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Chemical composition and nutritive value of corn silage harvested in the northeastern United States after Tropical Storm Irene

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ABSTRACT

In the fall of 2011, Hurricane (Tropical Storm) Irene caused significant damage to the forage corn crop in the northeastern United States. Compromised crops were subjected to various degrees of flooding, lodging, and contamination with sediment. The objective of this study was to determine if compromised plants harvested for silage fermented normally and if the nutritive value of these silages was adversely affected. The chemical and nutrient composition of compromised silages was compared with that from silages made from unaffected plants from the same region. The concentration of NE_L and in vitro digestibility of NDF were lower in plants compromised by the hurricane. In addition, the ash content of compromised silages was higher than that of unaffected silages. Specifically, concentrations of Al, Co, Fe, and Mn were higher in compromised silages. Overall, silage fermentation appeared to be normal; the final silage pH, and concentrations of fermentation acids, alcohols, and esters were similar between compromised and unaffected silages. Numbers of yeasts (but not molds) tended to be higher in compromised silage than in unaffected silage. Pathogenic microorganisms were not detected in any silage. The incidences and concentrations of mycotoxins were similar between compromised and normal silage. Several farms that fed compromised silage reported subsequent health issues with their animals.
Key words: silage, feeding, dairy

INTRODUCTION

It is well known that severe flooding can have detrimental effects on the quality of forage crops. Plants under stress from flooding usually respond by reduced photosynthesis and are thus more prone to root, ear, and stalk rot (Nielsen, 2003, 2011). In 2011, Hurricane Irene moved up the eastern coast of the United States becoming a tropical storm that caused severe damage to crops in the Northeast due to flooding and high winds. This insult occurred approximately 1 mo before normal harvest of corn, the predominant forage crop that is fed to lactating dairy cows in some of the affected areas. After the hurricane/storm, the Food and Drug Administration advised producers in the region to avoid harvesting crops for animal feed because of potential contamination by sewage, heavy metals, pathogens, and industrial chemicals (USDA, Office of Communications, 2011). The effects of flooding and high levels of sediment on the plants, on subsequent silage fermentation and nutritive value were unknown. Thus, this study was undertaken with specific objectives to determine if flooding from Tropical Storm Irene (August 28–29, 2011) affected nutrient composition, chemical composition, microbial contamination, and fermentation of corn silage harvested in the Northeastern United States.

MATERIALS AND METHODS

A regional study was undertaken to collect samples to evaluate the effects of Tropical Storm Irene on the nutritive value of corn silages. Extension and industry personnel collaborated to identify farms whose corn silage was compromised due to lodging, flooding, or both. Between March and June 2012, thirty corn silage samples (**FLO**) were collected from 28 farms whose fields were affected by flooding and 8 samples (**NRM**) were collected from 8 farms in the same region that reported no flooding to crops. Silages obtained for this study had been harvested between September 15 to November 28, 2011, and had ensiled between 120 and 180 d. Along with sample collection, a survey was conducted to obtain basic information about the farm, corn type, length of ensiling time, degree and extent of damage on corn crops before ensiling, abnormal appearance of corn silage, and animal response. Approximately 2 kg of fresh corn silage was collected for each sample and shipped to Cumberland Valley Analytical Services (CVAS, Maugansville, MD) for wet chemistry

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analysis. Samples were dried in a forced-draft oven (60°C for 48 h, Isotemp Oven model 750F, Fisher Scientific, Dubuque, IA) and ground to pass a 1-mm sieve using a Wiley mill (Arthur H. Thomas, Philadelphia, PA). The NDF content was analyzed using sulfite and amylase according to the procedures outlined by Van Soest et al. (1991) and corrected for ash content. The ADF content of samples was determined according to AOAC International (2000) procedures with some modification and corrected for ash. The modification included the use of Whatman 934-AH glass micro-fiber filters with 1.5-μm particle retention in lieu of fritted glass crucibles. The ADF content was corrected for ash by burning samples in a 535°C furnace for 2 h. The ADL content of samples was determined using the procedures of Goering and Van Soest (1970). In vitro ruminal NDF digestibility (**NDF-D**) was determined using the procedures outlined by Goering and Van Soest (1970) with a 30-h incubation time. Ash content was determined according to AOAC International (2000) methods with the modification of using 1.5-g sample weights, a furnace temperature of 535°C, and a 4-h ash time. Total N was determined by combustion of samples in a Leco CNS 528 Analyzer (Leco Corporation, St. Joseph, MI) and the values were multiplied by 6.25 to estimate CP. Soluble protein, expressed as percentage of CP, was determined following the procedures of Krishnamoorthy et al. (1982). Starch was determined following the procedures of Hall (2009). Water-soluble carbohydrates were determined using the colorimetric procedure by Dubois et al. (1956). The concentrations of minerals and heavy metals were determined following AOAC International (2000) methods by using inductively coupled plasma-mass spectrometry (ICP-MS, Perkin Elmer 3300 XL and 5300 DV ICP, Shelton, CT). The concentrations of alcohols and esters, specifically methanol, propanol, 1-butanol, 2-butanol, ethyl acetate, methyl acetate, propyl acetate, ethyl acetate, and propyl lactate were analyzed by Cumberland Valley Analytical Labs (Maugansville, MD) using a tandem gas chromatograph-mass spectrometer (Perkin Elmer, Waltham, MA) following AOAC International (2000) methods. Samples were also screened using thin layer chromatography for presence of the following mycotoxins: aflatoxins B1, B2, G1, G2; deoxynivalenol (**DON**); zearalenone; 15 acetyl-DON; 3 acetyl-DON; and T-2 toxin. Samples that tested positive for any specific mycotoxin were reanalyzed by HPLC (Shimazdu, Kyoto, Japan; AOAC International, 2000) to confirm the presence and determine the concentrations of the mycotoxin.

Portions of wet silage samples were processed for microbial population and fermentation end products at the University of Delaware. Water extracts of samples were prepared by combining 25 g of silage with 225 mL of 1/4 strength Ringer's solution (Oxoid BR0052G, Unipath, Basingstoke, UK) and blending in a Proctor-Silex 57171 blender (Hamilton Beach/Proctor-Silex Inc., Glen Allen, VA) on a medium setting for 1 min. The pH of the water extracts was determined and 10-fold serial dilutions of the extracts were used for the determination of yeasts and mold counts using pour plates with malt extract agar (Oxoid CM 0059). Plates were incubated aerobically at 30°C for 48 to 72 h. A portion of each water extract was acidified with H_2SO_4 and analyzed for concentrations of lactic acid and VFA by HPLC (Shimadzu SCL-10 AVP) equipped with a refractive index detector (RID 10A) following the procedures of Muck and Dickerson (1988).

Tests for *Listeria*, *Salmonella*, and *Escherichia coli* were performed by an immunoassay test that uses lateral flow test strip in a double antibody sandwich format (RapidChek Select, SDIX, Newark, DE). Detection was performed following the manufacturer's procedures with some modifications necessitated by the low pH of the samples. The modifications included the use of 6 *M* K_2HPO_4 (Sigma-Aldrich Chemical Company, St. Louis, MO) added at 5 mL per 225 mL of culture enrichment media in the *Listeria* test. Modifications for the *Salmonella* test included the use of 2 *M* 3-(*N*-morpholino) propanesulfonic acid (Sigma-Aldrich Chemical Company) added at 7.5 mL per 225 mL of culture enrichment media and incubating the samples at 37°C instead of the recommended 42°C temperature. Composition and temperature modifications for the *E. coli* test were the same to that of *Salmonella.* In addition, sample incubation time was lengthened from the recommended 8 to 24 h. Silage samples obtained from the University of Delaware Dairy Farm and spiked with varying levels of *Listeria monocytogenes*, *Salmonella enterica* serovar Enteritidis, and *E. coli* O175:H7 strain 4407 served as positive controls. From the positive controls, detection limit was established at 1 cfu/g of fresh silage for *Salmonella* and 10 cfu/g of fresh silage for *Listeria* and *E. coli.*

Data were analyzed as a completely randomized design with uneven replication using the Fit Model procedure of JMP (JMP Pro version 11, SAS Institute, Cary, NC). Microbial data were log-transformed before analysis. Significance was declared when the value of $P \leq 0.05$. The difference in means was determined using the Student's *t*-test option of JMP.

RESULTS AND DISCUSSION

High winds and rain from Tropical Storm Irene resulted in various degrees of lodging of corn plants. In some fields, lodging was so severe that harvesting was impossible (Figure 1). In other fields, lodging was only moderate and the crops were harvested, but the health of the plants was in question. Flooding from overflowing rivers also resulted in plants being submerged for various lengths of time. In many instances, the flooding that occurred reached above the ears of corn. When floodwaters receded, large quantities of sediment remained on the ears, leaves, and lower stalks of the plants in some of the fields (Figure 2). The degree of flooding and plant condition at harvest for the compromised silages as described by the producers submitting samples is shown in Table 1. More than half of the flooded fields had water at the ear or higher. Sixty percent of the compromised corn silages were exposed to flood waters for 24 h or more. Of these, 5 samples were exposed to flood waters for 48 to 96 h. If submerged for more than 48 to 72 h, plant death can occur because of a lack of oxygen in the soil (Thomison, 1995; Yordanova and Popova, 2007). Only a small percentage of the compromised fields in this study reported significant lodging, and this was not related type of hybrid (i.e., brown midrib vs. non-brown midrib; data not shown), but 57% of the fields had moderate to high concentrations of sediment on plants at harvest.

In general, the nutritive composition of the corn silages compromised by the storm was similar to that of unaffected silages (Table 2). For example, no differences were found in the concentrations of CP, ADF, NDF, and starch between silage types; however, FLO silages had lower NDF-D (52.5 vs. 60.3%) and lower NE_L (1.52 vs. 1.67 mcal/kg) than NRM silages. Due to a wide range of varieties and harvest dates, the lower NDF-D in FLO silages should be considered with caution. In particular, FLO silages were higher in ash (8.93%) content than NRM silages (3.85%). Ash levels in NRM corn silages were within the normal range (average of 4.33% ash from 193,083 corn silage samples analyzed by Dairy One Laboratories, between May 1, 2000, and April 30, 2013; Dairy One Laboratories, 2011). The range in ash values in FLO silages (Figure 3) was large (2.30 to 28.2%). In some instances (per-

Figure 1. A field with lodged plants after flooding. Color version available online.

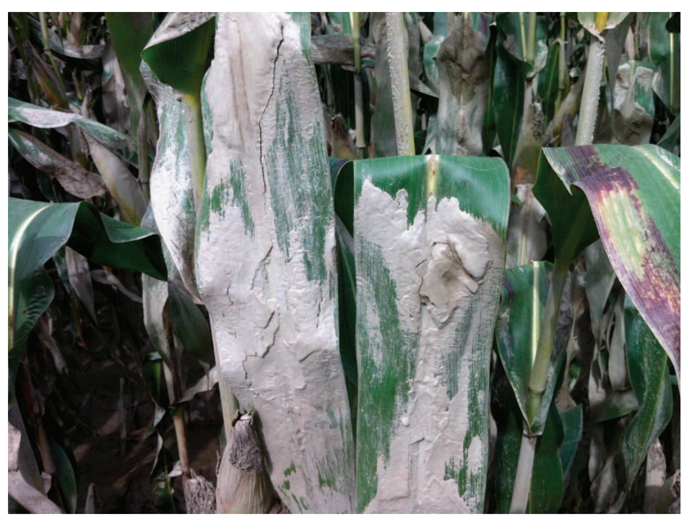

Figure 2. Sediment on a corn plant a week after flooding. Color version available online.

Table 1. Results from producer surveys on the effect of flooding from Hurricane Irene on 30 affected fields of corn

Description	No. of samples or time
Degree of flooding	
>Entire plant	8
>Ear to top of plant	9
>30.5 cm—below the ear	6
<30.5 cm	7
Time exposed to flood waters (h)	
>1 to 6	6
>6 to 12	6
>12 to 24	12
>24 to 36	1
>36 to 48	2
>48 to 72	1
>72 to 96	2
Degree of plant lodging in field	
No lodging	24
25% lodging	4
50% lodging	1
100% lodging	1
Sediment condition at harvest	
Moderate sediment	9
High sediment	8
No response	13
General plant condition at harvest	
Poor	7
Good	12
No response	11

sonal communication with producers) fields with plants containing extremely high sediment content could not be harvested with conventional pull-behind choppers. Elevated ash levels have the potential to increase the buffering capacity of harvested corn and increase the probability of clostridial fermentation if those spores are abundant (McDonald et al., 1991). Muck et al. (1999) reported that high ash levels from soil (approaching 50% by weight) resulted in an increase in the buffering capacity of potato vines but had no apparent effect on the subsequent fermentation. The authors speculated that the soil contaminant contained low levels of clostridial spores, that high numbers of lactic acid bacteria in these silages prevented a clostridial fermentation, or both. The buffering capacity was not measured in the current study, but corn plants are typically low in buffering capacity relative to alfalfa (McDonald et al., 1991).

The macro and trace mineral content of compromised and unaffected silages was generally similar (Table 3) with the exception of substantially higher concentrations of Fe (2,477 vs. 281 mg/kg, Figure 4) and slightly higher concentrations of Mn in the former. The highest concentration of Fe in a FLO sample was 12,534 mg/kg. This concentration is not particularly surprising given that the sediments in some of the affected areas contain more than 6% Fe by weight (USGS, 2014). One of the corn silage samples collected in this study had an ash content of 28.2%. In such circumstances, ash originating from sediments containing 6% Fe by weight could theoretically result in a Fe concentration of 14,000 mg/kg in the harvested plants. Mechanical wear of the chopping blades of the harvesters is another possible

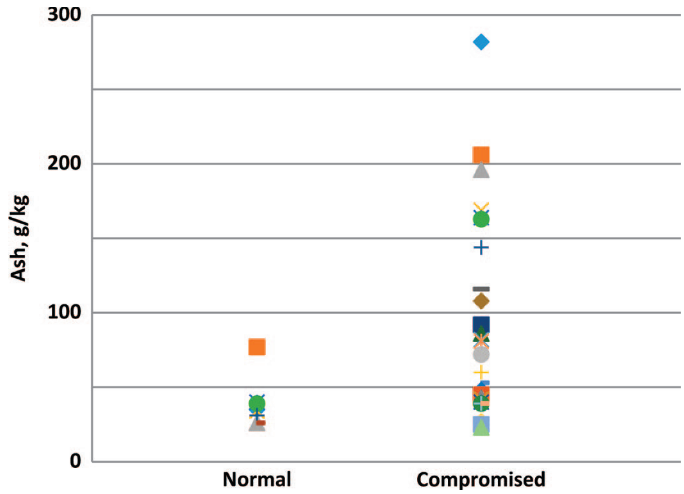

Figure 3. Individual ash contents of normal and compromised (flood-damaged) corn silages. Color version available online.

source of Fe in compromised corn silages. The form of the Fe in our samples was not determined. Although a high percentage of the Fe was probably in the ferric form (Fe^{3+}) and insoluble on the plant, there would be potential for reduction to the ferrous form (Fe^{2+}) due to the acidic conditions in silage (Hansen and Spears, 2009) and the abomasum of a cow that could lead to excessive amounts of available Fe (Beede, 2009). High levels of soluble Fe have been documented to interfere with the normal Zn and Cu status in ruminants (Phillippo et al., 1987; Prabowo et al., 1988). High Fe has also been reported to depress DM digestion and reduce VFA production in batch cultures of ruminal fluid

Table 2. Dry matter (g/kg) and chemical composition (g/kg, DM basis, unless stated otherwise) of unaffected corn silage (NRM) and compromised corn silage made from fields affected by Hurricane Irene (FLO)

	Corn silage, NRM			Corn silage, FLO			
Item	Mean	Minimum	Maximum	Mean	Minimum	Maximum	*P*-value
DM	352	286	422	379	273	517	0.22
CP	74	63	80	76	52	97	0.55
SP,[1] % of CP	54	47	62	52	33	66	0.52
NE_L,[2] Mcal/kg	1.67	1.58	1.78	1.52	0.86	1.74	0.03
ADF[3]	247	207	294	238	190	316	0.52
ADL	29	18	35	35	25	69	0.08
NDF[3]	406	357	461	395	334	524	0.57
NDF-D,[3,4] % of NDF	60	55	65	53	32	63	0.01
WSC[5]	12	6	21	13	6	30	0.73
Starch	328	280	395	302	73	420	0.34
NFC	457	398	516	418	164	541	0.18
Ash	39	26	77	89	23	282	0.04

[1]SP = soluble protein.

[2]Calculated as per NRC, 2001.

[3]Organic matter basis.

[4]30 h in vitro NDF digestibility.

[5]Water-soluble carbohydrates.

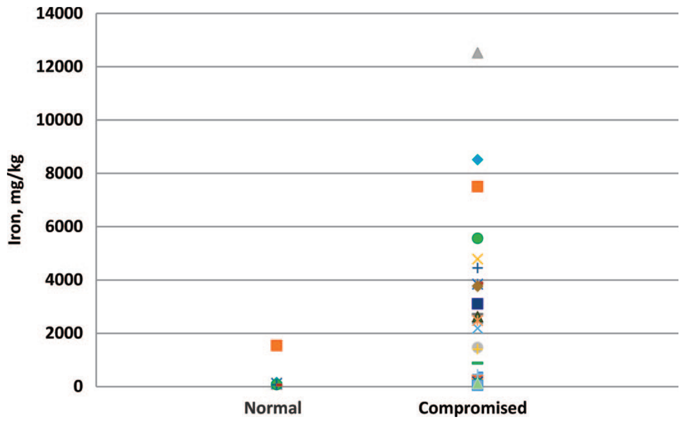

Figure 4. Individual Fe contents of normal and compromised (flood-damaged) corn silages. Color version available online.

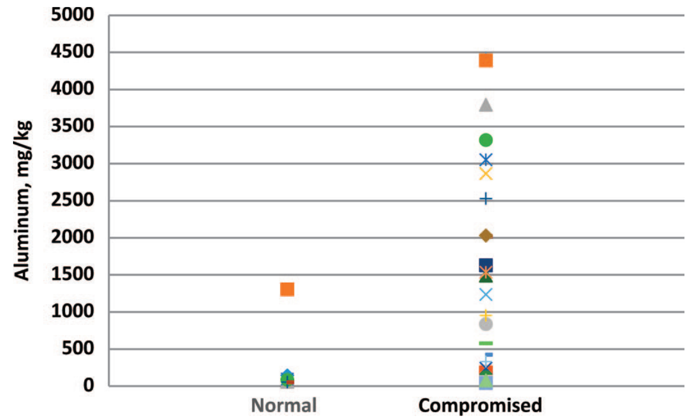

Figure 5. Individual Al contents of normal and compromised (flood-damaged) corn silages. Color version available online.

(Harrison et al., 1992). High Fe in feed (1,992 mg/kg) was hypothesized to cause toxicity in cattle (Oruc et al., 2009). High Fe from soil contamination to silage has also been reported to induce Cu deficiency in lactating cows when fed at 863 to 1,285 mg per kg of TMR DM (Von Steffl et al., 2009). Elevated levels of Mg, Mn, Zn, and Cu approached statistical significance between silage types in the current study. These marginal differences could be attributed to the levels known to be present in sediments in the affected watersheds. Levels of these minerals in certain sediments within the affected area were reported to be as high as 1.49% Mg, 2,401 mg/kg Mn, 112 mg/kg Zn, and 28.8 mg/kg Cu, (USGS, 2014).

The FLO silages had greater concentrations of Al (Figure 5) and Co and tended to have higher concentrations of Cd ($P < 0.09$) and Cr ($P < 0.06$ than NRM silages (Table 4). The high Al was most likely a result of this element being high in sediments throughout the region, averaging 4 to 6% by weight (USGS, 2014). Excess concentrations of Al have decreased intake and gain in lambs (Rosa et al., 1982) and high levels of Al fed to calves have been reported to decrease intake and BW gains by 17 and 47%, respectively (Crowe et al., 1990).

Although many of the fields from which FLO silages were harvested were submerged for substantial lengths of time and had high ash contents, it appears that these conditions did not adversely affect the ensiling of the corn crop (Table 5). All silages fermented normally as evidenced by no difference in silage pH or concentrations of the major organic acids between silage types and these measures being within the normal ranges for corn silages (Kung and Shaver, 2001). Butyric acid was detected in only 1 of 8 and 2 of 30 NRM and FLO corn silage samples, respectively, but the levels were below that of concern (Kung and Shaver, 2001). This finding is not surprising because this acid is seldom found in well-fermented corn silage. In the current study, the concentrations of alcohols and esters were similar between NRM and FLO silages (Table 6). High concentrations of alcohols are often associated with large losses of DM during silage fermentation because the pathways involved in their production produce copious amounts of CO_2. Certain esters in silages have also been associated with lower levels of DM intake (Gerlach

Table 3. Macro and trace mineral content (DM basis) of unaffected corn silage (NRM) and compromised corn silage made from fields affected by Hurricane Irene (FLO)

	Corn silage, NRM			Corn silage, FLO			
Item	Mean	Minimum	Maximum	Mean	Minimum	Maximum	*P*-value
Ca, g/kg	1.8	1.3	2.3	1.9	1.2	2.8	0.55
P, g/kg	2.3	1.8	3.0	2.4	1.8	3.6	0.68
Mg, g/kg	1.6	1.1	2.1	1.8	1.0	2.8	0.15
K, g/kg	8.8	7.1	11.3	10.0	7.0	15.3	0.10
Na, g/kg	0.1	<0.1	0.1	0.3	0.1	6.0	0.52
Fe, mg/kg	281	57	1,544	2,477	52	12,534	0.05
Mn, mg/kg	30	10	94	85	13	285	0.04
Zn, mg/kg	24	19	29	28	16	40	0.11
Cu, mg/kg	6	5	7	7	4	14	0.07

Table 4. Heavy metal contents (mg/kg, DM basis) of unaffected corn silage (NRM) and compromised corn silage made from fields affected by Hurricane Irene (FLO)

	Corn silage, NRM			Corn silage, FLO			
Item	Mean	Minimum	Maximum	Mean	Minimum	Maximum	*P*-value
Al	237	54	1,306	1,344	42	4,410	0.04
Sb	<5	<5	<5	<5	<5	<5	—
As	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	—
Ba	5	0.9	25	8	0.4	46	0.41
B	3	2	3	3	2	4	0.40
Cd	<0.3	<0.3	<0.3	0.6	<0.3	2.1	0.09
Cr	3	1	13	17	1	86	0.06
Co	<0.5	<0.5	<0.5	1.3	<0.5	4	0.04
Pb	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	0.53
Hg	<10	<10	<10	<10	<10	<10	—
Mo	<1	<1	<1	<1	<1	<1	—
Se	<10	<10	<10	<10	<10	<10	—
S	1,026	937	1,288	1,022	812	1,379	0.94
Tl	<12.5	<12.5	<12.5	<12.5	<12.5	<12.5	—

et al., 2013). However, the alcohol and ester profiles of the silages that we sampled indicated that normal fermentations took place.

The microbial composition and mycotoxin content of samples is shown in Table 7. Silages compromised by flooding tended ($P < 0.08$) to have more yeasts than NRM silages, but all silages had low numbers of molds. Silages with high numbers of yeasts tend to spoil more quickly than silages with lower numbers of yeasts when exposed to air (Kleinschmit et al., 2005) because many of these yeasts are lactate assimilators. Thus, feed-out of FLO silages during warm weather could have been more challenging than that of NRM silages. The pathogenic organisms *E. coli*, *Salmonella*, and *Listeria* were not detected in any of the collected silages, allaying concerns of possible contamination from barn runoff and sewage during flooding. It is possible that these pathogens, even when present on the plants following flooding, were washed off the plants during following rains before harvest or ultimately killed during fermentation and storage of the silages. Physical damage to corn plants before harvest can increase fungal growth and subsequently lead to higher levels of mycotoxins in the resulting silage (Teller et al., 2012). Thus, concerns existed that concentrations of mycotoxins would be higher in FLO corn silages. Deoxynivalenol was the prevalent mycotoxin detected in our samples, but at concentrations similar to those reported elsewhere for corn silages (Mansfield et al., 2008; Eckard et al., 2011). It was detected in 6 of 8 (75%) NRM silages and 27 of 30 (90%) FLO silages. Although the mean level of DON was not different between NRM (2.2 mg/kg) and FLO silages (3.4 mg/kg), the range was greater in the latter with several samples containing >5 mg/kg. Zearalenone was detected in 1 of 8 (12.5%) unaffected silages, whereas it was detected in 7 of 30 (23.3%) FLO corn silage samples. The mycotoxin, 15-acetyl DON was detected in 1 of the FLO silage samples, but in none of the NRM samples.

Twenty-five farms that harvested and fed FLO corn silage were surveyed to determine what, if any, effects were apparent as a result of feeding the FLO silage. Those surveyed included farmers, family members, or nutritionists (or a combination of these) from the

Table 5. The pH, fermentation acids (DM basis), and lactic:acetic ratio of unaffected corn silage (NRM) and compromised corn silage made from fields affected by Hurricane Irene (FLO)

	Corn silage, NRM			Corn silage, FLO			
Item	Mean	Minimum	Maximum	Mean	Minimum	Maximum	*P*-value
pH	3.87	3.72	4.06	4.03	3.67	5.51	0.22
Lactic acid, g/kg	50.0	24.0	8.1	42.3	11.0	75.0	0.28
Acetic acid, g/kg	28.8	16.1	5.9	26.0	2.1	57.2	0.61
Propionic acid,[1] g/kg	2.8	0.2	0.9	2.4	0.1	10.4	0.72
Butyric acid,[2] g/kg	2.0	0.0	2.0	4.7	0.3	9.1	—
Lactic:acetic ratio	2.0	4.5	4.2	2.2	0.3	5.4	0.9

[1]Propionic acid was detected in 7/8 and 26/30 NRM and FLO corn samples, respectively.

[2]Butyric acid was detected in 1/8 and 2/30 NRM and FLO corn samples, respectively.

Table 6. Alcohols and esters (g/kg, DM basis) of unaffected corn silage (NRM) and compromised corn silage harvested from fields affected by Hurricane Irene (FLO)

	Corn silage, NRM			Corn silage, FLO			
Item	Mean	Minimum	Maximum	Mean	Minimum	Maximum	*P*-value
Ethanol	8.73	1.64	16.35	6.62	0	27.05	0.30
Methanol	0.20	0.07	0.31	0.27	0.07	1.82	0.57
1-Propanol[1]	3.41	0	13.06	2.61	0	8.87	0.54
2-Butanol[2]	0.08	0	0.17	0.09	0	0.46	0.82
Ethyl acetate[3]	2.19	0.50	10.70	0.87	0	9.00	0.19
Methyl acetate	0.92	0.13	3.47	0.84	0.03	3.98	0.86
Propyl acetate[4]	ND[5]	ND	ND	0.10	0	1.37	—
Ethyl lactate[6]	0.18	0.04	0.32	0.11	0	0.40	0.08
Propyl lactate[7]	0.04	0	0.11	0.08	0	0.54	0.40

[1]1-Propanol was detected in 7/8 and 24/30 NRM and FLO corn silages respectively.

[2]2-Butanol was detected in 6/8 and 18/30 NRM and FLO corn silages, respectively.

[3]Ethyl acetate was detected in 8/8 and 24/30 NRM and FLO corn silage samples, respectively.

[4]Propyl acetate was not detected in NRM samples and in 10/30 FLO samples.

[5]Not detected.

[6]Ethyl lactate was detected in 8/8 and 27/30 NRM and FLO corn silage samples, respectively.

[7]Propyl lactate was detected in 5/8 and 20/30 NRM and FLO samples, respectively.

respective farms. Of these, 13 reported no effect, 12 reported at least 1 health effect, 6 reported multiple effects (Table 8). Although the findings are subjective, it is notable that more than 40% of the farms that were flooded reported some animal health effects. However, circumstances and management decisions varied widely among farms. Some farms had minimal crop damage, were able to segregate FLO from NRM corn silage, and were able to dilute contaminated feed with uncontaminated feed. In contrast, others had high levels of ash and ended up feeding large amounts of extreme FLO corn silages. Some farmers also reported feeding binders to reduce or prevent problems from mycotoxins.

CONCLUSIONS

Corn silage compromised by flooding and lodging from Hurricane Irene appeared to ensile normally, although concentrations of ash were high in many samples. The high ash resulted in high concentrations of Fe, Mn, and Al, whereas most the concentrations of other minerals and heavy metals were the same in FLO and NRM silages. Levels of detectable pathogenic organisms and molds in FLO and NRM corn silages were the same, but FLO corn silage tended to have higher levels of yeasts and higher incidences of DON, although the average concentration of this mycotoxin was relatively

Table 7. Yeast, mold, pathogenic microbe (wet weight basis), and mycotoxin (DM basis) content of unaffected corn silage (NRM) and compromised corn silage made from fields affected by Hurricane Irene (FLO)

	NRM			FLO			
Item	Mean	Minimum	Maximum	Mean	Minimum	Maximum	*P*-value[1]
Yeasts, log cfu/g	3.7	3	5.6	5.0	3	8.6	0.08
Molds, log cfu/g	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	—
Escherichia coli, log cfu/g	ND[2]	ND	ND	ND	ND	ND	—
Salmonella, log cfu/g	ND	ND	ND	ND	ND	ND	—
Listeria monocytogenes, log cfu/g	ND	ND	ND	ND	ND	ND	—
Deoxynivalenol (DON),[3] mg/kg	2.2	0.8	5	3.4	0.5	15.5	0.45
15-Acetyl DON,[4] mg/kg	ND	ND	ND	0.8	0.8	0.8	—
Zearalenone,[5] mg/kg	2.1	2.1	2.1	1.5	0.6	3.1	0.56

[1]Items with no *P*-value means that these items were not statistically analyzed.

[2]ND = not detected.

[3]DON was detected in 6/8 NRM corn silage samples and 27/30 FLO corn silage samples.

[4]15-Acetyl DON was not detected in NRM corn silage samples and was detected in 1/30 FLO corn silage samples.

[5]Zearalenone was detected in 1/8 NRM corn silage samples and 7/30 FLO corn silage samples.

Table 8. Reported effects on animals on farms feeding flood-damaged corn silage (FLO)

Category	Number
Affected farms responding to survey	25
No effect	13
Effect (including 1 "maybe")	12
Multiple effects	6
Low DMI	3
Reduced milk production	6
Reduced milk components	2
Reproductive problems	5
Digestive upsets	3
Other (possible reaction to 9-way vaccination)	1

low. Although quantitative animal health data were not collected, about half of producers with flooded forage perceived that feeding FLO silages resulted in some animal health issues.

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