Effect of tomato post-harvest treatment and storage conditions on the biological activity of benomyl and methylthiophanate residues in fruits and their processed products*

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⟨Received: February 13, 1981⟩

Abstract

The biological activity of benomyl and methylthiophanate residues in tomatoes and their processed products was examined. Fungicide residues were most active in concentrated pulp of tomatoes, less in pulp and the least in fresh fruits. The fungicide residues activity was very high after 90 days of storage of processed products. The pulp and concentrated pulp of tomatoes treated and stored for 14 days at 15°C, also contained very active fungicide residues. The translocation of benomyl from treated tomato skin into the tissue began slowly. This process was faster in green or yellow fruits, but it was the fastest in small green fruits. The influence of storage conditions on the activity of fungicide residues depended on the storage length. The residues were the least active in fruits stored under low pressure of 38 mm Hg for 14 days, but this activity increased during the storage period and the residues were very active after 34 days of tomato storage.

INTRODUCTION

Benzimidazole fungicides play a very important role in protecting fruits against some fungal diseases, particularly in control of storage diseases. These fungicides are also commonly used in the fungicide mixtures, widely recommended for control of field crop diseases. In both cases such fungicides as carbendazim, benomyl or methylthiophanate, are a component of the fungicide which influence the physiological life of treated fruits or plants ⟨Swinburne, 1979⟩.

The prolongation of good quality of fresh fruits is the main economic problem. Cool temperature, a modified atmosphere with a low oxygen and a high carbon dioxide concentration, are commonly used for storage of fruits and vegetables ⟨Anderson and Parsons, 1969; Anderson and Penney, 1973; Spalding and Reeder, 1974⟩. Low pressure storage is a new concept

*This work was partially supported by USDA Grant No FG-Po-351 <JB-17>.

for prolongation of post-harvest life of fruits, vegetables and cut flowers (Bangerth, 1973; Loughheed et al., 1978; Salunkhe and Wu, 1974; Spalding, 1979; Tolle, 1969). It is known that low pressure decreases the physiological processes in stored fruits (Bangerth, 1973) and delays the development of some pathogenic fungi (Borecka and Olak, 1978).

Apart from the storage conditions, the stage of tomato maturity plays a very important role in storage life of these fruits; mature-green tomatoes are most commonly stored (Kader and Morris, 1974; Lockhart et al., 1969; Lyons and Pratt, 1964; Parsons et al., 1970; Parsons and Spalding, 1972; Tolle, 1969). A temperature of 13-15°C is recommended for tomatoes. Temperature influences not only the colour of stored fruits, but also their susceptibility to fungal infection (Parsons and Spalding, 1972; McCulloch and Worthington, 1952). Besides the temperature, the stage of fruit maturity, and the storage conditions and the fungicide treatment influence the good quality of stored tomatoes (Channon and Thompson, 1973; Chastanger et al., 1977; Lockhart and Harrison, 1962; Parynow and Borecka, 1982; Spalding, 1980).

The fungicide antifungal activity degradation during the period of tomato storage is not thoroughly known. This problem is being investigated by us. Tomato pulp and concentrated pulp produced of treated tomatoes were also inoculated, because the fungicide residues problem in processed products seems to be still open.

MATERIALS AND METHODS

The experiments were carried out for two years, 1976 and 1977. Tomatoes cv. 'Pangham Cross', cv. 'Szkarlätna Kula' and their processed products were studied. 'Pangham Cross' is a popular glasshouse cultivar. 'Szkarlätna Kula' is widely cultivated outdoors and it is mostly used for processing.

Tomatoes cv. 'Pangham Cross' were stored at 15°C under hypobaric (low pressure) conditions, 38 mm Hg, 76 mm Hg, 190 mm Hg, and under controlled atmospheres, 5%CO₂ : 3%O₂, 0% CO₂ : 3%O₂, and in normal air. Tomatoes before storage were treated with water suspensions of 0.1% a.i. of benomyl or methylthiophanate; untreated fruits were also stored. Tomatoes were stored for 14, 20 and 34 days. Experiments were conducted in four replications, where one replication consisted of 10 tomatoes.

The activity of fungicide residues was established by means of a biological test with inhibition zone of growth of *Penicillium expansum* cultures growing on Czapek medium. Disks of tomato skin or tissue 0.5 cm in diameter or 0.5 ml of tomato pulp or concentrated pulp were put on the surface on one-day-old *Penicillium expansum* cultures inoculated with spore suspension. The inhibition zone of the culture growth was measured after a period of three days. These experiments were conducted in 10 replications, where one replication was one

plate with fungus. This biological method was used to establish the residues of fungicide translocation from the skin cv. 'Pangham Cross' tomato into the tissue. The activity of fungicide residues in the skin and tissue after 2 and 4 hours was also tested.

For comparison, were also tested the standard solution of benomyl from 0.1% a.i. to 0.003125% a.i. in pulp, concentrated pulp and in water suspension dropped on filter paper disks <Fig. 1>.

Fig. 1. Size of the inhibition zone of *Penicillium expansum* culture growth; standard curves
1 — concentrated pulp with benomyl; 2 — pulp with benomyl; 3 — filter paper disks with benomyl water solutions

The pulp and concentrated pulp of tomatoes cv. 'Szkarlata Kula' were prepared just after fruit treatment, the same was done with the tomatoes cv. 'Pangham Cross', but the latter were stored for 14 days before processing. The processed products of 'Szkarlata Kula' were stored for 30 and 90 days and fungicide activity was tested just after processing and after the storage period.

The influence of the maturity stage of tomatoes cv. 'Pangham Cross' on the activity of fungicide residues was also tested. Fruits were green, yellow and red. Small green fruits were also included.

The statistical analysis was done. The variance method was used. Mean figures were compared by Studnet's t-test. The percents were transformed for analysis on angle values corresponding to the percentage given by Bliss.

RESULTS AND DISCUSSION

The antifungal activity of benomyl and methylthiophanate residues in tomatoes was different. The residues of benomyl were biologically more active than those of methylthiophanate. The activity of fungicide residues varied with years, both fungicides were less active in 1976 than in 1977 (Tables 1, 2). This phenomenon depended probably on some factors influencing the chemical contents of the fruit.

Table 1

Biological activity of fungicide residues in yellow-green tomatoes cv. 'Pangham Cross' and in their processed products prepared just after treatment and after 14 days of fruit storage in normal air at 15°C. Test with *Penicillium expansum* inhibition zone growth in mm

Treatment	Directly after treatment			After 14 days of fruit storage		
	fruit	pulp	concentrated pulp	fruit	pulp	concentrated pulp
1976						
Benomyl 0.1% a.i.	1.4 c	1.3 c	2.9 d	2.2 d	7.4 f	8.2 g
Methylthiophanate 0.1% a.i.	0 a	0.6 b	0.5 b	1.4 c	6.1 e	6.5 e
Untreated	0 a	0 a	0 a	0 a	0 a	0 a
1977						
Benomyl 0.1% a.i.	6.6 c	7.4 c	1.0 c			
Methylthiophanate 0.1% a.i.	4.8 b	2.1 b	4.0 b			
Untreated	0.4 a	0 a	0 a			

L = 0.05.

Table 2

Biological activity of fungicide residues in red tomatoes cv. 'Szkarłatna Kula' and their processed products; presented as inhibition zone of growth of *Penicillium expansum* cultures in mm

Treatment	Fruits after treatment	Directly after processing		Days of storage of processed products			
				30		90	
		pulp	concentrated pulp	pulp	concentrated pulp	pulp	concentrated pulp
1976							
Benomyl 0.1% a.i.	2.8 c	6.0 d	8.2 e	7.4 d	10.4 e	6.5 c	9.6 d
Methylthiophanate 0.1% a.i.	4.0 b	1.5 b	2.5 c	0.7 b	1.4 c	0.6 b	0.9 b
Untreated		0 a	0 a	0 a	0 a	0 a	0 a
1977							
Benomyl 0.1% a.i.	3.8 b	9.4 d	13.2 e	—	—	6.6 d	11.7 e
Methylthiophanate 0.1% a.i.	0.7 a	2.2 b	5.0 c	—	—	1.6 B	5.3 c
Untreated		0 a	0 a	—	—	0 a	0 a

L = 0.05

The activity of benomyl was higher than that of methylthiophanate not only in the fruits, but also in the products of fruit processing. The fungicide residues were more active in concentrated tomato pulp than in the tomato pulp. The pulp and concentrated pulp made of tomatoes stored for 14 days after treatment than showed a similar activity of fungicide residues as those processed just after the treatment (Table 1). The concentrated pulp contained the most active fungicide residues. Processed products made of fruits just after treatment and stored for 30 and 90 days also contained very active fungicide residues (Table 2). Similarly as in the previous experiment, the residues in concentrated pulp were most active.

Because of higher activity of benomyl than methylthiophanate residues, benomyl was taken for the next experiments on tomatoes cv. 'Pangham Cross' treated at different stage of maturity. The activity of benomyl residues in the skin and tissue of tomatoes was tested. The skin of small green fruits treated with benomyl contained less active benomyl residues than in the other stage of maturity (Table 3). The speed of translocation of benomyl residues from the skin into the tissue in red tomatoes was slow, in yellow fruits faster, in small green fruits this process was fastest.

The activity of fungicide residues in small green fruits after 4 hours of treatment was highest. The residues in red tomatoes were the least active (Table 3).

Table 3

Influence of maturity stage of tomato cv. 'Pangham Cross', on the biological activity of benomyl residues, 2 and 4 hours after treatment, presented as inhibition zone of *Penicillium expansum* growth in mm

Stage of ripening	After 2 hours		After 4 hours	
	skin	tissue	skin	tissue
Small green fruit	3.1 b	2.1 ab	4.7 c	3.2 b
Full size green fruit	7.5 c	2.6 ab	5.5 cd	2.3 ab
Yellow fruit	7.7 c	2.8 b	5.9 d	2.3 ab
Red fruit	7.8 c	1.5 a	6.4 d	1.8 a

L = 0.05

The good quality of fresh tomatoes depended also on the storage conditions. These conditions influenced the activity of fungicide residues. The activity of fungicide residues under low pressure, controlled atmosphere and in normal air storage was compared. Benomyl residues were the least active under 38 mm Hg, but only for 14 days of storage; later the activity increased and they were most active after 34 days of tomato storage under these conditions. Methylthiophanate residues were the most active in normal air in tomatoes stored for 14 and 20 days; later the activity decreased, but it increased under controlled atmosphere 5%CO₂ : 3%O₂ and low pressure 38 mm Hg (Table 4).

Table 4

Biological activity of benomyl residues in tomato fruits cv. 'Pangham Cross' after storage under various conditions and length at 15°C; presented as inhibition zone of growth of *Penicillium expansum* culture in mm

Storage conditions	Treatment and days of storage					
	benomyl 0.1% a.i.	methylthio- phanate 0.1% a.i.	benomyl 0.1% a.i.	methylthio- phanate 0.1% a.i.	benomyl 0.1% a.i.	methylthio- phanate 0.1% a.i.
	14	14	20	20	34	34
Pressure 38 mm Hg	0.10 a	0 a	0.82 c	0.15 a	0.85 b	0.62 b
Pressure 78 mm Hg	0.17 b	0.04 b	0.51 a	0.40 b	0.65 a	0.45 a
Pressure 190 mm Hg	—	—	0.89 c	0.39 b	—	—
0% CO ₂ : 3% O ₂	0.27 b	0 a	—	—	—	—
5% CO ₂ : 3% O ₂	0.31 b	0 a	0.79 c	0.36 b	—	0.61 b
Normal	0.22 b	0.14 c	0.73 bc	0.81 c	0.65 a	0.44 a
Directly after treatment	—	—	0.66 b	0.48 b	—	—

L = 0.05

Because of the high level of fungicide activity in processed tomato products from treated fruits and of the lack of effectiveness of the treatment in a short storage period (Parynow and Borecka, 1982) we cannot recommend the use of fungicide treatment for prolongation of tomato storage life. This is particularly important in the case of fruits intended for processing. It was observed that storage of tomatoes for 14 days after treatment, before processing does not degrade high biological activity of the fungicide residues. Benzimidazole fungicides could not be used for protecting tomatoes against storage disorders.

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Badania nad biologiczną aktywnością pozostałości benomylu i metylotiofanatu w pomidorach przechowywanych w różnych warunkach oraz w przetworach pomidorowych

Streszczenie

Badano aktywność grzybobójczą benomylu i metylotiofanatu w owocach pomidorów, w przecierach i koncentratkach pomidorowych. Stwierdzono najwyższą aktywność fungicydów w koncentratkach, niższą w przecierach oraz najniższą w owocach świeżych. Przechowywanie owoców, przez 14 dni po zastosowaniu fungicydów, nie wpłynęło na zmniejszenie aktywności fungicydów w przetworach. Przemieszczanie się pozostałości fungicydów ze skórki do miąższu w przypadku czerwonych pomidorów następowało stosunkowo powoli, szybciej proces ten przebiegał w zielonych i żółtych pomidorach, najszybciej w przypadku zawiązków owocowych. Pozostałości fungicydów były mało aktywne w początkowym okresie przechowywania pomidorów; w warunkach obniżonego ciśnienia, aktywność ta jednak powoli wzrastała w miarę upływu czasu przechowywania.