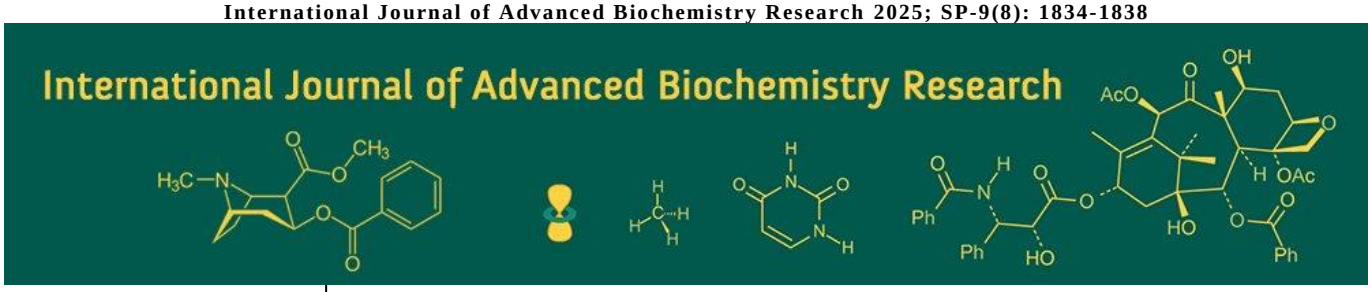

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Efficacy of turmeric leaf extract oil and ginger oil in controlling the growth of spoilage microorganisms in tomato

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Abstract
The common spices like turmeric and ginger are part of our regular food preparation and have been shown to possess various compounds which are having biological effects and also prevented spoilage of food by microorganisms. Antifungal and antimicrobial property of Ginger oil and Turmeric leaf extract oil have been widely used for controlling the growth of food spoilage microorganisms. A study was conducted earlier to check the efficacy of different concentrations of these extracts in controlling the growth of *Aspergillus* and *Penicillium* under *in vitro* conditions. In the current study was studied an attempt was made to test the efficacy of Turmeric leaf extract oil and Ginger oil in controlling the growth of spoilage microorganisms in Tomato. Different concentrations of Ginger oil and turmeric leaf extract oil were effective in significantly reducing the infection of *Aspergillus* in tomatoes (US 618) at all stages of storage (7, 14, 21 and 28 Days after treatment application). Similarly, standard check Bavistin (2 g/L) significantly reduced the infection of *Aspergillus* in tomatoes. Best control of *Aspergillus* or lowest disease severity in tomatoes was recorded in tomatoes treated with 100% turmeric leaf extract oil and 100% Ginger oil at different storage times. Different concentrations of Ginger oil and turmeric leaf extract oil were effective in significantly reducing the infection of *Penicillium* in tomatoes (US 618) at all stages of storage (7, 14, 21 and 28 Days after treatment application). Similarly, standard check Bavistin (2 g/L) significantly reduced the infection of *Penicillium* in tomatoes. Best control of *Penicillium* or lowest disease severity in tomatoes was recorded in tomatoes treated with 100% Ginger oil and 100% turmeric leaf extract oil at different storage times. The possibility of using ginger oil or turmeric leaf extract oil in delaying the deterioration of fruits and vegetables caused by spoilage microorganisms can be explored by carrying out scale up studies.

Keywords: Ginger oil, turmeric leaf extract oil, Bavistin, *Penicillium*, *Aspergillus*

1. Introduction
Turmeric (*Curcuma longa*) and Ginger (*Zingiber officinale*) are two of the most commonly consumed dietary condiments in the world and in our country. Antimicrobials from these plant products have been widely used for controlling the growth of plant pathogens and food spoilage microorganisms. Medicinal value and medicinal properties of Ginger oil and Turmeric leaf extract oil is very well known (Panpatil *et al.*, 2013; Azhari *et al.*, 2018) [8, 2]. Ginger also has broad range of antibacterial and antifungal activity (Jaiswal and Naik, 2021) [5]. Post-harvest losses in Tomato are very high due to attack by different spoilage organisms including *Aspergillus* and *Penicillium*. Antimicrobials from Ginger oil and Turmeric leaf extract oil have been widely used for controlling the growth of food spoilage microorganisms. This preservative property of spices has been attributed to the presence of some antimicrobial principles contained in their oils (Keskin and Toroglu, 2011) [7]. The antimicrobial compounds in spices and herbs are mostly in the essential oil fraction. In a previous experiment, efficacy of different concentrations of these extracts in controlling the growth of *Aspergillus* and *Penicillium* under *in vitro* conditions was studied. Since Ginger oil and Turmeric leaf extract oil have shown to be effective in controlling the growth of both *Aspergillus* and *Penicillium* under *in vitro* conditions, their efficacy needs to be tested by carrying out shelf life studies and other post harvest applications in Tomato. The current trial was initiated with the following objectives

1. Estimating the efficacy of Turmeric leaf extract oil and Ginger oil in controlling the growth of spoilage microorganisms in Tomato
2. Estimating the population of *Aspergillus* and *Penicillium* at different storage stages in Tomato

2. Materials and Methods

The microbial cultures from the Department of Agricultural Microbiology, College of Horticulture, Yalachahalli, Mysuru were used in the current trial. Fruit and vegetable spoilage organisms like *Aspergillus* and *Penicillium* were used in this experiment. The current experiment was carried out for two seasons from 2023 to 2025 at College of Horticulture, Yalachahalli, Mysuru. This experiment had 8 treatments and each treatment was replicated 3 times. Bavistin (50% WP Carbendazim) was used in the trial as a standard check to compare its efficacy against Ginger oil and Turmeric leaf extract in controlling the growth of spoilage organisms. Ginger oil and Turmeric leaf extract oil used in this study were provided by Dr. Harish, Department of Plantation, Spices, Medicinal and Aromatic crops, College of Horticulture, GKVK, Bangalore.

Treatment Number	Treatment details
T_1	Untreated Control-Distilled Water
T_2	Bavistin (2 g/L)
T_3	Ginger Oil (100%)
T_4	Ginger Oil (50%)
T_5	Ginger Oil (25%)
T_6	Turmeric leaf extract oil (100%)
T_7	Turmeric leaf extract oil (50%)
T_8	Turmeric leaf extract oil (25%)

The same set of eight treatments was used for both *Aspergillus* and *Penicillium* organisms. Fresh and disease free hybrid tomatoes (US 618) collected from a farmer in Karakanahalli village, Mysuru district were washed thoroughly with water. They were wiped with a clean cloth and air dried for some time. Different concentrations of Turmeric leaf extract oil and Ginger oil were prepared and kept ready. In each treatment and in each replicate there were ten tomatoes. Different concentrations of plant extracts were sprayed on all tomatoes present in different treatments and replicates and then they are allowed to air dry for one hour. All tomatoes from different treatments were then sprayed with spore suspensions of *Aspergillus* (10^5 spores/ml) and then incubated at room temperature for a period of one month. For another set of tomatoes, similar procedure was followed and then the tomatoes were sprayed with spore suspensions of *Penicillium* (10^5 spores/ml) and then incubated at room temperature for a period of one month.

The following observations were recorded during the current trial

1. Percent Disease severity in tomatoes at different stages
2. Enumeration of *Aspergillus* and *Penicillium*
3. Enumeration was done at different intervals: 7, 14, 21, 28 days after treatment application (DATA)

Experimental design used was Completely Randomized Design (CRD).

3. Results and Discussion

Among the treatments tested, all seven were significantly better than Untreated control at 7 days after treatment application (DATA) in reducing the activity of *Aspergillus* in Tomatoes (Table 1). The disease severity was on the lower side in all tested turmeric leaf extract oil and ginger oil treated tomatoes at 7 DATA. These values along with disease severity in tomatoes treated with Bavistin (2 g/L) differed significantly from untreated control (35.00%) at 7 DATA (Table 1). All the treatments involving the use of different concentrations of turmeric leaf extract oil and ginger oil and Bavistin (2 g/L) significantly reduced the disease severity of tomatoes compared to Untreated control at 14, 21 and 28 DATA (Table 1). The lowest amount of disease severity was recorded in tomatoes treated with 100% turmeric leaf extract oil followed by Bavistin (2 g/L) and 100% Ginger oil at both 21 and 28 DATA (Table 1). It should be noted that even lower concentrations of both Ginger oil and Turmeric leaf extract oil effectively reduced the severity of *Aspergillus* in tomatoes at different stages of storage (7, 14, 21 and 28 DATA) (Table 1). In a study conducted earlier turmeric leaf extract was able to inhibit the growth of *Aspergillus flavus* and *Fusarium moniliforme* under laboratory conditions (Azhari *et al.*, 2018) [2]. Similarly, ginger oil was shown to completely inhibit the growth of *Fusarium moniliforme* and *Aspergillus* under laboratory conditions (Teles *et al.*, 2019) [15]. Turmeric leaf extract oil has been shown to contain α-phellandrene, terpinolene, and p-cymene (11.07%) which strongly inhibited the growth of *Aspergillus flavus* by 95.3% (Sindhu *et al.*, 2011) [12]. The essential oils detected from different varieties of turmeric leaf samples were α-phellandrene, 2-carene, o-cymene, camphor, 2-bornanone, curdione, eucalyptol, curzerenone, α-lemenone, longiverbenone, boldenone, and α-curcumene. These compounds present in turmeric leaf extract effectively inhibited the growth of several microorganisms (Albaqami *et al.*, 2022) [1].

Among the treatments tested, all seven were significantly better than Untreated control at 7, 14, 21 AND 28 DATA in reducing the activity of *Penicillium* in Tomatoes (Table 2). The disease severity was lowest in tomatoes treated with Bavistin (2 g/L) (3.67%) and tomatoes treated with 100% turmeric leaf extract oil (3.83%) followed by 100% Ginger oil (4.42%) at 21 DATA (Table 2). Although these three treatments had lower disease severity values than other treatments, they did not differ significantly among themselves at 21 DATA except Untreated control (Table 2). The least amount of infection or least disease severity of *Penicillium* was recorded in tomatoes treated with 100% turmeric leaf extract oil followed by Bavistin (2 g/L) and 100% Ginger oil at 28 DATA (Table 2). Lower concentrations of both Ginger oil and Turmeric leaf extract oil effectively reduced the severity of *Penicillium* in tomatoes at different stages of storage (7, 14, 21 and 28 DATA) (Table 2). Antifungal activity of fractional distillate of turmeric oil was also observed earlier against *Aspergillus flavus*, *Aspergillus parasiticus*, *Fusarium moniliforme* and *Penicillium digitatum* (Jayaprakasha *et al.*, 2001) [6]. They observed that fraction two was more effective in controlling the growth of fungal pathogens. The major compounds in fraction two were aromatic tumerone, tumerone, curlone and other oxygenated compounds. It was also noted in this study that tomatoes treated with Bavistin inhibited the growth of both *Aspergillus* and *Penicillium* and the results were on par with the inhibition obtained by use of either Ginger oil or turmeric leaf extract oil. In studies conducted earlier

application of bavistin efficiently controlled the growth of spoilage microorganisms like *Aspergillus* sp., *Fusarium sp*., *Botrytis* sp. and *Penicillium digitatum* in stored onion (Garcia *et al*., 1997; Ranpise *et al*., 2001 and Sabale and Kalebere, 2004) [4, 9, 10]. It should be noted that even lower concentrations of both Ginger oil and Turmeric leaf extract oil effectively reduced the severity of *Penicillium* in tomatoes at different stages of storage (7, 14, 21 and 28 DATA) (Table 4). Antifungal activity of *Z. officinale* essential oil is well documented, mainly in filamentous fungi such as *Penicillium* spp., *Rhizopus* sp., *A. flavus*, *A. solani*, *A. oryzae*, *A. niger*, *F. moniliforme*, *F. verticillioides* (Singh *et al*., 2008; Sasidharan and Menon, 2010; Bellik, 2014 and Yamamoto-Ribeiro *et al*., 2013) [14, 11, 3, 16]. The antimicrobial activity of ginger oil can be attributed to its constituent monoterpenes and sesquiterpenes, as they are capable of altering the permeability and fluidity of the plasma membrane of microorganisms. *Z. officinale* essential oil contains considerable amounts of phenolic compounds (eugenol, shogaols, zingerone, gingerdiols, gingerols, etc.), which may be responsible for the observed effects, and has different chemotypes in which the efficiency can be attributed to the major compounds (Singh *et al*., 2005) [13].

The population of *Aspergillus* assessed from infected tomato varieties was highest in Untreated control treatment at all days of sampling and was significantly higher than the other treatments (Table 3). Similarly, the population of *Penicillium* assessed from infected tomato varieties was highest in Untreated control treatment at all days of sampling and was significantly higher than the other treatments (Table 4). In both cases the population of both *Aspergillus* and *Penicillium* increased as the incubation days increased. This also correlated with the disease severity levels which also increased as the incubation period of tomatoes increased.

The trials conducted using hybrid tomatoes (US 618) showed that these tomatoes stayed disease free longer than untreated tomatoes and were not infected or disease free for upto 4 weeks after treatment application. The study also showed that even 25% of ginger oil and 25% turmeric leaf extract oil were effective in significantly managing the growth of both *Aspergillus* and *Penicillium* at different times of storage. The efficacy of different concentrations of ginger oil and turmeric leaf extract oil in controlling the growth of *Penicillium* and *Aspergillus* should be tested in polyethylene bags.

Table 1: Efficacy of different concentrations of Ginger oil and Turmeric leaf extract oil in controlling the growth of *Aspergillus* in Tomato (US 618)

Treatment Number	Treatment details	Disease severity (%) at different days after Inoculation or treatment application			
		7 DATA	14 DATA	21 DATA	28 DATA
T_1	Untreated Control-Distilled Water	35.00^a	54.58^a	65.25^a	74.83^a
T_2	Bavistin (2 gm/L)	1.33^b	5.42^b	9.42^b	14.00^b
T_3	Ginger Oil (100%)	3.58^b	10.67^b	15.17^b	17.67^b
T_4	Ginger Oil (50%)	5.00^b	12.08^b	19.08^b	21.17^b
T_5	Ginger Oil (25%)	7.17^b	16.58^b	23.42^b	27.83^b
T_6	Turmeric leaf extract oil (100%)	1.42^b	3.92^b	6.92^b	9.25^b
T_7	Turmeric leaf extract oil (50%)	3.33^b	11.17^b	20.00^b	25.00^b
T_8	Turmeric leaf extract oil (25%)	6.00^b	13.33^b	23.33^b	26.08^b
	SEm±	5.50	9.13	11.1	11.15
	CD @ 1%	14.87	24.69	29.93	30.15

* DATA: Days after treatment application

Table 2: Efficacy of different concentrations of Ginger oil and Turmeric leaf extract oil in controlling the growth of *Penicillium* in Tomato (US 618)

Treatment Number	Treatment details	Disease severity (%) at different days after Inoculation or treatment application			
		7 DATA	14 DATA	21 DATA	28 DATA
T_1	Untreated Control-Distilled Water	16.33^a	40.00^a	54.92^a	68.42^a
T_2	Bavistin (2 gm/L)	0.67^b	1.83^b	3.67^{bc}	8.42^{bc}
T_3	Ginger Oil (100%)	1.33^b	2.58^b	4.42^{bc}	8.58^{bc}
T_4	Ginger Oil (50%)	1.67^b	4.33^b	9.42^{bc}	13.63^{bc}
T_5	Ginger Oil (25%)	2.17^b	6.25^b	11.42^{bc}	15.58^{bc}
T_6	Turmeric leaf extract oil (100%)	0^b	2.83^b	3.83^{bc}	6.92^{bc}
T_7	Turmeric leaf extract oil (50%)	1.17^b	4.50^b	6.75b^{bc}	9.58^{bc}
T_8	Turmeric leaf extract oil (25%)	2.83^b	5.75^b	16.50^b	19.58^b
	SEm±	2.53	5.20	5.52	6.03
	CD @ 1%	6.83	14.06	14.94	16.31

* DATA: Days after treatment application

Table 3: Population of *Aspergillus* in Tomatoes (US 618) treated with different concentrations of Ginger oil and Turmeric leaf extract oil

Treatment Number	Treatment details	Population of *Aspergillus* (cfu/gm)		
		7 DATA	14 DATA	21 DATA
T_1	Untreated Control-Distilled Water	$11.00^{a} \times 10^{5}$	$115.00^{a} \times 10^{5}$	$121.33^{a} \times 10^{5}$
T_2	Bavistin (2 gm/L)	$7.00^{cd} \times 10^{4}$	$8.00^{bc} \times 10^{4}$	$9.00^{b} \times 10^{4}$
T_3	Ginger Oil (100%)	$6.00^{de} \times 10^{4}$	$7.00^{bc} \times 10^{4}$	$8.33^{b} \times 10^{4}$
T_4	Ginger Oil (50%)	$8.00^{bc} \times 10^{4}$	$8.67^{bc} \times 10^{4}$	$10.33^{b} \times 10^{4}$
T_5	Ginger Oil (25%)	$8.67^{b} \times 10^{4}$	$9.67^{b} \times 10^{4}$	$12.00^{b} \times 10^{4}$
T_6	Turmeric leaf extract oil (100%)	$5.00^{e} \times 10^{4}$	$5.67^{bc} \times 10^{4}$	$8.00^{b} \times 10^{4}$
T_7	Turmeric leaf extract oil (50%)	$7.00^{cd} \times 10^{4}$	$7.67^{bc} \times 10^{4}$	$9.33^{b} \times 10^{4}$
T_8	Turmeric leaf extract oil (25%)	$8.00^{bc} \times 10^{4}$	$9.33^{b} \times 10^{4}$	$11.33^{b} \times 10^{4}$
	SEm±	0.47	1.22	1.60
	CD @ 1%	1.95	5.04	6.62

* DATA: Days after treatment application

Table 4: Population of *Penicillium* in Tomatoes (US 618) treated with different concentrations of Ginger oil and Turmeric leaf extract oil

Treatment Number	Treatment details	Population of *Penicillium* (cfu/gm)		
		7 DATA	14 DATA	21 DATA
T_1	Untreated Control-Distilled Water	$10.67^{a} \times 10^{5}$	$111.00^{a} \times 10^{5}$	$115.00^{a} \times 10^{5}$
T_2	Bavistin (2 gm/L)	$7.00^{bc} \times 10^{4}$	$7.67^{b} \times 10^{4}$	$8.33^{bc} \times 10^{4}$
T_3	Ginger Oil (100%)	$6.00^{cd} \times 10^{4}$	$6.33^{b} \times 10^{4}$	$7.33^{bc} \times 10^{4}$
T_4	Ginger Oil (50%)	$7.33^{bc} \times 10^{4}$	$7.67^{b} \times 10^{4}$	$9.00^{b} \times 10^{4}$
T_5	Ginger Oil (25%)	$8.67^{ab} \times 10^{4}$	$9.00^{b} \times 10^{4}$	$10.00^{b} \times 10^{4}$
T_6	Turmeric leaf extract oil (100%)	$4.67^{cd} \times 10^{4}$	$5.67^{b} \times 10^{4}$	$5.67^{bc} \times 10^{4}$
T_7	Turmeric leaf extract oil (50%)	$6.67^{bcd} \times 10^{4}$	$7.33^{b} \times 10^{4}$	$7.33^{bc} \times 10^{4}$
T_8	Turmeric leaf extract oil (25%)	$7.33^{bc} \times 10^{4}$	$8.67^{b} \times 10^{4}$	8.67×10^{4}
	SEm±	0.71	1.34	0.91
	CD @ 1%	2.92	5.53	3.74

* DATA: Days after treatment application

4. Conclusion

The current study has shown that different concentrations of Ginger oil and Turmeric leaf extract oil have been effective in controlling the growth of *Penicillium* and *Aspergillus* under ambient storage conditions. The best treatments of Turmeric leaf extract oil and Ginger oil in controlling the growth both *Aspergillus* and *Penicillium* in tomatoes were 100% Turmeric leaf extract oil and 100% Ginger oil under ambient storage conditions. The results obtained by these two treatments in controlling the growth of both *Aspergillus* and *Penicillium* were on par with the results obtained by use of standard check Bavistin. The effective concentrations of these products should be checked for their efficacy in controlling the growth of *Penicillium* and *Aspergillus* by carrying out studies in polyethylene bags. The possibility of using ginger oil or turmeric leaf extract oil in delaying the deterioration of fruits and vegetables caused by spoilage microorganisms can be explored by carrying out scale up studies.

5. Conflicts of Interest

The authors declare that they have no conflict of interest

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