OBSERVATIONS ON CRANBERRY FRUIT ROTS IN NOVA SCOTIA, 1945–55[1]

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Abstract

In Nova Scotia, a study of cranberry (Vaccinium macrocarpon) fruit rots between 1945 and 1955 showed that rot seldom occurred until after the fruit was harvested. End rot caused by Godronia cassandrae f. vaccinii was the most important rot of cranberry fruit. Sterile breakdown, which occurred most frequently in refrigerated and immature fruit, was the second most important cause of fruit loss in storage. Ceuthospora lunata and Sporonema oxycocci were isolated more often from infected fruit grown in a well-managed bog than from fruit produced in neglected or wild bogs. Guignardia vaccinii was the most abundant fungus on the skin of healthy fruit, but it seldom caused fruit rot. Latent infections of G. cassandrae f. vaccinii on the calyx may be the main source of inoculum for the initiation of storage rot by this fungus.

Introduction

Decay and breakdown of harvested fruit of cranberry, Vaccinium macrocarpon Ait., caused by pathogenic fungi and physiological factors are well documented in the literature (1, 2, 10, 11, 12, 13). Fruit decay may appear before harvest, during storage, or on the market. The amount of fruit breakdown varies from year to year among different areas of production, and among individual bogs.

Early rot caused by Guignardia vaccinii Shear; blotch rot, by Acanthorhynchus vaccinii Shear: bitter rot, by Glomerella cingulata (Stonem.) Spauld. & Schrenk; and end rot, by Godronia cassandrae Pk. f. vaccinii Groves have been reported to be the most important fungus diseases of cranberry fruit (12, 13). Zukerman (13) reported that ripe rot caused by Sporonema oxycocci Shear is currently a more abundant fruit pathogen in Massachusetts than in the past, and that the relative importance of several other rot organisms has changed. He also confirmed earlier reports that it is impossible to distinguish between cranberry rots without resorting to isolation and study of the causal organisms in culture.

Storage breakdown is one of the major problems of harvested cranberry fruit. Doughty et al. (6) reported that losses from physiological sterile breakdown in storage may reach 30% to 35% in some years. They also reported that a small amount of rot can be attributed to pathogenic organisms. Cranberries can normally be held in storage as fresh fruit for 2 to 3 months at 2.2 C to 4.4 C and a relative humidity of 80–85% (9).

In 1966, Chandler and Murray (4) conducted a study of the feasibility of the cranberry industry in western Nova Scotia which resulted in an expansion of this industry. Because of this renewed interest in cranberry production, records taken from 1945 to 1955 on the isolation, identification, and relative importance of the fungi and physiological factors that caused rot and breakdown of cranberry fruit are presented here.

Materials and methods

Potato dextrose agar (PDA) was the culture medium used throughout these studies. Most of the fungi isolated from cranberry fruit grew and sporulated on PDA and they were identified from spore structures and from their characteristic growth habits on this medium. All fruits from which isolations were made were surface sterilized with 70% ethanol. The isolation procedures were those normally employed for the isolation of pathogenic fungi from infected fruit; the skin was removed with a sterile scalpel and a small bit of tissue from the leading edge of the rot was transferred to PDA in petri plates. Skin isolations were made by shaving thin 3–5 mm^2 areas from the surface of the fruit and plating them on PDA. Unless otherwise stated the results were recorded as the percentage occurrence of fungal species or sterile breakdown in the rotted fruit from each sample.

In December 1945 a 5 lb sample of cranberries was obtained from the commercial packing houses at each of the bogs at Arichat in Richmond County and Auburn in Kings County, and isolations were made from the infected fruit. At the same time, a 1-lb sample of cranberries from each of the bogs at Aylesford and Lakeville, Kings County, was purchased from a retail outlet and stored in a refrigerator at approximately 5C for 1 month before isolations were attempted from the infected fruit in each sample.

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No detailed study of cranberry fruit rot was made between 1946 and 1954. However, during this period observations were made on the fungi found on unripe and mummified fruit, on berries found floating on flooded bogs, on berries that had overwintered on the bogs, and on blighted cranberry plants in cultivated bogs. Most of these observations were supported by isolations to determine the causal organisms, and they are included here as part of the cranberry disease syndrome in Nova Scotia.

In January 1955, isolations were made from infected fruit harvested from the following bogs in Kings County:

Palmer - a neglected bog in which renovation had commenced in 1954. Berries were of good size and well colored;

Oyler-Walker - one of the older, well managed bogs with natural frost protection. Fungicides and insecticides were applied for disease and insect control. Berries were large, well colored, and had been stored at approximately 3. *3C;*

Neglected - a bog without frost protection where the fruit had to be harvested before it was fully mature. Berries were small and poorly colored;

Wild - a natural bog along the seashore, Berries were small, well colored, and badly bruised from rough handling.

To determine if fruit rots could be initiated through the calyx, isolations were made from the dried adhering sepals and decaying flesh beneath the calyx from fruit of the Palmer and Wild bogs. Isolations were also made from the calyx and skin of healthy fruit from the same bogs. The frequency of fungal isolates from infected and healthy fruit was expressed as a percentage of the total fruit examined for each series of isolations.

It is not uncommon for cranberry fruit to have small red spots on the skin that are more prominent when the berries are poorly colored. A sample of light colored berries with prominent red spots was selected from among the healthy fruit from the Palmer and Wild bogs. Isolations were made from the red spots on the skin, from the flesh beneath the red spots and from apparently healthy areas of the skin. Isolations were also made from the skin of well colored, non-spotted berries from the same bogs. The incidence of each fungal species obtained in culture was recorded as a percentage of the total isolations for each test.

Results

In 1945, the end rot fungus G. cassandrae f-vaecinii was isolated from a greater number of infected cranberry fruit than other fungi (Table 1). This soft, watery rot that started at the calyx end and quickly involved the whole berry was the most prominent rot in the samples from the four bogs. About 24% of the rotted fruit were sterile, and sterility was greatest in the fruit that had been refrigerated. A. vaccinii and G. vaccinii were obtained inculture only when asection of a dark, blotchy area on the skin was included with the plated tissue.

In the period from 1946 to 1954, G. cassandrae f. vaccinii was the most abundant fungus found in infected unripe, ripe, or mummified cranberry fruit. From 13% to 57% of the decay in stored fruit was end rot, and the amount of this rot varied with the season and the location of the bog. S. oxycocci was the most abundant pathogen in fruit from flooded bogs. It was isolated from berries left on the bog over winter and was easily obtained from the remains of berries along the banks of previously flooded bogs. Pestalotia vaccinii (Shear) Guba and Diaporthe vaccinii Shear were isolated occasionally and were more prevalent on blighted twigs than on fruit. Few isolates of black rot caused by Ceuthospora lunata Shear were obtained from rotted fruit.

In 1955, G. cassandrae f. vaccinii was one of the major causes of breakdown in cranberry fruit from the four bogs (Table 2). Sterile breakdown was more prevalent than end rot in the immature fruit from the neglected bog. More black rot and ripe rot were found in the fruit from the Oyler-Walker bog than in fruit from the other three bogs.

G. cassandrae f. vaccinii was the most frequently isolated fungus from the calyxes and flesh of rotted fruit, while G. vaccinii occurred moot often in the calyxes and skin of healthy fruit (Table 3). In general there was a good correlation between the incidence of a fungus species in the flesh with that in the calyx of rotted fruit. With healthy fruit G. vaccinii was more prevalent in the skin than in the calyxes.

When isolations weremadefrom red spots, light-colored, or well-colored skin, G. vaccinii was present on the skin of a greater number of fruit than any other fungus (Table4). This fungus was isolated more often from the red spots on the skin of light-colored fruit than from well- or light-colored skin. In a few instances, G. vaccinii was isolated from the flesh beneath red skin spots.

Discussion and conclusions

The rot diseases of cranberries caused by the different fungi vary greatly in their prevalence in the different cranberry-growing regions of North America. Early rot caused by G. vaccinii is the most serious one in New Jersey; bitter rot caused by G-cingulata is most important in Massachusetts: while end rot caused by G. cassandrae f. vaccinii, is the most serious cranberry rot in Wisconsin and on the

Table 1. Percentage incidence of fungi from rotted cranberry fruit at four locations in 1945

Type of rot	Fungus isolated	Source* of fruit				
		Arichat	Auburn	Aylesford	Lakeville	Mean
Blotch	Acanthorhyncus vaccinii	0	3.2	8.0	0.6	4.1
Black	Ceuthospora lunata	7.0	14.8	0	0	3.1
Bitter	Glomerella cingulata	5.8	3.2	0	0	1.0
End	Godronia cassandrae f. vaccinii	48.8	36.7	57.4	42.9	48.6
Early	Guignardia vaccinii	0	4.5	11.6	3.8	6.9
	Penicillium spp.	0	2.5	1.2	5.8	2.8
	Pestalotia vaccinii	24.4	9.0	2.6	0	4.7
Ripe	Sporonema oxycocci	4.6	11.6	8.7	2.2	6.7
	Unidentified fungi	1.1	11.6	4.1	8.6	6.5
Sterile breakdown		9.3	13.5	19.0	40.0	24.1
Number of diseased fruit examined		86	155	413	312	

* Samples were obtained in December 1945; those from packing houses at Arichat and Auburn were examined immediately, while those from bogs at Aylesford and Lakeville were refrigerated at 5C for 1 month before examination.

Table 2. Percentage incidence of fungi from rotted cranberry fruit produced at four bogs in 1955

Type of rot	Fungus isolated	Source of fruit				
		Palmer	Oyler-Walker	Neglected	Wild	Mean
Blotch	Acanthorhyncus vaccinii	2.8	4.3	0.9	8.6	4.6
	Botrytis cinerea	0	0	0	0.5	0.1
Black	Ceuthospora lunata	0	12.9	1.8	0	2.9
	Diaporthe vaccinii	2.0	2.9	0	15.8	6.0
Bitter	Glomerella cingulata	0	0	0.9	0.5	0.3
End	Godronia cassandrae f. vaccinii	88.8	59.7	41.6	42.1	60.3
Early	Guignardia vaccinii	5.0	0	3.7	14.8	5.2
	Penicillium spp.	0	5.7	4.6	18.1	7.3
	Pestalotia vaccinii	0	1.4	0.9	0.5	0.6
Ripe	Sporonema oxycocci	9.5	17.2	4.6	5.2	9.0
	Unidentified spp.	0.4	3.6	0.9	2.7	1.6
Sterile breakdown		2.8	10.8	53.7	12.4	15.2
Number of diseased fruit examined		241	139	108	209	

Table 3. Percentage incidence of fungi from diseased and healthy tissues of cranberry fruit grown in two bogs in 1955

	Palmer bog				Wild bog			
	Diseased		Healthy		Diseased		Healthy	
Fungus isolated	Flesh	Calyx	Fresh	Calyx	Flesh	Calyx	Skin	Calyx
Acanthorhyncus vaccinii	0	3.4	0	10.0	10.0	5.0	10.0	1.2.5
Botrytis cinerea	0	0	0	0	1.0	0	0	0
Diaporthe vaccinii	15.9	14.7	0	0	14.0	21.0	0	10.0
Glomerella cingulata	0	0	0	0	0	1.0	0	0
Godronia cassandrae f. vaccinii	86.1	76.1	0	33.0	38.0	42. 0	7.5	10.0
Guignardia vaccinii	13. 8	12.5	83. 7	33.0	4.0	20.0	67. 5	35.0
Penicillium spp.	1.0	0	0	0	15.0	22.0	5.0	42.5
Sporonema oxycocci	5.3	3.4	0	6.0	7.0	9.0	0	10.0
Unidentified fungi	4.2	6.8	0	1.0	2.0	13.0	0	0
Sterile	2.1	0	16.0	3.0	17.0	11.0	22.5	10.0
Number of fruit examined	94	88	30	30	100	100	40	40

Table 4. Percentage incidence of fungi from the skin and flesh of cranberry fruit in 1955

	Appearance of skin			Flesh beneath red spots
Fungus isolated	Well-colored	Light-colored	Red spots	
Acanthorhyncus vaccinii	1.1	0	0	0
Diaporthe vaccinii	0.5	0	0	0
Godronia cassandrae f. vaccinii	0.5	0	0	0
Guignardia vaccinii	54.2	21.9	79.7	6.0
Unidentified fungi	0	0.8	0	0
Sterile	43.8	77.3	20.3	94.0
Number of isolations	628	128	128	100

Pacific Coast (5, 7, 13). Hall et al. (8) reported that the incidence of fruit rot is determined largely by the mean temperature during the growing season, In New Jersey, the fruit may rot in the bogs before harvest, but in Nova Scotia, rotting seldom occurs until after the fruit is stored.

In Nova Scotia from 1945 to 1955, G. cassandrae f. vaccinii was isolated from more infected fruit than any other fungus and was the most important cause of breakdown in stored fruit. Botrytis cinerea Pers. and Penicillium spp. are not normally considered to be pathogens of cranberry fruit, but

they may colonize berries through cracks and bruises caused by rough handling during harvest.

Cranberry fruit held in storage for a month or more may show sterile breakdown at temperatures above freezing, especially above 1OC, whereas those stored just below freezing may show much low temperature breakdown (5). Sterile breakdown was the second most important cause of loss of harvested fruit in Nova Scotia. Immature fruit may be more susceptible to sterile breakdown than mature fruit. When the fruit was harvested early from the Neglected bog, there was more sterile breakdown than fungus decay. Sterile breakdown ranked fourth after end rot, ripe rot, and black rot, as the cause of breakdown of fruit from the Oyler-Walker bog.

There are few reports in the literature on the colonization of the calyxes of cranberry fruit by fungi and the correlation of these calyx fungi with the causes of fruit rot. Here G. cassandrae f. vaccinii was the most prevalent fungus in the calyx and flesh of infected fruit and it was present on the calyxes of healthy fruit. The calyx may be one of the chief avenues of fruit infection, since end rot, as the name implies, most often occurs in Nova Scotia at the calyx end of the fruit.

Zukerman (13) reported that a great percentage of cranberries contain rot fungi at harvest, but they do not breakdown unless the proper stimulus or "triggering action" occurs. Here G. vaccinii was the most abundant fungus on the skin of healthy fruit, but it was not an important fruit rot pathogen. It was found in only a few rotted fruit, where it was usually associated with other more aggressive rot fungi. Although G. cassandrae f. vaccinii was the dominant fungus isolated from the calyx and flesh of infected fruit, it rarely occurred on the skin of healthy fruit. In Wisconsin, Carlson and Boone (3) found three fungi, A. vaccinii, G. vaccinii, and Gibbera compacta (Pk.) Shear associated with a berry speckle disease of cranberry. In Nova Scotia, G. vaccinii was most frequently associated with red spots on the skin, the flesh beneath the red spots, and the skin of unblemished fruit.

Zukerman (13) found that recent changes in the relative importance of several rot organisms in Massachusetts may have been due to changes in cultural practices. In this study Sporonema oxycocci and Ceuthospora lunata were relatively more important fruit pathogens in the well-managed Oyler-Walker bog than in the other three bogs.

In Nova Scotia end rot is the most important cause of cranberry fruit decay in storage. The fungus found most commonly on the skin of healthy fruit was G. vaccinii, the causal agent of early rot, but it is not an important fruit pathogen in Nova Scotia.

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