	3.00	1.00
Rosemary Oil	1.00	0.58	1.00	0.58	1.00	1.00	2.00	0.58	2.00	1.53	2.00	0.58
Sesame Oil	7.00	2.08	17.00	3.61	22.00	2.52	21.00	1.53	100.00	0.00	100.00	0.00
Wheat Germ Oil	11.00	1.73	14.00	1.53	18.00	2.00	21.00	1.53	20.00	1.53	24.00	1.15
Control 300 ppm P.S	2.00	0.58	2.00	0.58	2.00	0.00	4.00	1.15	5.00	1.53	5.00	2.00
Control No Preservatives	5.00	0.58	8.00	1.53	10.00	1.15	15.00	2.00	35.00	5.03	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.16. *Staphylococcus aureus* content in labneh at 150 µl\kg oil concentration and 150 ppm potassium sorbate

When comparing the positive control and negative control, with labneh samples at a concentration of 150 ppm p.s and 150µl\kg E.Os, almond sweet oil showed that there was obvious decrease in bacterial count lower than positive control during the storage period, with most efficient results at week one and week four where reduction rate was of 100%. (See table 4.16).

Concerning cedar wood oil and cinnamon oil and sesame oil when compared with positive control results showed that there was obvious decrease in *S. aureus* lower than positive control during the storage period, with most efficient results when used cedar wood oil at week four and five, and at week three when used cinnamon oil where reduction rate was of 100%.(see table 4.16).

Clove oil showed that there was obvious decrease in *S. aureus* count lower than positive control during the storage period, except second and fifth weeks. (See table 4.16).

Concerning rosemary oil and wheat germ oil didn't show obvious effect on the labneh sample compared to positive control. *S. aureus* count is less than negative control. (See table 4.16).

It is noteworthy to mention that all the essential oils at this concentration showed *S. aureus* count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the *S. aureus* count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E.Os were compared, the best E.O to be used to control *S. aureus* was: sesame oil and almond sweet oil followed by cedar wood oil, cinnamon oil and clove oil. (See table 4.16).

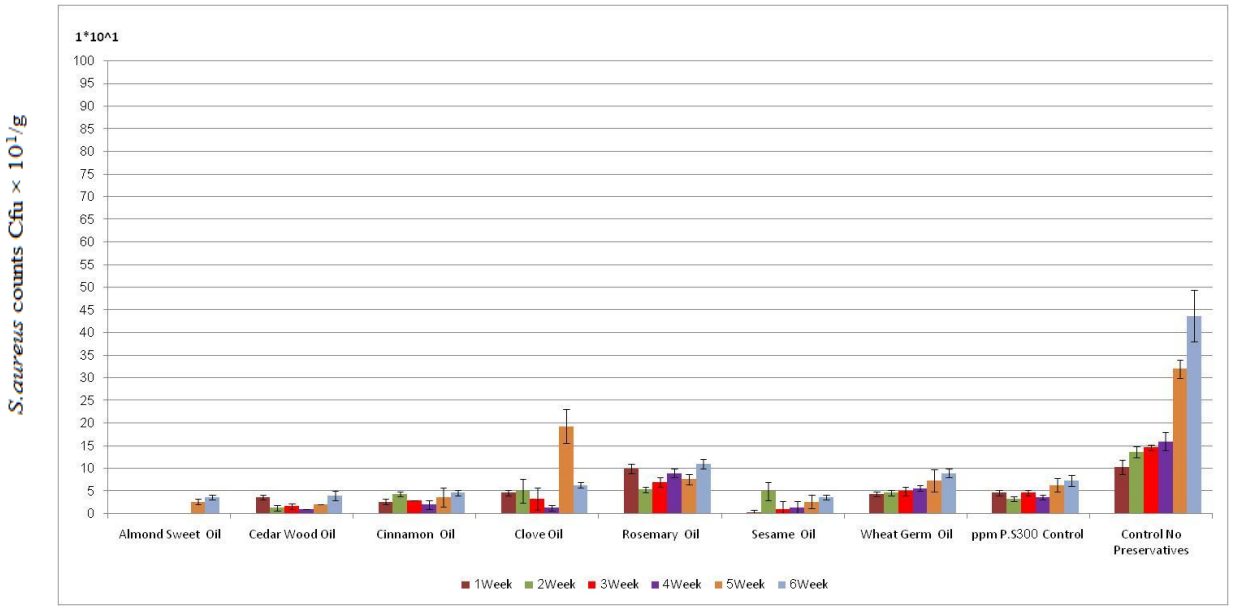


Figure 4.16: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 150 µl\kg oil concentration and150 ppm potassium sorbate on the counts of *Staphylococcus aureus*. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.16: Microbiological analysis of *Staphylococcus aureus* content of labneh during 6 weeks at 150 µl\kg oil concentration and 150 ppm p.s.

S. aureus with 150 µl\kg oil Con. and 150 PPM P.S	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	<10	0.00	<10	0.00	<10	0.00	<10	0.00	3.00	0.58	4.00	0.58
Cedar Wood Oil	4.00	0.58	1.00	0.58	2.00	0.58	1.00	0.00	2.00	0.00	4.00	1.00
Cinnamon Oil	3.00	0.58	4.00	0.58	3.00	0.00	2.00	1.00	4.00	2.08	4.00	0.58
Clove Oil	5.00	0.58	5.00	2.65	3.00	2.52	1.00	0.58	19.00	3.79	6.00	0.58
Rosemary Oil	10.00	1.00	5.00	0.58	7.00	1.00	9.00	1.00	8.00	1.15	11.00	1.00
Sesame Oil	1.00	0.58	5.00	2.00	1.00	1.73	1.00	1.53	3.00	1.53	4.00	0.58
Wheat Germ Oil	4.00	0.58	5.00	0.58	5.00	1.00	6.00	0.58	8.00	2.52	9.00	1.00
Control 300 ppm P.S	5.00	0.58	3.00	0.58	5.00	0.58	4.00	0.58	6.00	1.53	8.00	1.15
Control No Preservatives	10.00	1.53	14.00	1.15	15.00	0.58	16.00	2.00	32.00	2.00	44.00	6.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.17. *Staphylococcus aureus* content in labneh at 200 µl\kg oil concentration and 150 ppm potassium sorbate

When comparing the positive control and negative control, with labneh samples at a concentration of 200 ppm potassium sorbate and 150 µl\kg E.Os, almond sweet oil wheat germ oil didn't show obvious effect on the labneh sample compared to positive control. The bacterial count was less than negative control (See table 4.17).

Concerning cedar wood oil, cinnamon oil, clove oil, rosemary oil and sesame oil results showed that there was obvious decrease in bacterial count lower than positive control during the storage period (six weeks), with most efficient results at week two where reduction rate was of 100% when rosemary oil was used. (See table 4.17).

It is noteworthy to mention that all the essential oils at this concentration showed *S. aureus* count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the *S. aureus* count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E.Os were compared, the best E.O to be used to control *S. aureus* was: cinnamon oil and clove oil followed by rosemary oil and sesame oil. (See table 4.17).

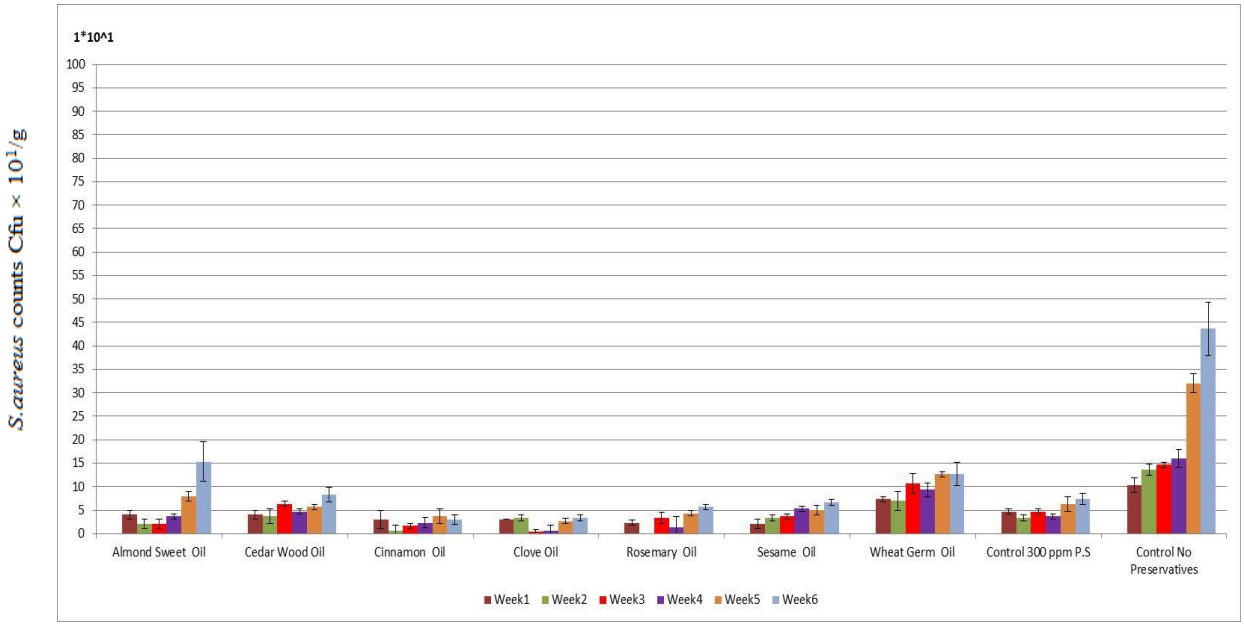


Figure 4.17: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 200 µl\kg oil concentration and150 ppm potassium sorbate on the counts of *Staphylococcus aureus*.
The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.17: Microbiological analysis of *Staphylococcus aureus* content of labneh during 6 weeks at 200 µl\kg oil concentration and 150 ppm p.s.

S. aureus with 200 µl\kg oil Concentration and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	4.00	1.00	2.00	1.00	2.00	1.00	4.00	0.58	8.00	1.00	15.00	4.16
Cedar Wood Oil	4.00	1.00	4.00	1.53	6.00	0.58	5.00	0.58	6.00	0.58	8.00	1.53
Cinnamon Oil	3.00	2.00	1.00	1.15	2.00	0.58	2.00	1.15	4.00	1.53	3.00	1.00
Clove Oil	3.00	0.00	3.00	0.58	1.00	0.58	1.00	1.15	3.00	0.58	3.00	0.58
Rosemary Oil	2.00	0.58	2.00	0.58	3.00	1.15	1.00	2.31	4.00	0.58	5.00	0.58
Sesame Oil	2.00	1.00	3.00	0.58	4.00	0.58	5.00	0.58	5.00	1.00	7.00	0.58
Wheat Germ Oil	8.00	0.58	7.00	2.00	11.00	2.08	9.00	1.53	13.00	0.58	13.00	2.52
Control 300 ppm P.S	5.00	0.58	3.00	0.58	5.00	0.58	4.00	0.58	6.00	1.53	8.00	1.15
Control No Preservatives	10.00	1.53	14.00	1.15	15.00	0.58	16.00	2.00	32.00	2.00	44.00	6.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.18. *Staphylococcus aureus* content in labneh at 250 µl\kg oil concentration and150 ppm potassium sorbate

When comparing the positive control and negative control, with labneh samples at a concentration of 250 ppm potassium sorbate and 150 µl\kg E.Os, almond sweet oil, cedar wood oil, rosemary oil and sesame oil didn't show obvious effect on the labneh samples compared to positive control. The bacterial count was less than negative control samples. (See table 4.18).

Concerning cinnamon oil, clove oil and wheat germ oil when compared with the positive control results showed that there was obvious decrease in *S. aureus* count lower than positive control during the storage period (six weeks). (See table 4.18).

It is noteworthy to mention that all the essential oils at this concentration showed *S. aureus* count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the *S. aureus* count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

When E.Os were compared, the best E.O to be used to control *S. aureus* was: wheat germ oil followed by clove oil and cinnamon oil. (See table 4.18).

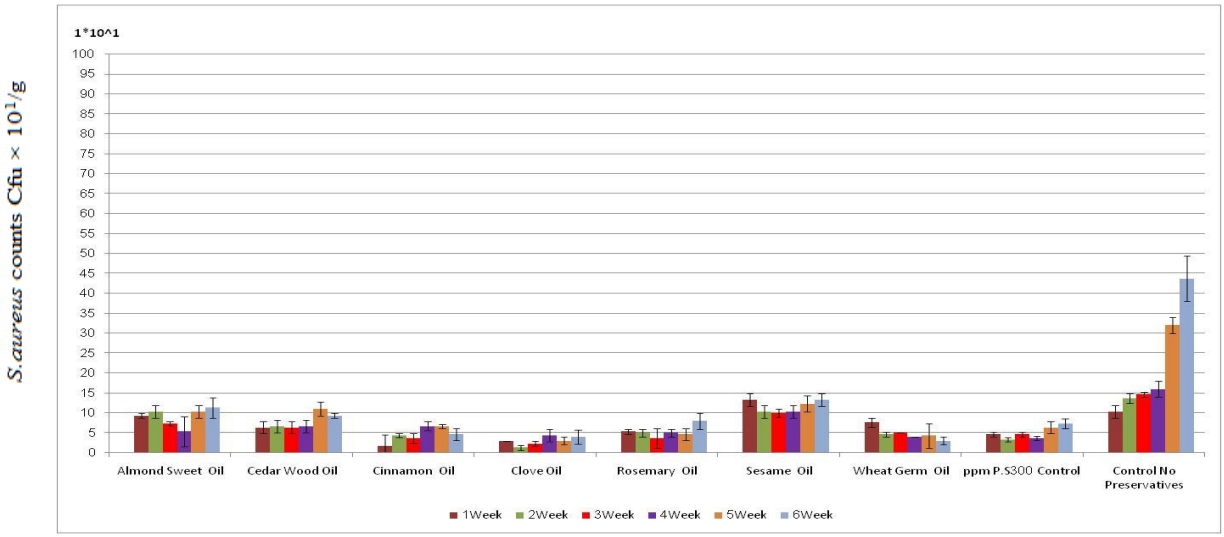


Figure 4.18: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 250 µl\kg oil concentration and150 ppm potassium sorbate on the counts of *Staphylococcus aureus*.

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.18: Microbiological analysis of *Staphylococcus aureus* content of labneh during 6 weeks at 250 µl\kg oil concentration and 150 ppm p.s.

S. aureus with 250 µl\kg oil and 150 PPM P.S	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	9.00	0.58	10.00	1.53	8.00	0.58	5.00	3.79	10.00	1.53	12.00	2.52
Cedar Wood Oil	6.00	1.53	7.00	1.53	6.00	1.53	7.00	1.53	11.00	1.73	9.00	0.58
Cinnamon Oil	2.00	2.89	4.00	0.58	4.00	1.15	7.00	1.15	7.00	0.58	4.00	1.53
Clove Oil	3.00	0.00	1.00	0.58	2.00	0.58	4.00	1.53	3.00	1.00	4.00	1.73
Rosemary Oil	5.00	0.58	5.00	1.00	4.00	2.52	5.00	1.00	5.00	1.53	8.00	2.00
Sesame Oil	13.00	1.53	10.00	1.53	10.00	1.00	10.00	1.53	12.00	2.08	13.00	1.53
Wheat Germ Oil	8.00	1.15	5.00	0.58	5.00	0.00	4.00	0.00	4.00	3.06	3.00	1.00
Control 300 ppm P.S	5.00	0.58	3.00	0.58	5.00	0.58	4.00	0.58	6.00	1.53	8.00	1.15
Control No Preservatives	10.00	1.53	14.00	1.15	15.00	0.58	16.00	2.00	32.00	2.00	44.00	6.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.19. *Staphylococcus aureus* content in labneh at 300 µl\kg oil concentration and 150 ppm potassium sorbate

When comparing the positive control and negative control, with labneh samples at a concentration of 150 ppm potassium sorbate and 300 µl\kg E.Os, when almond sweet oil and cedar wood was used results showed that there was obvious decrease in bacterial count lower than positive control during the storage period (six weeks) except in fourth week, and except in third and forth weeks when use cedar wood oil. (See table 4.19).

Concerning cinnamon oil and clove oil when compared with the positive control, results showed that there was obvious decrease in bacterial count lower than positive control during the storage period (six weeks), except in second week when used cinnamon oil, and except in second and fifth weeks when clove oil was used with best inhibition growth at first and second week. (See table 4.19).

When rosemary oil was compared with the positive control sample, results showed that there was obvious decrease in bacterial count lower than positive control during the storage period (six weeks), except in first and forth weeks which is slightly higher than positive control. but its decreased with time, indicating that the inhibitory effect needs time to be more effective, there is a difference in bacterial number between first and last week, with best inhibition growth at third week. (See table 4.19).

Sesame oil when compared with the positive control results showed that there was obvious decrease in bacterial count lower than positive control during the storage period, because there was a difference in the number of bacteria between first week and last week. (See table 4.19).

Wheat germ oil didn't show obvious effect on the labneh sample compared to positive control, but bacterial count was less than negative control. (See table 4.19).

It is noteworthy to mention that all the essential oils at this concentration showsed *S. aureus* count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the *S. aureus* count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm). When E.Os were compared, the best E.O to be

used to control *S. aureus* was: rosemary oil followed by clove oil, cinnamon oil, cedar wood oil, almond sweet oil and sesame oil, respectively. (See table 4.19).

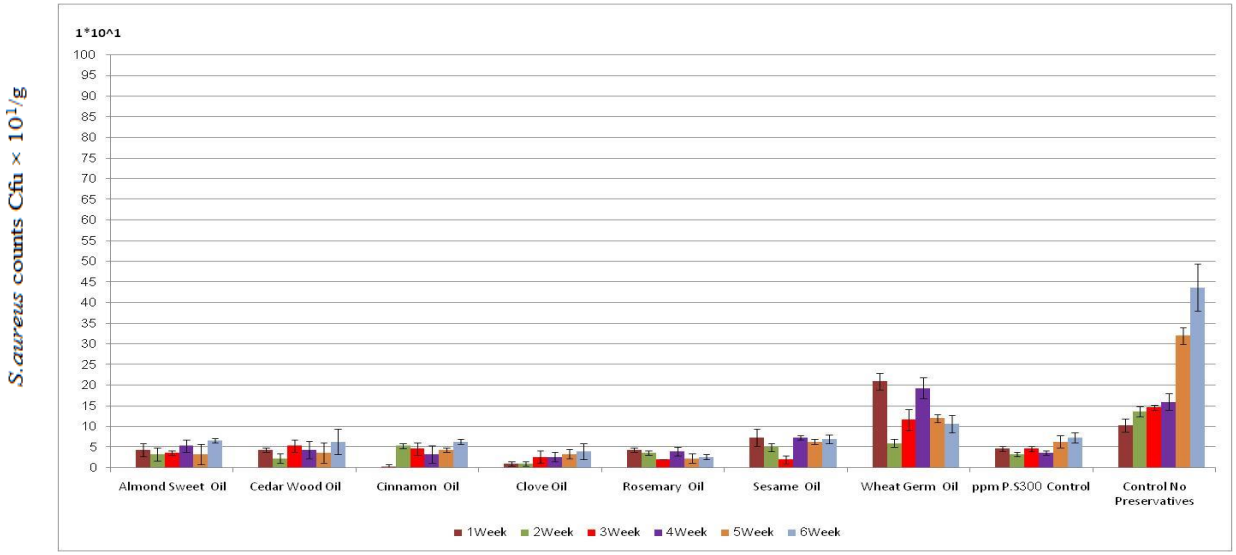


Figure 4.19: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 300 µl\kg oil concentration and150 ppm potassium sorbate on the counts of *Staphylococcus aureus*.
The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.19: Microbiological analysis of *Staphylococcus aureus* content of labneh during 6 weeks at 300 µl\kg oil concentration and 150 ppm p.s.

S. aureus with 300 µl\kg oil Con. and 150 PPM P.S	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	4.00	1.53	3.00	1.53	4.00	0.58	5.00	1.53	3.00	2.52	7.00	0.58
Cedar Wood Oil	4.00	0.58	2.00	1.15	5.00	1.53	4.00	2.08	4.00	2.52	6.00	3.06
Cinnamon Oil	1.00	0.58	5.00	0.58	5.00	1.53	3.00	2.08	4.00	0.58	6.00	0.58
Clove Oil	0.00	0.00	0.00	0.00	3.00	1.53	3.00	1.15	3.00	1.15	4.00	2.00
Rosemary Oil	4.00	0.58	4.00	0.58	2.00	0.00	4.00	1.00	2.00	1.15	3.00	0.58
Sesame Oil	8.00	2.08	5.00	1.00	2.00	1.00	8.00	0.58	6.00	0.58	7.00	1.00
Wheat Germ Oil	21.00	2.00	6.00	1.00	12.00	2.52	19.00	2.52	12.00	1.00	11.00	2.08
Control 300 ppm P.S	5.00	0.58	3.00	0.58	5.00	0.58	4.00	0.58	6.00	1.53	8.00	1.15
Control No Preservatives	10.00	1.53	14.00	1.15	15.00	0.58	16.00	2.00	32.00	2.00	44.00	6.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.20. *Staphylococcus aureus* content in labneh at 350 µl\kg oil concentration and 150 ppm potassium sorbate

When comparing the positive control and negative control, with labneh samples at a concentration of 150 ppm potassium sorbate and 350 µl\kg E.Os, almond sweet oil showed significant decrease in bacterial count in fifth week and last week, while in the first, second, , third and fourth, there was no significant decrease in bacterial count compared to positive control. The bacterial count was always lower than the negative control. (See table 4.20).

Cedar wood oil when compared with positive control didn't show obvious effect on the labneh sample compared to positive control in the first and second weeks of storage, but growth rate decreased significantly till the end of storage time, with results comparable to positive control. The bacterial count was lower than negative control during storage time. (See table 4.20).

Concerning cinnamon oil, clove and rosemary oil results showed that there was obvious decrease in bacterial count lower than positive control during the storage period except second and fifth weeks when clove oil was used, with best inhibition growth when used clove oil at second week, and at first week when used cinnamon oil (See table 4.20).

Sesame oil and Wheat germ oil didn't show obvious effect on the labneh sample compared to positive control. The bacterial count was always lower than the negative control showing the effectiveness of the essential oil. (See table 4.20).

It is noteworthy to mention that all the essential oils except sesame oil at this concentration showed *S. aureus* count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the *S. aureus* count when it is present with synthetic preservative (potassium sorbate) at half concentration (150 ppm) compared to that usually used for labneh preservation (300ppm).

This showed the effect of essential oils in labneh preservation and these combinations of natural preservative with synthetic one was better than synthetic preservative alone.

When E.Os were compared, the best E.O to be used to control *S. aureus* was: rosemary oil followed by clove oil, cinnamon oil and cedar wood oil, respectively. (See table 4.20).

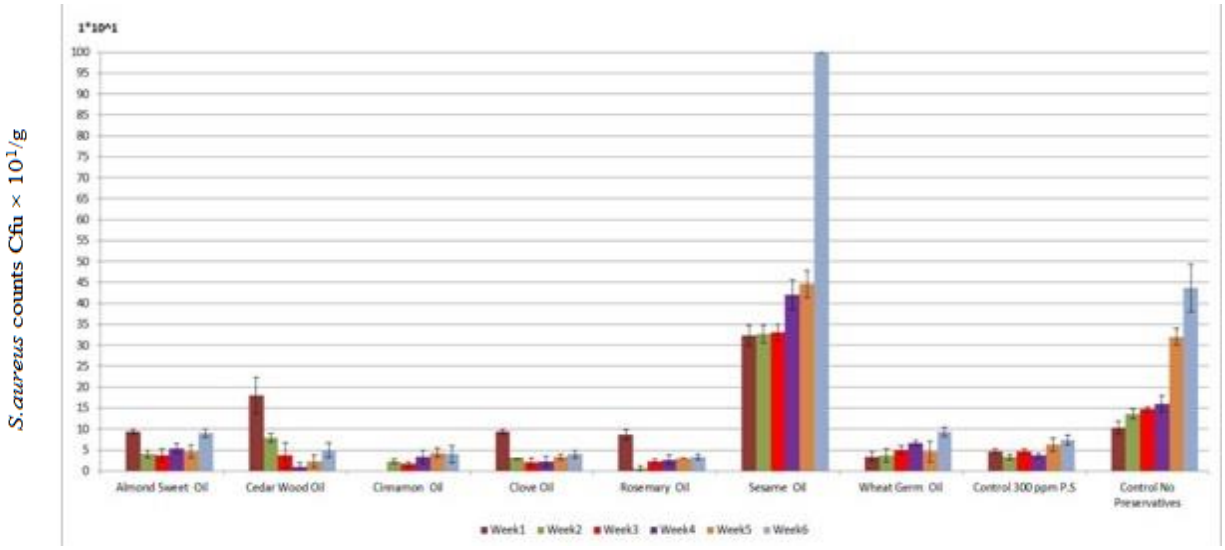


Figure 4.20: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, sesame and wheat germ essential oils at 350 µl\kg oil concentration and150 ppm potassium sorbate on the counts of *Staphylococcus aureus*. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.20: Microbiological analysis of *Staphylococcus aureus* content of labneh during 6 weeks at 350 µl\kg oil concentration and 150 ppm p.s.

S. aureus with 350 µl\kg oil Concentration and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	9.00	0.58	4.00	1.00	4.00	1.53	5.00	1.15	5.00	1.53	9.00	1.00
Cedar Wood Oil	18.00	4.36	8.00	1.00	4.00	3.06	1.00	1.00	2.00	1.53	5.00	1.73
Cinnamon Oil	<10	0.00	2.00	0.58	2.00	0.58	3.00	1.53	4.00	1.15	4.00	2.00
Clove Oil	9.00	0.58	3.00	0.00	2.00	1.00	2.00	1.15	3.00	0.58	4.00	1.00
Rosemary Oil	9.00	1.15	1.00	0.58	2.00	0.58	3.00	1.15	3.00	0.00	3.00	0.58
Sesame Oil	32.00	2.52	33.00	2.08	33.00	2.00	42.00	3.61	45.00	3.21	100.00	0.00
Wheat Germ Oil	3.00	1.15	4.00	1.53	5.00	1.00	7.00	0.58	5.00	2.52	9.00	1.15
Control 300 ppm P.S	5.00	0.58	3.00	0.58	5.00	0.58	4.00	0.58	6.00	1.53	8.00	1.15
Control No Preservatives	10.00	1.53	14.00	1.15	15.00	0.58	16.00	2.00	32.00	2.00	44.00	6.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.1.21. Coliforms content in labneh at 150 µl\kg oil concentration and 150 ppm potassium sorbate

Coliform bacteria were not detected at 150 µl\kg oil concentration and 150 ppm potassium sorbate in all samples.

4.1.1.22. Coliforms content in labneh at 200 µl\kg oil concentration and 150 ppm potassium sorbate

Coliform bacteria were not detected at 200 µl\kg oil concentration and 150 ppm potassium sorbate in all samples.

4.1.1.23. Coliforms content in labneh at 250 µl\kg oil concentration and 150 ppm potassium sorbate

Coliform bacteria were not detected at 250 µl\kg oil concentration and 150 ppm potassium sorbate in all samples.

4.1.1.24. Coliforms content in labneh at 300 µl\kg oil concentration and 150 ppm potassium sorbate

Coliform bacteria were not detected at 300 µl\kg oil concentration and 150 ppm potassium sorbate in all samples.

4.1.1.25. Coliforms content in labneh at 350 µl\kg oil concentration and 150 ppm potassium sorbate

Coliform bacteria were not detected at 350 µl\kg oil concentration and 150 ppm potassium sorbate in all samples.

4.1.1.26. *E. coli* O157:H7 content in labneh at 150 µl\kg oil concentration and 150 ppm potassium sorbate

E. coli bacteria were not detected at 150 µl\kg oil concentration and 150 ppm potassium sorbate in all samples

4.1.1.27. *E. coli* O157:H7 content in labneh at 200 µl\kg oil concentration and 150 ppm potassium sorbate

E. coli bacteria were not detected at 200 µl\kg oil concentration and 150 ppm potassium sorbate in all samples

4.1.1.28. *E. coli* O157:H7 content in labneh at 250 µl\kg oil concentration and 150 ppm potassium sorbate

E. coli bacteria were not detected at 250 µl\kg oil concentration and 150 ppm potassium sorbate in all samples

4.1.1.29. *E. coli* O157:H7 content in labneh at 300 µl\kg oil concentration and 150 ppm potassium sorbate

E. coli bacteria were not detected at 300 µl\kg oil concentration and150 ppm potassium sorbate in all samples

4.1.1.30. *E. coli* O157:H7 content in labneh at 350 µl\kg oil concentration and 150 ppm potassium sorbate

E. coli bacteria were not detected at 350 µl\kg oil concentration and 150 ppm potassium sorbate in all samples

4.1.2. Effect of Almond sweet, Cedar wood, Cinnamon, Clove, Rosemary, Sesame, Eucalyptus and Wheat germ essential oils in labneh, in the absence of synthetic preservative (potassium sorbate) on TVC of bacteria

Different types of E.Os such as almond sweet, cedar wood, cinnamon, clove, eucalyptus, rosemary, sesame and wheat germ oil, were used as preservatives of labneh sample and compared to positive control (potassium sorbate, 300 ppm) which used in labneh manufacturing in Palestine and compared to negative control (no preservatives added). Some essential oils such as cinnamon, clove and Rosemary showed a clear effect with reduction in bacterial, mold and yeast count throughout the six weeks, and others such as almond sweet, cedar wood, sesame and wheat germ did not show obvious effect.

The total viable count (TVC) decreased in the presence of essential oils compared with the positive control samples. This activity is due to the antibacterial effect of essential oils, during storage period. On the other hand, total bacterial viable count reached 13.00×10^1 cfu/g in the positive control sample, while in the best three essential oils clove, rosemary and eucalyptus the total bacterial viable count, such as labneh treated with cinnamon at 400 µl\kg TVC reached 11.00×10^1 cfu/g. While at 500 µl\kg oil concentration the best three essential oils were: cinnamon, rosemary and eucalyptus, total bacterial viable count in cinnamon reached 12×10^1 cfu/g, while 12.00×10^1 cfu/g in rosemary labneh and in eucalyptus labneh TVC reached 14×10^1 cfu/g.

At 600 µl\kg oil concentration the TVC reached 12.00×10^1 cfu/g in rosemary labneh, while in cinnamon labneh TVC reached 13.00×10^1 cfu/g and in eucalyptus labneh TVC reached 13.00×10^1 cfu/g. This activity is due to the antibacterial effect of essential oils, during per storage period.

Quality and shelf life of labneh are evaluated with mold and yeast counts, so molds were detected at small number in labneh containing clove oil, cinnamon oil, rosemary oil and eucalyptus oil throughout the storage period. At the end of the storage period molds number

reached 7.00× 10^1 cfu/g in positive control sample, while in the treated labneh with 300 µl\kg mold content reached 6×10^1 cfu/g for labneh treated with eucalyptus oil. At 400 µl\kg oil concentration the best three essential oils were clove, rosemary and eucalyptus, mold in treated labneh with eucalyptus reached 2× 10^1 cfu/g, while in clove labneh, mold content reached 6.00 × 10^1 cfu/g and in rosemary labneh, mold number reached 5.00× 10^1 cfu/g. At 500 µl\kg oil concentration the best three essential oils were cinnamon, rosemary and eucalyptus, mold in treated labneh with cinnamon reach 5.00× 10^1 cfu/g, while in rosemary and eucalyptus labneh mold number reached 7.00× 10^1 cfu/g, respectively. At 600 µl\kg oil concentration the best four essential oils were cinnamon, clove, rosemary and eucalyptus, mold in treated labneh with cinnamon reached 4.00× 10^1 cfu/g, while in clove labneh mold number reached 6.00× 10^1 cfu/g, and in rosemary and eucalyptus labneh mold number reached 5.00× 10^1 cfu/g, respectively.

Yeast were detected at small number in labneh containing rosemary, and eucalyptus oil throughout and at the end of the storage period, at least like positive control effect. At 300 µl\kg, yeast reached 5.0 × 10^1 cfu/g in the positive control sample, while in labneh treated with eucalyptus, yeast in the sixth week reach 7.00×10^1 cfu/g. At 400 µl\kg oil concentration the best essential oils rosemary and eucalyptus, yeast in labneh treated with eucalyptus reach 4.00×10^1 cfu/g, while in rosemary labneh yeast reached 6.00×10^1 cfu/g. At 500 µl\kg oil concentration the best essential oils cinnamon and clove, yeast in treated labneh reached 6.00×10^1 cfu/g for labneh treated with cinnamon and clove, respectively. At 600 µl\kg oil concentration the best essential oils clove and eucalyptus, yeast in treated labneh with clove reached 5×10^1 cfu/g, while in eucalyptus labneh, yeast reached 5.00×10^1 cfu/g, followed by rosemary and cinnamon yeast number reached 6.00× 10^1 cfu/g, respectively. In other essential oils (Almond sweet, Cedar wood, Sesame and Wheat germ) there was no obvious effect on yeast content.

The results obtained for *Staphylococcus aureus* indicated that bacteria detected at small number compared with positive control, in labneh containing rosemary, and eucalyptus oil throughout and at the of end the storage period. At the end of the storage period *S. aureus*

number reached 8.00 × 10^1 cfu/g in positive control sample, while at 400 µl\kg oil concentration in labneh treated with eucalyptus oil *S. aureus* number reached 9.00× 10^1 cfu/g. At 400 µl\kg oil concentration the best essential oils are rosemary and eucalyptus, *S. aureus* in treated labneh reach 9 × 10^1cfu/g in labneh treated with rosemary and eucalyptus, respectively. At 500 µl\kg oil concentration the best essential oil is cinnamon, *S. aureus* in treated labneh reached 8×10^1 cfu/g, followed by eucalyptus, *S. aureus* number reached 9×10^1 cfu/g. At 600 µl\kg oil concentration the best essential oil is rosemary, *S. aureus* in treated labneh reached 6×10^1 cfu/g, followed by cinnamon 7×10^1 cfu/g, then eucalyptus 8×10^1 cfu/g, then clove 8×10^1 cfu/g. While in labneh containing (Sesame, cedar wood, almond sweet and Wheat germ oils) were didn't show obvious effect.

Both coliform and *E. coli* were not detected in any of the labneh prepared by addition of the respective essential oils. This effect may be attributed to an effect of active compounds in the essential oils; Burt (2004) reported that essential oils contain phenolic compounds that are primarily responsible for their antimicrobial properties.

Our results indicated that these bacteria show a few inhibits at low concentrations of the different essential oils, while, an increase in the oil concentrations lead to decreases in bacterial, yeast and mold counts.

Cinnamon oil, clove oil, rosemary oil and eucalyptus have good antiseptic, antibacterial and antifungal properties, because contain phenols and monoterpene, alcohols, monoterpene, aldehydes esters, lactones and phenylpropenes (K.Hüsnü¸ Buchbauer, 2010).

The phenylpropenes constitute a relatively small part of essential oils, and those that have been most thoroughly studied are eugenol, isoeugenol, vanillin, safrole, and cinnamaldehyde. The comparison of the molecules that are chemically similar to eugenol and isoeugenol indicated that the free hydroxyl groups are important for their activity against bacteria (Laekeman et al., 1990). Furthermore, the antimicrobial activity of phenylpropenes depends on the kind and number of substituents on the aromatic ring, selected microbial strains, and the experimental test parameter such as choice of growth medium, temperature, etc.(Pauli and Kubeczka,2010).

Clove oil contains 80% of eugenol, 4.5% in cinnamon oil and it's the bioactive compound that responsible for antibacterial and antifungal effect. And its antimicrobial activity is linked to its ability to permeabilize the cell membrane and interact with proteins. Eugenol's action on membranes occurs mainly by a non-specific permeabilization (Gill and Holley, 2006a; Hemaiswarya and Doble, 2009).

Eugenol induced minor changes in the fatty acid profile of *Pseudomonas fluorescens*, *E. coli*, *Brochotrix thermosphacta*, *S. enterica*, and *S. aureus*, and cell damages to *E. coli* and *B. thermosphacta* cells (Di Pasquaetal, 2006, 2007).

Consistent with this, eugenol has proven to inhibit the activity of the following enzymes: ATPase, histidine decarboxylase, amylase, and protease. Inhibition of the ATPase may be important for cell killing at high Eugenol concentrations because energy generation needed for cell recovery is impaired (Gill and Holley, 2006a).

The antifungal mode of action of eugenol needs further investigation,but it is known to depend on cell proliferation (Bennis et al., 2004).

Cinnamon oil contains 68% of Cinnamaldehyde and it's the bioactive compound that responsible for antibacterial and antifungal effect, aldehyde groups are reactive and have the ability to cross-link covalently with DNA and proteins through amine groups, thereby interfering with their normal function (Feron et al., 1991). However, the mode of action of cinnamaldehyde, a phenylpropene aldehyde, is inconclusive.

At least three things are believed to occur: At low concentrations, cinnamaldehyde inhibits different enzymes involved in cytokinesis, or to less important cell functions. At higher but sub-lethal concentrations, it acts as an ATPase inhibitor, and at lethal concentrations it perturbs cell membrane. Cinnamaldehyde was suggested to inhibit cytokinesis as a mode of action on *B. cereus* because cells could not separate although septa were present after division (Kwon et al., 2003). At sub-lethal concentrations, cinnamaldehyde gains access to the periplasm and inhibits the activity of trans membrane. ATPase Sub-lethal concentrations of cinnamaldehyde did not affect the integrity of the outer membrane of *E. coli*, but it inhibited growth and bioluminescence of *Photobacterium leiognathi* (13.6–1362 μg/mL; Gill and Holley, 2006 a, b).

Many studies have demonstrated that cinnamaldehyde interacts with the cell membrane, but it is not yet clear how it perturbs membranes.

It is not a general mode of action of cinnamaldehyde to disrupt membranes as illustrated by Di Pasqua et al. (2007).

Among fungi, the primary mode of action of cinnamaldehyde has also been proposed to be inhibition of cell division. This was proposed because cinnamaldehyde inhibited the cell wall synthesizing enzymes in *S. cerevisiae* by functioning as a noncompetitive inhibitor of β1,3 glucan synthase and a mixed inhibitor of chitin synthase isozymes (Bang etal.,2000).

Terpenoids can be sub divided into alcohols, esters, aldehydes, ketones, ethers, phenols, and epoxides. Examples of terpenoids are: thymol, carvacrol, linalool, linalyl acetate, citronellal, piperitone, menthol, and geraniol.

4.1.2.1. Total viable count in labneh at 300 µl\kg oil concentration

When comparing the positive control and negative control, with labneh samples at a concentration of 300 µl\kg E.Os, almond sweet oil, cedar wood oil, sesame oil and wheat germ oil didn't show obvious effect on the labneh sample compared to positive control and negative control .(See table 4.21).

Cinnamon oil didn't show obvious effect on the labneh sample compared to positive control. The bacterial count is less than negative control. (See table 4.21).

Concerning clove oil, eucalyptus and rosemary oil, when compared with the positive control results showed that there was relative decrease in bacterial count, which is higher than positive control, there was a clear effect on the multiplication of bacteria where they grow slowly compared to almond sweet oil and cedar wood. This count was always lower than the negative control showing the effectiveness of the essential oil. (See table 4.21).

It is noteworthy to mention that all the essential oils except almond sweet oil, cedar wood oil, sesame oil and wheat germ oil at this concentration showed bacterial count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the bacterial count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm). This showed the beneficial effect of essential oils in labneh preservation.

When E.Os were compared, the best E.O to be used to control TVC was: eucalyptus oil, followed clove oil, rosemary oil and cinnamon oil. (See table 4.21).

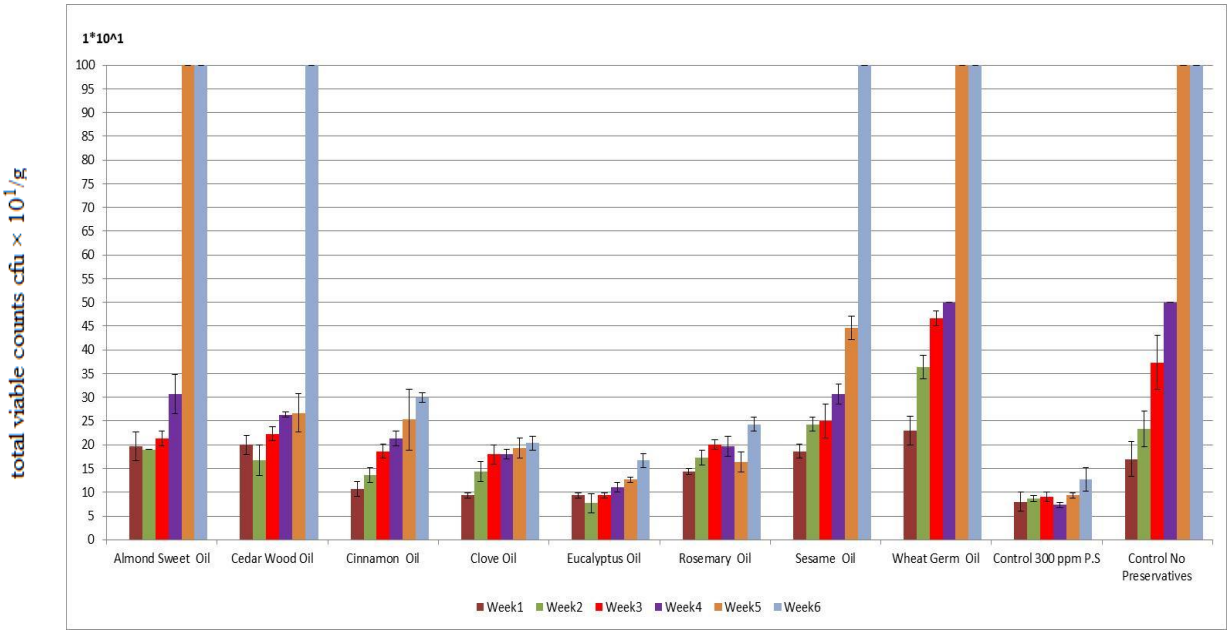


Figure 4.21: Effect of almond sweet, cedar wood, cinnamon, clove, eucalyptus, rosemary, sesame and wheat germ essential oils at 300 µl\kg oil concentration on the counts of total bacterial count. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.21: Microbiological analysis of total viable counts of labneh during 6 weeks at 300 µl\kg oil concentration.

T.V.C with 300 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	20.00	3.06	19.00	0.00	21.00	1.53	31.00	4.16	100.00	0.00	100.00	0.00
Cedar Wood Oil	20.00	2.00	17.00	3.21	22.00	1.53	26.00	0.58	27.00	4.04	100.00	0.00
Cinnamon Oil	11.00	1.53	14.00	1.53	19.00	1.53	21.00	1.53	25.00	6.43	30.00	1.00
Clove Oil	9.00	0.58	14.00	2.08	18.00	2.00	18.00	1.00	19.00	2.08	20.00	1.53
Eucalyptus Oil	9.00	0.58	8.00	2.08	9.00	0.58	11.00	1.00	13.00	0.58	16.00	1.53
Rosemary Oil	14.00	0.58	18.00	1.53	20.00	1.00	20.00	2.08	16.00	2.08	24.00	1.53
Sesame Oil	19.00	1.53	24.00	1.53	25.00	3.61	31.00	2.08	45.00	2.52	100.00	0.00
Wheat Germ Oil	23.00	3.00	36.00	2.52	47.00	1.53	50.00	0.00	100.00	0.00	100.00	0.00
Control 300 ppm P.S	8.00	2.00	9.00	0.58	9.00	1.00	8.00	0.58	9.00	0.58	13.00	2.52
Control No Preservatives	17.00	3.61	23.00	3.79	37.00	6.00	50.00	0.00	100.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.2. Total viable count in labneh at 400 µl\kg oil concentration

When comparing the positive control and negative control, with labneh samples at a concentration of 400 µl\kg E.Os, almond sweet oil, cedar wood oil, sesame oil and wheat germ oil didn't show obvious effect on the labneh samples compared to positive control. This count was always lower than the negative control showing the effectiveness of the essential oil. (See table 4.22).

When cinnamon oil was used results showed that there was obvious decrease in bacterial count lower than positive control during the storage period (six weeks).

Concerning clove oil, eucalyptus oil and rosemary oil when compared with the positive control results showed that there was relative obvious decrease in bacterial, the bacteria count is a higher than positive control and bacteria did not multiply very quickly compared with the samples without preservatives due to the effect of oil. (See table 4.22).

It is noteworthy to mention that all the essential oils except at this concentration showed bacterial count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the bacterial count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm).

When E.Os were compared, the best E.O to be used to control TVC was: cinnamon oil, followed rosemary oil and eucalyptus oil. (See table 4.22).

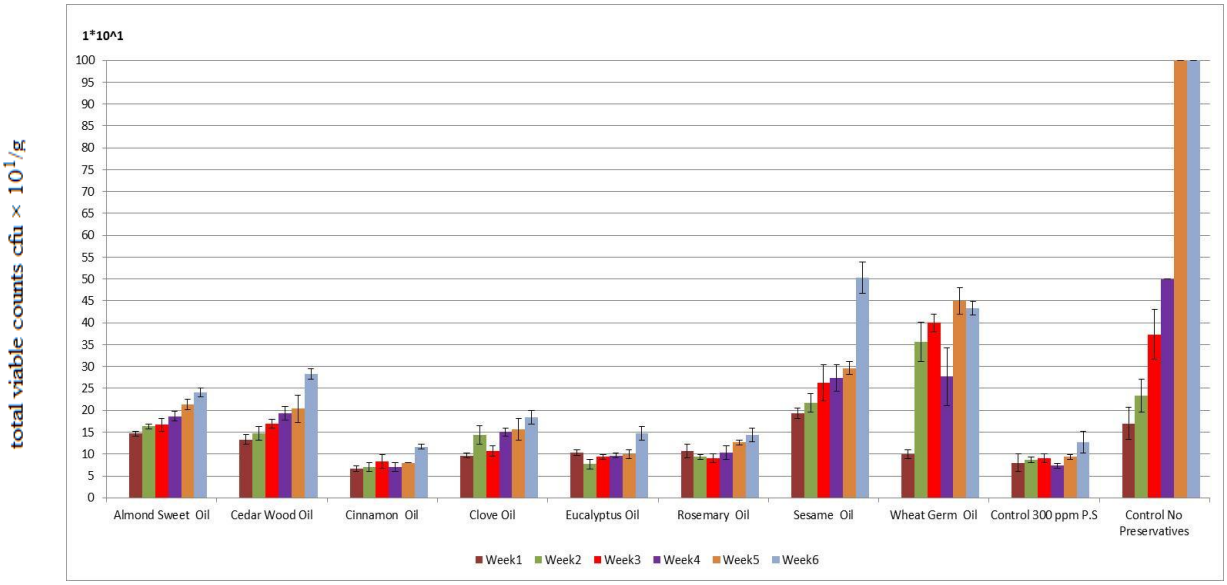


Figure 4.22: Effect of almond sweet, cedar wood, cinnamon, clove, eucalyptus, rosemary, sesame and wheat germ essential oils at 400 µl\kg oil concentration on the counts of total bacterial count.
The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.22: Microbiological analysis of total viable counts of labneh during 6 weeks at 400 µl\kg oil concentration.

T.V.C with 400 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	15.00	0.58	16.00	0.58	17.00	1.53	19.00	1.15	21.00	1.15	24.00	1.00
Cedar Wood Oil	13.00	1.15	15.00	1.53	17.00	1.00	19.00	1.53	20.00	3.06	28.00	1.15
Cinnamon Oil	7.00	0.58	7.00	1.00	8.00	1.53	7.00	1.00	8.00	0.00	11.00	0.58
Clove Oil	10.00	0.58	14.00	2.08	11.00	1.15	15.00	1.00	16.00	2.52	18.00	1.53
Eucalyptus Oil	10.00	0.58	8.00	1.15	9.00	0.58	10.00	0.58	10.00	1.00	14.00	1.53
Rosemary Oil	11.00	1.53	9.00	0.58	9.00	1.00	10.00	1.53	13.00	0.58	14.00	1.53
Sesame Oil	19.00	1.15	22.00	2.08	26.00	4.16	28.00	3.06	30.00	1.53	51.00	3.51
Wheat Germ Oil	10.00	1.00	36.00	4.51	40.00	2.00	28.00	6.66	45.00	3.00	43.00	1.53
Control 300 ppm P.S	8.00	2.00	9.00	0.58	9.00	1.00	8.00	0.58	9.00	0.58	13.00	2.52
Control No Preservatives	17.00	3.61	23.00	3.79	37.00	6.00	50.00	0.00	100.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.3. Total viable count in labneh at 500 µl\kg oil concentration

When comparing the positive control and negative control, with labneh samples at a concentration of 500 µl\kg E.Os, almond sweet oil, cedar wood oil, sesame oil, wheat germ oil and clove oil didn't show obvious effect on the labneh samples compared to positive control. The bacterial count was less than negative control. (See table 4.23).

When cinnamon oil was used results showed that there was obvious decrease in bacterial count and even lower than positive control during the storage period (six weeks).

Concerning eucalyptus and rosemary oil when compared with the positive control results showed that there was obvious decrease in bacterial count lower than positive control during the storage period, except in first, fourth and last weeks in eucalyptus labneh, and except in third and fourth weeks in rosemary labneh. The bacterial count was always lower than the negative control showing the effectiveness of the essential oil, because the bacteria count is a bit higher than positive control and bacteria did not multiply very quickly compared with the samples without preservatives. (See table 4.23).

It is noteworthy to mention that all the essential oils at this concentration showed bacterial count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the bacterial count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm).

When E.Os were compared, the best E.O to be used to control TVC was: cinnamon oil, followed by rosemary oil and eucalyptus. (See table 4.23).

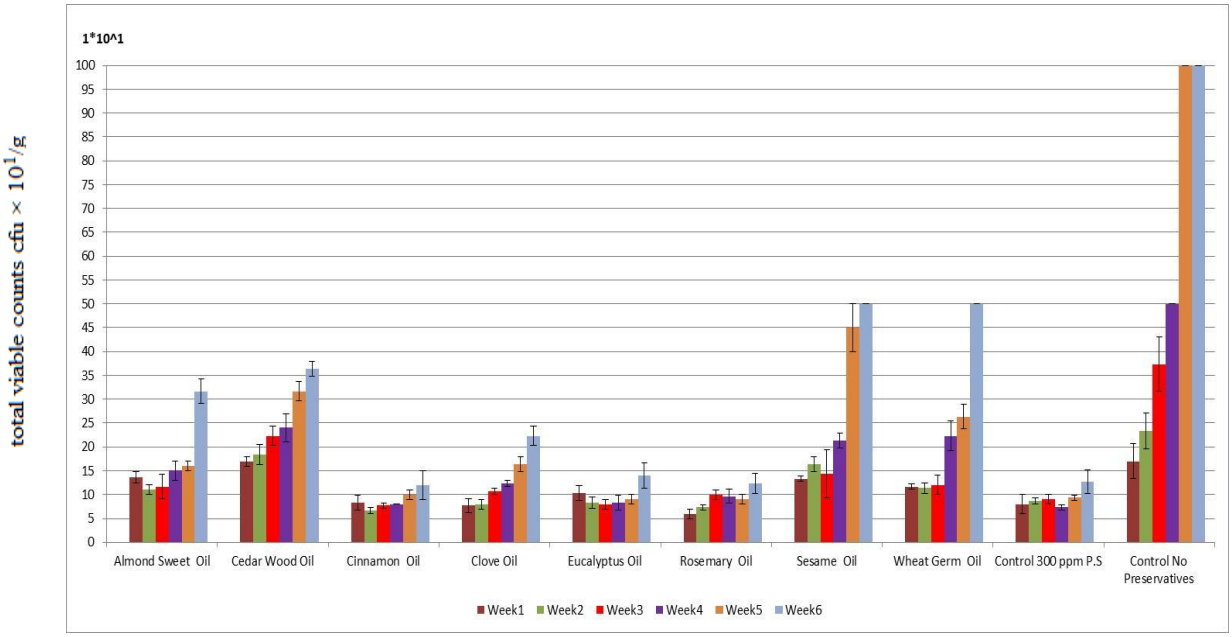


Figure 4.23: Effect of almond sweet, cedar wood, cinnamon, clove, eucalyptus, rosemary, sesame and wheat germ essential oils at 500 µl\kg oil concentration on the counts of total bacterial count. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.23: Microbiological analysis of total viable counts of labneh during 6 weeks at 500 µl\kg oil concentration.

T.V.C with 500 µl\kg oil Con.	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	14.00	1.15	11.00	1.00	12.00	2.52	15.00	2.00	16.00	1.00	32.00	2.52
Cedar Wood Oil	17.00	1.00	18.00	2.08	22.00	2.08	24.00	3.00	32.00	2.08	36.00	1.53
Cinnamon Oil	8.00	1.53	7.00	0.58	8.00	0.58	8.00	0.00	10.00	1.00	12.00	3.00
Clove Oil	8.00	1.53	8.00	1.00	11.00	0.58	12.00	0.58	16.00	1.53	22.00	2.08
Eucalyptus Oil	10.00	1.53	8.00	1.15	8.00	1.00	8.00	1.53	9.00	1.00	14.00	2.65
Rosemary Oil	6.00	1.00	8.00	0.58	10.00	1.00	10.00	1.53	9.00	1.00	12.00	2.08
Sesame Oil	13.00	0.58	16.00	1.53	14.00	5.03	21.00	1.53	45.00	5.00	50.00	0.00
Wheat Germ Oil	12.00	0.58	12.00	1.15	12.00	2.00	22.00	3.06	26.00	2.52	50.00	0.00
Control 300 ppm P.S	8.00	2.00	9.00	0.58	9.00	1.00	8.00	0.58	9.00	0.58	13.00	2.52
Control No Preservatives	17.00	3.61	23.00	3.79	37.00	6.00	50.00	0.00	100.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.4. Total viable count in labneh at 600 µl\kg oil concentration

When comparing the positive control and negative control, with labneh samples at a concentration of 600 µl\kg E.Os, almond sweet oil, cedar wood oil, sesame oil and wheat germ oil didn't show obvious effect on the labneh sample compared to positive control. (See table 4.24).

Concerning cinnamon oil, clove oil, eucalyptus oil and rosemary results showed that there was relative obvious decrease in bacterial count, because the bacteria count was a slightly higher than positive control especially in the last week and because bacteria did not multiply very quickly compared with samples without preservatives due to the effect of essential oil. (See table 4.24).

It is noteworthy to mention that all the essential oils except sesame oil at this concentration showed bacterial count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the bacterial count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm). This showed the effect of essential oils in labneh preservation.
When E.Os were compared, the best E.Os to be used to control TVC was: rosemary oil followed by cinnamon oil and eucalyptus oil. (See table 4.24).

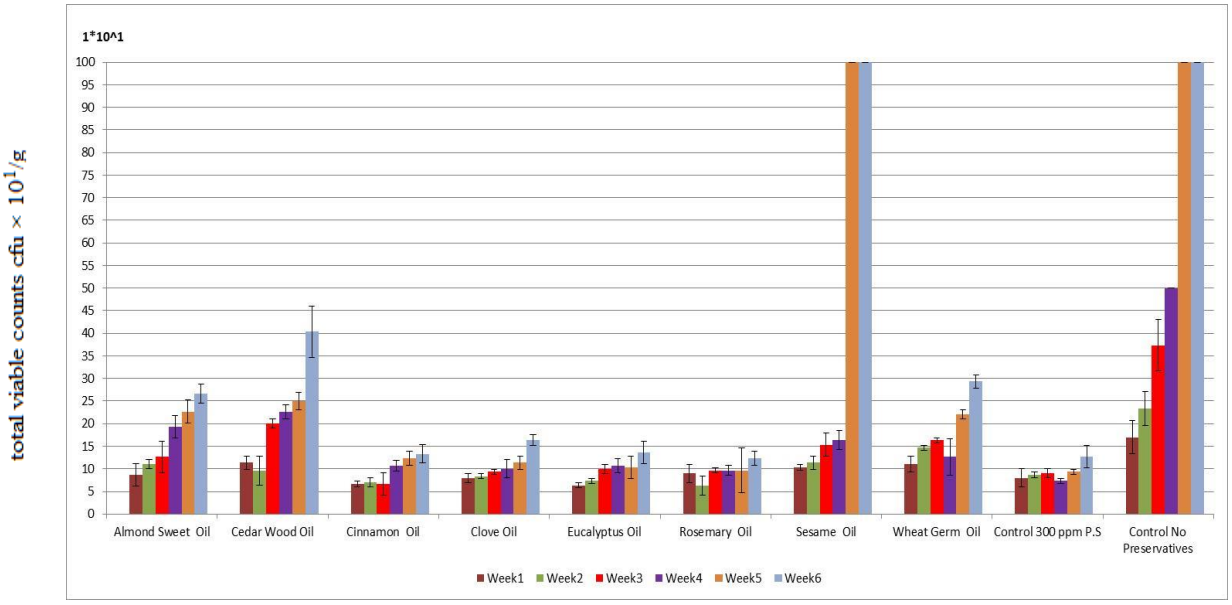


Figure 4.24: Effect of almond sweet, cedar wood, cinnamon, clove, eucalyptus, rosemary, sesame and wheat germ essential oils at 600 µl\kg oil concentration on the counts of total bacterial count.
The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.24: Microbiological analysis of total viable counts of labneh during 6 weeks at 600 µl\kg oil concentration.

T.V.C with 600 µl\kg oil Con.	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	9.00	2.52	11.00	1.00	13.00	3.51	19.00	2.52	23.00	2.52	27.00	2.08
Cedar Wood Oil	12.00	1.53	10.00	3.21	20.00	1.00	23.00	1.53	25.00	2.00	41.00	6.00
Cinnamon Oil	7.00	0.58	7.00	1.00	7.00	2.52	11.00	1.15	12.00	1.53	13.00	2.08
Clove Oil	8.00	1.00	8.00	0.58	9.00	0.58	10.00	2.00	12.00	1.53	16.00	1.15
Eucalyptus Oil	6.00	0.58	8.00	0.58	10.00	1.00	11.00	1.53	10.00	2.52	13.00	2.52
Rosemary Oil	9.00	2.00	6.00	2.08	10.00	0.58	10.00	1.15	10.00	4.93	12.00	1.53
Sesame Oil	10.00	0.58	12.00	1.53	15.00	2.52	16.00	2.08	100.00	0.00	100.00	0.00
Wheat Germ Oil	11.00	1.73	15.00	0.58	16.00	0.58	13.00	4.04	22.00	1.00	29.00	1.53
Control 300 ppm P.S	8.00	2.00	9.00	0.58	9.00	1.00	8.00	0.58	9.00	0.58	13.00	2.52
Control No Preservatives	17.00	3.61	23.00	3.79	37.00	6.00	50.00	0.00	100.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.5. Mold content in labneh at 300 µl\kg oil concentration

When comparing the positive control and negative control, with a labneh sample at a concentration of 300 µl\kg E.Os, almond sweet oil and cedar wood didn't show obvious effect on the labneh samples compared to positive control.The mold count was less than negative control. (See table 4.25).

Concerning cinnamon oil when compared with the positive control didn't show obvious effect on the labneh sample, but showed lower results than negative control in all weeks, but the cinnamin gave better effect compared with almond sweet oil and cedar wood oil extracts. (See table 4.25).

Concerning clove oil when compared with the positive control results showed that there was obvious relative effect, where the molds were less than positive control. Clove oil showed the effect in reducing the level of molds was more than almond sweet oil and cedar wood oil, and lower than negative control in all weeks. (See table 4.25).

Eucalyptus oil when compared with the positive control results showed that there was obvious decrease in mold count even lower than positive control during the storage period (six weeks). (See table 4.25).

When rosemary oil, sesame oil and wheat germ oil was used, no obvious effect on the labneh sample compared to positive control, but mold count was less than negative control.

It is noteworthy to mention that all the essential oils except at this concentration showed mold count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the mold count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm). This shows the effect of essential oils in labneh preservation.

When different E.Os were compared, the best E.Os to be used to control mold was: eucalyptus oil followed by clove oil and rosemary oil. (See table 4.25).

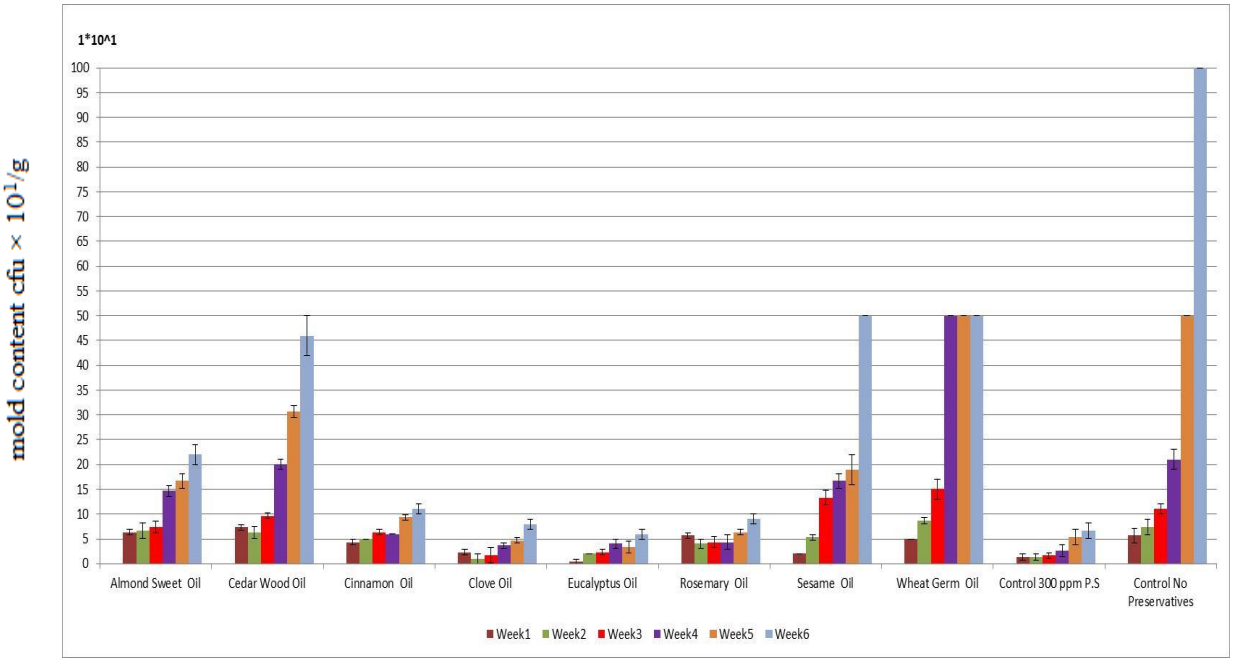


Figure 4.25: Effect of almond sweet, cedar wood, cinnamon, clove, eucalyptus, rosemary, sesame and wheat germ essential oils at 300µl\kg oil concentration on the counts of mold. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.25: Microbiological analysis of mold content of labneh during 6 weeks at 300 µl\kg oil concentration.

Mold with 300 µl\kg oil Con.	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	6.00	0.58	7.00	1.53	8.00	1.15	15.00	1.15	17.00	1.53	22.00	2.00
Cedar Wood Oil	8.00	0.58	6.00	1.15	10.00	0.58	20.00	1.00	31.00	1.15	46.00	4.00
Cinnamon Oil	4.00	0.58	5.00	0.00	6.00	0.58	6.00	0.00	9.00	0.58	11.00	1.00
Clove Oil	2.00	0.58	1.00	1.00	2.00	1.53	4.00	0.58	5.00	0.58	8.00	1.00
Eucalyptus Oil	1.00	0.58	2.00	0.00	2.00	0.58	4.00	1.00	3.00	1.15	6.00	1.00
Rosemary Oil	6.00	0.58	4.00	1.00	4.00	1.15	4.00	1.53	6.00	0.58	9.00	1.00
Sesame Oil	2.00	0.00	5.00	0.58	13.00	1.53	17.00	1.53	19.00	3.00	50.00	0.00
Wheat Germ Oil	5.00	0.00	9.00	0.58	15.00	2.00	50.00	0.00	50.00	0.00	50.00	0.00
Control 300 ppm P.S	1.00	0.58	1.00	0.58	2.00	0.58	3.00	1.15	5.00	1.53	7.00	1.53
Control No Preservatives	6.00	1.53	8.00	1.53	11.00	1.00	21.00	2.00	50.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.6. Mold content in labneh at 400 µl\kg oil concentration

When comparing the positive control and negative control, with labneh samples at a concentration of 400 µl\kg E.Os, almond sweet oil, cedar wood oil, sesame oil, wheat germ oil and Cinnamon oil didn't show obvious effect on the labneh samples compared to positive control. The molds count was less than negative control. (See table 4.26).

Concerning clove oil and eucalyptus oil when compared with the positive control results showed that there was obvious decrease in molds count. Molds content began to decrease from the first week, and then increased with storage time; clove oil showed the same positive control effect, and this count was always lower than the negative control showing the effectiveness of the essential oil. (See table 4.26).

Rosemary oil when compared with the positive control results showed that there was obvious decrease in mold count lower than positive control during the storage period, after the third week. (See table 4.26).

It is noteworthy to mention that all the essential oils at this concentration showed mold count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the mold count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm). This showed the effect of essential oils in labneh preservation.

When different E.Os, were compared, the best E.Os to be used to control mold was: eucalyptus oil followed by rosemary oil and clove oil. (See table 4.26).

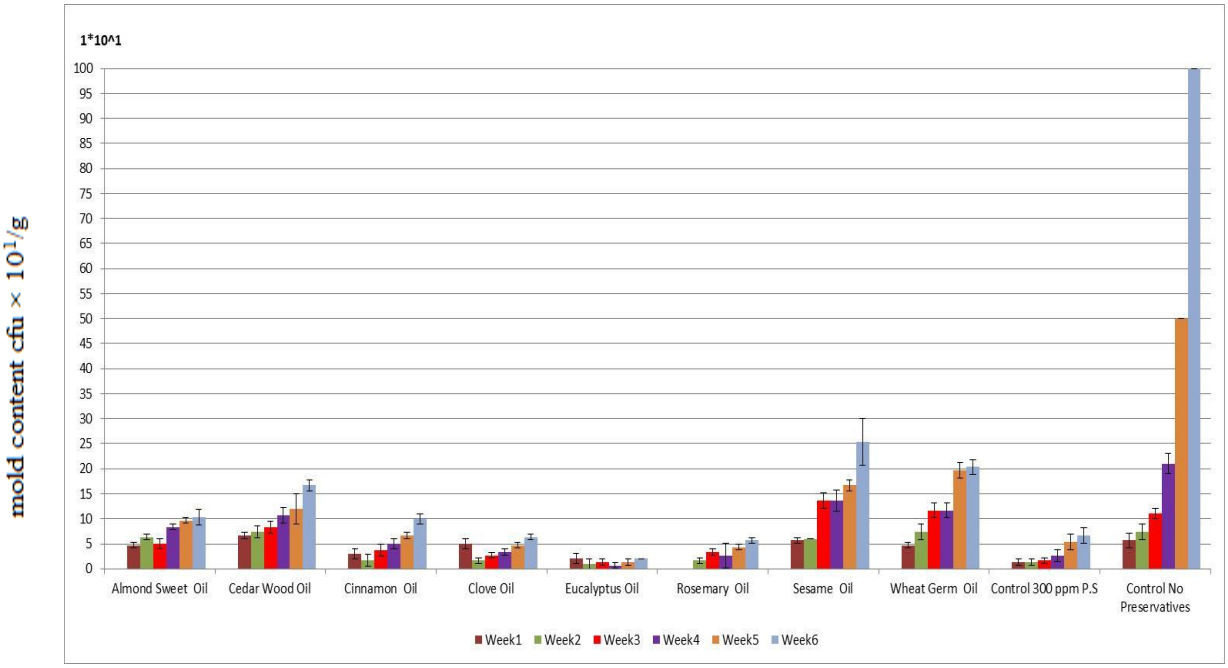


Figure 4.26: Effect of almond sweet, cedar wood, cinnamon, clove, eucalyptus, rosemary, sesame and wheat germ essential oils at 400µl\kg oil concentration on the counts of mold. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.26: Microbiological analysis of mold content of labneh during 6 weeks at 400 µl\kg oil concentration.

Mold with 400 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	5.00	0.58	6.00	0.58	5.00	1.00	8.00	0.58	10.00	0.58	10.00	1.53
Cedar Wood Oil	7.00	0.58	8.00	1.15	8.00	1.15	11.00	1.53	12.00	3.00	17.00	1.15
Cinnamon Oil	3.00	1.00	2.00	1.15	4.00	1.15	5.00	1.00	7.00	0.58	10.00	1.00
Clove Oil	5.00	1.00	2.00	0.58	3.00	0.58	3.00	0.58	5.00	0.58	6.00	0.58
Eucalyptus Oil	2.00	1.00	1.00	1.00	1.00	0.58	1.00	0.58	1.00	0.58	2.00	0.00
Rosemary Oil	0.00	0.00	2.00	0.58	3.00	0.58	3.00	2.52	4.00	0.58	5.00	0.58
Sesame Oil	6.00	0.58	6.00	0.00	14.00	1.53	14.00	2.08	17.00	1.15	25.00	5.00
Wheat Germ Oil	5.00	0.58	8.00	1.53	12.00	1.53	12.00	1.53	110.00	1.53	20.00	1.53
Control 300 ppm P.S	1.00	0.58	1.00	0.58	2.00	0.58	3.00	1.15	5.00	1.53	7.00	1.53
Control No Preservatives	6.00	1.53	8.00	1.53	11.00	1.00	21.00	2.00	50.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.7. Mold content in labneh at 500 µl\kg oil concentration

When comparing the positive control and negative control, with labneh samples at a concentration of 500 µl\kg E.Os, almond sweet oil, cedar wood oil, sesame oil and wheat germ oil were used the results didn't show obvious effect on the labneh sample compared to positive control. The mold count was less than negative control. (See table 4.27).

Concerning cinnamon oil when compared with the positive control results showed that there was relative obvious decrease in mold count, mold content approximately constant from the first week until the last week as well mold content in the last week less than positive control, this is evidence of the effect of oil throughout the six weeks. (See table 4.27).

Clove oil when compared with the positive control, results showed that there was relative obvious decrease in mold count, mold growth is slow compared with natural growth. In the sixth week, mold content comparatively was more than positive control but mold does not grow rapidly such as negative control. (See table 4.27).

Concerning eucalyptus oil, rosemary oil when compared with the positive control results showed that there was relative obvious decrease in mold count, mold content approximately constant from the first week until the last week as well mold content in the last week was similar to positive control, this is evidence of the effect of oil throughout the six weeks, eucalyptus oil showed the same positive control effect. (See table 4.27).

It is noteworthy to mention that all the essential oils at this concentration showed mold count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the mold count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm). This showed the effect of essential oils in labneh preservation.

When different E.Os were compared, the best E.O to be used to control mold was: cinnamon oil, eucalyptus oil, rosemary oil followed by clove oil. (See table 4.27).

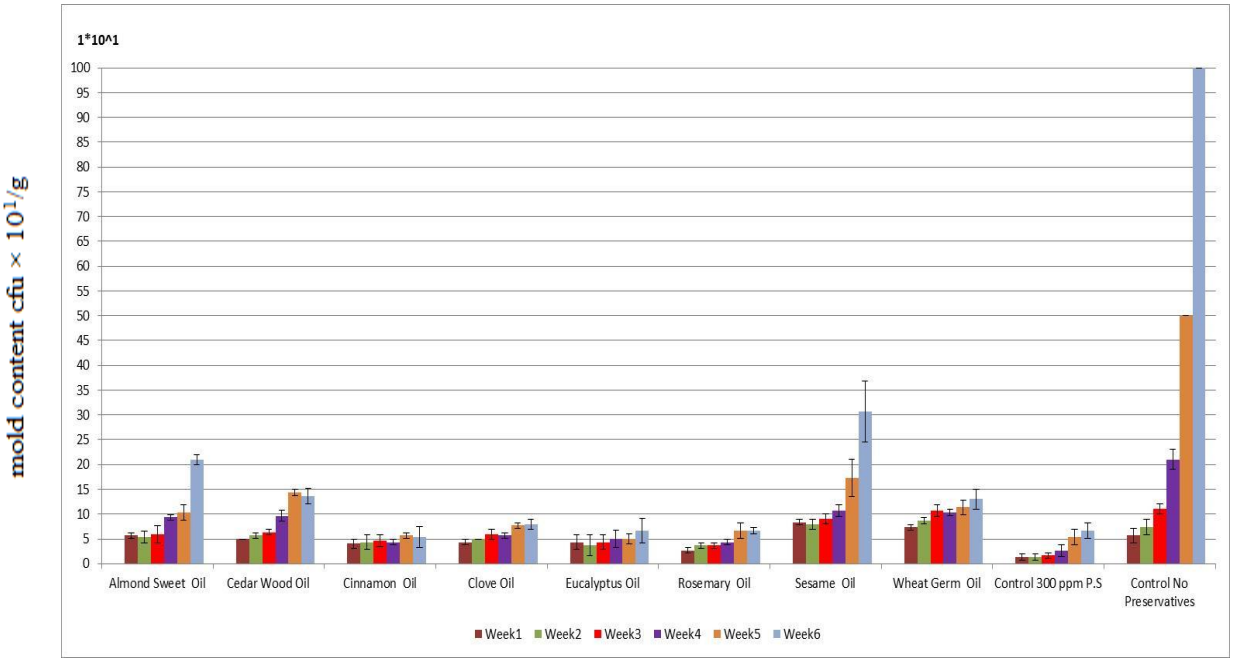


Figure 4.27: Effect of almond sweet, cedar wood, cinnamon, clove, eucalyptus, rosemary, sesame and wheat germ essential oils at 500µl\kg oil concentration on the counts of mold. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.27: Microbiological analysis of mold content of labneh during 6 weeks at 500 µl\kg oil concentration.

Mold with 500 µl\kg oil Con.	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	6.00	0.58	5.00	1.15	6.00	1.73	9.00	0.58	10.00	1.53	21.00	1.00
Cedar Wood Oil	5.00	0.00	6.00	0.58	6.00	0.58	10.00	1.15	14.00	0.58	13.00	1.53
Cinnamon Oil	4.00	1.00	4.00	1.53	5.00	1.15	4.00	0.58	6.00	0.58	5.00	2.08
Clove Oil	4.00	0.58	5.00	0.00	6.00	1.00	6.00	0.58	8.00	0.58	8.00	1.00
Eucalyptus Oil	4.00	1.53	4.00	2.08	4.00	1.53	5.00	1.73	5.00	1.00	7.00	2.52
Rosemary Oil	3.00	0.58	4.00	0.58	4.00	0.58	4.00	0.58	7.00	1.53	7.00	0.58
Sesame Oil	8.00	0.58	8.00	1.00	9.00	1.00	11.00	1.15	18.00	3.79	31.00	6.11
Wheat Germ Oil	8.00	0.58	9.00	0.58	11.00	1.15	10.00	0.58	12.00	1.53	13.00	2.00
Control 300 ppm P.S	1.00	0.58	1.00	0.58	2.00	0.58	3.00	1.15	5.00	1.53	7.00	1.53
Control No Preservatives	6.00	1.53	8.00	1.53	11.00	1.00	21.00	2.00	50.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.8. Mold content in labneh at 600 µl\kg oil concentration

When comparing the positive control and negative control, with labneh samples at a concentration of 600 µl\kg E.Os, almond sweet oil, cedar wood oil, sesame oil and wheat germ oil didn't showed obvious effect on the labneh sample compared to positive control. The mold count was less than negative control. (See table 4.28).

When cinnamon oil, rosemary oil, eucalyptus oil and clove oil was used and compared with the positive control, results showed that there was relative obvious decrease in mold count, mold content approximately constant from the first week until the last week as well mold content in the last week less than positive control, this is an evidence of the effect of oil throughout the six weeks. (See table 4.28).

It is noteworthy to mention that all the essential oils at this concentration showed mold count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the mold count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm). This showed the effect of essential oils in labneh preservation.

When all E.Os were compared with the positive control, the best E.O was rosemary oil, followed by eucalyptus oil, cinnamon oil and clove oil. (See table 4.28).

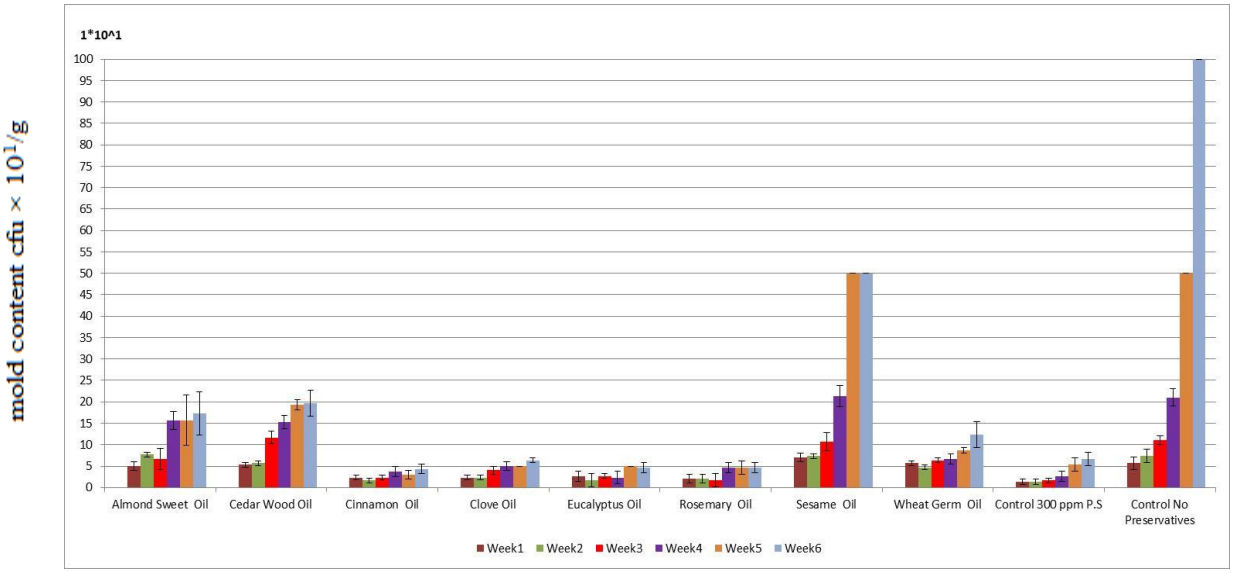


Figure 4.28: Effect of almond sweet, cedar wood, cinnamon, clove, eucalyptus, rosemary, sesame and wheat germ essential oils at 600µl\kg oil concentration on the counts of mold. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.28: Microbiological analysis of mold content of labneh during 6 weeks at 600 µl\kg oil concentration.

Mold with 600 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	5.00	1.00	8.00	0.58	7.00	2.52	16.00	2.08	16.00	5.86	18.00	5.03
Cedar Wood Oil	5.00	0.58	6.00	0.58	12.00	1.53	15.00	1.53	19.00	1.15	19.00	3.06
Cinnamon Oil	2.00	0.58	2.00	0.58	2.00	0.58	4.00	1.15	3.00	1.00	4.00	1.15
Clove Oil	2.00	0.58	2.00	0.58	4.00	1.00	5.00	1.00	5.00	0.00	6.00	0.58
Eucalyptus Oil	3.00	1.15	2.00	1.53	3.00	0.58	2.00	1.53	5.00	0.00	5.00	1.15
Rosemary Oil	2.00	1.00	2.00	1.00	2.00	1.53	5.00	1.15	5.00	1.53	5.00	1.15
Sesame Oil	7.00	1.00	8.00	0.58	11.00	2.08	21.00	2.52	50.00	0.00	50.00	0.00
Wheat Germ Oil	6.00	0.58	5.00	0.58	6.00	0.58	7.00	1.15	9.00	0.58	12.00	3.06
Control 300 ppm P.S	1.00	0.58	1.00	0.58	2.00	0.58	3.00	1.15	5.00	1.53	7.00	1.53
Control No Preservatives	6.00	1.53	8.00	1.53	11.00	1.00	21.00	2.00	50.00	0.00	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.9. Yeast content in labneh at 300 µl\kg oil concentration

When comparing the positive control and negative control, with labneh samples at a concentration of 300 µl\kg E.Os, almond sweet oil, cedar wood oil, cinnamon oil, sesame oil, wheat germ and clove oil didn't show obvious effect on the labneh sample compared to positive control. The yeast count was less than negative control. (See table 4.29).

Concerning eucalyptus oil and rosemary oil compared with positive control oil results showed that there was relative obvious decrease in yeast count, the number of yeast in the sixth week in labneh sample is slightly more than bacteria number in sixth week in the positive control, also multiplication of yeast was slow compared with normal multiplication due to the essential oil effect.

It is noteworthy to mention that all the essential oils at this concentration showed yeast count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the yeast count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm). This showed the effect of essential oils in labneh preservation.

When all E.Os were compared with the positive control, the best E.O was rosemary oil followed by eucalyptus oil. (See table 4.29).

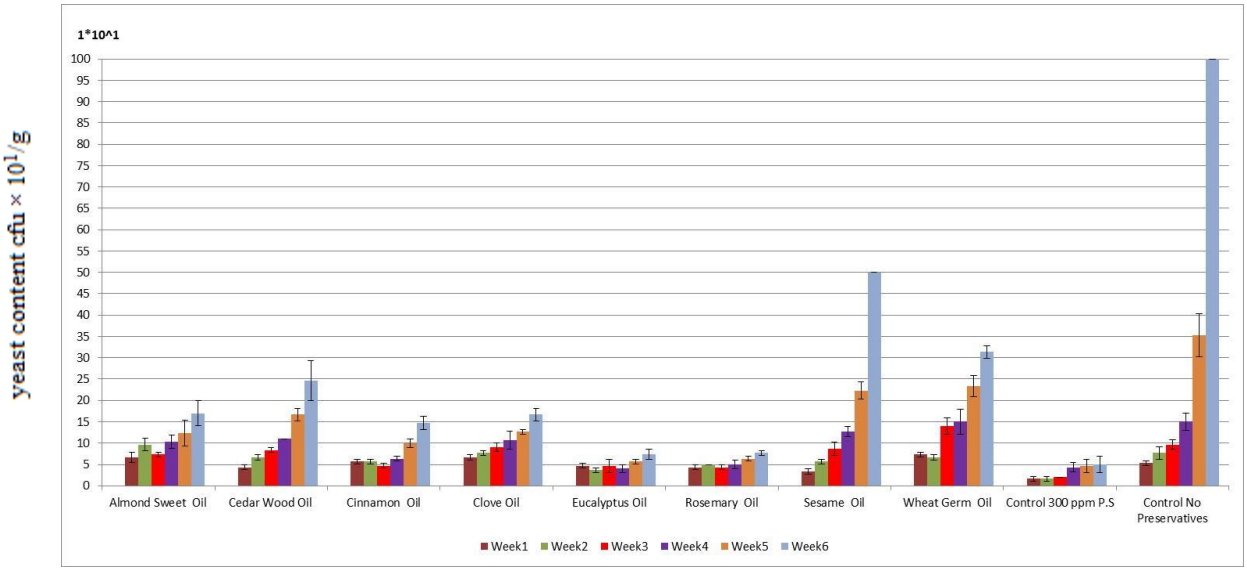


Figure 4.29: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, eucalyptus, sesame and wheat germ essential oils at 300 µl\kg oil concentration on the counts of yeast. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.29: Microbiological analysis of yeast content of labneh during 6 weeks at 300 µl\kg oil concentration.

Yeast with 300 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	7.00	1.15	10.00	1.53	8.00	0.58	10.00	1.53	12.00	3.06	17.00	3.00
Cedar Wood Oil	4.00	0.58	7.00	0.58	8.00	0.58	11.00	0.00	17.00	1.53	25.00	5.00
Cinnamon Oil	6.00	0.58	6.00	0.58	5.00	0.58	6.00	0.58	10.00	1.00	15.00	1.53
Clove Oil	7.00	0.58	8.00	0.58	9.00	1.00	11.00	2.08	13.00	0.58	17.00	1.53
Eucalyptus Oil	5.00	0.58	4.00	0.58	5.00	1.53	4.00	1.00	6.00	0.58	7.00	1.15
Rosemary Oil	4.00	0.58	5.00	0.00	4.00	0.58	5.00	1.00	6.00	0.58	7.00	0.58
Sesame Oil	3.00	0.58	6.00	0.58	9.00	1.53	13.00	1.15	22.00	2.08	50.00	0.00
Wheat Germ Oil	8.00	0.58	7.00	0.58	14.00	2.00	15.00	3.00	23.00	2.52	31.00	1.53
Control 300 ppm P.S	2.00	0.58	2.00	0.58	2.00	0.00	4.00	1.15	5.00	1.53	5.00	2.00
Control No Preservatives	5.00	0.58	8.00	1.53	10.00	1.15	15.00	2.00	35.00	5.03	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.10. Yeast content in labneh at 400 µl\kg oil concentration

When comparing the positive control and negative control, with labneh samples at a concentration of 400 µl\kg E.Os, almond sweet oil, cedar wood oil, sesame oil and wheat germ oil didn't show obvious effect on the labneh samples compared to positive control. The yeast count was less than negative control. (See table 4.30).

Concerning cinnamon oil, clove oil, eucalyptus oil and rosemary oil when compared with the positive control results showed that there was relative obvious decrease in bacterial count, because the number of bacteria in the sixth week in labneh sample is a bit higher than positive control in the sixth week, also multiplication of yeasts was slow compared with normal multiplication due to the oil effect of, the oil effect like positive control effect until the end of storage period. (See table 4.30).

It is noteworthy to mention that all the essential oils at this concentration showed yeast count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the yeast count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm). This showed the effect of essential oils in labneh preservation.

When all E.Os were compared with the positive control, the best E.O was eucalyptus oil, clove oil followed by cinnamon oil. (See table 4.30).

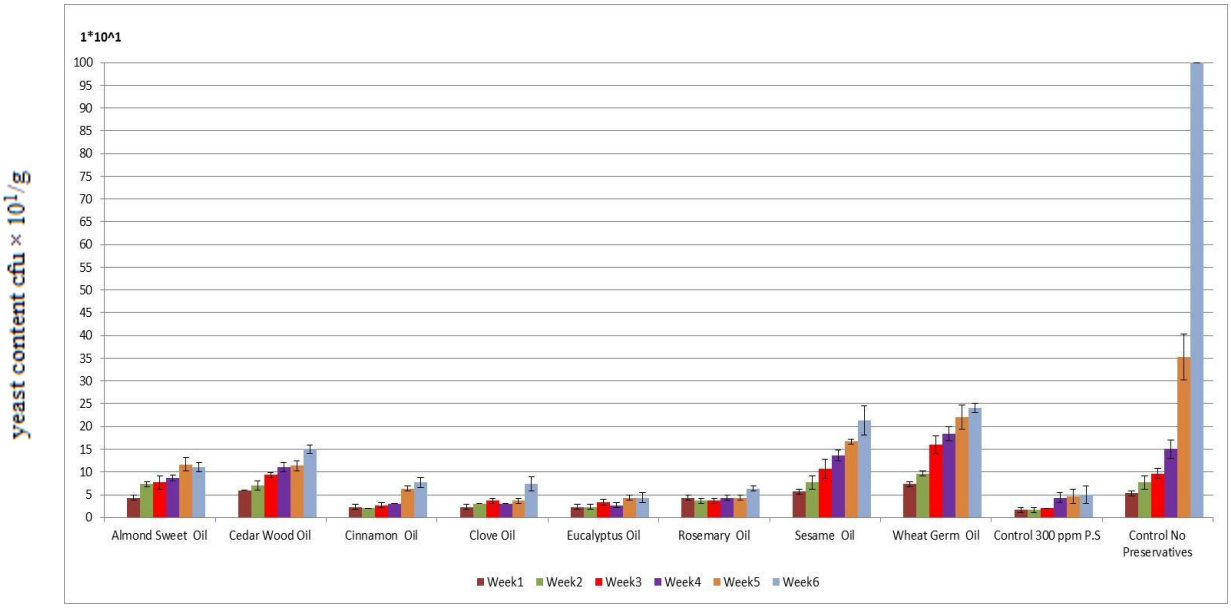


Figure 4.30: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, eucalyptus, sesame and wheat germ essential oils at 400 µl\kg oil concentration on the counts of yeast. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.30: Microbiological analysis of yeast content of labneh during 6 weeks at 400 µl\kg oil concentration.

Yeast with 400 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	4.00	0.58	8.00	0.58	8.00	1.53	9.00	0.58	12.00	1.53	11.00	1.00
Cedar Wood Oil	6.00	0.00	7.00	1.00	9.00	0.58	11.00	1.00	12.00	1.15	15.00	1.00
Cinnamon Oil	2.00	0.58	2.00	0.00	3.00	0.58	3.00	0.00	6.00	0.58	7.00	1.15
Clove Oil	2.00	0.58	3.00	0.00	4.00	0.58	3.00	0.00	4.00	0.58	7.00	1.53
Eucalyptus Oil	2.00	0.58	2.00	0.58	3.00	0.58	3.00	0.58	4.00	0.58	4.00	1.15
Rosemary Oil	4.00	0.58	4.00	0.58	4.00	0.58	4.00	0.58	4.00	0.58	6.00	0.58
Sesame Oil	6.00	0.58	8.00	1.53	11.00	2.08	14.00	1.15	17.00	0.58	21.00	3.21
Wheat Germ Oil	8.00	0.58	10.00	0.58	16.00	2.00	18.00	1.53	22.00	2.65	24.00	1.00
Control 300 ppm P.S	2.00	0.58	2.00	0.58	2.00	0.00	4.00	1.15	5.00	1.53	5.00	2.00
Control No Preservatives	5.00	0.58	8.00	1.53	10.00	1.15	15.00	2.00	35.00	5.03	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.11. Yeast content in labneh at 500 µl\kg oil concentration

When comparing the positive control and negative control, with labneh samples at a concentration of 500 µl\kg E.Os, almond sweet oil, sesame oil, wheat germ oil and cedar wood oil didn't show obvious effect on the labneh sample compared to positive control. The bacterial count was less than negative control. (See table 4.31).

Concerning cinnamon oil, clove oil, eucalyptus oil and rosemary oil when compared with the positive control results showed that there was relative obvious decrease in bacterial count, because the bacteria count is a bit higher than positive control in sixth week in labneh sample, also multiplication of yeasts was slow compared with normal multiplication due to the oil effect of, the effect of oil like positive control effect until the end of period. (See table 4.31).

It is noteworthy to mention that all the essential oils at this concentration showed yeast count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the yeast count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm). This showed the effect of essential oils in labneh preservation.

When all E.Os were compared with the positive control, the best E.O is cinnamon oil and clove oil followed by eucalyptus oil rosemary oil. (See table 4.31).

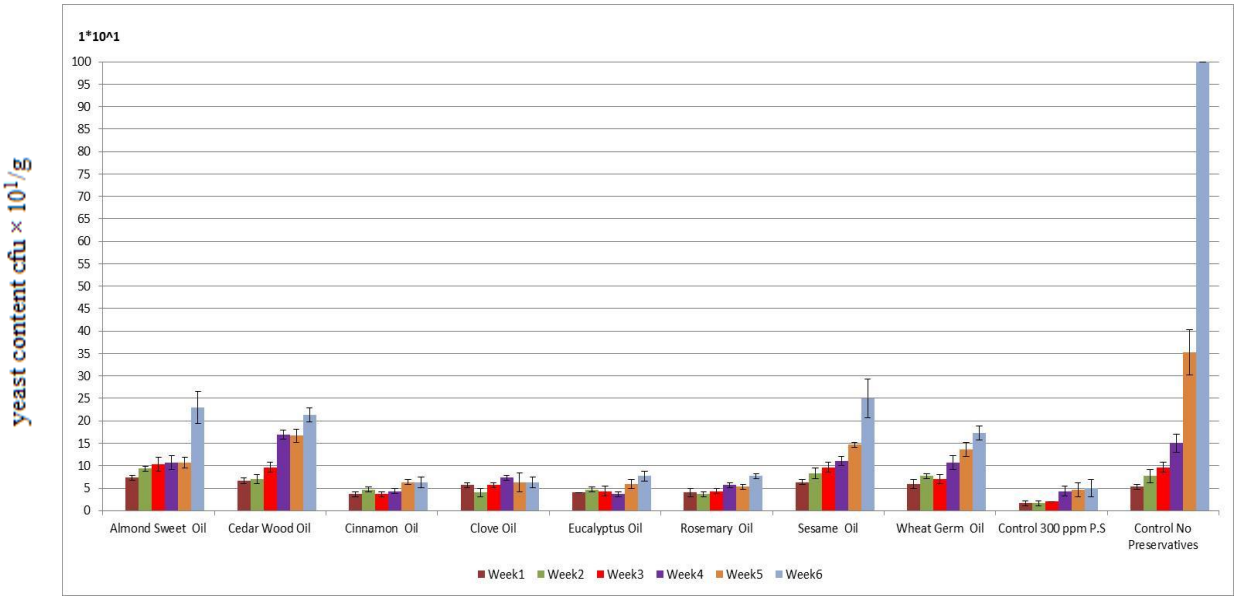


Figure 4.31: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, eucalyptus, sesame and wheat germ essential oils at 500 µl\kg oil concentration on the counts of yeast. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.31: Microbiological analysis of yeast content of labneh during 6 weeks at 500 µl\kg oil concentration.

Yeast with 500 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	8.00	0.58	9.00	0.58	10.00	1.53	11.00	1.53	11.00	1.15	23.00	3.61
Cedar Wood Oil	7.00	0.58	7.00	1.00	10.00	1.15	17.00	1.00	17.00	1.53	21.00	1.53
Cinnamon Oil	4.00	0.58	5.00	0.58	4.00	0.58	4.00	0.58	6.00	0.58	6.00	1.15
Clove Oil	6.00	0.58	4.00	1.00	6.00	0.58	8.00	0.58	6.00	2.08	6.00	1.15
Eucalyptus Oil	4.00	0.00	5.00	0.58	4.00	1.15	4.00	0.58	6.00	1.00	7.00	1.15
Rosemary Oil	4.00	1.00	4.00	0.58	4.00	0.58	6.00	0.58	5.00	0.58	7.00	0.58
Sesame Oil	6.00	0.58	8.00	1.15	10.00	1.15	11.00	1.00	15.00	0.58	25.00	4.36
Wheat Germ Oil	6.00	1.00	8.00	0.58	7.00	1.00	11.00	1.53	14.00	1.53	18.00	1.53
Control 300 ppm P.S	2.00	0.58	2.00	0.58	2.00	0.00	4.00	1.15	5.00	1.53	5.00	2.00
Control No Preservatives	5.00	0.58	8.00	1.53	10.00	1.15	15.00	2.00	35.00	5.03	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.12. Yeast content in labneh at 600 µl\kg oil concentration

When comparing the positive control and negative control, with labneh samples at a concentration of 600 µl\kg E.Os, almond sweet oil, sesame oil, wheat germ oil and cedar wood oil didn't show obvious effect on the labneh sample compared to positive control. The bacterial count was less than negative control. (See table 4.32).

Concerning cinnamon oil, clove oil and eucalyptus oil when compared with the positive results showed that there was obvious decrease in bacterial count, because bacteria count is a bit higher than positive control in the sixth week in the labneh sample, also multiplication of yeasts slow compared with normal multiplication due to the oil effect of, and the effect of oil like positive control effect until the end of period. (See table 4.32).

It is noteworthy to mention that all the essential oils at this concentration showed yeast count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the yeast count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm). This showed the effect of essential oils in labneh preservation.

When all E.Os were compared with the positive control, the best E.O were clove oil and eucalyptus oil followed by cinnamon oil and rosemary oil. (See table 4.32).

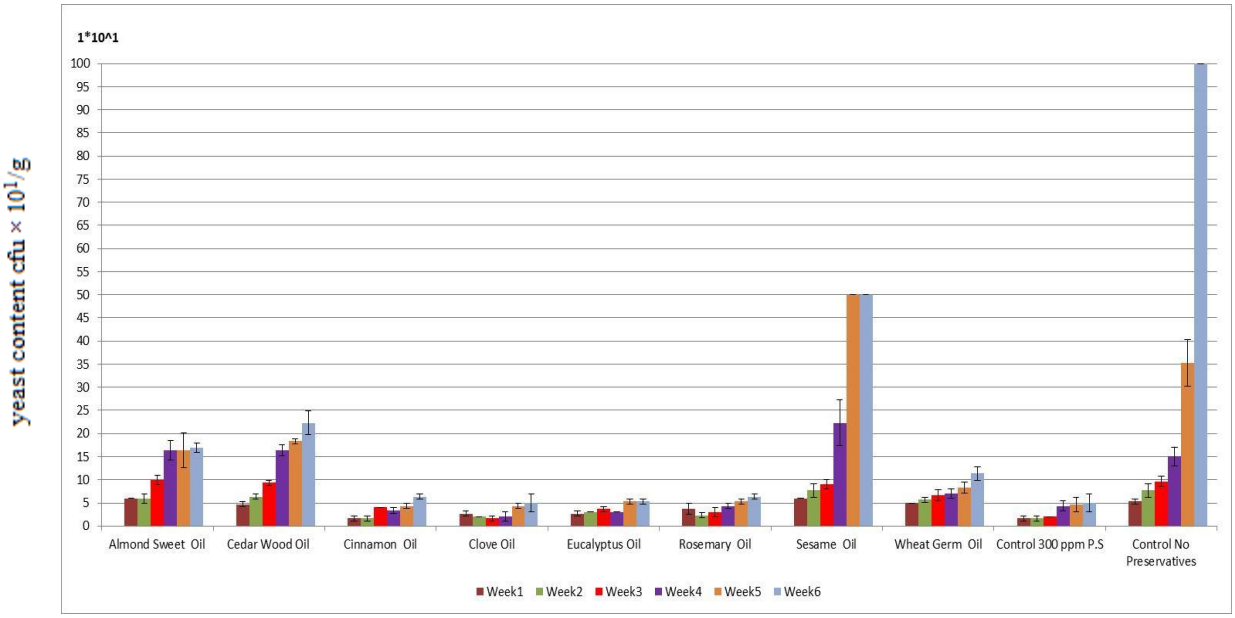


Figure 4.32: Effect of almond sweet, cedar wood, cinnamon, clove, rosemary, eucalyptus, sesame and wheat germ essential oils at 600 µl\kg oil concentration on the counts of yeast. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.32: Microbiological analysis of yeast content of labneh during 6 weeks at 600 µl\kg oil concentration.

Yeast with 600 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	6.00	0.00	6.00	1.00	10.00	1.00	16.00	2.08	16.00	3.79	17.00	1.00
Cedar Wood Oil	5.00	0.58	6.00	0.58	9.00	0.58	16.00	1.15	18.00	0.58	22.00	2.52
Cinnamon Oil	2.00	0.58	2.00	0.58	4.00	0.00	3.00	0.58	4.00	0.58	6.00	0.58
Clove Oil	3.00	0.58	2.00	0.00	2.00	0.58	2.00	1.00	4.00	0.58	5.00	2.00
Eucalyptus Oil	3.00	0.58	3.00	0.00	4.00	0.58	3.00	0.00	5.00	0.58	5.00	0.58
Rosemary Oil	4.00	1.15	2.00	0.58	3.00	1.00	4.00	0.58	5.00	0.58	6.00	0.58
Sesame Oil	6.00	0.00	8.00	1.53	9.00	1.00	22.00	4.93	50.00	0.00	50.00	0.00
Wheat Germ Oil	5.00	0.00	6.00	0.58	7.00	1.15	7.00	1.00	8.00	1.15	12.00	1.53
Control 300 ppm P.S	2.00	0.58	2.00	0.58	2.00	0.00	4.00	1.15	5.00	1.53	5.00	2.00
Control No Preservatives	5.00	0.58	8.00	1.53	10.00	1.15	15.00	2.00	35.00	5.03	100.00	0.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.13. *Staphylococcus aureus* content in labneh at 300 µl\kg oil concentration

When comparing the positive control and negative control, with labneh samples at a concentration of 300 µl\kg E.Os, almond sweet oil, cedar wood oil, rosemary oil, sesame oil, wheat germ oil, cinnamon oil and clove oil didn't show obvious effect on the labneh sample compared to positive control. The bacterial count was less than negative control. (See table 4.33).

When eucalyptus oil was used when compared with the positive control, results showed that there was relative obvious decrease in *S. aureus* count; the effect of oils was like positive control effect. (See table 4.33).

It is noteworthy to mention that all the essential oils at this concentration showed *S. aureus* count less than the negative control throughout the six weeks. (See table 4.33).

This is a promising result showing the effectiveness of essential oils on the *S. aureus* count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm). This showed the effect of essential oils in labneh preservation.

When all E.Os were compared with the positive control, the best E.O was eucalyptus oil. (See table 4.33).

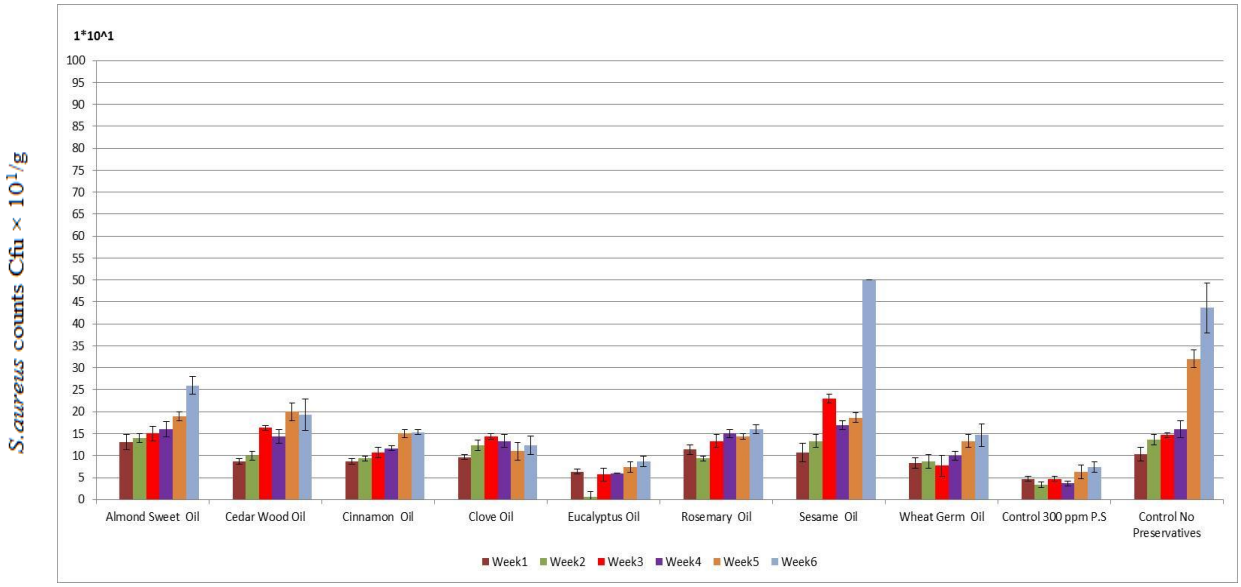


Figure 4.33: Effect of almond sweet, cedar wood, cinnamon, clove, eucalyptus, rosemary, sesame and wheat germ essential oils at 300 µl\kg oil concentration on the counts of *Staphylococcus aureus*. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.33: Microbiological analysis of *S. aureus* content of labneh during 6 weeks at 300 µl\kg oil concentration.

S. aureus with 300 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	13.00	1.73	14.00	1.00	15.00	1.73	16.00	1.73	19.00	1.00	26.00	2.00
Cedar Wood Oil	9.00	0.58	10.00	1.00	16.00	0.58	14.00	1.53	20.00	2.00	19.00	3.51
Cinnamon Oil	9.00	0.58	9.00	0.58	11.00	1.15	12.00	0.58	15.00	1.00	15.00	0.58
Clove Oil	10.00	0.58	12.00	1.15	14.00	0.58	13.00	1.53	11.00	2.00	12.00	2.08
Eucalyptus Oil	6.00	0.58	1.00	1.15	6.00	1.53	6.00	0.00	8.00	1.15	8.00	1.15
Rosemary Oil	12.00	1.15	9.00	0.58	13.00	1.53	15.00	1.00	14.00	0.58	16.00	1.00
Sesame Oil	11.00	2.08	13.00	1.53	23.00	1.00	17.00	1.00	19.00	1.15	50.00	0.00
Wheat Germ Oil	8.00	1.15	9.00	1.53	8.00	2.31	10.00	1.00	13.00	1.53	15.00	2.52
Control 300 ppm P.S	5.00	0.58	3.00	0.58	5.00	0.58	4.00	0.58	6.00	1.53	8.00	1.15
Control No Preservatives	10.00	1.53	14.00	1.15	15.00	0.58	16.00	2.00	32.00	2.00	44.00	6.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.14. *Staphylococcus aureus* content in labneh at 400 µl\kg oil concentration

When comparing the positive control and negative control, with labneh samples at a concentration of 400 µl\kg E.Os, almond sweet oil, cedar wood oil, sesame oil and clove oil didn't show obvious effect on the labneh sample compared to positive control. The bacterial count was less than negative control. (See table 4.34).

Concerning cinnamon oil, eucalyptus oil, rosemary oil and wheat germ oil when compared with the positive control results showed that there was relative obvious decrease in bacterial count, the effect was approximately similar to positive control effect, specifically the number of bacteria in the sixth week was close to the number of bacteria in the sixth week in positive control, the effect on the growth of bacteria appears at the end of the period, in the sixth week. The bacterial count is less than negative control. (See table 4.34).

It is noteworthy to mention that all the essential oils at this concentration showed *S. aureus* count less than the negative control throughout the six weeks.

This is a promising result showing the effectiveness of essential oils on the *S. aureus* count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm). This showed the effect of essential oils in labneh preservation.

When all E.Os were compared with the positive control, the best E.Os was wheat germ oil, eucalyptus oil, rosemary oil, cinnamon, clove oil. (See table 4.34).

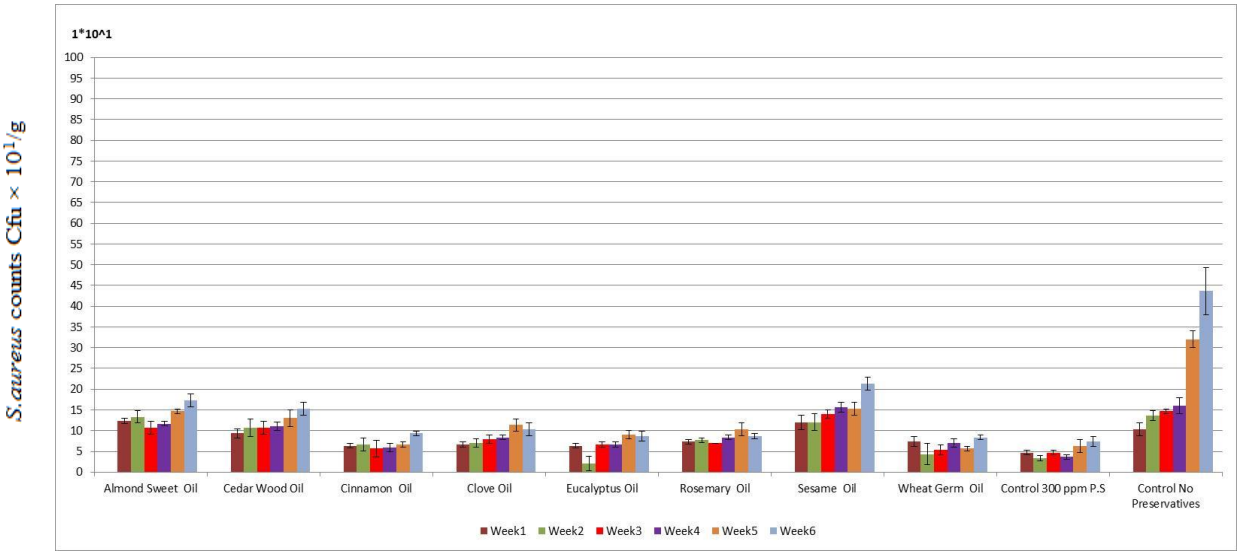


Figure 4.34: Effect of almond sweet, cedar wood, cinnamon, clove, eucalyptus, rosemary, sesame and wheat germ essential oils at 400 µl\kg oil concentration on the counts of *Staphylococcus aureus*. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.34: Microbiological analysis of *Staphylococcus aureus* content of labneh during 6 weeks at 400 µl\kg oil concentration.

S. aureus with 400 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	12.00	0.58	13.00	1.53	11.00	1.53	12.00	0.58	15.00	0.58	18.00	1.53
Cedar Wood Oil	9.00	1.15	11.00	2.08	11.00	1.53	11.00	1.00	13.00	2.00	15.00	1.53
Cinnamon Oil	6.00	0.58	7.00	1.53	6.00	2.08	6.00	1.00	7.00	0.58	9.00	0.58
Clove Oil	7.00	0.58	7.00	1.00	8.00	1.00	8.00	0.58	12.00	1.53	10.00	1.53
Eucalyptus Oil	6.00	0.58	2.00	1.73	7.00	0.58	7.00	0.58	9.00	1.00	9.00	1.15
Rosemary Oil	8.00	0.58	8.00	0.58	7.00	0.00	8.00	0.58	10.00	1.53	9.00	0.58
Sesame Oil	12.00	1.73	12.00	2.00	14.00	1.00	16.00	1.15	15.00	1.53	21.00	1.53
Wheat Germ Oil	8.00	1.15	4.00	2.52	5.00	1.15	7.00	1.00	6.00	0.58	8.00	0.58
Control 300 ppm P.S	5.00	0.58	3.00	0.58	5.00	0.58	4.00	0.58	6.00	1.53	8.00	1.15
Control No Preservatives	10.00	1.53	14.00	1.15	15.00	0.58	16.00	2.00	32.00	2.00	44.00	6.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.15. *Staphylococcus aureus* content in labneh at 500 µl\kg oil concentration

When comparing the positive control and negative control, with labneh samples at a concentration of 500 µl\kg E.Os, almond sweet oil, cedar wood oil, sesame oil, wheat germ oil and clove oil didn't show obvious effect on the labneh sample compared to positive control. The bacterial count was less than negative control. (See table 4.35).

Concerning cinnamon oil, eucalyptus oil when compared with the positive control results showed that there was relative obvious decrease in bacterial count, the effect was approximately like positive control effect, specifically the number of bacteria in the sixth week was close to the number of bacteria in the sixth week in positive control, the effect on the growth of bacteria appears at the end of the period. (See table 4.35).

It is noteworthy to mention that all the essential oils at this concentration showed that *S. aureus* count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the *S. aureus* count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm). This showed the effect of essential oils in labneh preservation.

When all E.Os were compared with the positive control, the best E.O was cinnamon oil, followed by eucalyptus oil, rosemary oil and clove oil. (See table 4.35).

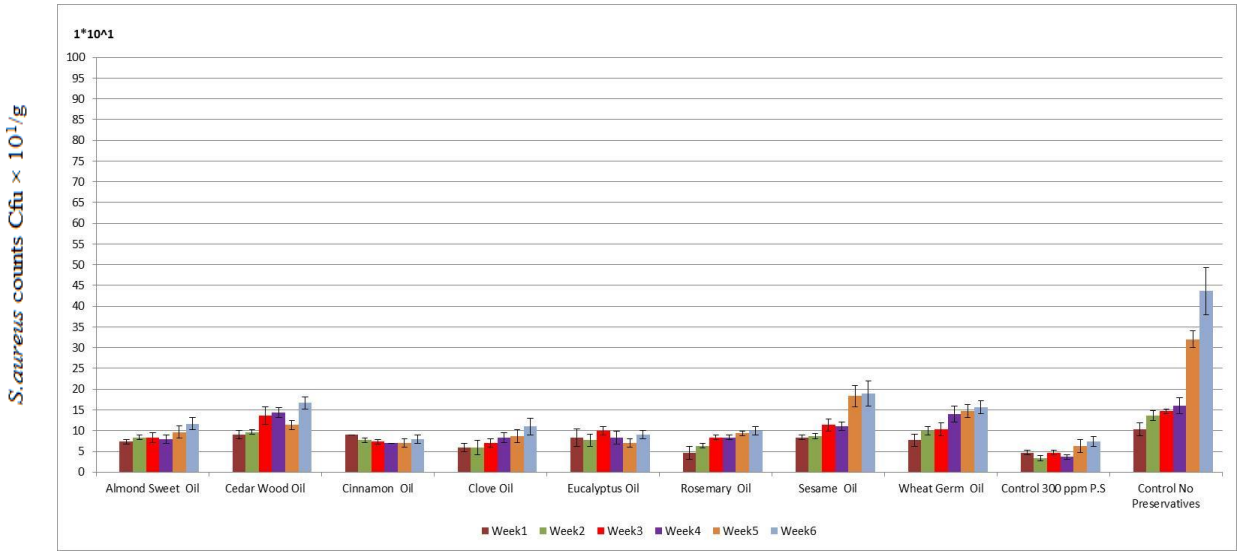


Figure 4.35: Effect of almond sweet, cedar wood, cinnamon, clove, eucalyptus, rosemary, sesame and wheat germ essential oils at 500 µl\kg oil concentration on the counts of *Staphylococcus aureus*. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.35: Microbiological analysis of *Staphylococcus aureus* content of labneh during 6 weeks at 500 µl\kg oil concentration.

S. aureus with 500 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	8.00	0.58	8.00	0.58	8.00	1.15	8.00	1.00	10.00	1.53	12.00	1.53
Cedar Wood Oil	9.00	1.00	10.00	0.58	14.00	2.08	14.00	1.15	12.00	1.15	17.00	1.53
Cinnamon Oil	9.00	0.00	8.00	0.58	8.00	0.58	7.00	0.00	7.00	1.00	8.00	1.00
Clove Oil	6.00	1.00	6.00	1.73	7.00	1.00	8.00	1.15	9.00	1.53	11.00	2.00
Eucalyptus Oil	8.00	2.08	8.00	1.53	10.00	1.00	8.00	1.53	7.00	1.00	9.00	1.00
Rosemary Oil	5.00	1.53	6.00	0.58	8.00	0.58	8.00	0.58	9.00	0.58	10.00	1.00
Sesame Oil	8.00	0.58	9.00	0.58	12.00	1.53	11.00	1.00	18.00	2.52	19.00	3.00
Wheat Germ Oil	8.00	1.53	10.00	1.00	10.00	1.53	14.00	2.00	15.00	1.53	16.00	1.53
Control 300 ppm P.S	5.00	0.58	3.00	0.58	5.00	0.58	4.00	0.58	6.00	1.53	8.00	1.15
Control No Preservatives	10.00	1.53	14.00	1.15	15.00	0.58	16.00	2.00	32.00	2.00	44.00	6.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.16. *Staphylococcus aureus* content in labneh at 600 µl\kg oil concentration

When comparing the positive control and negative control, with a labneh sample at a concentration of 600 µl\kg E.Os, almond sweet oil, sesame oil, wheat germ oil and cedar wood oil didn't show obvious effect on the labneh sample compared to positive control. The bacterial count was less than negative control. (See table 4.36).

Concerning cinnamon oil when compared with the positive control oil results showed that there was obvious decrease in bacterial count lower than positive control during the storage period. (See table 4.36).

Both clove oil and eucalyptus oil when compared with the positive control, results showed that there was relative obvious decrease in bacterial count, bacteria multiply slow compared to normal multiplication due to the oil effect, the effect was approximately like positive control effect such as cinnamon oil effect. (See table 4.36).

When rosemary oil was used results showed that there was relative obvious decrease in bacterial count, because bacteria multiply slowly compared to normal multiplication due to the oil effect, there was a difference in the number of bacteria from the first week until the sixth week, the number of bacteria decreases continuously until the end of the period. (See table 4.36).

It is noteworthy to mention that all the essential oils at this concentration showed that *S. aureus* count less than the negative control throughout the six weeks. This is a promising result showing the effectiveness of essential oils on the *S. aureus* count when the absence of synthetic preservative (potassium sorbate) compared to that usually used for labneh preservation (300ppm). This showed the effect of essential oils in labneh preservation.

When all E.Os were compared with the positive control, the best E.O was rosemary oil, followed by cinnamon oil, eucalyptus oil, and clove oil. (See table 4.36).

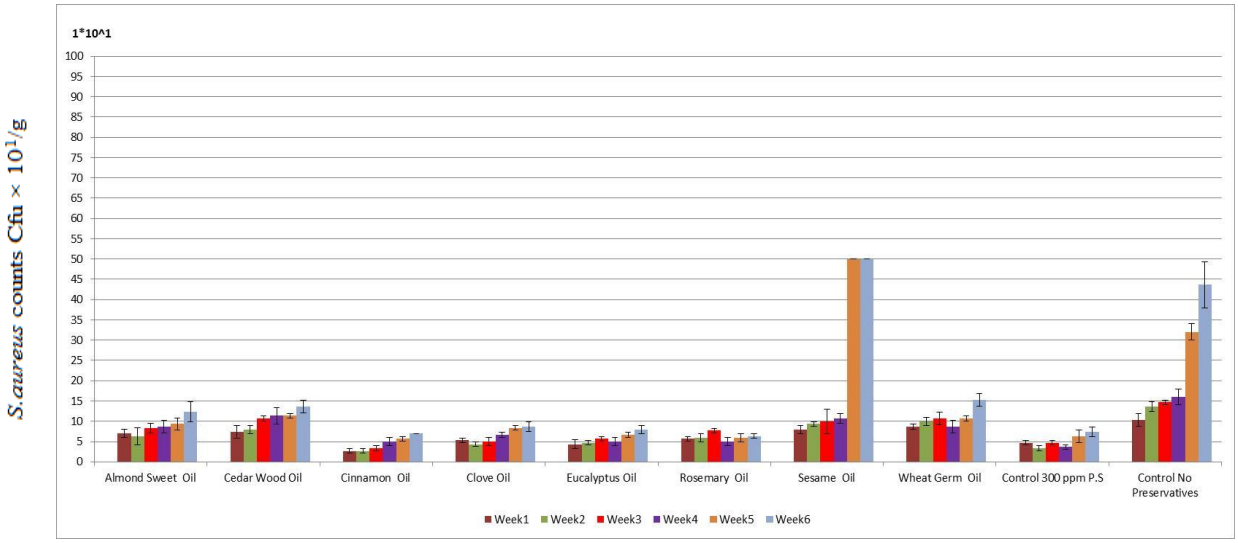


Figure 4.36: Effect of almond sweet, cedar wood, cinnamon, clove, eucalyptus, rosemary, sesame and wheat germ essential oils at 600 µl\kg oil concentration on the counts of *Staphylococcus aureus*. The analysis was done at dilution as 1×10^{-1} cfu /g labneh

Tables 4.36: Microbiological analysis of *Staphylococcus aureus* content of labneh during 6 weeks at 600 µl\kg oil concentration.

S. aureus with 600 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
Scale	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	7.00	1.00	6.00	2.08	8.00	1.15	9.00	1.53	9.00	1.53	12.00	2.52
Cedar Wood Oil	8.00	1.53	8.00	1.00	11.00	0.58	12.00	2.08	12.00	0.58	14.00	1.53
Cinnamon Oil	3.00	0.58	3.00	0.58	3.00	0.58	5.00	1.00	6.00	0.58	7.00	0.00
Clove Oil	5.00	0.58	4.00	0.58	5.00	1.00	7.00	0.58	8.00	0.58	8.00	1.15
Eucalyptus Oil	4.00	1.15	5.00	0.58	6.00	0.58	5.00	1.00	7.00	0.58	8.00	1.00
Rosemary Oil	6.00	0.58	6.00	1.00	8.00	0.58	5.00	1.00	6.00	1.00	6.00	0.58
Sesame Oil	8.00	1.00	9.00	0.58	10.00	3.00	11.00	1.15	50.00	0.00	50.00	0.00
Wheat Germ Oil	9.00	0.58	10.00	1.00	11.00	1.53	9.00	1.53	11.00	0.58	15.00	1.53
Control 300 ppm P.S	5.00	0.58	3.00	0.58	5.00	0.58	4.00	0.58	6.00	1.53	8.00	1.15
Control No Preservatives	10.00	1.53	14.00	1.15	15.00	0.58	16.00	2.00	32.00	2.00	44.00	6.00

The analysis was done at dilution as 1×10^{-1} cfu /g labneh

4.1.2.17. Coliforms content in labneh at 300 µl\kg oil concentration

Coliform bacteria were not detected at 300 µl\kg oil concentration in all samples

4.1.2.18. Coliforms content in labneh at 400 µl\kg oil concentration

Coliform bacteria were not detected at 400 µl\kg oil concentration in all samples

4.1.2.19. Coliforms content in labneh at 500 µl\kg oil concentration

Coliform bacteria were not detected at 500 µl\kg oil concentration in all samples

4.1.2.20. Coliforms content in labneh at 600 µl\kg oil concentration

Coliform bacteria were not detected at 600 µl\kg oil concentration in all samples

4.1.2.21. *Escherichia coli* O157:H7 content in labneh at 300 µl\kg oil concentration

E. coli bacteria were not detected at 300 µl\kg oil concentration in all samples

4.1.2.22. *Escherichia coli* O157:H7 content in labneh at 400 µl\kg oil concentration

E. coli bacteria were not detected at 400 µl\kg oil concentration in all samples

4.1.2.23. *Escherichia coli* O157:H7 content in labneh at 500 µl\kg oil concentration

E. coli bacteria were not detected at 500 µl\kg oil concentration in all samples

4.1.2.24. *Escherichia coli* O157:H7 content in labneh at 600 µl\kg oil concentration

E. coli bacteria were not detected at 600 µl\kg oil concentration in all samples

4.2. Effect of essential oils on chemical properties, Total Solids and PH of labneh

4.2.1. Effect of Almond sweet, Cedar wood, Cinnamon, Clove, Rosemary, Sesame and Wheat germ essential oils at 150 µl\kg, 200 µl\kg, 250 µl\kg, 300 µl\kg and 350 µl\kg, respectively, in the presence of synthetic preservative (potassium sorbate at 150 ppm) on chemical properties of labneh

4.2.1.1. Effect of essential oils and 150 ppm of potassium sorbate on total solids content of labneh

Tables (4.37, 4.38, 4.39, 4.40 and 4.41) show the changes during storage in the total solids (TS) content of labneh made with several types of essential oils and 150 PPM Potassium Sorbate. The TS content did not increase or slightly increased in all treatments as the storage period increased. This was in accordance with the results of Thabet et al., 2014 and Mutlag and Hassan (2008) who also reported that there were no observable differences in TS of labneh produced by addition of three different essential oils.

All samples were similar to the positive control at all concentrations in all weeks, the proportion of solids slightly increased during storage period, TS increased and could be described to moisture loss. Similarly, Ismail *et al*. (2006) also reported that there were no observable differences in TS of labneh produced by addition of six different essential oils. The data are also similar to those of Tamime (1978a 1978b), Tamime and Robinson (1985) and Mehaia and ElKhadragy (1999), who reported that the TS of labneh ranged between 22 - 26%.

Table 4.37: Total solids (TS) content of labneh at 150 µl\kg oil concentration and 150 PPM of Potassium Sorbate in function of storage time

Total Solid % with 150 µl\kg oil Con. and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	26.26	0.08	26.30	0.05	26.75	0.30	26.16	0.02	26.10	0.02	26.24	0.17
Cedar Wood Oil	26.04	0.05	26.17	0.02	26.37	0.03	26.15	0.05	26.07	0.04	26.52	0.06
Cinnamon Oil	27.44	0.19	27.38	0.20	27.40	0.21	27.88	0.79	27.63	0.40	27.82	0.02
Clove Oil	26.40	0.17	26.34	0.20	26.48	0.04	26.52	0.29	26.38	0.34	26.54	0.04
Rosemary Oil	26.60	0.13	26.53	0.25	26.69	0.22	26.07	0.57	26.53	0.40	26.93	0.03
Sesame Oil	27.41	0.35	27.14	0.07	27.60	0.12	27.81	0.09	27.59	0.51	27.86	0.29
Wheat Germ Oil	26.62	0.15	26.54	0.23	26.59	0.37	26.65	0.10	26.67	0.06	26.96	0.22
Control 300 ppm P.S	26.22	0.23	26.47	0.20	25.68	0.13	26.24	0.15	26.15	0.04	26.85	0.17
Control No Preservatives	24.77	0.06	24.26	0.10	24.67	0.10	24.25	0.31	24.88	0.15	25.92	0.15

Table 4.38: Total solids (TS) content of labneh at 200 µl\kg oil concentration and 150 PPM of Potassium Sorbate in function of storage time

Total Solid % with 200 µl\kg oil Con. and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	26.61	0.12	26.99	0.24	26.74	0.29	26.51	0.39	27.01	0.87	26.87	0.05
Cedar Wood Oil	27.49	0.28	27.92	0.30	27.42	0.67	27.48	0.15	27.06	0.06	27.82	0.10
Cinnamon Oil	27.61	0.12	27.41	0.33	27.62	0.08	27.79	0.18	27.31	0.34	27.75	0.44
Clove Oil	26.62	0.13	26.35	0.24	26.60	0.13	26.70	0.81	26.74	0.09	26.84	0.55
Rosemary Oil	26.75	0.09	26.37	0.26	26.76	1.21	26.72	0.38	26.71	0.09	26.85	0.04
Sesame Oil	26.54	0.11	26.69	0.42	26.42	0.20	26.71	0.13	26.71	0.66	26.68	0.07
Wheat Germ Oil	24.54	0.32	24.63	0.19	24.87	1.01	24.43	0.25	24.96	0.35	24.75	0.21
Control 300 ppm P.S	25.32	0.17	25.49	0.13	25.64	0.09	25.72	0.20	25.87	0.21	26.03	0.16
Control No Preservatives	24.51	0.12	24.66	0.16	24.68	0.10	24.81	0.18	24.89	0.16	25.23	0.18

Table 4.39: Total solids (TS) content of labneh at 250 µl\kg oil concentration and 150 PPM of Potassium Sorbate in function of storage time

Total solid % with 250 µl\kg oil Concentration and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	26.54	0.31	26.59	0.06	26.60	0.31	26.68	0.13	26.73	0.18	26.88	0.21
Cedar Wood Oil	27.75	0.22	27.74	0.22	27.41	0.10	27.51	0.18	27.53	0.50	27.42	0.19
Cinnamon Oil	26.82	0.05	26.58	0.38	26.53	0.10	26.73	0.03	26.75	0.21	26.83	0.27
Clove Oil	26.73	0.09	26.70	0.15	26.75	0.10	26.85	0.20	26.50	0.12	26.88	0.15
Rosemary Oil	26.63	0.13	26.77	0.10	26.24	0.23	26.74	0.10	26.92	0.03	26.01	0.08
Sesame Oil	26.81	0.13	26.47	0.08	26.87	0.23	26.89	0.30	26.84	0.16	26.91	0.32
Wheat Germ Oil	26.58	0.10	26.82	0.20	26.76	0.22	26.75	0.44	26.88	0.26	26.90	0.19
Control 300 ppm P.S	26.18	0.14	26.35	0.18	26.47	0.19	26.56	0.21	26.78	0.11	26.87	0.22
Control No Preservatives	25.34	0.19	25.45	0.13	25.59	0.15	25.65	0.20	25.78	0.26	25.91	0.11

Table 4.40: Total solids (TS) content of labneh at 300 µl\kg oil concentration and 150 PPM of Potassium Sorbate in function of storage time

Total solid % with 300 µl\kg oil Concentration and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	24.47	0.14	24.61	0.07	24.76	0.38	24.73	0.48	24.80	0.05	24.86	0.23
Cedar Wood Oil	23.26	0.62	23.77	0.10	23.54	5.18	23.63	0.10	23.68	0.22	23.68	0.39
Cinnamon Oil	23.60	0.23	23.90	0.08	23.72	0.49	23.53	0.32	23.64	0.21	23.78	0.06
Clove Oil	23.84	0.04	23.87	0.93	23.86	0.74	23.89	0.38	23.85	0.28	23.89	0.06
Rosemary Oil	24.67	0.11	24.81	0.05	23.99	0.10	24.66	0.07	24.90	0.21	24.96	0.33
Sesame Oil	23.52	0.08	23.54	0.37	23.50	0.40	23.66	0.26	23.72	0.16	23.76	0.22
Wheat Germ Oil	24.40	0.28	24.35	0.37	24.39	0.20	24.58	0.09	24.63	0.30	24.67	0.25
Control 300 ppm P.S	24.38	0.17	24.49	0.19	24.57	0.13	24.74	0.11	24.81	0.09	24.88	0.30
Control No Preservatives	24.61	0.08	24.73	0.11	24.77	0.19	24.81	0.31	24.93	0.36	25.18	0.09

Table 4.41: Total solids (TS) content of labneh at 350 µl\kg oil concentration and 150 PPM of Potassium Sorbate in function of storage time

Total solid % with 350 µl\kg oil Concentration and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	23.23	0.22	23.47	0.25	23.54	0.23	23.52	0.11	23.70	0.15	23.79	0.29
Cedar Wood Oil	23.23	0.23	23.66	0.27	23.74	0.78	23.74	0.39	23.73	0.23	23.86	0.84
Cinnamon Oil	24.81	0.11	24.78	0.24	24.83	0.25	24.90	0.16	24.96	0.12	25.14	0.33
Clove Oil	26.66	0.24	26.64	1.27	26.66	0.15	26.74	0.10	26.87	0.19	26.90	0.15
Rosemary Oil	24.66	0.37	24.77	0.15	24.76	0.24	24.78	0.10	24.81	0.66	24.86	0.43
Sesame Oil	24.22	0.10	24.55	0.08	24.68	0.13	24.76	0.18	24.83	0.16	25.37	0.20
Wheat Germ Oil	26.54	0.20	26.78	0.11	26.64	0.39	26.73	0.45	27.15	0.34	27.60	0.20
Control 300 ppm P.S	25.48	0.11	25.47	0.28	25.68	0.20	25.77	0.15	25.79	0.04	25.83	0.18
Control No Preservatives	24.34	0.10	24.56	0.13	24.73	0.16	24.85	0.23	24.91	0.16	25.21	0.13

4.2.1.2. Effect of essential oils and 150 ppm of potassium sorbate on pH of labneh

Tables (4.42, 4.43, 4.44, 4.45 and 4.46) show the changes during storage in pH of labneh made with several types of essential oils and 150 ppm of Potassium Sorbate.

The change in pH is a very important factor, since it affects the shelf life and the acceptability of labneh. Based on the results presented in mentioned tables, it is evident that pH values of the treated labneh decreased with an increase in the storage period.

The highest values were obtained with labneh containing 250 µl\kg of the essential oils and 150 ppm Potassium Sorbate at the first week, then decreased to the end of storage (6 week), suggesting that the essential oils have a stimulatory effect on the starter culture and total viable count (Dawood, 2002). These results were in agreement with that obtained by Abbas and Osman (1998), who reported that the pH decreased gradually during storage period and titratable acidity, increased gradually during storage period.

Generally in concentrated yogurt such as labneh, acidity and pH values varies depending on the starter culture and draining conditions. For this reason, in terms of acidity and pH there have been main different values in the literature (Rosenthal et al., 1980; Guler, 2007; Abou Ayana and Gamal El Deen, 2011 and Senel et al., 2011).

Table 4.42. Effect of some essential oils on pH of labneh during storage at 150 µl\kg oil concentration and 150 ppm of Potassium Sorbate

pH with 150 µl\kg oil Concentration and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	3.67	0.03	4.02	0.03	3.85	0.05	3.75	0.04	3.86	0.01	3.74	0.02
Cedar Wood Oil	4.07	0.04	3.94	0.02	3.90	0.02	3.85	0.05	3.73	0.03	3.70	0.01
Cinnamon Oil	3.94	0.02	3.98	0.03	3.96	0.02	3.85	0.05	3.80	0.01	3.81	0.01
Clove Oil	4.29	0.01	4.03	0.06	3.86	0.04	3.83	0.05	3.82	0.02	3.74	0.02
Rosemary Oil	4.29	0.01	4.26	0.03	3.97	0.05	3.86	0.05	3.78	0.02	3.75	0.02
Sesame Oil	4.02	0.03	4.04	0.05	3.92	0.03	3.98	0.06	3.83	0.05	3.78	0.03
Wheat Germ Oil	4.30	0.01	4.03	0.05	3.96	0.06	3.81	0.02	3.73	0.03	3.67	0.03
Control 300 ppm P.S	4.09	0.00	4.05	0.01	4.00	0.01	4.00	0.00	3.90	0.01	3.87	0.01
Control No Preservatives	4.00	0.01	3.92	0.01	3.81	0.01	3.74	0.01	3.60	0.02	3.45	0.01

Table 4.43. Effect of some essential oils on pH degree of labneh during storage at 200 µl\kg oil concentration and 150 ppm of Potassium Sorbate

pH with 200 µl\kg oil Concentration and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	3.93	0.03	3.92	0.03	3.91	0.01	3.90	0.02	3.82	0.03	3.77	0.02
Cedar Wood Oil	3.94	0.03	3.92	0.02	4.00	0.11	3.93	0.04	3.78	0.04	3.81	0.01
Cinnamon Oil	3.93	0.02	3.92	0.02	3.91	0.01	3.95	0.06	3.85	0.05	3.84	0.01
Clove Oil	3.94	0.02	3.96	0.05	3.95	0.03	3.85	0.04	3.81	0.01	3.81	0.02
Rosemary Oil	3.92	0.03	3.94	0.04	3.94	0.03	3.88	0.03	3.83	0.02	3.85	0.05
Sesame Oil	3.94	0.03	3.99	0.01	4.02	0.05	3.93	0.02	3.85	0.05	3.83	0.01
Wheat Germ Oil	3.92	0.01	3.95	0.02	3.94	0.02	3.97	0.03	3.82	0.05	3.72	0.04
Control 300 ppm P.S	4.09	0.00	4.05	0.00	4.00	0.01	4.00	0.02	3.90	0.01	3.87	0.01
Control No Preservatives	4.00	0.01	3.92	0.00	3.81	0.01	3.74	0.01	3.60	0.01	3.45	0.02

Table 4.44. Effect of some essential oils on pH degree of labneh during storage at 250 µl\kg oil concentration and 150 ppm of Potassium Sorbate

pH with 250 µl\kg oil Concentration and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	4.04	0.04	4.12	0.04	4.10	0.01	3.97	0.05	3.84	0.03	3.90	0.01
Cedar Wood Oil	4.10	0.02	4.12	0.02	4.20	0.02	3.93	0.03	3.90	0.04	3.84	0.02
Cinnamon Oil	4.29	0.03	4.03	0.03	4.18	0.03	4.18	0.00	3.91	0.05	3.87	0.04
Clove Oil	4.31	0.02	4.07	0.04	4.11	0.02	4.11	0.01	3.97	0.03	3.89	0.09
Rosemary Oil	4.31	0.01	4.07	0.03	4.18	0.02	4.17	0.01	4.10	0.01	3.91	0.04
Sesame Oil	4.21	0.03	4.05	0.05	4.13	0.04	4.12	0.08	3.99	0.03	3.96	0.04
Wheat Germ Oil	4.15	0.08	4.11	0.02	4.09	0.02	3.99	0.01	3.95	0.02	3.96	0.03
Control 300 ppm P.S	4.09	0.01	4.05	0.02	4.00	0.02	4.00	0.00	3.90	0.01	3.87	0.00
Control No Preservatives	4.00	0.01	3.92	0.01	3.81	0.01	3.74	0.01	3.60	0.01	3.45	0.00

Table 4.45. Effect of some essential oils on pH degree of labneh during storage at 300 µl\kg oil concentration and 150 ppm of Potassium Sorbate

pH with 300 µl\kg oil Concentration and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	4.00	0.01	3.93	0.02	3.93	0.02	3.97	0.05	4.02	0.07	3.86	0.03
Cedar Wood Oil	3.99	0.08	3.98	0.02	3.99	0.03	4.00	0.02	3.99	0.03	3.76	0.03
Cinnamon Oil	3.97	0.02	4.00	0.01	3.99	0.03	3.87	0.02	3.82	0.01	3.88	0.02
Clove Oil	4.00	0.01	3.94	0.02	3.86	0.19	3.89	0.02	3.86	0.02	3.76	0.04
Rosemary Oil	4.00	0.01	3.95	0.01	4.01	0.01	4.00	0.01	4.04	0.01	3.97	0.03
Sesame Oil	4.02	0.02	4.01	0.01	3.84	0.02	3.85	0.03	3.81	0.02	3.76	0.04
Wheat Germ Oil	3.95	0.02	3.96	0.02	3.83	0.02	3.83	0.01	3.75	0.02	3.69	0.02
Control 300 ppm P.S	4.09	0.00	4.05	0.00	4.00	0.01	4.00	0.00	3.90	0.01	3.87	0.01
Control No Preservatives	4.00	0.00	3.92	0.00	3.81	0.01	3.74	0.01	3.60	0.01	3.45	0.01

Table 4.46. Effect of some essential oils on pH degree of labneh during storage at 350 µl\kg oil concentration and 150ppm of Potassium Sorbate

pH with 350 µl\kg oil Concentration and 150 PPM Potassium Sorbate	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	3.85	0.01	3.83	0.02	3.87	0.04	3.83	0.03	3.80	0.02	3.75	0.04
Cedar Wood Oil	4.01	0.01	3.93	0.02	3.86	0.03	3.88	0.02	3.82	0.01	3.86	0.04
Cinnamon Oil	3.95	0.01	3.91	0.01	3.87	0.01	3.82	0.02	3.88	0.02	3.89	0.01
Clove Oil	3.91	0.01	3.87	0.02	3.85	0.00	3.86	0.05	3.89	0.01	3.91	0.02
Rosemary Oil	3.98	0.03	3.91	0.01	3.92	0.02	3.98	0.02	4.04	0.02	3.88	0.01
Sesame Oil	3.86	0.01	3.81	0.01	3.73	0.03	3.70	0.01	3.62	0.01	3.44	0.02
Wheat Germ Oil	3.95	0.01	3.86	0.01	3.84	0.01	3.73	0.01	3.80	0.01	3.76	0.01
Control 300 ppm P.S	4.09	0.00	4.05	0.00	4.00	0.06	4.00	0.07	3.90	0.11	3.87	0.02
Control No Preservatives	4.00	0.01	3.92	0.02	3.81	0.05	3.74	0.03	3.60	0.02	3.45	0.01

4.2.2. Effect of Almond sweet, Cedar wood, Cinnamon, Clove, Rosemary, Sesame, Eucalyptus and Wheat germ essential oils at 300 µl\kg, 400 µl\kg, 500 µl\kg, 600 µl\kg, respectively, in the absence of synthetic preservative potassium sorbate on chemical properties of labneh: Total solids and pH

4.2.2.1. Effect of essential oils on total solids content of labneh

Tables (4.47, 4.48, 4.49 and 4.50) show the changes in the total solids (TS) during storage. The TS content increased slightly in all treatments as the storage period increased. Clove labneh at week 6 had the highest TS content (600 µl\kg oil; 25.86%), followed by Eucalyptus labneh at week 6 (400 µl\kg oil; 24.97%).

All samples were similar to the positive control at all concentrations in all weeks; the proportion of solids slightly increased during storage period, this increase could be described by moisture loss. Similarly, Ismail *et al*. (2006) also reported that there were no observable differences in TS of labneh produced by addition of six different essential oils. The data is also similar to those of Tamime (1978a 1978b), Tamime and Robinson (1985), who reported that the TS of labneh ranged between 22 - 26%.

Table 4.47: Changes during storage in the total solids (TS) content of labneh at 300 µl\kg oil concentration

Total solid with 300 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	24.57	0.04	24.68	0.19	24.77	0.18	24.78	0.26	24.87	0.08	24.93	0.17
Cedar Wood Oil	24.40	0.16	24.49	0.16	24.68	0.10	24.75	0.45	24.83	0.19	24.89	0.05
Cinnamon Oil	24.48	0.10	24.43	0.14	24.47	0.54	24.65	0.18	24.79	0.53	24.88	0.09
Clove Oil	23.77	0.10	23.84	0.04	23.79	0.51	23.85	0.36	23.87	0.53	23.92	0.30
Eucalyptus Oil	24.18	0.07	24.27	0.12	24.28	0.20	24.36	0.09	24.42	0.28	24.65	0.13
Rosemary Oil	24.36	0.18	24.41	0.52	24.37	0.23	24.78	0.30	24.85	0.08	24.91	0.08
Sesame Oil	24.24	0.24	24.32	0.29	24.42	0.05	24.64	0.21	24.58	0.47	24.75	0.30
Wheat Germ Oil	24.42	0.31	24.53	0.25	24.49	0.03	24.61	0.32	24.81	0.18	24.86	0.28
Control 300 ppm P.S	24.22	0.13	24.47	0.30	24.68	0.18	24.74	0.18	24.75	0.09	24.83	0.20
Control No Preservatives	24.37	0.06	24.46	0.11	24.67	0.12	24.75	0.28	24.88	0.36	24.96	0.17

Table 4.48: Changes during storage in the total solids (TS) content of labneh at 400 µl\kg oil concentration

Total solid with 400 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	24.29	0.06	24.29	0.25	24.37	0.50	24.77	0.10	24.84	0.07	24.89	0.25
Cedar Wood Oil	24.18	0.44	24.48	0.20	24.76	0.12	24.75	0.16	24.81	0.08	24.79	0.54
Cinnamon Oil	24.32	0.24	24.34	0.30	24.43	0.11	24.59	0.16	24.90	0.08	24.94	0.08
Clove Oil	23.39	0.10	23.31	0.33	23.41	0.51	23.46	0.37	23.54	0.45	23.72	0.45
Eucalyptus Oil	24.56	0.10	24.61	0.18	24.74	0.30	24.82	0.12	24.85	0.25	24.97	0.12
Rosemary Oil	23.58	0.12	23.60	0.52	23.71	0.30	23.80	0.06	23.86	0.19	23.85	0.19
Sesame Oil	24.15	0.08	24.28	0.34	24.22	0.12	24.78	0.14	24.81	0.05	24.92	0.27
Wheat Germ Oil	24.37	0.22	24.44	0.32	24.54	0.09	24.61	0.16	24.73	0.06	24.88	0.22
Control 300 ppm P.S	24.19	0.11	24.34	0.31	24.48	0.18	24.54	0.16	24.77	0.08	24.89	0.21
Control No Preservatives	24.25	0.09	24.45	0.10	24.65	0.16	24.73	0.28	24.85	0.33	25.89	0.12

Table 4.49: Changes during storage in the total solids (TS) content of labneh at 500 µl\kg oil concentration

Total solid with 500 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	24.40	0.16	24.64	0.32	24.72	0.34	24.76	0.07	24.84	0.20	24.87	0.44
Cedar Wood Oil	24.44	0.26	24.58	0.32	24.86	0.13	24.80	0.30	24.86	0.17	24.92	0.14
Cinnamon Oil	24.49	0.20	24.41	0.17	24.77	0.55	24.77	0.14	24.78	0.22	24.81	0.15
Clove Oil	24.49	0.27	24.59	0.20	25.07	0.11	24.83	0.36	23.89	0.29	23.93	0.31
Eucalyptus Oil	23.80	0.12	23.88	0.26	23.97	0.33	24.09	0.14	24.32	0.08	24.55	0.18
Rosemary Oil	24.47	0.25	24.46	0.17	24.51	0.24	24.61	0.17	24.73	0.15	24.87	0.06
Sesame Oil	24.30	0.08	24.62	0.07	24.42	0.37	24.70	0.27	24.74	0.12	24.89	0.05
Wheat Germ Oil	23.51	0.31	23.68	0.20	23.71	0.49	23.86	0.06	23.91	0.17	24.08	0.21
Control 300 ppm P.S	24.14	0.14	24.44	0.30	24.56	0.12	24.72	0.13	24.87	0.10	24.95	0.20
Control No Preservatives	24.34	0.07	24.44	0.18	24.65	0.11	24.82	0.22	24.88	0.26	24.98	0.17

Table 4.50: Changes during storage in the total solids (TS) content of labneh at 600 µl\kg oil concentration

Total solid with 600 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	24.38	0.23	24.47	0.08	23.58	0.07	23.62	0.48	23.73	0.22	23.83	0.13
Cedar Wood Oil	24.46	0.20	24.46	0.28	24.53	0.07	24.57	0.30	24.65	0.31	24.85	0.28
Cinnamon Oil	24.43	0.15	24.52	0.22	24.60	0.05	24.71	0.09	24.74	0.07	24.87	0.10
Clove Oil	25.15	0.34	25.24	0.23	25.31	0.13	25.59	0.37	25.73	0.29	25.86	0.24
Eucalyptus Oil	24.37	0.14	24.39	0.26	24.48	0.11	24.58	0.09	24.62	0.51	24.74	0.24
Rosemary Oil	24.50	0.15	24.56	0.13	24.63	0.04	24.78	0.12	24.86	0.09	24.84	0.35
Sesame Oil	24.58	0.23	24.56	0.19	24.68	0.29	24.73	0.04	24.83	0.11	24.94	0.21
Wheat Germ Oil	24.52	0.30	24.61	1.04	24.62	0.35	24.65	0.12	24.76	0.07	24.84	0.11
Control 300 ppm P.S	24.31	0.17	24.49	0.30	24.67	0.16	24.81	0.18	24.86	0.14	24.91	0.22
Control No Preservatives	24.19	0.06	24.32	0.15	24.46	0.12	24.58	0.17	24.87	0.30	25.12	0.08

4.2.2.2. Effect of essential oils on pH

Tables (4.51, 4.52, 4.53, 4.54 and 4.55) show the changes during storage in pH of labneh made with several types of essential oils in the absence of synthetic preservative potassium sorbate.

The change in pH is a very important factor, since it affects the shelf life and the acceptability of labneh. Based on the results presented in tables, it is evident that pH values of the treated labneh decreased with an increase in the storage period. The highest pH values (4.05) were obtained with labneh containing 500 µl\kg of the essential oils in the first week for rosemary oil, and its decrease to the end of storage (6 week) to pH 3.79, suggesting that the essential oils had a stimulatory effect on the starter culture and total viable count (Dawood, 2002). These results were in agreement with that obtained by Abbas and Osman (1998), who reported that the pH decrease gradually during storage period and Titratable acidity increased gradually during storage period.

Generally in concentrated yogurt such as labneh, acidity and pH values varies depending on the starter culture and draining conditions. For this reason, in terms of acidity and pH there have been main different values in the literature (Rosenthal et al., 1980; Guler, 2007; Abou Ayana and Gamal El Deen, 2011 and Senel et al., 2011).

Table 4.51. Effect of some essential oils on pH degree of labneh during storage at 300 µl\kg oil concentration

pH with 300 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	3.82	0.01	3.82	0.02	3.76	0.01	3.71	0.01	3.70	0.01	3.64	0.01
Cedar Wood Oil	3.83	0.01	3.81	0.01	3.76	0.01	3.71	0.01	3.68	0.01	3.63	0.02
Cinnamon Oil	3.81	0.01	3.80	0.01	3.74	0.01	3.76	0.01	3.71	0.01	3.64	0.03
Clove Oil	3.83	0.01	3.81	0.01	3.74	0.01	3.75	0.01	3.71	0.01	3.70	0.01
Eucalyptus Oil	3.83	0.01	3.81	0.01	3.75	0.01	3.72	0.02	3.70	0.01	3.69	0.01
Rosemary Oil	3.83	0.01	3.81	0.01	3.80	0.01	3.81	0.01	3.80	0.01	3.71	0.01
Sesame Oil	3.81	0.00	3.80	0.01	3.73	0.01	3.72	0.00	3.69	0.01	3.68	0.01
Wheat Germ Oil	3.90	0.01	3.83	0.01	3.80	0.00	3.72	0.01	3.64	0.01	3.60	0.01
Control 300 ppm P.S	4.09	0.00	4.05	0.00	4.00	0.01	4.00	0.00	3.90	0.01	3.87	0.01
Control No Preservatives	4.00	0.01	3.92	0.01	3.81	0.01	3.74	0.01	3.60	0.01	3.45	0.00

Table 4.52. Effect of some essential oils on pH degree of labneh during storage at 400 µl\kg oil concentration

pH with 400 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	3.86	0.01	3.86	0.01	3.85	0.01	3.82	0.01	3.74	0.01	3.72	0.01
Cedar Wood Oil	3.92	0.01	3.84	0.01	3.80	0.01	3.74	0.01	3.78	0.01	3.70	0.01
Cinnamon Oil	3.85	0.01	3.84	0.01	3.75	0.01	3.75	0.01	3.73	0.01	3.70	0.01
Clove Oil	3.84	0.01	3.82	0.00	3.76	0.01	3.74	0.01	3.71	0.01	3.71	0.01
Eucalyptus Oil	3.85	0.00	3.83	0.00	3.80	0.01	3.75	0.01	3.73	0.01	3.70	0.01
Rosemary Oil	3.91	0.02	3.85	0.01	3.85	0.01	3.84	0.01	3.78	0.01	3.72	0.01
Sesame Oil	3.90	0.00	3.82	0.01	3.74	0.01	3.70	0.01	3.69	0.01	3.70	0.01
Wheat Germ Oil	3.94	0.01	3.86	0.01	3.83	0.01	3.75	0.01	3.71	0.00	3.69	0.01
Control 300 ppm P.S	4.09	0.00	4.05	0.00	4.00	0.01	4.00	0.00	3.90	0.01	3.87	0.01
Control No Preservatives	4.00	0.01	3.92	0.01	3.81	0.01	3.74	0.01	3.60	0.01	3.45	0.00

Table 4.53. Effect of some essential oils on pH degree of labneh during storage at 500 µl\kg oil concentration

pH with 500 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	4.00	0.01	4.00	0.00	3.99	0.01	3.95	0.01	3.88	0.01	3.73	0.01
Cedar Wood Oil	4.00	0.00	3.85	0.01	3.86	0.01	3.81	0.01	3.72	0.01	3.70	0.00
Cinnamon Oil	3.99	0.01	3.99	0.00	3.94	0.01	3.90	0.01	3.84	0.01	3.77	0.01
Clove Oil	4.01	0.01	4.00	0.00	4.00	0.01	4.01	0.01	3.91	0.01	3.82	0.01
Eucalyptus Oil	3.90	0.00	3.90	0.01	3.90	0.00	3.89	0.01	3.80	0.01	3.75	0.01
Rosemary Oil	4.05	0.00	4.00	0.00	4.01	0.01	4.00	0.01	3.81	0.01	3.79	0.01
Sesame Oil	3.90	0.01	3.98	0.03	3.90	0.01	3.81	0.01	3.80	0.01	3.73	0.01
Wheat Germ Oil	3.93	0.01	3.90	0.00	3.87	0.01	3.87	0.01	3.81	0.01	3.77	0.01
Control 300 ppm P.S	4.09	0.00	4.05	0.00	4.00	0.01	4.00	0.00	3.90	0.01	3.87	0.01
Control No Preservatives	4.00	0.01	3.92	0.01	3.81	0.01	3.74	0.01	3.60	0.01	3.45	0.00

Table 4.54. Effect of some essential oils on pH degree of labneh during storage at 600 µl\kg oil concentration

pH with 600 µl\kg oil Concentration	Week1		Week2		Week3		Week4		Week5		Week6	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Almond Sweet Oil	4.05	0.01	3.94	0.01	3.87	0.01	3.83	0.02	3.79	0.01	3.70	0.01
Cedar Wood Oil	4.00	0.01	3.91	0.01	3.93	0.02	3.90	0.00	3.87	0.01	3.80	0.00
Cinnamon Oil	3.98	0.01	3.94	0.01	3.93	0.01	3.91	0.01	3.89	0.01	3.84	0.01
Clove Oil	3.98	0.01	3.95	0.00	3.95	0.02	3.93	0.01	3.84	0.01	3.80	0.01
Eucalyptus Oil	3.97	0.01	3.92	0.01	3.90	0.00	3.86	0.01	3.85	0.01	3.80	0.01
Rosemary Oil	3.99	0.01	3.95	0.01	3.92	0.01	3.90	0.00	3.85	0.00	3.80	0.01
Sesame Oil	3.90	0.01	3.90	0.01	3.83	0.01	3.80	0.00	3.67	0.00	3.61	0.01
Wheat Germ Oil	4.01	0.01	3.95	0.01	3.92	0.01	3.90	0.01	3.90	0.00	3.85	0.01
Control 300 ppm P.S	4.09	0.00	4.05	0.00	4.00	0.01	4.00	0.00	3.90	0.01	3.87	0.01
Control No Preservatives	4.00	0.01	3.92	0.01	3.81	0.01	3.74	0.01	3.60	0.01	3.45	0.00

4.3. Effect of essential oils on organoleptic properties, flavour, body, texture and appearance of labneh

Results given in table (4.55) show the organoleptic evaluation of labneh which was treated with essential oil and potassium sorbate, compared with the untreated control (positive control) and with (negative control), and results given in table (4.56) show the organoleptic evaluation of labneh which was treated with essential oil without potassium sorbate, compared with the untreated control (positive control) and with (negative control).

4.3.1. Effect of Almond sweet, Cedar wood, Cinnamon, Clove, Rosemary, Sesame and Wheat germ essential oils at 150 µl\kg, 200 µl\kg, 250 µl\kg, 300 µl\kg and 300 µl\kg respectively, in the presence of synthetic preservative (potassium sorbate at 150 ppm) on organoleptic properties of labneh

The organoleptic properties of the different labneh were also investigated and the results are presented in tables [4.55.A and B].

There were considerable and obvious differences in the flavour of these treated samples as compared with the untreated control, labneh containing essential oils at 150 ppm potassium sorbate were the most acceptable. The total scores of labneh containing essential oils decreased with an increase in the concentration of the essential oils. In addition, in all cases the total scores of the sensory evaluation decreased gradually during storage. The best oil and most acceptable is sesame oil at 150 µl\kg concentration followed by almond sweet oil at 150 µl\kg, rosemary oil at 200 µl\kg and clove oil at 150 µl\kg.(see table 4.55A,B)

Table 4.55.A: Organoleptic properties of labneh treated with almond sweet, cedar wood, cinnamon, clove, rosemary, sesame, wheat germ essential oils essential oils during 6 weeks.

Oil	Concentration	Score fresh labneh	Score week 1	Score week 2	Score week 3	Score week 4	Score week 5	Score week 6
positive Control	300 ppm	96	96	93	91	87	82	77
negative Control	zero	96	93	86	82	71	66	59
Almond sweet	150	96	94	92	90	90	86	79
Almond sweet	200	96	94	93	88	85	83	78
Almond sweet	250	96	93	93	90	87	83	75
Almond sweet	300	96	93	92	88	83	79	73
Almond sweet	350	96	92	90	89	84	80	71
Cedar wood	150	96	90	86	87	84	74	64
Cedar wood	200	96	95	92	86	81	76	67
Cedar wood	250	96	93	90	90	83	79	70
Cedar wood	300	96	92	91	86	83	80	72
Cedar wood	350	96	92	90	84	82	72	61
Cinnamon	150	96	90	87	82	78	80	73
Cinnamon	200	96	86	89	85	80	76	71
Cinnamon	250	96	83	82	78	76	73	72
Cinnamon	300	96	78	76	77	75	73	69
Cinnamon	350	96	75	72	69	70	67	62
Clove	150	96	90	90	88	83	84	73
Clove	200	96	85	83	81	77	73	68
Clove	250	96	80	81	76	73	72	65
Clove	300	96	82	80	78	74	73	67
Clove	350	96	80	78	73	70	67	64
Rosemary	150	96	91	90	86	84	83	81
Rosemary	200	96	90	91	91	87	84	75
Rosemary	250	96	90	90	91	86	83	79
Rosemary	300	96	87	86	80	83	78	73

Table 4.55.B: Organoleptic properties of labneh treated with almond sweet, cedar wood, cinnamon, clove, rosemary, sesame, wheat germ essential oils during 6 weeks.

Rosemary	350	96	88	82	77	74	73	68
Sesame	150	96	95	93	90	92	90	83
Sesame	200	96	93	94	92	91	87	82
Sesame	250	96	95	90	86	88	84	81
Sesame	300	96	91	91	90	84	81	78
Sesame	350	96	92	89	90	86	83	80
Wheat germ	150	96	94	94	83	82	71	63
Wheat germ	200	96	93	90	76	73	68	55
Wheat germ	250	96	94	91	83	81	72	62
Wheat germ	300	96	92	87	75	68	60	62
Wheat germ	350	96	92	85	73	62	66	58

All results were evaluated as a percentage %, for flavour (50 points), body and texture (40 points), and appearance (10 points).

4.3.2. Effect of Almond sweet, Cedar wood, Cinnamon, Clove, eucalyptus, Rosemary, Sesame and Wheat germ essential oils at 300 µl\kg, 400 µl\kg, 500 µl\kg, 600 µl\kg, respectively, in the absence of synthetic preservative on organoleptic properties of labneh

The organoleptic properties of the different labneh samples were also investigated and the results were presented in tables [4.56].

There were considerable and obvious differences in the flavour of these treated samples as compared with the untreated control, labneh containing essential oils at 300 µl\kg were the most acceptable, The total scores of labneh containing essential oils decreased with an increase in the concentration of the essential oils. In addition, in all cases the total scores of the sensory evaluation decreased gradually during storage.

The best oil and most acceptable oil was rosemary at 300 µl\kg concentration followed by almond sweet at 500 µl\kg. It is noted that the almond sweet, cedar wood, wheat germ and sesame essential oil do not have the strong taste or distinctive taste, but the evaluation was not very good, especially in the last weeks because the taste of acidity in labneh sample.

Table 4.56: Organoleptic properties of labneh treated with almond sweet, cedar wood, cinnamon, clove, eucalyptus, rosemary, sesame, wheat germ essential oils during 6 weeks.

Oil	Concentration	Score fresh labneh	Score week 1	Score week 2	Score week 3	Score week 4	Score week 5	Score week 6
positive Control	300 ppm	96	96	93	91	87	82	77
negative Control	zero	96	93	86	82	71	66	59
Almond sweet	300	96	92	90	83	76	77	72
Almond sweet	400	96	90	91	82	79	75	73
Almond sweet	500	96	89	90	87	83	80	75
Almond sweet	600	96	87	86	83	76	73	70
Cedar wood	300	96	91	88	87	82	75	62
Cedar wood	400	96	93	90	85	80	76	64
Cedar wood	500	96	93	86	84	83	73	71
Cedar wood	600	96	90	88	82	80	80	68
Cinnamon	300	96	85	79	80	76	73	71
Cinnamon	400	96	86	80	78	74	75	68
Cinnamon	500	96	79	76	74	70	70	67
Cinnamon	600	96	76	74	75	70	68	64
Clove	300	96	80	82	77	75	71	68
Clove	400	96	73	70	68	63	58	52
Clove	500	96	70	67	67	60	61	54
Clove	600	96	66	62	58	52	50	50
eucalyptus	300	96	83	80	77	73	72	67
eucalyptus	400	96	81	78	76	76	71	68
eucalyptus	500	96	78	74	71	68	63	66
eucalyptus	600	96	71	72	70	67	68	64
Rosemary	300	96	90	88	86	82	80	78
Rosemary	400	96	91	91	91	84	81	75
Rosemary	500	96	88	90	84	80	76	70
Rosemary	600	96	86	83	79	80	75	73
Sesame	300	96	90	91	87	83	73	70
Sesame	400	96	91	90	83	74	70	64
Sesame	500	96	86	83	78	71	68	61
Sesame	600	96	83	80	75	70	64	63
Wheat germ	300	96	91	87	80	82	60	54
Wheat germ	400	96	92	83	82	73	62	51
Wheat germ	500	96	88	85	80	81	50	60
Wheat germ	600	96	86	84	77	81	56	48

All results were evaluated as a percentage %, for flavour (50 points), body and texture (40 points), and appearance (10 points).

CHAPTER SIX

GENERAL CONCLUSION

AND RECOMMENDATION

Conclusion and Recommendation

E.Os have a wide spectrum of antimicrobial activity, their use as preservatives in food have not yet been extended. In the last few decades, consumers are demanding healthy safe food with least concentration of synthetic food additives and least heat treatment. Essential oils represent an alternative to synthetic preservatives in the food industry against spoilage bacteria especially *Coliforms*, *E. coli O157:H7*, yeast, mold, *S. aureus* which were tested in this study. Most of the selected plant extracts used in this study, have antimicrobial active compounds of that could substitute natamycin, sodium benzoate and potassium sorbate.

Labneh is a middle eastern fermented milk, that is highly consumed but with a major problem in its short shelf life due to contamination during processing, leading to use of synthetic potassium sorbate at different concentrations. The addition of essential oils can be used as a single substitute to potassium sorbate to increase the shelf life, or by the combination of natural preservatives and synthetic preservatives leading to better results using low concentration of synthetic antimicrobial agents (150ppm of potassium sorbate). According to our study, there are two possibilities either using natural plant extracts as substitutes and /or use in combination with synthetic antimicrobial agent. Our results showed that Cinnamon, clove and rosemary essential oil at 300 µl\kg, 350 µl\kg with 150 ppm potassium sorbate can be used in order to increase the shelf life of labneh for up to 6 weeks at 5 ± 1^{o}C with acceptable taste, flavour and texture.

Eucalyptus, rosemary, cinnamon and clove essential oils at concentrations of (400, 500, 600 µl\kg) can be used to increase the shelf life of labneh for up to 6 weeks without any synthetic preservatives. An increase in the essential oils concentrations lead to a decrease in bacterial, yeast and mold counts.

Both coliform and E. coli were not detected in any of the labneh samples prepared by addition of the respective essential oils.

The choice of an E.O and its concentration in a particular food is important, because a small amount can cause sensory alterations.

Cinnamon oil, clove oil, rosemary oil and eucalyptus oil have good antiseptic, antibacterial and antifungal properties compared to other oil used in this study, because of the presence of

phenols, monoterpene, alcohols, aldehydes esters and lactones which affect the growth of pathogenic microorganisms specially gram positive.

Although the literature data about the antimicrobial effect of E.Os are abundant, there are new areas of application to be discovered specially the effect of the chemical composition and its physicochemical effects.

Extraction of the active ingredients of these oils or other oils and their applications as preservatives or antioxidants on food may give appreciable results.

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- **Appendices**

Appendix A: Certificate of analysis for clove oil

DÜLLBERG
KONZENTRA

Certificate of Analysis

Mat.-No	1001158	Batch-No	0000024094
Product	Clove Oil	No. of Analysis	40000020201
Company No	102886		
Company	Sun Pharm Drug Store		

Characteristic	Value	Unit	Lower Limit	Upper Limit
Appearance (sensorical)	Corresponds	clear Liquid		
Colour (sensorical)	Corresponds	colourless to yellow		
Smell (sensorical)	Corresponds	spicy		
Relative density (20/20)	1,0395		1,030	1,055
Refractive index (at 20° C)	1,5335		1,528	1,537
Optical rotation (at 20° C)	-1,21	°	-2,0	0,0
Solubility in Ethanol 70%	Corresponds			
Solubility set values	Corresponds	clear soluble		
Fatty resinified volatile oils	corresponds DAB			
Foreign Esters	corresponds DAB			
foreign phenoles	corresponds DAB			
Water soluble compounds	Corresponds			
Halogens	corresponds DAB			
Acidic or alkaline substances	corresponds DAB			
Chromatographic Profile	corresponds			
Acetyleugenol	0,86	A%	0,001	
beta-Caryophyllene	14,70	A%	8,0	18,0
Eugenol	80,01	A%	80,0	

Observations/ Remarks: corresponds to DAB

Date of manufacture 21.07.2014 Date of retest 20.07.2016

Created SROY
Date 22.07.2014

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Düllberg Konzentra m.b.H.Hamburg
Registergericht: HamburgHR B 37513
Steuernummer: 49 /615 /00287

Kommanditgesellschaft: Sitz Hamburg
Registergericht: Hamburg HR A 47413
Geschäftsführer: Manfred Düllberg
Christian Düllberg

Deutsche Bank AG
BLZ 200 700 00/Kto 49 09007
IBAN:DE51200700000490900700
BIC: DEUTDEHH

Appendix B: Certificate of analysis for cinnamon oil

DÜLLBERG KONZENTRA

Certificate of Analysis

Mat.-No	2003423	Batch-No	0000034198
Product	Cinnamon Oil	No. of Analysis	40000033008
Company No	102180		
Company			
Your Product	6116		

Characteristic	Value	Unit	Lower Limit	Upper Limit
Appearance (sensorical)	Corresponds	clear Liquid		
Colour (sensorical)	Corresponds	pale yellow to yellow		
Relative density (20/4)	1,0228		1,000	1,040
Refractive index (at 20°C)	1,5845		1,573	1,600
Optical rotation (at 20°C)	-1,20	°	-2,0	0,0
Chromatographic Profile	corresponds			
Eugenol	4,57	A%	3,0	6,0
Linalool	2,74	A%	1,0	5,0
Cinnamicaldehyde	68,11	A%	60,0	80,0

Observations/ Remarks: corresponds to BP

Date of manufacture 09.02.2015 Date of retest 08.02.2018

Created PM
Date 10.02.2015

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Appendix C: Certificate of analysis for rosemary oil

DÜLLBERG KONZENTRA

Certificate of Analysis

Mat.-No	2003312	Batch-No	0000021243
Product	Rosemary Oil	No. of Analysis	40000016930
Company No	102180		
Company			
Your Product	6126		

Characteristic	Value	Unit	Lower Limit	Upper Limit
Appearance (sensorical)	Corresponds	clear Liquid		
Colour (sensorical)	Corresponds	colourless to pale yellowish		
Relative density (20/20)	0,9091		0,895	0,920
Refractive index (at 20°C)	1,4676		1,464	1,473
Optical rotation (at 20°C)	1,18	°	-5,0	8,0
Chromatographic Profile	corresponds			
Borneol	4,00	A%	1,5	5,0
Bornylacetate	0,97	A%	0,10	1,50
Camphene	5,20	A%	2,5	6,0
Camphor	10,60	A%	5,0	15,0
Cineole	40,30	A%	38,0	55,0
para-Cymene	1,30	A%	0,80	2,50
Limonene	3,70	A%	1,5	4,0
beta-Myrcene	1,70	A%	1,0	2,0
alpha-Pinene	12,70	A%	9,0	14,0
beta-Pinene	8,80	A%	4,0	9,0
alpha-Terpineol	2,40	A%	1,0	2,6
Verbenone	0,00	A%		0,40

Observations/ Remarks: corresponds to to the constants of Ph. Eur

Date of manufacture 28.05.2014 Date of expiry at least 27.05.2017

Created AD
Date 02.06.2014

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974/1
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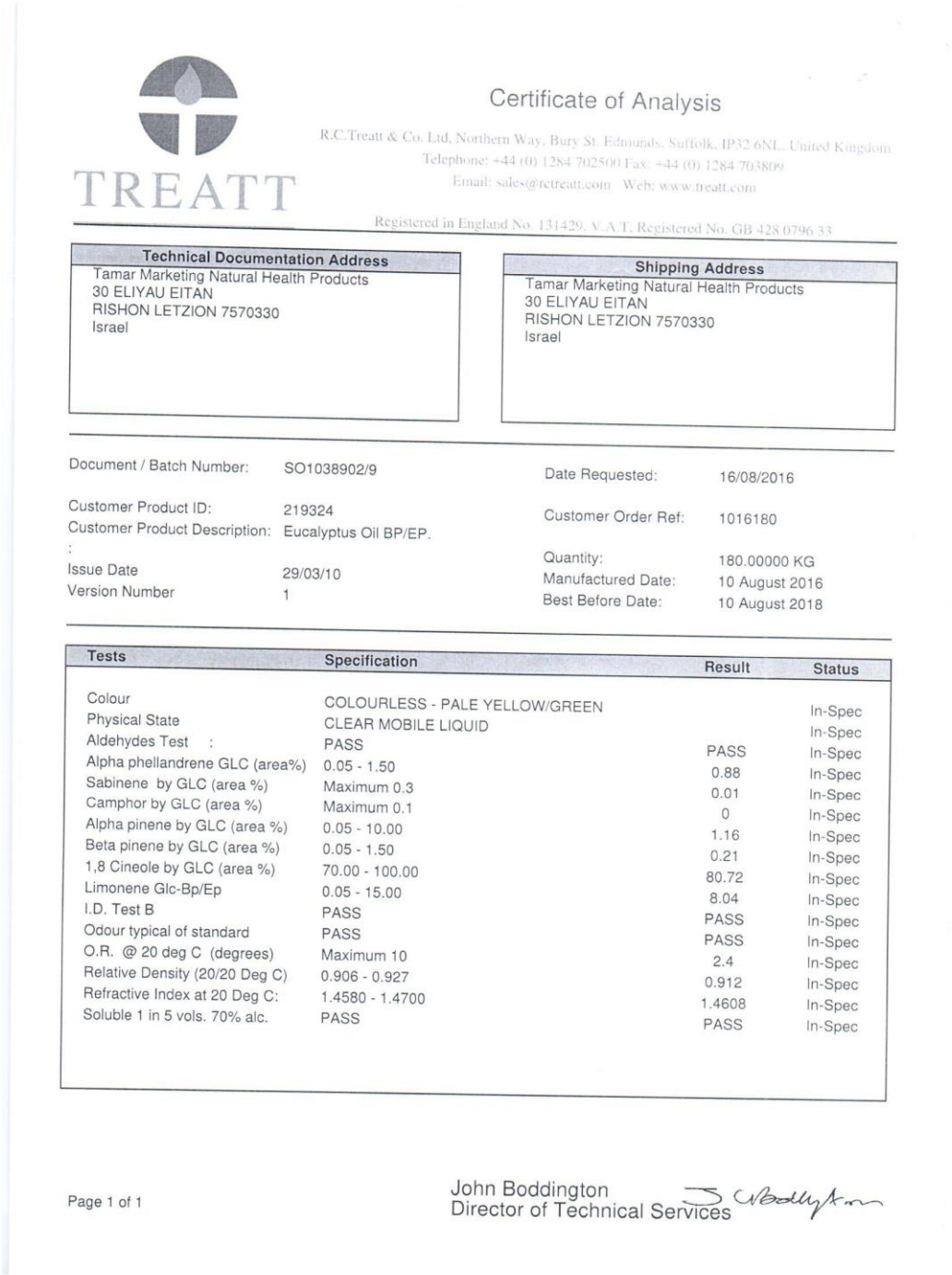
Düllberg Konzentra m.b.H.Hamburg
Registergericht: HamburgHR B 37513
Steuernummer: 49 /615 /00287

Kommanditgesellschaft: Sitz Hamburg
Registergericht: Hamburg HR A 47413
Geschäftsführer: Manfred Düllberg
Christian Düllberg

Deutsche Bank AG
BLZ 200 700 00/Kto 49 00007
IBAN:DE51200700000490000700
BIC: DEUTDEHH

Appendix D: Certificate of analysis for eucalypyus oil



TREATT

Certificate of Analysis

R.C.Treatt & Co. Ltd, Northern Way, Bury St. Edmunds, Suffolk, IP32 6NL, United Kingdom
Telephone: +44 (0) 1284 702500 Fax: +44 (0) 1284 703809
Email: sales@rctreatt.com Web: www.treatt.com
Registered in England No. 131429. V.A.T. Registered No. GB 428 0796 33

Technical Documentation Address	Shipping Address
Tamar Marketing Natural Health Products 30 ELIYAU EITAN RISHON LETZION 7570330 Israel	Tamar Marketing Natural Health Products 30 ELIYAU EITAN RISHON LETZION 7570330 Israel

Document / Batch Number:	SO1038902/9	Date Requested:	16/08/2016
Customer Product ID:	219324	Customer Order Ref:	1016180
Customer Product Description:	Eucalyptus Oil BP/EP.		
:		Quantity:	180.00000 KG
Issue Date	29/03/10	Manufactured Date:	10 August 2016
Version Number	1	Best Before Date:	10 August 2018

Tests	Specification	Result	Status
Colour	COLOURLESS - PALE YELLOW/GREEN		In-Spec
Physical State	CLEAR MOBILE LIQUID		In-Spec
Aldehydes Test :	PASS	PASS	In-Spec
Alpha phellandrene GLC (area%)	0.05 - 1.50	0.88	In-Spec
Sabinene by GLC (area %)	Maximum 0.3	0.01	In-Spec
Camphor by GLC (area %)	Maximum 0.1	0	In-Spec
Alpha pinene by GLC (area %)	0.05 - 10.00	1.16	In-Spec
Beta pinene by GLC (area %)	0.05 - 1.50	0.21	In-Spec
1,8 Cineole by GLC (area %)	70.00 - 100.00	80.72	In-Spec
Limonene Glc-Bp/Ep	0.05 - 15.00	8.04	In-Spec
I.D. Test B	PASS	PASS	In-Spec
Odour typical of standard	PASS	PASS	In-Spec
O.R. @ 20 deg C (degrees)	Maximum 10	2.4	In-Spec
Relative Density (20/20 Deg C)	0.906 - 0.927	0.912	In-Spec
Refractive Index at 20 Deg C:	1.4580 - 1.4700	1.4608	In-Spec
Soluble 1 in 5 vols. 70% alc.	PASS	PASS	In-Spec

Page 1 of 1

John Boddington
Director of Technical Services

فاعلية الزيوت العطرية الأساسية المختارة ضد البكتيريا التي تنقلها الأغذية لتوسيع فترة صلاحية اللبنة

إعداد: مهند نبيل ابراهيم الايوبي

المشرف: د. فؤاد الريما وي

د. كلود الاعمي

الملخص

الطريقة الرئيسة لإنتاج اللبنة تكون بتصفية اللبن بواسطة قطعة من القماش، لإزالة نسبة من الماء، والوصول الى المستوى الإجمالي المطلوب من المواد الصلبة. مما يجعلها خطوة حساسة للغاية في صناعة اللبنة، و يرجع ذلك إلى صعوبة تنظيف وتعقيم أكياس القماش المستخدمة في إنتاجها، مما يزيد من التلوث الميكروبي، للحد من البكتيريا الضارة هناك عدة طرق, وتعدّ طريقة إستخدام المواد الحافظة الطبيعية واحدة من أكثر الطرق المقبولة لتمديد فترة صلاحية المنتجات الغذائية القابلة للفساد: مثل إضافة الزيوت العطرية. وقد إستخدمت في هذه الدراسة الزيوت العطرية لزيادة فترة صلاحية اللبنة من ثمانية وعشرين يوما إلى سته وثلاثين يوما على الأقل، وكذلك تم تخفيض نسبة المادة الحافظة الكيميائية (سوربات البوتاسيوم)، وتم قياس نشاط البكتيريا ونشاطها بعد إضافة الزيوت، ومن أهمها العد البكتيري الإجمالي (total viable count)، وبكتيريا (*Escherichia coli O157:H7*)، وبكتيريا (Coliforms)، وبكتيريا (*Staphylococcus aureus*)، والأعفان والخمائر. وقد إستخدمت عدة تراكيز مختلفة من الزيوت العطرية لتمديد العمر الإفتراضي للبنة لمدة ستة أسابيع على الأقل.

واستخدمت في هذه الدراسة الزيوت العطرية التالية: زيت القرفة وزيت القرنفل وزيت إكليل الجبل وزيت اللوز الحلو وزيت السمسم وزيت جنين القمح وزيت خشب السدر وزيت الكينا. بحيث تم إضافتها إلى اللبنة على مرحلتين: المرحلة الأولى إضافة الزيوت العطرية بتراكيز مختلفة 350 ميكرولتر/ كجم و 300 ميكرولتر/ كغم و 250 ميكرولتر/ كغم و200 ميكرولتر/ كغم و 150 ميكرولتر/ كغم، مع إضافة المادة الحافظة الاصطناعية (سوربات البوتاسيوم) (150 ppm) وهي نصف الكمية المستخدمة حاليا في مصانع الألبان على المستوى المحلي حيث إنها تضاف بكمية (300 ppm). وكانت المرحلة الثانية بإضافة الزيوت العطرية فقط، أي بدون إضافة سوربات البوتاسيوم، بتراكيز مختلفة 300 ميكرولتر/ كغم و 400 ميكرولتر/ كغم و 500 ميكرولتر/ كغم و 600 ميكرولتر/ كغم.

وتؤثر إضافة الزيوت العطرية على المواد الصلبة، وعلى درجة الحموضة بشكل طفيف. في نتائج المرحلة الأولى، إنخفض عدد البكتيريا الكلي (TVC) في وجود الزيوت العطرية الأساسية موازنة مع العينات المرجعية، حيث كانت تحتوي على (300ppm) من سوربات البوتاسيوم. وكانت أفضل ثلاثة زيوت عطرية أساسية هي: زيت القرفة وزيت القرنفل وزيت إكليل الجبل. وفي المرحلة الثانية (بدون المادة الحافظة الكيميائية) كانت أفضل ثلاثة زيوت عطرية هي: زيت القرنفل وزيت إكليل الجبل وزيت شجرة الكينا.

وأظهرت نتائج المرحلة الأولى إنخفاض عدد الأعفان في عينات اللبنة المضاف إليها زيت القرفة وزيت القرنفل وزيت إكليل الجبل، أما عند إضافة الزيوت العطرية فقط كانت أفضل ثلاثة زيوت هي: زيت القرنفل وزيت إكليل الجبل وزيت شجرة الكينا. كما إنخفضت أعداد الخمائر موازنة مع العينات المرجعية، بحيث كانت أفضل النتائج في المرحلة الأولى للبنة المضاف إليها زيت القرفة وزيت القرنفل وزيت إكليل الجبل وزيت اللوز الحلو وزيت خشب السدر، أما في المرحلة الثانية كان أفضل الزيوت هو زيت القرنفل وزيت الكينا عند تركيز 600 ميكرولتر/كغم. كما أظهرت النتائج أن زيت القرفة وزيت القرنفل وزيت إكليل الجبل وزيت اللوز الحلو وزيت خشب السدر تؤثر على نمو بكتيريا *S. aureus* أما في المرحلة الثانية كانت أفضل نتيجة عند إضافة زيت إكليل الجبل عند تركيز600 ميكرولتر/كغم.

وتبين أنه لم تظهر بكتيريا (*Escherichia coli O157:H7*) وبكتيريا (Coliform) في جميع العينات التي تم اختبارها، وكذلك في العينات المرجعية.

وأظهرت النتائج أن اللبنة الأكثر قبولا من ناحية الخصائص الحسية، هي اللبنة التي تحتوي على 150 ميكرولتر/كغم من زيت السمسم وزيت إكليل الجبل، وإستنتجت الدراسة أن زيت القرفة عند تركيز 300 ميكرولتر/ كغم، يتبعه زيت اللوز الحلو عند تركيز 500 ميكرولتر/كغم. وإستنتجت الدراسة أن تركيز 600 ميكرولتر/كغم، و (350 ميكرولتر/ كغم من زيت القرفة وزيت إكليل الجبل وزيت القرنفل وزيت الكينا مع 150 ppm من سوربات البوتاسيوم) يمكن استخدامها لزيادة فترة صلاحية اللبنة لمدة تصل إلى ستة أسابيع، لما لهذه الزيوت من خصائص مطهرة، فهي مضادة للبكتيريا ومضادة للفطريات.