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Analysis of biological activities of *Aloe vera* gel and extract used as the potential use in natural food additives

Análisis de las actividades biológicas del gel y el extracto de *Aloe vera* utilizados como posibles aditivos alimentarios naturales

Nuray Gamze Yörük

University of Dokuz Eylül, Faculty of Veterinary Medicine, Department of Food Hygiene and Technology. İzmir, Türkiye.
**Corresponding author: nuraygamzeyoruk@gmail.com*

ABSTRACT

The purpose of this study is to evaluate the antimicrobial properties of *Aloe vera* Gel (AVG) and *Aloe vera* Extract (AVE). In the context of food safety, the potential use of these natural products as food preservatives and their effects at the microbial level have been the primary focus. As part of the study, AVG and AVE were prepared in different concentrations (1%, 2%, 3%, 4%, and 5% w/v). The microorganisms used in the tests included *Salmonella* spp., *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis* subsp. *spizizenii*, *Candida albicans*, and *Aspergillus niger*. Microbiological analyses were conducted in accordance with ISO standards, and the microbial loads were evaluated at different dilutions. The data's statistical analysis was carried out using the Wilcoxon Signed Rank Test, Nonparametric Friedman Test, and Two-Way ANOVA. Both forms of AVG and AVE were found to be effective against certain tested bacteria and fungi. Specifically, the gel form of AVG showed effectiveness against *B. subtilis and E. coli*, while the extract form was ineffective against these microorganisms. Statistical analyses indicated that time is a significant factor in the antimicrobial effectiveness of AVG and AVE. The study presented findings that support the potential use of AVG and AVE as food preservatives.

Key words: *Aloe vera* gel; *Aloe vera* extract; biological activity; natural food additives

RESUMEN

El propósito de este estudio es evaluar las propiedades antimicrobianas del gel de *Aloe vera* (AVG) y el extracto de *Aloe vera* (AVE). En el contexto de la seguridad alimentaria, el enfoque principal ha sido el uso potencial de estos productos naturales como conservantes de alimentos y sus efectos a nivel microbiano. Como parte del estudio, se prepararon AVG y AVE en diferentes concentraciones (1, 2, 3, 4 y 5% p/v). Los microorganismos utilizados en las pruebas incluyeron *Salmonella* spp., *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis* subsp. *spizizenii*, *Candida albicans* y *Aspergillus niger*. Los análisis microbiológicos se realizaron de acuerdo con las normas ISO y las cargas microbianas se evaluaron en diferentes diluciones. El análisis estadístico de los datos se realizó mediante la prueba de rangos con signos de Wilcoxon, la prueba no paramétrica de Friedman y el ANOVA bidireccional. Se descubrió que ambas formas de AVG y AVE eran efectivas contra ciertas bacterias y hongos probados. Específicamente, la forma de gel de AVG mostró efectividad contra *B. subtilis* y *E. coli*, mientras que la forma de extracto fue ineficaz contra estos microorganismos. Los análisis estadísticos indicaron que el tiempo es un factor importante en la eficacia antimicrobiana de AVG y AVE. El estudio presentó hallazgos que respaldan el uso potencial de AVG y AVE como conservantes de alimentos.

Palabras clave: Gel de *Aloe vera*; extracto de *Aloe vera*; actividad biológica; aditivos alimentarios naturales

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INTRODUCTION

The earliest record of the use of *Aloe vera* (AV) (*Aloe barbadensis* Miller) dates back to approximately 2200 BC, found on clay tablets with Sumerian hieroglyphs, where it was used as a laxative. The term Aloe originates from the Arabic word 'alloeh', which means a bright bitter substance, and Vera comes from the Latin word 'verus', meaning true [1]. Greek researchers named the AV plant as the universal panacea two thousand years ago, while Egyptian researchers called it the plant of immortality [2].

In modern times, food safety, being one of the most basic needs of people, also holds critical importance for health. With technological advancement, numerous chemical food additives are used to prevent food spoilage and extend shelf life. Due to the negative effects and potential carcinogenicity of these food additives accumulating in the body over time, consumers are increasingly turning to organic foods. Consequently, many natural antimicrobial and antioxidant agents are becoming popular. *Aloe vera* is recognized as one of these natural antimicrobials [3]. AV leaves primarily consist of two components: latex and gel [4]. AV latex (also known as Aloe extract or juice) is a bitter, yellow liquid that comes from pericyclic tubules beneath the leaf's epidermis. AV latex constitutes 20 to 30% of the total leaf weight, is rich in phenolic compounds, and has antibacterial properties against Gram–positive bacteria [4, 5, 6]. The four main C–glycosyl components of AV latex are Aloesin; Aloin A, Aloin B, and Aloeresin A [7].

On the other hand, AV gel is a sticky, colorless gel derived from parenchymatous cells in fresh leaves, accounting for 70% to 80% of the leaf weight [8]. Polysaccharides in AV gel consist of Polymannan chains containing significantly more mannose than glucose [8, 9, 10, 11, 12]. The presence of bioactive components providing antioxidant properties and agents like mannans, anthraquinone, C–glycoside, and lectin in AV leaves have made aloe vera popular in the food industry [13]. AV contains numerous molecules including anthraquinone glycosides, polyhexoses, mannose, alkaloids, phenolic compounds, phytosterols, lectins, and vitamins (vitamins A, B_1, B_2, B_4, B_6, B_{12}, and – tocopherol) [14, 15, 16]. Due to its anthraquinone content, AV has antibacterial, antiviral, and antifungal activity [17, 18, 19]. Due to its antimicrobial properties, AV has been used in various food products such as yogurts, candy, ice cream, jams, instant tea granules, and soft drinks [20, 21]. The frequent use of AV gel and AV extract as a preservative in food products, which are continuously ingested into our bodies, suggests the need to investigate the effect of this preservative. However, this study focuses not so much on the benefits and harms of food preservatives, but rather on understanding how protective they are against contaminants with high toxicity. The effect of food preservatives at the microbial level is deemed important as it also indicates how far fungal and microbial contaminants in food can be removed. Based on these reasons, the purpose of this study is to evaluate the antimicrobial efficacy of AV gel and AV extract.

MATERIALS AND METHODS

In this study, natural and preservative–free commercial Aloe Vera Gel (AVG) (FOREVER®, 1 liter) and Aloe Vera Extract (AVE) (Nurbal Healing®50g) food supplements were utilized.

Preparation for biological activity analysis of AV Gel and AV Extract

To evaluate the antimicrobial properties of AVG and AVE, nutrient broth (NB) (LAB M–LAB 068, A Neogen Company, UK) containing AVG and AVE dilutions of 1, 2 3, 4, and 5% (w/v) were prepared. For bacteria and fungi, samples were incubated at 37°C (Nüve EN 055, Türkiye) for 24–48 hours (h) and 25°C for 120 h, respectively. Meanwhile, microbiological analyses of the samples were conducted at the initial, 24, 48, 72, 96, and 120th h, in accordance with ISO standards. The antimicrobial test microorganisms included *Salmonella* spp. (550 cfu·g^{-1}) (American Type Culture Collection® (ATCC) 14028); coagulase positive *Staphylococcus* (550 cfu·g^{-1}) (National Culture Type Collection® England (NCTC) 6571); *Escherichia coli* (550 cfu·g^{-1}) (NCTC® 10788); *Bacillus subtilis* subsp. *spizizenii* (550 cfu·g^{-1}) (NCTC® 10400); *Candida albicans* (550 cfu·g^{-1}) (National Collection of Pathogenic Fungi (NCPF) 3179) and *Aspergillus niger* (550 cfu·g^{-1}) (ATCC® 16404). *C. albicans* and *A. niger* were maintained at 25°C (Binder KB 053, Germany) for 72 h in 200 mL of NB, and other microorganisms were incubated at 37°C (Nüve EN 055, Türkiye) for 24 h.

Preparation of 1, 2, 3, 4, and 5% dilutions of extract and gel

The dilutions of AV gel and AV extract were prepared with nutrient broth (NB) in concentrations of 1, 2, 3, 4, and 5% (w/v). To achieve sterile mixtures, these dilutions were autoclaved to ensure sterility (Hirayama® HG80) at 121°C for 15 min. Fresh cultures of *Salmonella* spp., coagulase positive *Staphylococcus*, *E. coli*, and *B. subtilis* were added to the AVG and AVE mixtures prepared in NB at these five different concentrations and incubated at 37°C (Nüve EN 055, Türkiye) for 24 h. Fresh cultures of *C. albicans* and *A. niger* were introduced and incubated at 25°C (Binder KB 053, Germany) for 72 h. The load of each microorganism in the control group was determined for each dilution prior to each analysis (FIG. 1).

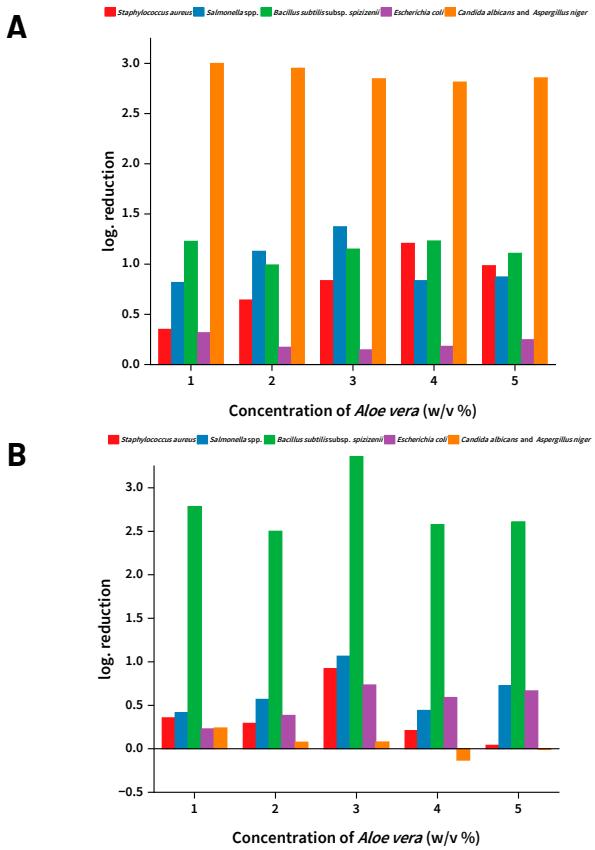

FIGURE 1. Effects of AV gel (A) and extract (B) on the microorganisms according to concentrations (1, 2, 3, 4, and 5% w/v)

Microbiological Analysis of Samples

To evaluate the bacterial and fungal load, 1 mL of microorganism enriched with nutrient broth (NB) was taken and diluted with sterilized TPS (LAB M–LAB 204, Neogen Culture Media, UK) from 10^{-1} to 10^{-10}. The number of coagulase positive *Staphylococcus* strains was determined by cultivating them on Baird Parker agar (BPA; sterile NCM0200A, Neogen Culture Media, USA) using the spread plate method, in accordance with the ISO 6888–1 standard. Colony count results were obtained after incubation for 48 h at 37°C (Nüve EN 055, Türkiye) [22]. *Salmonella* spp. were cultured on Xylose Lysine Deoxycholate (XLD) agar (NCM0021A, Neogen Culture Media, USA), which was sterilized by boiling three times in a microwave (Beko® Intellowave MD 1593), and the quantity of microorganisms (cfu·g^{-1}) was determined by the spread plate method. In accordance with the ISO 6579–1 standard, 0.1 mL of inoculation was cultured on XLD agar (NCM0021A, Neogen Culture Media, USA) under aseptic conditions using the spread plate method. The colony count was obtained after 24 hours of incubation at 37°C (Nüve EN 055, Türkiye) [23]. The cultivation carried out by the pour plate method on TBX agar (LAB M–Neogen Culture Media NCM1001A HarlequinTM TBGA, UK) sterilized by autoclaving for 15 min at 121°C yielded the number of *E. coli*. Parallel cultivation on TBX agar under aseptic conditions using the pour plate method was performed with 0.1 mL solution in accordance with the ISO 16649–2 standard. The colony count results were obtained after 24 h of incubation at 41.5°C (Binder KB 115, Germany) [24].

Parallel cultivation of *B. subtilis* subsp. *spizizenii* samples was conducted on Plate Count Agar (PCA) (NCM 0010A, Neogen Culture Media, USA) using the pour plate method with 1 mL of solution in accordance with the ISO 4833–1 standard. The colonies were counted after 72 h of incubation at 30°C (Binder KB 053, Germany) [25].

To determine *C. albicans* and *A. niger* counts of samples, parallel cultivation was performed on DRBC agar (LAB M–LAB217, A Neogen Company, UK) using the spread plate method. Parallel cultivation on DRBC agar was performed under aseptic conditions using the spread plate method with 0.1 mL of solution in accordance with the ISO 21527–1 standard. Mold and yeast counts were determined after five days of incubation at 25°C (Binder KB 053, Germany) [26]. (FIG. 1).

Statistical analysis

In the study, the microbiological analysis results of the efficacy of AVG and AVE were statistically evaluated by the Wilcoxon Signed Rank Test was used for binary (dependent) comparisons and the Nonparametric Friedman Test was employed for multiple comparisons. The effect of AV's gel and extract forms against bacteria and fungi was examined according to the concentrations of AVG and AVE (1, 2, 3, 4, and 5% w/v) (FIG. 1). Statistical analyses were conducted separately for each microorganism. Two-Way ANOVA analysis was used to investigate the effect of AV extract at different concentrations on the logarithmic results of the tested microorganisms. In the Two-Way ANOVA model, the variable that is dependent was the log of analysis results, the independent variable was the log percentage value, and the covariate variable was time (hour).

RESULTS AND DISCUSSION

TABLE I presents the microbiological results for AVG and AVE (A, B, C, and D). It was found that both forms of AV were effective against *S. aureus, C. albicans*, and *A. niger*, but ineffective against *Salmonella* spp. No significant difference was observed in the load (log) of *Salmonella* spp. depending on various AV concentrations. It was determined that the gel form of AV was effective against *E. coli* and *B. subtilis*, whereas the extract form was found to be ineffective. The Friedman Test revealed a significant difference between the dilution rates of AV extract and the log values of *S. aureus, C. albicans*, and *A. niger* ($P<0.01$). In contrast, no significant difference was found between the dilution rates of AV extract and the log values of *Salmonella* spp. ($p = 0.091$), *E. coli*, and *B. subtilis* ($P>0.05$).

According to the results of the Wilcoxon Signed Rank Test, there was a significant difference between the load (log) of *S. aureus, C. albicans, A. niger, B. subtilis*, and the dilution rates (log) of AV extract ($P<0.05$). Furthermore, a significant difference was found between the *E. coli* load (log) and the 1% value (log). There was no significant difference between the AV extract load (log) and values (log) at various dilution rates for *Salmonella* spp. and *B. subtilis* ($P>0.05$). The Wilcoxon Signed Rank Test used to determine if there was a significant difference between the microorganisms' own load (log) and the values (log) at different AV gel concentrations indicated a significant difference ($P<0.05$) between the own load (log) of *C. albicans, A. niger,* and *S. aureus*, and the values (log) of AV gel concentrations. Additionally, a significant difference was detected between the own load (log) of *Salmonella* spp. and the 1% (log) value.

Regarding the analysis results for *S. aureus*, while the log percentages of Aloe vera extract created a significant difference in log values, the time variable had no effect. On the other hand, while log percentages did not cause a significant difference in the log values of Aloe vera gel, time created a significant difference.

When we performed the same analysis separately for log percentages and time using the Kruskal Wallis Test, log percentages resulted in a significant difference for the log values of Aloe vera extract, but time did not create a significant difference. On the other hand, both log percentages and time did not cause a significant difference in the log values of Aloe vera gel (FIGS. 2 and 3).

For Molds/Yeasts, while log percentages created a significant difference in the log values for Aloe Vera extract and gel, the effect of the covariate variable time was not significant (FIGS. 4 and 5).

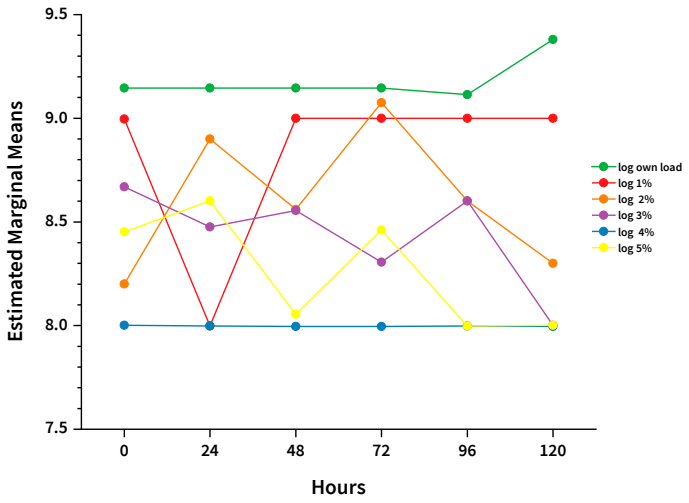

FIGURE 2. Estimated Marginal Means of *Staphylococcus aureus* (Aloe Vera Extract)

TABLE I
Test statistics of microorganisms according to Friedman test Aloe Vera Extract and Aloe Vera Gel (A and C) and Wilcoxon test Aloe Vera Extract and Aloe Vera Gel (B and D)

A: Test Statistics[1]	***Salmonella* spp.**	**Yeast/mould**	**TMAB**	***Escherichia coli***	***Staphylococcus aureus***
N	7	6	6	6	6
Chi-Square	27.158	9.495	15.773	8.61	5.101
df	5	5	5	5	5
Asymp. Sig.	0.000[b]	0,091[c]	0.008[b]	0,126[c]	0,404[c]

[1]: Friedman Test, [b]: significant difference (P<0.01), [c]: no difference (P>0.05)

C: Test Statistics[1]	**Salmonella spp.**	**Yeast/mould**	**TMAB**	***Escherichia coli***	***Staphylococcus aureus***
N	7	6	6	6	6
Chi-Square	21.81	10.902	18.561	8.301	12.067
df	5	5	5	5	5
Asymp. Sig.	0.001[b]	0,053[c]	0.002[b]	0.14[c]	0.034[b]

[1]: Friedman Test, [b]: significant difference (P<0.01), [c]: no difference (P>0.05)

Pairwise comparison of the own loads of the microorganisms and concentrations

B: Test Statistics[1]	**1%**	**2%**	**3%**	**4%**	**5%**
S. aureus Z	-2,388[b]	-2,371[b]	-2,371[b]	-2,414[b]	-2,371[b]
P	0.017	0.018	0.018	0.016	0.018
Salmonella spp. Z	-0,734[b]	-0,314[b]	-0,943[c]	-0,105[b]	-0,314[b]
P	0.463	0.753	0.345	0.917	0.753
Yeast/mould Z	-2,201[b]	-2,201[b]	-2,201[b]	-2,207[b]	-2,201[b]
P	0.028	0.028	0.028	0.027	0.028
TMAB Z	-2,201[b]	-1,992[b]	-1,992[b]	-1,992[b]	-1,782[b]
P	0.028	0.046	0.046	0.046	0.075
E. coli Z	-2,201[b]	-0,734[b]	-0,524[b]	-0,734[b]	-0,943[b]
P	0.028	0.463	0.600	0.463	0.345

[1]: Wilcoxon Signed Ranks Test, [b]: Based on negative ranks, [c]: Based on positive ranks

Pairwise comparison of the own loads of the microorganisms and concentrations

D: Test Statistics[1]	**1%**	**2%**	**% 3**	**4%**	**5%**
S. aureus Z	-2,384[b]	-2,370[b]	-2,366[b]	-2,414[b]	-0,507[b]
P	0.017	0.017	0.018	0.016	0.612
Salmonella spp. Z	-1,992[b]	-0,105[b]	-0,524[c]	-1,153[b]	-0,314[c]
P	0.046	0.917	0.600	0.249	0.753
Yeast/mould Z	-2,201[b]	-2,201[b]	-2,201[b]	-2,201[b]	-2,201[b]
P	0.028	0.028	0.028	0.028	0.028
TMAB Z	-0,943[b]	-1,782[b]	-1,572[b]	-1,363[b]	-1,782[b]
P	0.345	0.075	0.116	0.173	0.075
E. coli Z	-1,153[b]	-0,314[b]	-0,524[c]	-0,524[c]	-0,105[b]
P	0.249	0.753	0.600	0.600	0.917

[1]: Wilcoxon Signed Ranks Test, [b]: Based on negative ranks, [c]: Based on positive ranks

Regarding the Total Mesophilic Aerobic Bacteria (TMAB) counts, while the log percentages did not create a significant difference in the log values of Aloe Vera extract, time had a significant effect. Conversely, the effect of AV concentrations and time on the log count of TMAB was found to be significant. When conducting the same analysis separately for log percentages and time using the Kruskal Wallis test, log percentages did not result in a significant difference for the log values of Aloe vera extract and gel, while time did create a significant difference (FIGS. 6 and 7).

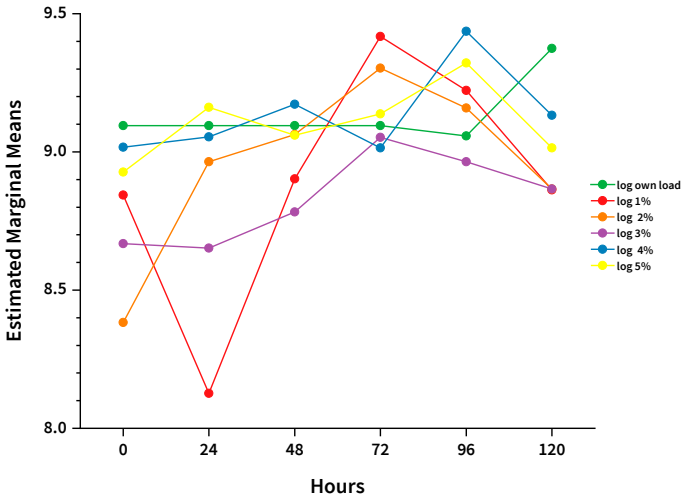

FIGURE 3. Estimated Marginal Means of *Staphylococcus aureus* (Aloe Vera Gel)

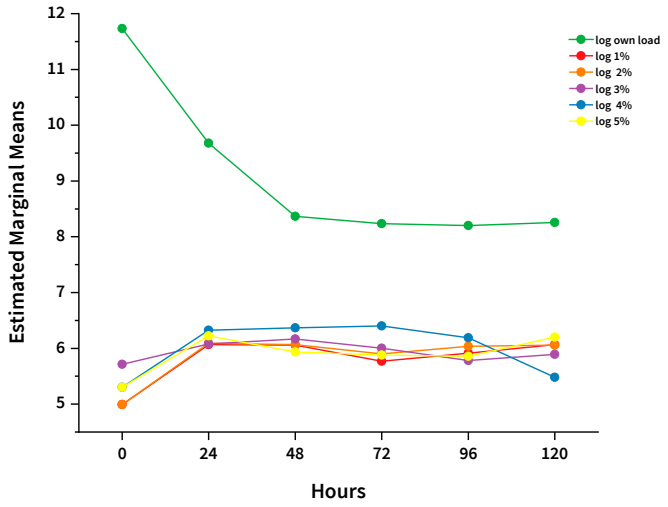

FIGURE 4. Estimated Marginal Means of Yeast and Mould (Aloe Vera Extract)

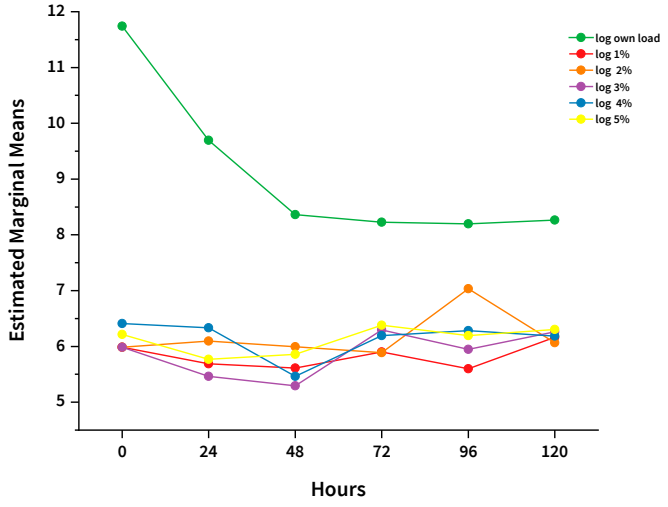

FIGURE 5. Estimated Marginal Means of Yeast and Mould (Aloe Vera Gel)

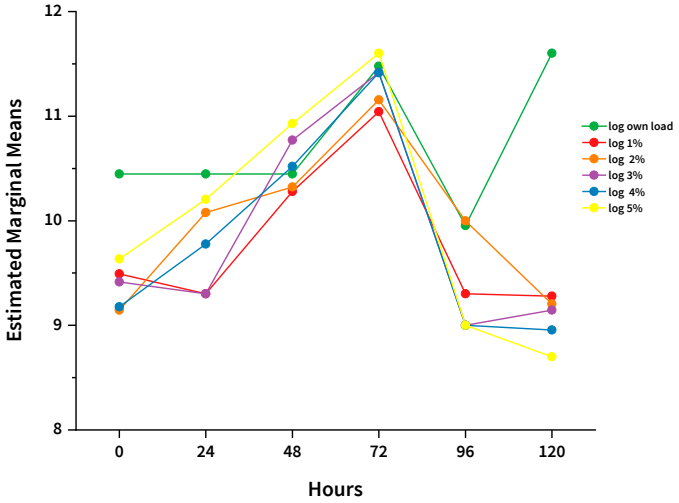

FIGURE 6. Estimated Marginal Means of Total Mesophilic Aerobic Bacteria (Aloe Vera Extract)

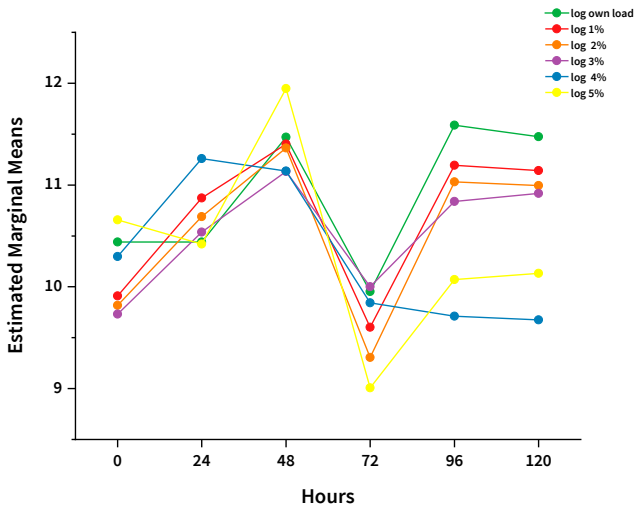

FIGURE 7. Estimated Marginal Means of Total Mesophilic Aerobic Bacteria (Aloe Vera Gel)

According to the analysis results for *E. coli*, while log percentages did not cause a significant difference in the log values of Aloe Vera extract and gel, time did have a significant effect. Again, when performing the same analysis for log percentages and time using the Kruskal Wallis test, log percentages did not create a significant difference in the log values of Aloe Vera extract and gel, while time did (FIGS. 8 and 9).

The results for *Salmonella* spp. showed that while log percentages did not create a significant difference in the log values of Aloe vera extract and gel, time had a significant effect. The Kruskal Wallis test results for *Salmonella* spp. regarding log percentages and time indicated that log percentages did not create a significant difference in the log values of Aloe vera extract and gel, while time did create a significant difference (FIGS. 10 and 11).

Bhat *et al.* [18] there was no mold–yeast growth in both the control group and nuggets with added AV until the 14th d, and on the 21st d, there was a significant reduction in mold–yeast growth in nuggets with added AV compared to the control group.

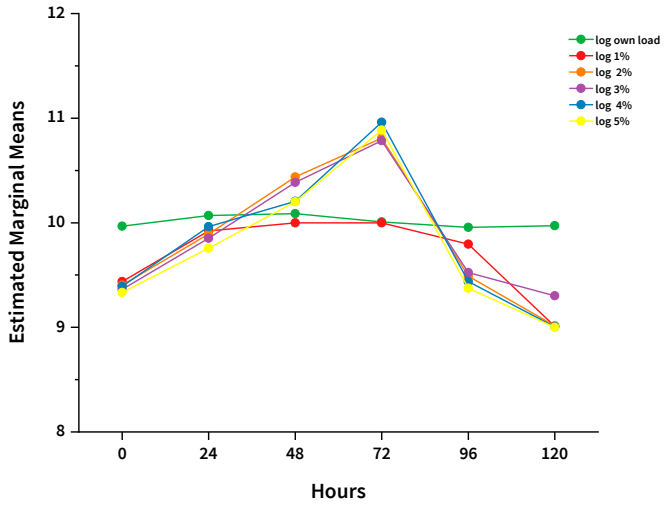

FIGURE 8. Estimated Marginal Means of *Escherichia coli* (Aloe Vera Extract)

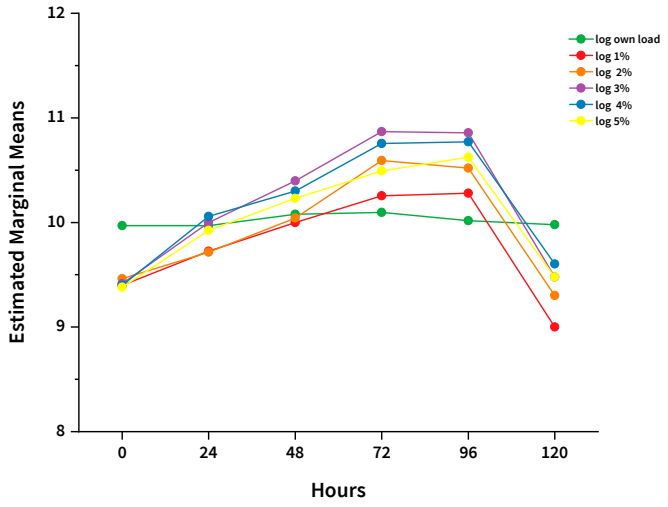

FIGURE 9. Estimated Marginal Means of *Escherichia coli* (Aloe Vera Gel)

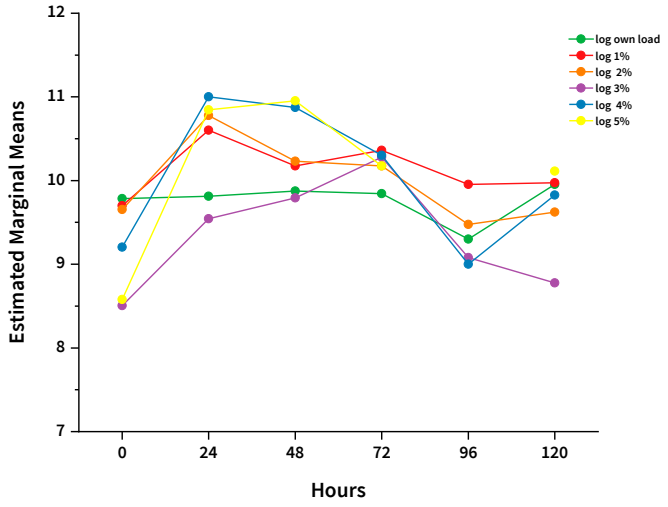

FIGURE 10. Estimated Marginal Means of *Salmonella* spp. (Aloe Vera Extract)

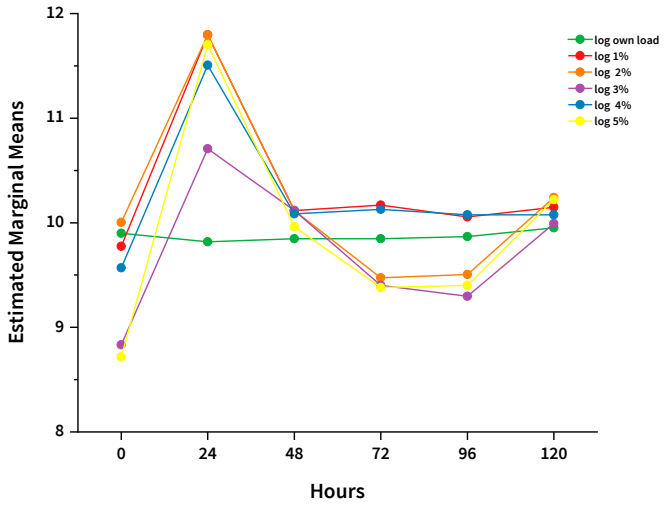

FIGURE 11. Estimated Marginal Means of *Salmonella* spp. (Aloe Vera Gel)

According to Shahrezaee *et al.* [27], the total number of living organisms in nugget dough and half-baked nuggets increased by approximately 2 log cfu·g-1 after 6 d of cold storage post-production. The same study also reported an initial decrease in microbial load in nugget doughs containing 1.5 and 2.5% AV gel powder (AGP). However, AGP did not prevent the increase in the total bacterial count during 6 d of cold storage. According to the researchers 2.5 and 3.5% AGP at 4°C cold storage effectively prevented coliform proliferation for up to 4 d, while 1.5% AGP provided protection only for 2 d. Overall, they reported that 3.5% AGP was ideal for preventing coliform contamination and that there was no mold-yeast growth due to the effectiveness of AGP as an antifungal. Serial dilutions of AV prepared by diluting by 1/10 significantly inhibited the growth of *S. aureus*, and a moderate AV concentration inhibited the growth of *E. coli*, *Pseudomonas aeruginosa*, and *Salmonella typhi*.

Mandal *et al.* [11] stated that proteins in the AV structure were powerful antifungals, which supports our findings. Valverde *et al.* [28] determined that TMAB and Mold–Yeast counts for table grapes harvested in the control groups were 4.6 and 3.5 log cfu·g^{-1}, respectively. They investigated that mold-yeast counts in AV-treated grapes decreased by 1.5 log cfu·g^{-1} after 21 d at 20°C and 2.6 log cfu·g^{-1} after 4 d of cold storage.

Sitara *et al.* [29] found that a 0.35% gel concentration of Aloe Vera was antifungal, inhibiting *A. niger* by 24.29%, *Aspergillus flavus* by 9.26%, and *Penicillium digitatum* by 6.24%. According to Abdul Qadir and colleagues [30], AV was effective against four pathogenic bacteria: *B. subtilis*, *S. aureus*, *Pasteurella multocida*, *E. coli*, and fungi such as *A. flavus*, *Rhizoctonia solani*, *A. niger*, and *Alternaria alternate*. Similar to our study, Jeevitha and colleagues [31] demonstrated that AV had antifungal activity against *C. albicans* using minimum inhibitory concentration and minimum fungicidal concentration tests.

In a study conducted by Alemdar and Agaoglu [6] AV juice had antimicrobial effects against *Mycobacterium smegmatis*, *Klebsiella pneumoniae*, *Enterobacter faecalis*, *Micrococcus luteus*, *C. albicans*, and *Bacillus sphericus*. Another study investigated the antimicrobial properties of AV gel against *P. digitatum* and *B. subtilis*. *In vitro*, 250 mL·L^{-1} of AV gel caused a 4 log cfu·g^{-1} decrease in *P. digitatum* and a 2 log cfu·g^{-1} decrease in *Botrytis cinerea* [32].

Consistent with the findings of the current study, Shahat *et al*. [33] reported in their antimicrobial efficacy studies with 24 different medicinal plants in Saudi Arabia that four Gram-positive (*B. cereus, S. aureus, M. luteus, Micrococcus roseus*) and four Gram-negative (*K. pneumoniae, Proteus vulgaris, Pseudomonas aeruginosa*) were resistant to the effect of these plants. In their studies on the antibacterial activity of plant extracts widely consumed in Asia, Alzoreky *et al*. [34] found that Gram-positive bacteria (*S. aureus* and *B. cereus*) were less resistant than Gram-negative bacteria (*E. coli*). In their study on the antimicrobial effects of 14 plant extracts obtained from 13 plant species on 2 Gram-positive and 5 Gram-negative microorganisms, Keleş *et al*. [35] determined that the most sensitive microorganism to these plants was *S. aureus*, a Gram-positive microorganism, and the most resistant microorganisms were *E. coli* and *K. pneumoniae*, both Gram-negative microorganisms.

Similar to the findings of the current study, Bilenler [36] found that Gram-positive bacteria (*S. aureus, S. hominis, S. warneri, S. epidermidis, B. cereus, E. faecalis, Enterobacter* spp., *Streptococcus* spp., *Salmonella* spp., *Shigella Flexner*) were more sensitive than Gram-negative bacteria to the antimicrobial effects of black mulberry. It was also noted that black mulberry significantly slowed the growth of *C. albicans*. This was attributed to the fact that *C. albicans* is a eukaryotic microorganism, unlike prokaryotic microorganisms.

Hayat *et al.* [37] investigated the antimicrobial effects of Aloe vera extracts on *Erwinia carotovora, E. coli, K. pneumoniae, Salmonella typhi, B. subtilis, B. cereus, S. aureus*, and *C. albicans*, finding that the efficacy was higher on Gram-positive microorganisms due to lipopolysaccharides in their cell walls. The greatest antimicrobial effect was observed in the *C. albicans* studies [38, 39].

CONCLUSIONS

With the advancement of technology, cheaper and more practical methods are being utilized to increase food diversity while ensuring these foods meet appropriate quality standards. To achieve this, chemical or artificial food additives are commonly used. These substances are added in various forms as preservatives, stabilizers, and emulsifiers in different food classes, including ready-to-eat, not-ready-to-eat, processed, unprocessed, and packaged foods (etc; cheese, yogurt, fish, packet of raw chicken or meat...). However, it is known that such substances can cause nutritional health problems over time and sometimes lead to hereditary (hereditary anomalies, reproductive issues, etc.) and metabolic (cancer, diabetes, liver problems, etc.) complications. Consequently, there is an increasing trend towards organic food or natural food additives to ensure quality assurance in terms of taste, texture, and color in foods. It is imperative to prioritize human health over food production and delivery.

The results obtained in the current study have demonstrated that both AVG and AVE are effective against *S. aureus, C. albicans*, and *A. niger*, and AVG is effective against *E. coli*. This indicates a need for further research to establish the antibacterial properties of Aloe vera in foods and its role in the food industry, as Aloe vera is considered a natural antimicrobial agent in this study. It was found that AVG and AVE effectively inhibited the growth of *S. aureus, C. albicans,* and *A. niger*. Interestingly, these preparations were found to be ineffective against *Salmonella* spp., suggesting a selective antimicrobial action of Aloe vera components. The study did not observe a significant variance in the bacterial load of *Salmonella* spp., indicating a consistent resistance pattern in this specific microorganism. However, a notable efficacy of AVG, particularly against *E. coli* and *B. subtilis*, was recorded, while AVE was found to be less effective. This points towards a distinct influence of the form in which Aloe vera is applied. The study also underscored the critical role of time in the antimicrobial effectiveness of Aloe vera products, as seen in the Kruskal Wallis test results.

This pattern was consistent across different microbial species, including molds/yeasts and Total Mesophilic Aerobic Bacteria (TMAB), confirming the broad-spectrum antimicrobial nature of Aloe vera. These results not only highlight the selective effectiveness against certain microorganisms and the variance in response between AVG and AVE but also suggest the potential for targeted applications in controlling specific microbial threats.

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Consent for publication

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Compliance with ethical standards

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