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GC/MS evaluation of the composition of the *Aloe vera* gel and extract

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A R T I C L E I N F O

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A B S T R A C T

This study aimed to investigate the potential use of *Aloe vera* (AV) as a food additive given its critical importance in food safety and health. Specifically, the natural antimicrobial and antioxidant properties of AV were examined to prevent food spoilage and extend its shelf life. This study was conducted using commercially available *aloe vera* gel (AVG) and *aloe vera* extract (AVE). These samples were tested using gas chromatography–mass spectrometry (GC–MS). The analysis involves identifying and quantifying the components using natural helium gas. The antimicrobial and antifungal effects of these components were evaluated and compared with those reported in the literature. GC–MS analysis revealed that the *Aloe vera* gel and extract contained various volatile components, including phenolic compounds, anthraquinone glycosides, and different esters. According to GC–MS results of the two different forms of AV, the main volatile compounds of the gel form were levoglucosan, tridecanoic acid, decanoic acid methyl ester, octadecanoic acid methyl ester, octadecanoic acid, nonadeca-1.18-diyn-4.16-diol and squalene, whereas the extract form contained volatile compounds with antifungal activity such as tridecanoic acid, octadecanoic acid methyl ester, octadecanoic acid, nonanoic acid and eicosyl acetate. Both samples exhibited antimicrobial and antifungal activities, especially against pathogens such as *Staphylococcus aureus*, *Candida albicans*, *Aspergillus niger*, and *Escherichia coli*. This study demonstrated the potential of *Aloe vera* gel and extract as a natural preservative for use in food because of its constituent components. This study highlights the potential use of *Aloe vera* as a natural additive in the food industry. Due to its antimicrobial and antifungal properties, *Aloe vera* offers an organic alternative to chemical additives. *Aloe vera* is effective at preventing food spoilage and extending shelf life, making it a suitable option for meeting consumer demand for organic and natural products.

1. Introduction

With the increasing global population and diminishing food resources, the integration of technology and traditional methods has become essential for preventing food spoilage. Food safety, which is a fundamental need today, is also of critical importance to human health. With technological advancements, numerous chemical food additives have been used to prevent food spoilage and extend shelf life. However, owing to the adverse effects and potential carcinogenicity of the cumulative effects of these additives on the body, consumers are increasingly turning to organic foods. In this context, natural antimicrobial and antioxidant agents are becoming more popular (Borchers et al., 2010). This scenario has highlighted the use of *Aloe vera*, a plant known for its significant therapeutic potential that has been used since ancient times in various parts of the world. In ancient Egypt, *Aloe vera*'s "blood" (i.e., *Aloe vera* extract (AVE)) was used for beauty, health, and immortality, whereas *Aloe vera* gel (AVG) was employed in mummification rituals and accompanied pharaohs in their journey to the afterlife (Dalichow, 2012). Ebers Papyrus, one of the oldest medical documents written in Thebes approximately 1550 BCE, describes several formulations based on *aloe vera* in hieroglyphics, detailing its medical properties for the first time. This document was preserved at Leipzig University in Germany (Ebers, 1873; Herrmann-Lingen et al., 2008). *Aloe vera* was planted around temples, pyramids, and along roads to the Valley of the Kings in Ancient Egypt and was seen as a sign that the deceased had reached "the other shore" when it bloomed. Ancient Egyptians used *Aloe vera* for mummification and as a purgative in enemas. Cleopatra's legendary bright eyes were due to a drop made from aloe, and Nefertiti's skin beauty and complexion were attributed to daily baths in donkey milk and *Aloe vera* gel (Ursin, 2020). At approximately 700–800 CE, the Chinese used aloe to treat sinusitis, fever, and convulsions in children. In the 8th century, the poet Liu Yu Xi described his recovery from

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persistent eczema, which no medicine could cure, through a concoction prepared by a traveling plant seller containing aloe and liquorice roots (Loret, 1982). Samurai warriors coat their bodies with aloe pulp before battles to ward off evil spirits and seek immortality.[1] The Chinese pharmacist Li Shih-Shen, who lived between 1518 and 1593, recognized *Aloe vera* among therapeutically beneficial plants, and contemporary Chinese medicine uses aloe pulp to treat arteriosclerosis (Shehata et al., 2004). Primarily, *Aloe vera* has been revered as a therapeutic and pharmacopoeic plant with healing properties in sacred texts since the Sumerians, earning various names such as "Desert Lily" in Africa, "Heaven's Staff" in India, "Plant of Immortality" in Egypt, "Divine Plant" in Russia, and "Miracle Plant" in Europe (Arosio et al., 2000; Habeeb et al., 2007; Haller, 1990; Ni & Tizard, 2004).

Aloe vera is now used worldwide in creams, food supplements, yogurts, detergents, and other "health" drinks. By tracing the therapeutic roots of *Aloe vera* to ancient times, this study aimed to identify the volatile components present in unadulterated AVGs and AVEs after separation and their classification as antimicrobial agents. The next section describes the chemical components and antimicrobial effects of the *Aloe vera* plant. Subsequently, the study focused on detecting volatile oils formed using gas chromatography–mass spectrometry at various concentrations (1%, 2%, 3%, 4%, and 5% (*w/v*)) of AVG and AVE, which are specifically produced for use in foods. Finally, the identified components were compared with the literature to conclude and present evidence to answer the research question.

2. Structure of *Aloe vera*

2.1. Gel structure of the Aloe vera plant

Aloe vera is a natural antimicrobial agent. AV latex, also known as aloe juice or aloe extract, is a bitter yellow liquid that exudes from the pericyclic tubules beneath the epidermis. AV latex comprises 20–30% of the total leaf weight, is rich in phenolic compounds, and exhibits antibacterial properties against gram-positive bacteria such as *Bacillus subtilis, Enterococcus faecalis, Shigella flexneri, Streptococcus pyrogenes* (Boudreau & Beland, 2006; Surjushe et al., 2008; Alemdar & Agaoglu, 2009; Danish et al., 2020). The four main C-glycosyl components of AV latex are aloin A, aloin B, aloesin, and aloeresin A (Boudreau et al., 2013). In contrast, AV gel is a colorless and sticky substance obtained from parenchymal cells in fresh leaves, constituting 70–80% of the leaf weight (Kılıç et al., 2020). The polysaccharides in the AV gel are composed of polymannan chains containing more mannose than glucose (Channe et al., 1979; Femenia et al., 1999; Kılıç et al., 2020; Mandal & Das, 1980; Yaron, 1993). The bioactive components of AV leaves, such as mannans, anthraquinone, C-glycosides, and lectins, which have antioxidant properties, have made *aloe vera* popular in the food industry (Rodriguez et al., 2010). Studies have shown that the ratios of minerals and trace elements in *Aloe vera* gel vary depending on the age of the leaf and the part used. *Aloe vera* gel contains calcium, chlorine, copper, chromium, iron, lithium, magnesium, manganese, phosphorus, potassium, sodium, and zinc, with calcium, potassium, magnesium, and sodium being the most abundant. A study of three *Aloe vera* producers over a 112-week period revealed that *Aloe vera* gel contained an average of 390 mg/L potassium, 186 mg/L sodium, 313 mg/L calcium, and 55 mg/L magnesium (Surjushe et al., 2008). AVG contains various enzymes, including alkaline phosphatase, amylase, bradykinase, carboxypeptidase, catalase, cellulase, lipase, and peroxidase. Bradykinase helps reduce excessive inflammation when applied topically to the skin, whereas other enzymes assist in the breakdown of sugars and fats (Heck et al., 1981). The gel contains β-sitosterol, lupeol (a triterpenic alcohol with analgesic and antimicrobial properties), and campesterol (Rajasekaran et al., 2006). Owing to their similar structures, these phytosterols, when combined with cholesterol, inhibit each other's solubility. An increase in the amount of phytosterols reduces the solubility of cholesterol, thereby increasing its fecal excretion and precipitation. Thus, they can fight excess cholesterol. It also possesses analgesic, anti-inflammatory, and antiseptic properties. *Aloe vera* gel contains a multitude of molecules, including anthraquinone glycosides, polyhexoses, mannose, alkaloids, phenolic compounds, phytosterols, lectins, and vitamins (vitamins A, B1, B2, B4, B6, B12, and tocopherol) (Hamman, 2008; Mulay et al., 2013; Nejatzadeh-Barandozi, 2013). AV has antibacterial, antiviral, and antifungal activities (Alves et al., 2004; Çete et al., 2010; Bhat et al., 2015).

2.2. Structure of the Aloe vera extract

This extract, also known as latex or sap, is found in the upper and lower epidermis (pericyclic cells) of *Aloe vera* leaves. This yellow and bitter sap contains 20–40% anthracene derivatives, referred to as anthraquinones, and chromones. At high doses, anthraquinones have a laxative effect, but at low concentrations, they possess strong antimicrobial properties and facilitate intestinal absorption (Sims et al., 1971). They also exhibit potent analgesic properties. Studies on *Aloe vera* extracts have frequently identified and characterized anthraquinone derivatives (Grindlay & Reynolds, 1986; Koshioka et al., 1982; Matasyoh et al., 2008). These compounds are abundant and have various therapeutic properties. Aloin, a glycoside of aloe-emodin, constitutes 15–40% of the sap content and releases aloe-emodin upon hydrolysis in the digestive system. Barbaloin, also known as aloin A and B, is the main component of sap and possesses analgesic, antibacterial, and antiviral properties. Aloin is an active component that has laxative properties. Aloe-emodin acts as an irritant stimulant in the digestive system and has antifungal, antibacterial, hepatoprotective, antiviral, and antitumor properties (Arosio et al., 2000).

These therapeutic effects have been linked to the inhibition of urokinase secretion and prevention of tubule formation in endothelial cells (two main mechanisms in angiogenesis) (Yordanova et al., 2017). Among the components of the extract, aloe-emodin-9-anthrone is known to be a metabolite of isobarbaloin and a potent laxative agent. Aloetic acid is recognized for its natural antibiotic effect and enhanced efficacy when used with other water-soluble anthraquinones. Chrysophanic acid stimulates bile secretion and is known for its fungicidal effects on skin fungi. Aloe-ulcin inhibits gastric secretion. Cinnamic acid ester plays a role in the inflammatory process and has analgesic and anesthetic effects. The essential oil in the extract is known to be a component of *Aloe vera* that has analgesic effects. Resestanol, found in the extract, has bactericidal and anti-inflammatory effects and can also produce a natural corticoid effect.

2.3. Content and form of the plant

Aloe vera is a natural antimicrobial agent. AV latex, also known as aloe juice or aloe extract, is a bitter, yellow liquid that emerges from pericyclic tubules beneath the epidermis. It constitutes 20–30% of the total leaf weight and is rich in phenolic compounds, displaying antibacterial properties against gram-positive bacteria (Boudreau & Beland, 2006; Surjushe et al., 2008; Alemdar & Agaoglu, 2009). The four primary C-glycosyl components of AV latex are aloin A, aloin B, aloesin, and aloeresin A (Boudreau et al., 2013). Conversely, AV gel, a colorless and sticky substance, is derived from parenchymal cells in fresh leaves, making up 70–80% of the leaf weight (Kılıç et al., 2020). The polysaccharides in the AV gel consist of polymannan chains containing more mannose than glucose (Channe et al., 1979; Femenia et al., 1999; Kılıç et al., 2020; Mandal & Das, 1980; Yaron, 1993). The sap and gel within the *Aloe vera* leaf had distinct appearances and chemical compositions. The plant components are listed in Table 1.

[1] In the Gospel of John, "Nicodeme came to the place where Jesus was buried in the middle of the night, bringing about a hundred pounds of aloe and myrrh (John 1939).

Table 1
Summary of the chemical composition of unprocessed *aloe vera* leaves (gel and extract).

Component Type	Species/Compounds
Essential Amino Acids	Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Valine
Secondary Amino Acids	Aspartic Acid, Glutamic Acid, Alanine, Arginine, Cystine, Glycine, Histidine, Proline, Hydroxyproline, Serine, Tyrosine
Minerals and Trace Elements	Calcium, Chlorine, Copper, Chromium, Iron, Lithium, Magnesium, Manganese, Phosphorus, Potassium, Sodium, Zinc
Chromones	8-C-glucosyl-(2'-O-cinnamyl)-7-*O*-methylaloediol A, 8-C-glucosyl-(*S*)-aloesol, 8-C-glucosyl-7-*O*-methyl-(*S*)-aloesol, 8-C-glucosyl-7-*O*-methylaloediol, 8-C-glucosyl-noreugenin, isoaloresin D, isobarbaloin, neoaloesin A
Mono- and Polysaccharides	Glucose, Mannose, Cellulose, Aldo-Pentose, L-Rhamnose, Acemannan, Aloeride
Anthraquinones	Aloin A and B (or barbaloines), aloe-emodin, aloetic acid, chrysophanic acid, aloe-ulcin, anthracene and anthranol, emodin of aloe, cinnamic acid ester, ether oil, resestanol
Vitamins	A, B1, B2, B3, B6, B9, B12, C, E
Organic Compounds and Lipids	
Enzymes	Alkaline phosphatase, amylase, bradykinase, carboxypeptidase, catalase, cellulase, lipase, peroxidase
Sterols	Beta-sitosterol, lupeol, campesterol, cholesterol, salicylic acid, gibberellin, lupeol, lignins, uric acid, arachidonic acid

The bioactive components of AV leaves, including mannans, anthraquinone, C-glycosides, and lectins, which have antioxidant properties, have been widely used in the food industry (Rodriguez et al., 2010). Owing to its antimicrobial properties, AV has been utilized in various food products, such as yogurts, jams, instant tea granules, confectioneries, nonalcoholic beverages, and ice cream (Ahlawat & Khatkar, 2011; Steenkamp & Stewart, 2007). However, its role as a primary preservative in daily consumed basic food items such as meat and meat products, dairy, and other daily food items necessitates careful examination of its toxicity. The use of *Aloe vera* in goat and buffalo meat, milk, and dairy products has been reported in the literature (Kılıç et al., 2020).

Goat meat pieces coated with 3% *Aloe vera* gel and packed under modified atmospheric conditions, when stored at 4 °C for 42 days, exhibited lower oxidation and free fatty acid values. Buffalo meat prepared with 4% *Aloe vera* and 2% arjuna tree bark extract was found to have good sensory and structural characteristics. Chicken nuggets augmented with 5%, 10%, and 15% *Aloe vera* pulp (roots) and stored in low-density polyethylene bags at 4 °C for 21 days showed significantly lower lipid oxidation and microbial counts than did the control group. *Aloe vera* extract increased the moisture content, emulsion stability, and cooking yield of nuggets without affecting their sensory properties. Shrimp coated with 75% and 100% *Aloe vera* gel exhibited inhibited lipid oxidation, preserved structural properties, and improved sensory quality after 7 days of storage at 4 °C.

In *Aloe vera*-supplemented probiotic yogurts, the number of syneresis events increased, the pH decreased, and the *Lactobacillus acidophilus* and *Bifidobacterium bifidum* counts decreased over the 28-day storage period at 4 °C. However, the yogurt maintained adequate probiotic bacterial counts. The addition of *Aloe vera* gel powder to fermented milk caused an increase in angiotensin-converting enzyme inhibitor activity and proteolysis. *Aloe vera* powder increased the viable counts of *Lactobacillus casei* NCDC19, which remained high throughout the storage period. The addition of thyme and *Aloe vera* extracts increased the logarithmic bacterial count of L. *acidophilus* in Doogh. In particular, the combined use of zinc and *Aloe vera* extracts resulted in the highest probiotic bacterial counts.

The use of *Aloe vera* to extend the shelf life of fruits and vegetables has proven effective against pathogens such as *Penicillium digitatum* and *Botrytis cinerea*, thereby prolonging the spoilage times of fruits and vegetables. *Aloe vera* gel-based edible coatings have delayed physical changes in fruits and vegetables and have extended their shelf life. Specifically, in table grapes, it reduced weight loss, color change, and softening, extending the shelf life to 35 d at 1 °C. Edible coatings reduced mesophilic aerobic, yeast, and mold counts. *Aloe vera* gel inhibited fungal spoilage in pomegranate arils and other fruits and slowed the ripening process. *Aloe vera* gel and chitosan-based coatings reduced microbial growth and water loss in blueberry fruits. The application of *Aloe vera* gel to eggplants, cherries, raspberries, pineapples, and other fruits and vegetables improved their physical and chemical parameters, extending their shelf life. Fruit drinks and water containing *Aloe vera* had positive effects on microbial activity and antioxidant activity. These beverages were found to be acceptable to consumers in terms of flavor and appearance.

These results demonstrate the positive outcomes of using *Aloe vera* extract and gel in the food industry. The potential toxicity of *Aloe vera* extract and gel is an important consideration, and further research is needed to fully understand its implications.

2.4. *Toxicity of the Aloe vera plant*

When orally administered to mice, *A. vera* gel (in its lyophilized form) showed no toxic effects at doses of 1–24 mg/kg in either acute or chronic treatment. Administration of fresh or lyophilized gel to mice or rats, either orally or intravenously, at acute doses of 20 g/kg or 5 g/kg daily for 45 days did not result in any toxicity. A study published in 1998 investigated the effects of *Aloe vera* gel on growth and metabolic parameters in mice (Herlihy et al., 1998). For this study, AVG raw gel was extracted from the leaf, lyophilized, and turned into a fine powder, which was further filtered over charcoal to remove anthraquinones. The raw form of *Aloe vera* gel, when administered as a dietary supplement at concentrations of 3%, 5%, and 10%, at approximately 330, 550, and 1100 mg/kg, respectively, for 1.5 months, caused diarrhea, growth retardation, polydipsia, and polyuria in mice. At a concentration of 1% (approximately 110 mg/kg), oral administration caused no toxic effects. However, when administered for 5.5 months, 1% dose led to alterations in parathyroid hormone and calcitonin serum levels, suggesting that *aloe vera* gel might affect calcium metabolism. Another study (Guo & Mei, 2016) reported that low dietary supplementation of *Aloe vera*, 1% *w*/w gel, or 0.02% *w/v* whole leaf in drinking water caused no adverse effects or changes in physiological parameters in mice. Another study using oral *Aloe vera* gel in mice showed no genotoxic effects in either acute or chronic treatments (Boudreau & Beland, 2006). These studies suggest that AVG without anthraquinones does not have toxic effects. However, the safety outcomes differed in studies where AVG and AVE were used together, indicating that the inclusion or exclusion of anthraquinone can vary.

Research on the toxicity of acemannan, a compound found in *Aloe vera*, began in the 1930s. A study by (Peng et al., 1991) demonstrated the wound-healing efficacy of acemannan. However, a study by (Fogleman et al., 1992) used test mice and examined commercial acemannan, which was 78–84% lyophilized and contained less than 10% water, calcium, and magnesium. In their study, (Fogleman et al., 1992) single or multiple doses of acemannan were administered intravenously or intraperitoneally to rats and dogs. No signs of toxicity were observed in rats or mice at a single dose; however, vomiting and diarrhea were observed in dogs after intravenous or intraperitoneal injection. Repeated intravenous administration of acemannan caused macrophage and monocyte accumulation in the lungs of mice and in the liver and spleen of rats. The intravenous administration of a high dose (80 mg/kg) to mice resulted in a 30% mortality rate, and the administration of a moderate dose (40 mg/kg) resulted in a 15% mortality rate. They reported a 25% mortality rate at doses of 100–200 mg/kg administered intraperitoneally. Also, this study investigated the acute and subchronic toxicity of oral administration. Acemannan was administered to the rats for 14 days at approximately 4 mg/kg, for 6 months at 2 mg/kg, and for

90 days at 1.5 mg/kg. No toxicity or death was observed in the rats or dogs after 14 days. However, bleeding, kidney enlargement, and pyelonephritis have been reported in rats after 6 months, suggesting that long-term use of acemannan might cause kidney toxicity.

These toxicity reports, as presented for commercially available acemannan in 1992, highlight the need to examine *Aloe vera* gel and extracts available on the market today, especially since *Aloe vera* is constantly consumed through food. Therefore, within the scope of this study, 1% concentrations of AVG and AVE (1%, *w/v*) were created using gas chromatography–mass spectrometry and comparatively analyzed. This will contribute to research aimed at creating a healthier food preservative by removing harmful toxic residues by examining AVGs and AVEs available on the market. For these reasons, the third section covers the methodology and materials for this analysis, and the fourth section presents the findings of the analysis.

3. Materials and methods

In this study, natural and preservative-free commercial *Aloe vera* gel (AVG) (FOREVER®, 1 L) and *Aloe vera* extract (AVE) (NURBAL HEALING®, 50 g) were used as food supplements.

For GC–MS analysis of AVG and AVE, AVG and AVE (0.5 mL) were collected and diluted with 5 mL of methanol before being transferred to vials. The samples were analyzed using a Thermo 8000 Evo® GC–MS instrument. The injection volume was 2 μL, and high-purity natural helium with at least 99.999% purity was used at a constant flow rate of 1.3 mL/min. The analysis employed an HP-5 MS column (30 m × 0.25 mm × 0.25 μm) connected to a split-splitless inlet with an MS detector. The injector and ion source temperatures were set at 280 °C and 300 °C, respectively. The oven program was as follows: held at 90 °C for 1 min, increased at a rate of 30 °C/min to 150 °C, and held for 1 min. Subsequently, the temperature was increased to 190 °C at 10 °C/min and held for 2 min. Then, the temperature was increased at 10 °C/min to 285 °C and finally held for 5 min. The total GC run time was 25 min. All peak points were scanned and compared with the WILEY 9 library, and the mass spectral EM voltage was set at 200 Rel with a scanning range of 50–550 *m/z*. The relative percentage of each component was calculated by dividing the average peak area by the total peak area. Mass spectra and chromatograms were analyzed using Trace Finder® 3.0.

4. Results and discussion

In this study, examining the volatile components of AVG and AVE identified by GC–MS, all peak points were scanned and compared with the WILEY 9 library. Table 2 presents the scanning results.

Table 2 details the components of *aloe vera* gel (AVG) and *aloe vera* extract (AVE) and their potential activities. A graph showing the analysis of these components by GC–MS is provided in Fig. 1.

The analysis identified the presence of common volatile components and those that varied between AVG and AVE, as detailed in Table 3.

It has been determined that AVG contains volatile components such as levoglucosan, tridecanoic acid, decanoic acid methyl ester, octadecanoic acid methyl ester, octadecanoic acid, nonadeca-1,18-diyn-4,16-diol, and squalene. AVE includes volatile components with antifungal activity, such as tridecanoic acid, octadecanoic acid methyl ester, octadecanoic acid, nonanoic acid, and eicosyl acetate Table 4. Additionally, components such as benzo-furan decanoic acid, 2,3-dihydro octadecanoic acid methyl ester, 4-methoxycinnamic acid, and 6-hydroxy-4,7-dimethylcoumarin were also found. Both AVG and AVE samples contained antimicrobial volatile components, such as methyl ester, squalene, 2,2-dimethyl-1-pyrrolylpropanol, nonanoic acid, and eicosyl acetate Table 2.

For the AVG form, benzofuran, 2,3-dihydro- has been shown to be a component that can be used as an antimicrobial, antioxidant, and food additive. 1.6-Anhydro-α-d-galacto-pyranose/1.6-anhydro-β-D-gluco-pyranose (levoglucosan) was identified for its antifungal properties, indicating its potential use in the food industry to inhibit fungal growth. Tridecanoic acid (CAS) is known for its antifungal effects on fungal growth and is found in gels. 1-Naphthalenol, 3-methyl-(CAS), is a potential food-coating material because of its antifungal, pesticide, and antioxidant properties. Decanoic acid, a methyl ester with antifungal and antimicrobial properties, is a volatile component of AVG that can be used to extend the shelf life of foods. 4-Methoxycinnamic acid, a component of AVG, possesses anti-inflammatory, anticancer, antifungal, and antimicrobial properties. Octadecanoic acid methyl ester (CAS), a volatile component, can be used as an antifungal agent and food additive. Octadecanoic acid (CAS) is known for its antifungal and solidifying properties, suggesting its use in nonpesticide agricultural fertilization because of its nonstick properties. Octadecanoic acid is a long-chain saturated fatty acid. Unlike other saturated fatty acids, stearic acid does not appear to increase serum cholesterol concentrations (Grundy, 1994) suggesting that fats rich in octadecanoic acid can be used in the diet. This component is also frequently used in cosmetic products such as soaps and shampoos. However, Zishan et al. (2023) suggests potential kidney-related discomfort with frequent consumption. Nephrotoxic medical plants have the potential to harm renal tissue and compromise renal function.

6-Hydroxy-4,7-dimethylcoumarin, which has anti-inflammatory, anticoagulant, antimicrobial, and antifungal properties, is a component that can be used to extend the shelf life of food. Nonadeca-1,18-diyn-4,16-diol, which possesses antifungal, antituberculosis, and cytotoxic properties, appears to require cautious use or further research on food consumption. Considering the lack of specific findings in living beings, it is suggested that exposure to a cytotoxic component should be controlled. Octadecanoic acid and methyl ester (CAS) appear to be useful as antifungal, antibacterial, and food additives. (+−)-1,2-Epoxy-3-tetradecanol (myristic acid) requires further research, as its specific activity has not been determined. Hexadecanedioic acid dimethyl ester (CAS) is a component that can be used as an antioxidant, nematicide, pesticide, antiandrogenic, hypocholesterolemic, hemolytic, or flavoring agent. However, its contribution to extending the shelf life of foods has not been researched. Octadecanoic acid and 2-hydroxy-1-(hydroxymethyl)ethyl ester (CAS) disrupt the cell cycle in G2 cells and induce apoptosis. Care should be taken when using this antimicrobial component to extend the shelf life of food. Ergosta-5,24(28)-dien-3-ol (3á)-(CAS), which has cytotoxic and antifungal properties, is a component that requires careful use due to its cytotoxic effects. Eicosenoic acid methyl ester (CAS), which possesses hypocholesterolemic properties, is a component that requires caution for use in extending the shelf life of food. Octadecenamide (*Z*)- (CAS) can be used in food packaging, adhesives, sealing chemicals, and surfactants. Squalene, identified in AVG, possesses antibacterial, antioxidant, antitumor, cancer-preventive, pesticidal, immunostimulant, and lipoxygenase inhibitor properties. Vitamin E (α-tocopherol) has been identified in AVG as a component with antioxidant, biokinetic, and bioavailability properties.

The analysis of the volatile components of the AVEs is presented in Table 5.

In this study, 21 compounds were identified in the AVE. 2,2-Dimethyl-1-pyrazylpropanol is known for its antibacterial properties. However, t-butyl 3-hydroxy-2,3-diphenyl-5-oxo-2-propylcyclopent-1-ene-1-carboxylate was observed as a component with undetermined activity. Nonanoic acid (CAS), known for its antimicrobial, antifungal, and insect-repellent properties, has been identified by the FDA as a food additive that can be directly added to human foods under appropriate conditions as a synthetic flavoring agent and adjuvant (https://pubchem.ncbi.nlm.nih.gov/compound/Nonanoicacid#section=FDA Requirements&fullscreen = true) (E)-1,1,1-Trifluoro-4-phenyl-3-penten-2-one was identified in AVE as a component known for its infection counteractivity, apoptosis induction, antibody conjugation, and potential use in natural products. Isoval acid monotms were observed as fatty acid components. The compound (3-[(t-butyl)dimethylsilyl]propyl acetate) identified among the AVE components requires further study for its

Table 2
Aloe vera (gel and extract) composition.

No.	RT	Name of The Compound	Molecular Formula	MW	Peak Area	Activity	Library Name
A: *Aloe vera* gel							
1	3.89	Benzofuran. 2.3-dihydro-(CAS)	C_8H_8O	120.15	89,147,480.16	Antimicrobial, Antioxidant, Food additives	WILEY9
2	5.97	5-(2-Bromotetrafluoroethyl)-5-hydroxy-3-methyl-4.5-dihyroisoxazole	$C_6H_6BrF_4NO_2$	279	4,004,746.752		WILEY9
3	6.12	1.6-anhydro-alpha-d-galacto-pyranose 1.6-anhydro-beta–D-glucopyranose (levoglucosan)	$C_6H_{10}O_5$	162.14	512,994,509.8	Anti-fungal	WILEY9
4	6.49	(3-[(t-Butyl)dimethylsilyl]propyl acetate	$C_{11}H_{24}O_2Si$	216.4	823,699,559.6		WILEY9
5	6.82	Tridecanoic acid (CAS)	$C_{13}H_{26}O_2$	214.34	61,205,194.71	Anti-fungal	WILEY9
6	7.54	1-Naphthalenol 3-methyl-(CAS)	$C_{11}H_{10}O$	158.2	42,178,887.65	Antifungal, Pesticide, Antioxidant	WILEY9
7	8.60	Decanoic acid. Methyl ester	$C_{11}H_{22}O_2$	186.2912	55,224,761.96	Antifungal, Antimicrobial	WILEY9
8	8.96	4-Methoxycinnamic acid	$C_{10}H_{10}O_3$	178.18	1,900,124.102	Anti-inflammatory, Anticancer, Anti-fungal, Antimicrobial	WILEY9
9	11.45	Octadecanoic acid. Methyl ester (CAS)	$C_{19}H_{38}O_2$	298.50	1,052,911,694	Antifungal, Food additives	WILEY9
10	11.90	Octadecanoic acid (CAS)	$C_{18}H_{36}O_2$	284.47	555,899,815.2	Antifungal, Plasticizers, Agricultural products (nonpesticidal), Anti-adhesive agents	WILEY9
11	11.93	6-Hydroxy-4.7-dimethylcoumarin	$C_{11}H_{10}O_3$	190.19	555,899,815.2	Anti-inflammatory, Anticoagulant, Antimicrobial, Antifungal	WILEY9
12	13.60	Nonadeca-1.18-diyn-4.16-diol	$C_9H_{16}O_2$	156.22	271,106,882.6	Antifungal, Anti-tuberculosis, Cytotoxic	WILEY9
13	13.95	Octadecanoic acid. Methyl ester (CAS)	$C_{19}H_{38}O_2$	298.50	1,019,579,776	Antifungal, Antibacterial, Food additives	WILEY9
14	14.05	(+−)-1.2-Epoxy-3-Tetradecanol (Myristic acid)	$C_{14}H_{28}O_2$	228.37	290,172,044.1		WILEY9
15	14.31	Octadecanoic acid (CAS)	$C_{18}H_{36}O_2$	284.47	218,819,542.2	Plasticizers, Agricultural products (nonpesticidal), Anti-adhesive agents	WILEY9
16	17.59	Hexadecanedioic acid. Dimethyl ester (CAS)	$C_{17}H_{34}O_4$	270	607,985,928.4	Antioxidant, Nematacide, Pesticide. Antiandrogenic, Hypocholesterolemia, Hemolytic, Flavor	WILEY9
17	18.44	Octadecanoic acid. 2-hydroxy-1-(hydroxymethyl)ethyl ester (CAS)	$C_{21}H_{42}O_4$	358.5558	57,584,107.41	Perturbs cell cycle and induce apoptosis in Hep G2 cells. Antimicrobial	WILEY9
18	18.51	Ergosta-5.24 (28)-dien-3-ol. (3á)-(CAS)	$C_{28}H_{46}O$	398.7	1,566,291,020	Cytotoxic effect, Antifungal	WILEY9
19	19.39	Eicosenoic acid. Methyl ester (CAS)	$C_{21}H_{38}O_2$	322	464,476.013	Hypocholesterolemia	WILEY9
20	19.73	9-Octadecenamide. (*Z*)- (CAS)	$C_{18}H_{35}NO$	281.5	6,862,780,226	Food packaging, Adhesives and sealant chemicals, Surface active agents	WILEY9
21	20.11	Squalene	$C_{30}H_{50}$	410	439,833,581.6	Antibacterial, Antioxidant, Antitumor, Cancer preventive, Pesticide, Immunostimulant, Lipoxygenase inhibitor	WILEY9
22	23.37	Vit E	$C_{29}H_{50}O_2$	430	551,459,493	Antioxidant, Biokinetic, Bioavailability	WILEY9
B: *Aloe vera* extract							
No.	RT	Name Of The Compound	Molecular Formula	MW	Peak Area	Activity	Library Name
1	3.75	2.2-Dimethyl-1-pyrazylpropanol	$C_9H_{14}N_2O$	166	269,503,250.4	Antibacterial	WILEY9
2	4.42	t-Butyl 3-hydroxy-2.3-diphenyl-5-oxo-2-propylcyclopent-1-ene-1-carboxylate	$C_{14}H_{22}O_4$	254	87,080,738.54		WILEY9
3	4.58	Nonanoic acid (CAS)	$CH_3(CH_2)_7CO_2H$	158.24	36,647,199.41	Antimicrobial, Antifungal, A pest insect	WILEY9
4	5.64	(E)-1.1.1-Trifluroro-4-phenyl-3-penten-2-one	$C_{11}H_9F_{3O}$	214.187	44,427,268.01	Anti-infection, Apoptosis, Antibody- conjugate, Natural Products	WILEY9
5	6.04	Isoval acid-monotms-	$C_5H_{10}O_2$	102.1317	1,229,184,696	Fatty acids	WILEY9
6	6.50	(3-[(t-Butyl) dimethylsilyl] propyl acetate	$C_{11}H_{24}O_2Si$	216.4	174,814,405.2		WILEY9
7	7.19	Octadecanoic acid (CAS)	$C_{18}H_{36}O_2$	284.47	3,243,089.465	Plasticizers, Agricultural products (nonpesticidal), Anti-adhesive agents, Antifungal	WILEY9
8	11.46	Decanoic acid. Methyl ester (CAS)	$C_{11}H_{22}O_2$	186.2912	834,710,218.6	Pesticides, Fatty acids, Food additives, Antifungal, Antimicrobial	WILEY9
9	11.91	Octadecanoic acid (CAS)	$C_{18}H_{36}O_2$	284.47	1,837,207,178	Plasticizers, Agricultural products (nonpesticidal), Anti-adhesive agents, Antifungal	WILEY9
10	13.60	7.10-Hexadecanedioic acid. Methyl ester (CAS)	$C_{17}H_{30}O_2$	266.4	485,911,309	Fatty acid esters, Antioxidant, Nematacide, Pesticide, Antiandrogenic, Hypocholesterolemia, Hemolytic, Flavor	WILEY9
11	13.67	Oleic acide. Methyl ester	$C_{19}H_{36}O_2$	296.5	738,374,168.1	Anti-inflammatory. Cancer preventive. Anti-Androgenic. Hypocholesterolemia Fatty acids ester. Stabilizer. Flavoute. Non-Pesticide. Food additive	WILEY9
12	13.94	Heneicosanoic acid. Methyl ester (CAS)	$C_{22}H_{44}O_2$	340.5836	1,050,847,545	Fatty acids ester	WILEY9
13	14.00	(+−)-1.2. Epoxy-3-Tetradecanol	$C_{14}H_{28}O_2$	228	148,835,001.5		WILEY9
14	14.31	Octadecanoic acid (CAS)	$C_{18}H_{36}O_2$	284.47	232,631,225.3	Plasticizers. Agricultural products (nonpesticidal). Anti-adhesive agents, Antifungal	WILEY9
15	17.59	Tridecanedoic acid. Dimethyl ester (CAS)	$C_{15}H_{28}O_4$	272.38	514,589,482.8	Antifungal	WILEY9
16	18.03	Cholest-5 –en-3-ol (3á)- (CAS)	$C_{27}H_{46}O$	386.7	204,905,350.7	Antioxidant. Anticancer. antihyperlipidemic	WILEY9

(*continued on next page*)

Table 2 (*continued*)

No.	RT	Name of The Compound	Molecular Formula	MW	Peak Area	Activity	Library Name
A: *Aloe vera* gel							
17	18.51	Ergosta-5.24 (28)-dien-3-ol. (3á)- (CAS)	$C_{28}H_{46}O$	398.7	14,279,447.92	Ergosterol and its derivatives antifungal. Food additive	WILEY9
18	19.23	Hexadecanedioic acid. Dimethyl ester (CAS)	$C_{18}H_{34}O_4$	314.4602	404,124,965.7	Fatty acids. Pesticides	WILEY9
19	19.72	Eicosyl acetate	$C_{22}H_{44}O_2$	340.5836	3,535,857,966	Antimicrobial and anti-fungal activity	WILEY9
20	20.12	Methyl ethyl 2.2.4-trichlorotridecanoate	$C_{16}H_{27}Cl_3O_4$	388	1,340,584,347		WILEY9
21	23.38	Vitamin E (α-tocopherol)	$C_{29}H_{50}O_2$	430	61,239,546.2	Antioxidant. Biokinetic. Bioavailability	WILEY9

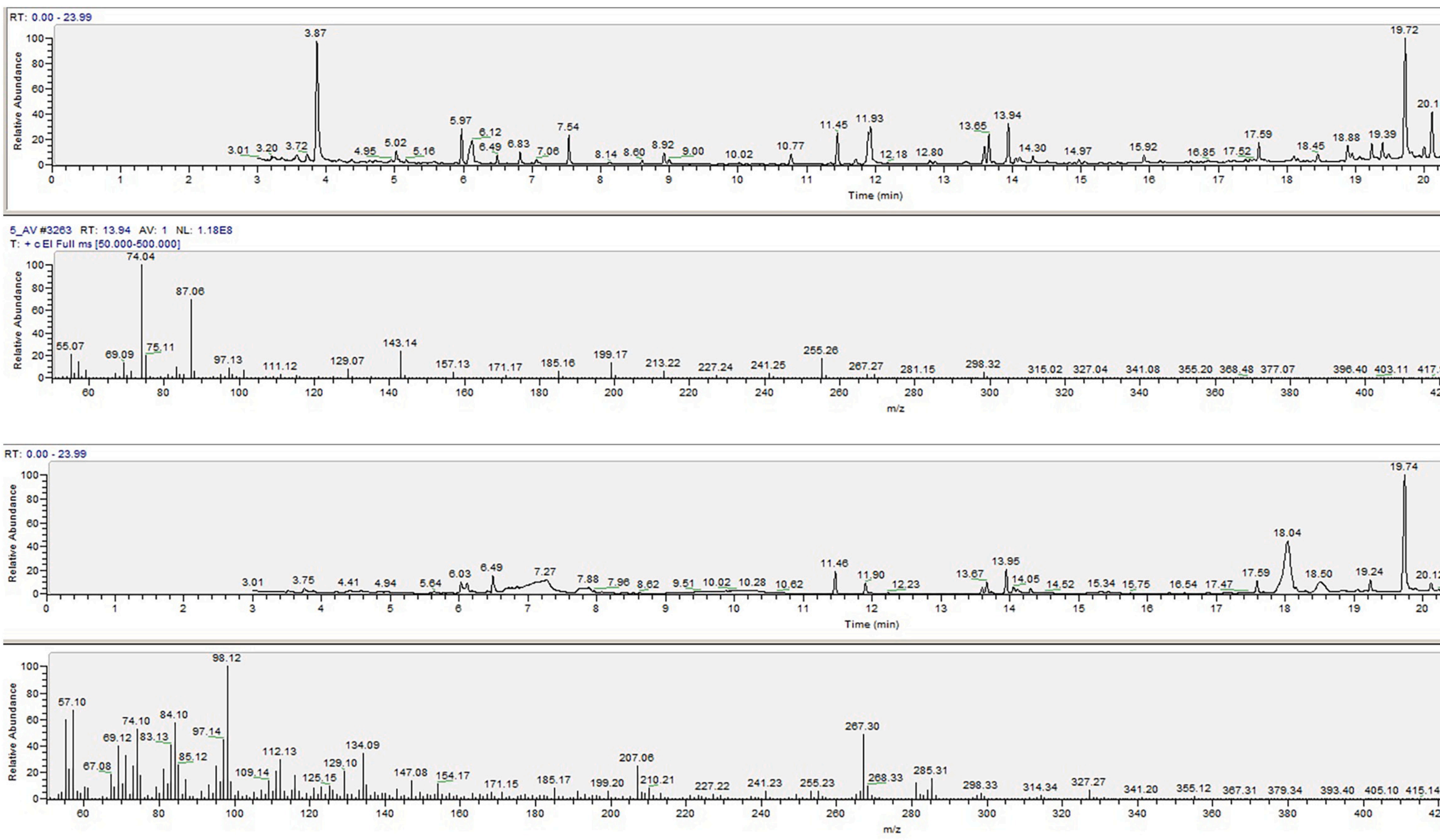

Fig. 1. Retention times and peaks of AV gel (A) and extract (B) composition by GC–MS.

ability to extend the shelf life of food products. Octadecanoic acid (CAS) is a common component found in both AVG and AVE. Decanoic acid, methyl ester (CAS), known for its use in pesticides and its fatty acid, antifungal, and antimicrobial properties, is among the AVE components. Hexadecanedioic acid, methyl ester (CAS), a fatty acid ester, antioxidant, nematicide, pesticide, antiandrogenic, hypocholesterolemic, hemolytic, and flavoring agent, is recognized among the acceptable food products in the AVE. Oleic acid, a methyl ester, has been identified as an AVE component with anti-inflammatory, cancer-preventive, antiandrogenic, hypocholesterolemic, stabilizer, aroma, and food additive properties. Heneicosanoic acid methyl ester (CAS) is a type of fatty acid ester. (+−)-1,2-Epoxy-3-tetradecanol is an AVE component with unspecified activity. Tridecanedoic acid dimethyl ester (CAS), identified as an AVE component, possesses antifungal properties. Cholest-5-en-3-ol (3á)-CAS is an AVE with antioxidant, anticancer, and antihyperlipidemic properties. Ergosta-5,24(28)-dien-3-ol, (3á)- (CAS), ergosterol, and its derivatives have been identified as components of AVEs that can be used as antifungal agents and food additives. Eicosyl acetate is an AVE component that exhibits antimicrobial and antifungal activities but requires further research. Methyl ethyl 2,2,4-trichlorotridecanoate is another AVE component with unspecified activity. Vitamin E (α-tocopherol), a common component of both AVG and AVE, possesses antioxidant, biokinetic, and bioavailability properties.

The results obtained from our AV GC–MS analysis are consistent with the findings of (Arsene et al., 2022; Alrumman, 2018; Kumar et al., 2016; Jeevitha et al., 2015; Lakshmi & Rajalakshmi, 2011; Saccu et al., 2001) in terms of volatile components with antimicrobial efficacy and phytochemical properties. As shown in Fig. 1 (A and B) and Tables 2 and 3, AVG contained volatile components such as levoglucosan, tridecanoic acid, decanoic acid methyl ester, octadecanoic acid methyl ester, octadecanoic acid, nonadeca-1,18-diyn-4,16-diol, and squalene Table 4, whereas AVE contained components such as tridecanoic acid, octadecanoic acid methyl ester, octadecanoic acid, nonanoic acid, and eicosyl acetate with antifungal activity Table 5. Additionally, compounds such as benzo-furan decanoic acid, 2,3-dihydro-octadecanoic acid methyl ester, 4-methoxycinnamic acid, and 6-hydroxy-4,7-dimethylcoumarin

Table 3
Antimicrobial (A) and antifungal (B) effects of the *Aloe vera* gel and extract compounds.

	Aloe Vera	Extract	Gel
A	Benzofuran. 2.3-dihydro-(CAS)	−	+
	Decanoic acid. Methyl ester	+	+
	4-Methoxycinnamic acid	−	+
	6-Hydroxy-4.7-dimethylcoumarin	−	+
	Octadecanoic acid. Methyl ester (CAS)	−	+
	Squalene	−	+
	2.2-Dimethyl-1-pyrazylpropanol	+	−
	Nonanoic acid (CAS)	+	−
	Eicosyl acetate	+	−
B	1.6-anhydro-alpha-d-galacto-pyranose 1.6-anhydro-beta-D-glucopyranose (levoglucosan)	−	+
	Tridecanoic acid (CAS)	+	+
	Decanoic acid. Methyl ester	−	+
	Octadecanoic acid. Methyl ester (CAS)	+	+
	Octadecanoic acid (CAS)	+	+
	Nonadeca-1.18-diyn-4.16-diol	−	+
	Squalene	−	+
	Nonanoic acid (CAS)	+	−
	Eicosyl acetate	+	−

(+) Chemical structures found in *aloe vera* extract or gel.
(−) Chemical structures not found in *aloe vera* extract or gel.

were identified. Both AVG and AVE samples contained antimicrobial volatile components, such as methyl ester, squalene, 2.2-dimethyl-1-pyrazylpropanol, nonanoic acid, and eicosyl acetate Table 1.

Furthermore, the high antimicrobial and antifungal properties of decanoic acid methyl ester, nonanoic acid (CAS), and eicosyl acetate in the extract are considered sources of the high antimicrobial and antifungal activities against *S. aureus, C. albicans*, and *A. niger*. High antifungal activities of tridecanedioic acid, dimethyl ester, and ergosta-5,24 (28)-dien-3-ol (3á) were also noted. In the gel, the high antimicrobial activity against *E. coli* and *B. subtilis* was attributed to the antimicrobial activities of 4-methoxycinnamic acid, 6-hydroxy-4.7-dimethylcoumarin, and squalene, which were identified only in the gel. The high efficacy of 6-hydroxy-4.7-dimethylcoumarin and squalene is attributed to their phytochemical properties.

The high antifungal activity in both gel and extract forms is supported by the literature, indicating that it stems from the tridecanoic acid, decanoic acid methyl ester, and octadecanoic acid found in both AV forms. Various compounds in AVG and AVE, including their chemical name, molecular formula, molecular weight (MW), peak area, and potential activities, were obtained from the WILEY 9 library scans. No volatile gas-reported toxicity was found. However, commercial AVG and AVE in the market need to comply with the World Health Organization (WHO) guidelines, stating that the gel's water content must be greater than 98.5%, and the water content of the extract should not exceed 12%. According to the WHO, the pesticide content per product should be limited to 0.05 mg/kg, with cadmium at 0.3 mg/kg and lead at 10 mg/kg. Therefore, radioactive residue analysis is recommended. Anthraquinones, particularly aloin and aloe-emodin, have been shown to have mutagenic and genotoxic effects. Therefore, it remains necessary to ensure these anthraquinone derivatives are absent in compositions intended for oral use. In this study, no anthraquinone derivatives were detected in the commercially obtained AVG or AVE. However, the safety of using only market-available AV products for packaging or extending the shelf life of food products and whether necessary precautions are taken have not been conclusively established. Despite procedures such as banning unfit foods during inspections and applying adequate penalties to businesses, it is still unclear whether human health is adequately safeguarded.

5. Conclusions

With the advancement of technology and increasing food variety, less expensive and more practical methods are being employed to ensure

Table 4
Volatile compounds of AVG.

No.	RT	Compound Name	Molecular Formula	MW	Peak Area	Activity
1	3.89	Benzofuran. 2.3-dihydro-(CAS)	C_8H_8O	120.15	89,147,480.16	Antimicrobial, Antioxidant, Food additives
2	5.97	5-(2-Bromotetrafluoroethyl)-5-hydroxy-3-methyl-4.5-dihyroisoxazole	$C_6H_6BrF_4NO_2$	279	4,004,746.752	
3	6.12	1.6-anhydro-α-d-galacto-pyranose 1.6-anhydro-β-D-glucopyranose (levoglucosan)	$C_6H_{10}O_5$	162.14	512,994,509.8	Anti-fungal
4	6.49	(3-[(t-Butyl)dimethylsilyl]propyl acetate	$C_{11}\ H_{24}\ O_2\ Si$	216.4	823,699,559.6	
5	6.82	Tridecanoic acid (CAS)	$C_{13}H_{26}O_2$	214.34	61,205,194.71	Anti-fungal
6	7.54	1-Naphthalenol 3-methyl-(CAS)	$C_{11}H_{10}O$	158.2	42,178,887.65	Antifungal, Pesticide, Antioxidant
7	8.60	Decanoic acid. Methyl ester	$C_{11}H_{22}O_2$	186.2912	55,224,761.96	Antifungal, Antimicrobial
8	8.96	4-Methoxycinnamic acid	$C_{10}H_{10}O_3$	178.18	1,900,124.102	Anti-inflammatory, Anticancer, Anti-fungal, Antimicrobial
9	11.45	Octadecanoic acid. Methyl ester (CAS)	$C_{19}H_{38}O_2$	298.50	1,052,911,694	Antifungal, Food additives
10	11.90	Octadecanoic acid (CAS)	$C_{18}H_{36}O_2$	284.47	555,899,815.2	Antifungal, Plasticizers, Agricultural products (nonpesticidal), Anti-adhesive agents
11	11.93	6-Hydroxy-4.7-dimethylcoumarin	$C_{11}H_{10}O_3$	190.19	555,899,815.2	Anti-inflammatory, Anticoagulant, Antimicrobial, Antifungal
12	13.60	Nonadeca-1.18-diyn-4.16-diol	$C_9H_{16}O_2$	156.22	271,106,882.6	Antifungal, Anti-tuberculosis, Cytotoxic
13	13.95	Octadecanoic acid. Methyl ester (CAS)	$C_{19}H_{38}O_2$	298.50	1,019,579,776	Antifungal, Antibacterial, Food additives
14	14.05	(+−)-1.2-Epoxy-3-Tetradecanol (Myristic acid)	$C_{14}H_{28}O_2$	228.37	290,172,044.1	
15	14.31	Octadecanoic acid (CAS)	$C_{18}H_{36}O_2$	284.47	218,819,542.2	Plasticizers, Agricultural products (nonpesticidal), Anti-adhesive agents
16	17.59	Hexadecanedioic acid. Dimethyl ester (CAS)	$C_{17}H_{34}O_4$	270	607,985,928.4	Antioxidant, Nematacide, Pesticide. Antiandrogenic, Hypocholesterolemia, Hemolytic, Flavor
17	18.44	Octadecanoic acid. 2-hydroxy-1-(hydroxymethyl)ethyl ester (CAS)	$C_{21}H_{42}O_4$	358.5558	57,584,107.41	Perturbs cell cycle and induce apoptosis in Hep G2 cells. Antimicrobial
18	18.51	Ergosta-5.24 (28)-dien-3-ol. (3á)-(CAS)	$C_{28}H_{46}O$	398.7	1,566,291,020	Cytotoxic effect, Antifungal
19	19.39	Eicosenoic acid. Methyl ester (CAS)	$C_{21}H_{38}O_2$	322	464,476.013	Hypocholesterolemia
20	19.73	9-Octadecenamide. (*Z*)- (CAS)	$C_{18}H_{35}NO$	281.5	6,862,780,226	Food packaging, Adhesives and sealant chemicals, Surface active agents
21	20.11	Squalene	$C_{30}H_{50}$	410	439,833,581.6	Antibacterial, Antioxidant, Antitumor, Cancer preventive, Pesticide, Immunostimulant, Lipoxygenase inhibitor
22	23.37	Vit E	$C_{29}H_{50}O_2$	430	551,459,493	Antioxidant, Biokinetic, Bioavailability

Table 5
Volatile compounds of AVE.

No.	RT	Compound Name	Molecular Formula	MW	Peak Area	Activity
1	3.75	2.2-Dimethyl-1-pyrazylpropanol	$C_9H_{14}N_2O$	166	269,503,250.4	Antibacterial
2	4.42	t-Butyl 3-hydroxy-2.3-diphenyl-5-oxo-2-propylcyclopent-1-ene-1-carboxylate	$C_{14}H_{22}O_4$	254	87,080,738.54	
3	4.58	Nonanoic acid (CAS)	$CH_3(CH_2)_7CO_2H$	158.24	36,647,199.41	Antimicrobial, Antifungal, A pest insect
4	5.64	(E)-1.1.1-Trifluroro-4-phenyl-3-penten-2-one	$C_{11}H_9F_{3O}$	214.187	44,427,268.01	Anti-infection, Apoptosis, Antibody-conjugate, Natural Products
5	6.04	Isoval acid-monotms-	$C_5H_{10}O_2$	102.1317	1,229,184,696	Fatty acids
6	6.50	(3-[(t-Butyl) dimethylsilyl] propyl acetate	$C_{11}H_{24}O_2Si$	216.4	174,814,405.2	
7	7.19	Octadecanoic acid (CAS)	$C_{18}H_{36}O_2$	284.47	3,243,089.465	Plasticizers, Agricultural products (nonpesticidal), Anti-adhesive agents, Antifungal
8	11.46	Decanoic acid. Methyl ester (CAS)	$C_{11}H_{22}O_2$	186.2912	834,710,218.6	Pesticides, Fatty acids, Food additives, Antifungal, Antimicrobial
9	11.91	Octadecanoic acid (CAS)	$C_{18}H_{36}O_2$	284.47	1,837,207,178	Plasticizers, Agricultural products (nonpesticidal), Anti-adhesive agents, Antifungal
10	13.60	7.10-Hexadecanedioic acid. Methyl ester (CAS)	$C_{17}H_{30}O_2$	266.4	485,911,309	Fatty acid esters, Antioxidant, Nematacide, Pesticide, Antiandrogenic, Hypocholesterolemia, Hemolytic, Flavor
11	13.67	Oleic acide. Methyl ester	$C_{19}H_{36}O_2$	296.5	738,374,168.1	Anti-inflammatory, Cancer preventive, Anti-Androgenic, Hypocholesterolemia, Fatty acids ester, Stabilizer. Flavoute, Non-Pesticide, Food additive
12	13.94	Heneicosanoic acid. Methyl ester (CAS)	$C_{22}H_{44}O_2$	340.5836	1,050,847,545	Fatty acids ester
13	14.00	(+−)-1.2. Epoxy-3-Tetradecanol	$C_{14}H_{28}O_2$	228	148,835,001.5	
14	14.31	Octadecanoic acid (CAS)	$C_{18}H_{36}O_2$	284.47	232,631,225.3	Plasticizers, Agricultural products (nonpesticidal), Anti-adhesive agents, Antifungal
15	17.59	Tridecanedoic acid. Dimethyl ester (CAS)	$C_{15}H_{28}O_4$	272.38	514,589,482.8	Antifungal
16	18.03	Cholest-5 –en-3-ol (3á)- (CAS)	$C_{27}H_{46}O$	386.7	204,905,350.7	Antioxidant, Anticancer, Anti-hyperlipidemic
17	18.51	Ergosta-5.24 (28)-dien-3-ol. (3á)- (CAS)	$C_{28}H_{46}O$	398.7	14,279,447.92	Ergosterol and its derivatives antifungal, food additive
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19	19.72	Eicosyl acetate	$C_{22}H_{44}O_2$	340.5836	3,535,857,966	Antimicrobial and Antifungal
20	20.12	Methyl ethyl 2.2.4-trichlorotridecanoate	$C_{16}H_{27}\ Cl_3O_4$	388	1,340,584,347	
21	23.38	Vitamin E (α-tocopherol)	$C_{29}H_{50}O_2$	430	61,239,546.2	Antioxidant, Biokinetic, Bioavailability

that these foods are of appropriate quality. Chemical and artificial food additives are commonly used for this purpose. These substances are added to various food classes, such as ready-to-eat foods, unready foods, and processed, unprocessed, and packaged foods as preservatives, stabilizers, and emulsifiers. However, these types of substances can lead to nutritional health issues over time and sometimes to hereditary (heritable anomalies, reproductive issues, etc.) and metabolic (cancer, diabetes, liver issues, etc.) complications. As a result, there is an increasing trend toward the use of organic or natural food additives to ensure quality assurance in terms of taste, texture, and color. Notably, human health is more important than food production and distribution.

The results obtained in the present study revealed that both AVG and AVE are effective against *S. aureus*, *C. albicans*, and *A. niger*, whereas AVG is effective against *E. coli*. Further research is needed to determine the antimicrobial effects of *Aloe vera* on food and its role in the food industry.

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Consent for publication

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CRediT authorship contribution statement

Nuray Gamze Yoruk: Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Özlem Istanbullu Paksoy:** Writing – review & editing, Writing – original draft, Software, Resources.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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