Special Report

Disorders in Crisphead Lettuce Shipments to the New York Market, 1972-1984

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The volume of crisphead (iceberg) lettuce (*Lactuca sativa* var. *capitata* L.) delivered by truck and rail to metropolitan New York exceeds 170,000 t annually, second only to the volume of potatoes shipped to this market (11,12). Presumably, the initial quality of lettuce leaving production areas is good enough to meet grade and condition standards for commercial acceptance at terminal markets. U.S. Department of Agriculture inspectors have indicated, however, that of all fresh fruit and vegetable produce crops, lettuce has the highest number of shipments rejected or discounted on the New York market because of rots, physiological disorders, and injuries.

Maintaining lettuce in transit vehicles depends on the initial quality and vigor of the product, the manner in which the product is handled and precooled, the configuration of the load, the effectiveness of protective services provided by the carrier, and the efficiency of transport. Rots may develop in transit if incipient or latent infections were present when the lettuce was harvested. Transit delays and high commodity temperatures enhance decay development and provide opportunities for new infections. Additionally, physiological and other disorders can be initiated or aggravated. Undesirable high temperatures accelerate respiration, speed up senescence, cause leaf yellowing, and increase moisture loss. The lettuce can be warmed in transit by inadequate precooling and by solid, tight loads that restrict refrigerated air from circulating around and through the load. Transit vehicles with faulty refrigeration systems or inadequately equipped or poorly designed carriers also contribute to poor condition of lettuce on arrival at terminal markets.

The Fresh Products Branch of the USDA Agricultural Marketing Service in New York City allowed us to review inspection certificates describing the arrival condition of nearly 23,000 crisphead lettuce shipments to the New York market during 1972–1984. Inspections were principally requested by receivers and in many cases involved shipments whose acceptance quality was questioned. The inspected shipments (Table 1) contained approximately 22% of all the crisphead lettuce delivered to the New York market (11,12). Information relevant to this report was abstracted from the certificates, stored, and subsequently retrieved from a computerized data bank.

Six cartons of lettuce, usually with 24 heads each, are routinely inspected in a shipment. A greater number may be evaluated at the request of the receiver or shipper. A representative sampling of the cartons is usually based on their positions throughout the load. When the railcar or trailer is not immediately unloaded, however, sampling may be restricted to doorway or other locations. Occasionally, inspections are requested on partial loads in the carrier or on unloads within the premises of the receiver. All heads in each carton are individually inspected for disorders on wrapper and outer head leaves. Heads may also be severely trimmed or torn apart to look for internal disorders. A need for a more extensive and critical examination is often dictated by the time of year (specific disorders are more likely during some months), cultivar susceptibility, and history of disorders in lettuce grown in certain areas.

Data reported here were obtained by inspections of 22,931 crisphead lettuce shipments, varying from 765 in 1978 to 3,143 in 1972 (Table 1). Approximately equal numbers of railcar and truck-trailer shipments were inspected during 1972–1984. Railcar inspections predominated before 1976, then truck-trailer inspections predominated; many of the truck shipments, however, were piggybacked on flatbed railcars from western regions to unloading facilities at nearby railroad yards. Shipments averaged 708 cartons each when delivered by truck and 916 cartons when delivered by rail. These carton totals are conservative because in a number of cases each year, inspections were made only on the portion of a shipment remaining after it was sold and distributed.

During 1972–1984, 25 disorders of crisphead lettuce were identified or described by USDA inspectors, who are trained to diagnose disorders principally by symptomatology. USDA market pathologists assisted in disease identification upon request. The principal diseases were bacterial soft rot (*Pseudomonas* and *Erwinia* spp.), gray mold rot (*Botrytis cinerea*), watery soft rot (*Sclerotinia sclerotiorum* and *S. minor*), and unidentified decays of head leaves (not identified because of lack of characteristic symptoms and of time and facilities for definitive diagnoses). A few cases of downy mildew (*Bremia lactucae*) and spotted wilt virus were also noted, as well as five isolated occurrences of decay caused by species of *Penicillium, Fusarium*, and *Rhizopus*. The common nonparasitic diseases or physiological disorders identified were tipburn, russet spotting, rib discoloration, rusty brown discoloration, brown stain, pink rib, and marginal browning. Minor disorders nominally termed physiological were leaf yellowing, leaf wilting, and misshapen heads. The remaining disorders reported were bruise damage, freeze damage, insect damage, field frost, broken ribs, and grade defects.

The most damaging disorders of lettuce shipped to the New York market from all domestic sources, Canada, and Mexico are shown in Table 2. Bacterial soft rot was by far the most commercially damaging as well as the most prevalent disorder. The bacteria cause a soft, slimy rot that often requires heavy trimming or disposal of the lettuce head. The disease is initiated at harvest, in the packinghouse, or in transit, and temperature greatly influences its progress. The magnitude of the disease is manifested not only by its presence in 12,958 (56.5%) of the shipments inspected but also by the extent of its occurrences. In three of every four affected shipments, more than 5% of the inspected heads were rotted to some degree. Moreover, 1,010 of these shipments had bacterial soft rot in more than 20% of the lettuce heads.

Bruise damage, associated with a progressive reddish brown discoloration of the leaf tissue, was the next most frequent disorder. This condition, induced by mechanical injury of lettuce tissue during rough handling at harvest and marketing (6), was noted in 12,678 (55.3%) of the shipments. More than

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Table 1. Crisphead lettuce shipments inspected by USDA on the New York market, 1972–1984

Year	Railcar		Truck-trailer		Other[a]		Total	
	Shipments (no.)	Cartons[b] (no.)	Shipments (no.)	Cartons (no.)	Shipments (no.)	Cartons (no.)	Shipments (no.)	Cartons (no.)
1972	2,328	2,078,035	741	514,920	74	57,197	3,143	2,650,152
1973	2,076	1,846,209	708	475,492	17	12,961	2,801	2,334,662
1974	1,662	1,573,135	507	3,44,721	37	30,674	2,206	1,948,530
1975	1,451	1,375,741	648	467,335	2	1,600	2,101	1,844,676
1976	934	955,932	1,057	803,596	8	4,837	1,999	1,764,365
1977	675	701,785	769	613,574	24	24,043	1,468	1,339,402
1978	204	213,585	558	432,719	3	640	765	646,944
1979	238	220,258	786	517,672	6	4,330	1,030	742,260
1980	446	382,658	836	536,473	30	19,331	1,312	938,462
1981	281	217,882	1,128	767,998	5	3,185	1,414	989,065
1982	565	454,146	977	690,095	1	725	1,543	1,144,966
1983	292	217,735	1,635	1,163,754	3	902	1,930	1,382,391
1984	182	144,667	1,036	737,034	1	800	1,219	882,501
Total	11,334	10,381,768	11,386	8,065,383	211	161,225	22,931	18,608,376

[a] Air, piggybacked trailer or container, or undetermined.
[b] Generally 24 heads per carton, with an average net weight of 22.7 kg.

Table 2. Leading disorders of crisphead lettuce reported in USDA inspections of shipments arriving on the New York market, 1972–1984

Disorder	Number of shipments affected according to incidence class (% heads)						
	0	1	2–5	6–12	13–20	21–50	51–100
Bacterial soft rot	9,973	109	2,788	7,281	1,770	791	219
Bruise damage	10,253	234	4,334	5,162	2,040	875	33
Tipburn	13,153	450	3,400	3,277	1,588	972	91
Unidentified decays	18,644	2,390	1,784	85	17	9	2
Russet spotting	20,450	239	1,071	825	223	111	12
Rib discoloration	20,827	165	899	799	192	44	5
Rusty brown discoloration	22,017	25	211	238	174	204	62
Brown stain	22,269	33	243	218	115	50	3
Gray mold rot	22,271	21	294	230	51	59	5
Freeze damage	22,305	2	28	136	132	222	106
Watery soft rot	22,660	9	113	104	27	15	3
Broken ribs[a]	20,376	46	1,642	842	19	6	0
Field frost[a]	21,466	53	649	530	195	36	2
Grade defects[a]	21,561	65	841	430	20	14	0

[a] Less commercially damaging than other disorders.

12% of the heads in almost 3,000 shipments had bruise damage (Table 2).

The prevailing view on the market that tipburn is the most damaging nonparasitic disease of crisphead lettuce is supported by the USDA inspection reports. About 43% of the shipments had tipburn, and its occurrence in the shipments was comparable to that of bacterial soft rot. Of 9,778 shipments with tipburn, almost 6,000 had more than 5% and 2,651 had more than 12% of the heads affected (Table 2).

Tipburn is normally expressed as an irregular brown border of necrotic tissue at the margins of outer head leaves and occasionally of inner head leaves (8). Affected tissue usually remains moist, allowing opportunistic bacteria to infect injured areas and initiate soft rots. Infections by soft rot bacteria are thought to follow tipburn during the marketing of lettuce, and this association is supported by the USDA inspections (Table 3). Bacterial soft rot was present in 64.3% of shipments with tipburn, compared with 50.7% of those without tipburn. The inspections also revealed a consistent increase in the association of bacterial soft rot with tipburn (Table 3).

Unidentified decays were reported in 18.7% of the inspections; usually only 1% of the heads were affected (Table 2). Most were probably bacterial soft rot, gray mold rot, or watery soft rot—all of which cause similar symptoms, especially when no mold is readily observable.

Two other important nonparasitic diseases of crisphead

Table 3. Association of bacterial soft rot with tipburn in USDA inspections of crisphead lettuce shipments on the New York market, 1972–1984

Year	Shipments with tipburn (no.)	Shipments with bacterial soft rot (no.)	Bacterial soft rot in tipburn shipments	
			(no.)	(%)
1972	1,414	1,295	674	47.7
1973	1,259	1,311	726	57.7
1974	871	1,064	473	54.3
1975	867	1,064	503	58.0
1976	825	868	414	50.2
1977	543	604	335	61.7
1978	267	437	209	78.3
1979	433	656	313	72.3
1980	549	896	412	75.0
1981	689	1,046	535	77.6
1982	643	1,145	491	76.4
1983	964	1,593	822	85.3
1984	444	970	369	83.1
Total	9,768[a]	12,949[a]	6,276	

[a] Do not include 10 records of tipburn and 9 records of bacterial soft rot in shipments for which specific years are unknown.

lettuce are russet spotting and rib discoloration. The former is a rust-colored spotting of head leaf surfaces that develops mostly after harvest. Rib discoloration appears as a yellow to dark brown area about 0.5 cm wide and up to several centimeters long on the inner surface of the midrib or secondary ribs of a few outer head leaves. Russet spotting and rib discoloration each were found in about 10% of the inspections, with russet spotting slightly more frequent and extensive (Table 2). Bacterial soft rot often follows either disorder.

Other important disorders were rusty brown discoloration (4% of shipments), brown stain (2.9%), gray mold rot (2.9%), freeze damage (2.7%), and watery soft rot (1.2%). Three disorders more prevalent than these but less damaging commercially were broken ribs (11.1% of shipments), field frost (6.4%), and grade defects (6%). Field frost damage is manifested by blistering and peeling of the epidermis on wrapper and outer head leaves. Minor mechanical injuries were the reasons for the bulk of the grade defects; others were soft or poorly trimmed heads and soil on the lettuce. Broken ribs, field frost, and grade defects were not as commercially damaging as other disorders.

Rusty brown discoloration of crisphead lettuce was first noted on the New York market in 1961 and was considered to be an atypical form of rib discoloration. The diffuse discoloration usually affects the midribs of outer head leaves but may spread to lateral veins and interveinal tissues and affect wrapper and inner head leaves. Severe losses occurred in eastern markets in 1969, especially on the cultivar Climax grown in California and Arizona during the winter months (4). An association of rusty brown discoloration with lettuce mosaic virus has been reported (5).

Brown stain occurs when respiratory carbon dioxide (CO_2) from lettuce reaches injurious levels in load compartments of railcars and trailers (7). Decreased oxygen levels and increased carbon monoxide concentrations were found to increase brown stain damage at injurious CO_2 levels (10). Brown stain lesions on leaf surfaces typically are slightly sunken with speckled margins and about 0.5 cm wide and 1 cm long. Lesions may coalesce to involve larger areas. Brown stain was initially reported in 1970 on the California summer crop of the cultivar Calmar, which was particularly susceptible (9).

The prevalence of rusty brown discoloration and brown stain is shown in Table 4. Both disorders occurred with about equal frequency in shipments to the New York market during 1972–1977. About 95% of rusty brown discoloration was observed during winter and spring, and about 95% of brown stain was observed during late spring and summer. More than 98% of the shipments with the disorders originated from California and Arizona.

Dramatic reductions of rusty brown discoloration and brown stain were reported in the inspected lettuce shipments during 1978–1984 (Table 4). The incidence of rusty brown discoloration declined from 4.9% to 2.7%, probably reflecting a change to cultivars less susceptible than Climax and to use of virus-free seed. Brown stain was practically nonexistent (0.1%). Cultivar changes, reduction of CO_2 buildups in loads, and decline in use of modified atmospheres in western lettuce shipments all contributed to the virtual elimination of brown stain.

The relatively low incidence (2.9%) of gray mold rot contrasts sharply with results of an earlier study on the importance of this lettuce disease on the New York market (3). A considerable number of gray mold rot observations may have been inadvertently listed as unidentified decays (Table 2). The pathogen causes a soft rot, and mold growth usually is not visible in the early stages or occasionally even in more advanced stages of the rot.

Watery soft rot, which can be very destructive, was identified in 271 (1.2%) of inspected shipments (Table 2). Because early symptoms, with no surface mold growth, can resemble those of gray mold rot or bacterial soft rot, we suspect many watery soft rot occurrences were listed as unidentified decays.

Freeze damage was reported in 626 shipments (Table 2),

Table 4. Rusty brown discoloration and brown stain in USDA inspections of California and Arizona crisphead lettuce shipments on the New York market, 1972–1984

Period and disorder	Bimonthly occurrences of disorders						Total	
	Jan.–Feb.	Mar.–Apr.	May–June	July–Aug.	Sept.–Oct.	Nov.–Dec.	(no.)	(%)
1972–1977[a]								
Rusty brown discoloration	341	253	40	9	10	7	660	4.9
Brown stain	14	15	242	283	87	5	646	4.8
1978–1984[b]								
Rusty brown discoloration	119	50	28	3	14	23	237	2.7
Brown stain	0	5	1	1	0	2	9	0.1

[a] 13,352 shipments.
[b] 8,892 shipments.

Table 5. Crisphead lettuce shipments damaged by eight disorders reported in USDA inspections on the New York market, 1972–1984

Source and pack	Number of shipments inspected	Percentage of shipments with:							
		Bacterial soft rot	Bruise damage	Tipburn	Unidentified decays	Russet spotting	Rib discoloration	Freeze damage	Gray mold rot
California									
Naked	16,559	58.2	58.5	41.9	19.2	10.7	8.7	2.4	3.3
Wrapped	1,643	32.9	22.0	24.4	13.9	5.5	4.6	2.8	1.6
Arizona									
Naked	3,923	57.8	56.6	54.4	18.9	14.0	11.6	1.7	1.5
Wrapped	119	41.2	19.3	37.8	13.4	6.7	3.4	4.2	2.5
Other[a]	687	66.8	55.7	37.6	18.2	8.6	18.5	1.2	3.8

[a] Naked (619) and wrapped (68) lettuce shipments from New Mexico (170), Texas (154), Colorado (94), Arkansas (20), and 13 other states, Mexico, Canada, and unidentified sources (249).

usually caused by malfunctioning refrigeration systems in the carriers. More than half of these shipments had 21–100% of the heads frozen.

Insect damage was reported in 631 (2.8%) of inspected shipments, but in about 80% of these, only 5% or less of the heads were affected. Aphids were identified in only a few shipments.

Marginal browning, a yellow to brown necrosis of wrapper and outer head leaves, occurred in 189 (0.8%) of shipments, and pink rib, discoloration of the midribs of the outer head leaves, occurred in 50 (0.2%).

California is the nation's leading supplier of lettuce because the crop can be grown year-round. Arizona producers also harvest crisphead lettuce during the winter months. The more than 22,000 shipments from California and Arizona inspected on the New York market during 1972–1984 (Table 5) constituted 97% of all crisphead lettuce inspected during this period. The most damaging conditions in lettuce from these two states were bacterial soft rot, bruise damage, tipburn, unidentified decays, russet spotting, rib discoloration, freeze damage, and gray mold rot. These eight disorders were also the leading contributors to quality loss in shipments from all other sources.

The incidences of six of these leading disorders in shipments from California are shown in Table 6, and the incidences in shipments from Arizona are shown in Table 7. The heads of lettuce, usually 24 per carton, arrived unwrapped (naked) or individually packaged in heat-shrinkable or stretchable plastic films.

The order of frequency of the leading disorders was similar for California and Arizona whether the lettuce was prepackaged or not (Table 5). California shipments were slightly less affected by the disorders, but differences could not be considered significant. Occurrences of the disorders were substantially fewer in prepackaged shipments, regardless of the source. Compared with the naked pack, wrapped lettuce from California had 42% fewer shipments with tipburn, 47% fewer with russet spotting or rib discoloration, and 44% fewer with bacterial soft rot. Only 119 prepackaged lettuce shipments from Arizona were inspected, but results were similar to those for California (Tables 6 and 7).

The reduced incidences of bacterial soft rot, bruise damage, and physiological disorders in prepackaged lettuce could be attributed to trimming the heads before they were wrapped. Also, naked lettuce is usually bulge-packed, resulting in more mechanical damage and subsequent decay. Removal of most if not all wrapper leaves reduces the number of potential pathogens and eliminates the older, less vigorous leaves that may be decayed or carrying pathogens. Furthermore, trimming greatly enhances the opportunities for detecting diseases and other disorders that mandate culling defective heads before shipment, thereby diminishing the opportunities for new

Table 6. Incidence of six leading disorders reported in USDA inspections of California crisphead lettuce shipments on the New York market, 1972–1984

	Percentage of shipments affected according to incidence class (% heads)						
Pack and disorder	**0**	**1**	**2–5**	**6–12**	**13–20**	**21–50**	**51–100**
Naked (16,559 shipments)							
Bacterial soft rot	41.8	0.4	13.1	32.3	7.9	3.5	1.0
Bruise damage	41.5	1.0	19.9	23.7	9.5	4.2	0.2
Tipburn	58.1	2.0	15.2	13.8	6.7	3.9	0.3
Unidentified decays	80.8	10.7	8.0	0.4	<0.1	<0.1	<0.1
Russet spotting	89.3	1.0	4.8	3.6	0.8	0.4	0.1
Rib discoloration	91.2	0.7	3.9	3.2	0.8	0.1	0.1
Wrapped (1,643 shipments)							
Bacterial soft rot	67.1	0.4	4.8	19.6	5.5	2.2	0.4
Tipburn	75.7	2.7	9.2	6.5	3.1	2.6	0.2
Bruise damage	78.0	1.1	11.7	6.9	1.4	0.9	0
Unidentified decays	86.1	7.6	5.7	0.4	0.1	0.1	0
Russet spotting	94.4	0.7	1.9	1.2	1.2	0.5	0.1
Rib discoloration	95.4	0.7	2.1	0.9	0.5	0.2	0.2

Table 7. Incidence of six leading disorders reported in USDA inspections of Arizona crisphead lettuce shipments on the New York market, 1972–1984

	Percentage of shipments affected according to incidence class (% heads)						
Pack and disorder	**0**	**1**	**2–5**	**6–12**	**13–20**	**21–50**	**51–100**
Naked (3,923 shipments)							
Bacterial soft rot	42.2	0.7	11.8	34.9	7.2	2.7	0.5
Bruise damage	43.4	0.9	18.3	24.0	10.1	3.3	<0.1
Tipburn	45.6	1.6	16.3	19.5	9.7	6.3	1.0
Unidentified decays	81.1	10.9	7.7	0.3	<0.1	0	0
Russet spotting	86.0	1.4	5.3	4.6	1.7	0.9	0.1
Rib discoloration	88.4	0.8	4.3	5.3	0.9	0.3	0
Wrapped (119 shipments)							
Bacterial soft rot	58.8	0.9	6.7	19.3	7.6	5.9	0.8
Tipburn	62.2	3.4	6.7	15.1	3.4	9.2	0
Bruise damage	80.7	0.9	9.2	7.6	0.8	0.8	0
Unidentified decays	86.6	9.2	4.2	0	0	0	0
Russet spotting	93.3	0	2.5	3.4	0.8	0	0
Rib discoloration	96.6	0	2.5	0.9	0	0	0

bacterial soft rot infections and other decays. The film wraps also prevent spread of pathogens from rotted heads to sound ones.

Results of the USDA inspections were not truly representative of the arrival condition of all crisphead lettuce on the New York market during 1972–1984 because a disproportionate number of distressed shipments were included—shipments that failed to meet grade or did not meet previously agreed on specifications by shippers and receivers regarding lettuce quality. The federal inspection office located in New York City's Produce Terminal Market at Hunt's Point estimates that up to 60% of the inspected shipments were distressed.

There is no question, however, that the inspection reports provide a comprehensive representation of the diseases and other disorders that contribute to the huge losses experienced annually in the marketing of this commodity (1,2). The data presented in this report were derived from examination of at least 3.3 million lettuce heads by trained federal inspectors over a 13-year period. Results from so large a sample are reliable, and we suggest that a more concerted production and marketing research effort is needed to assure quality and to lessen physical losses of this important commodity.

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