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Chemical Composition and Nutritive Value of Corn Silage Affected By Hurricane Irene

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ABSTRACT

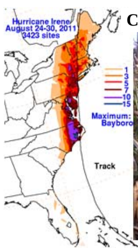
In the Fall of 2011, Hurricane Irene caused extensive damage to a significant part of the forage corn crop grown on flood plains in the Northeast region of the United States. Impacted crops were subjected to various degrees of flooding, lodging and contamination with silt. Several attributes were used to compare corn silage made from fields that had been flooded (henceforth 'flooded corn silage') and silage made from fields that had not been flooded (henceforth 'unflooded corn silage') including nutrient composition, heavy metal concentration, fermentation products, microbes, and mycotoxins. The concentration of NE_L and *in vitro* digestibility of NDF (NDFd) were lower in flooded corn silage. In addition, the ash content of flooded corn silage was higher than in unflooded corn silages as were the concentrations of Al, Co, Cd, Cr, Mn, and Fe. Iron and aluminum concentrations were as high as 12,534 and 4,410 ppm, respectively in flooded corn silage. Silage fermentation appears to have occurred normally for both types of silage as the final silage pH, concentrations of fermentation acids, alcohols, and esters were similar between flooded and unflooded corn silages. Numbers of yeasts (but not molds) tended to be higher in flooded silage than in unflooded corn silage. Pathogenic microorganisms were not detected in any of the samples and concentrations of mycotoxins were similar for flooded and unflooded corn silage. More than 40% of the farms that fed flooded corn silage reported animal health impacts including reduced dry-matter intake, digestive upset, reduced milk fat, reduced lactation, elevated somatic cell count, reduced conception rate, higher rates of abortion, and cow -death.

INTRODUCTION

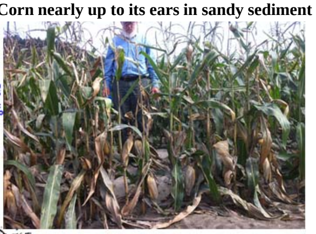
Corn silage is the primary source of roughage for total mixed rations in the Northeastern U.S., and the majority of prime farm land is dedicated to this crop. Many of the farmers are severely land limited, and there are few crop farmers from whom to buy standing corn when concerns about inventories arise. Much of the best corn-producing land is located in river valleys, many of which are narrow and are the sole outlet for sizable subwatersheds. Some of the dairy farms in these areas raise as few as 20 acres of corn silage, making each acre very important for their inventory. Hurricane Irene, by then weakened to a tropical storm, swept across the region approximately one month before silage harvest. Floodwaters deposited varying amounts of sediment on the corn plants in affected fields, and in some cases caused plant lodging. Unpublished records from the 1990s describe similar circumstance on farms along the Lamoille River of Vermont. These records indicate that feeding the damaged corn silage had mixed outcomes ranging from no effects to significant deleterious livestock health impacts. This tragedy afforded our team with the opportunity to characterize the feed parameters of flood-damaged corn fields as well as record the animal health/performance outcomes that resulted from feeding affected crops.

OBJECTIVE

Characterize the nutritive value, heavy metal and mycotoxin contents, fermentation byproducts, and microbial profile of corn silage produced from fields affected by the floodwaters of Tropical Storm Irene.



Corn nearly up to its ears in sandy sediment



Sediment-laden corn plants

MATERIALS AND METHODS

- Thirty samples of corn silage made from flood damaged corn were obtained from 28 farms in affected areas of Vermont, New York, Pennsylvania, Massachusetts, and Delaware; the vast majority of these samples were collected from Vermont farms. Eight corn silage samples from different unflooded farms within Vermont were collected to represent the characteristics of unflooded corn silage.
- Upon collection, samples were vacuum sealed, and sent to Cumberland Valley Analytical Services (CVAS, Hagerstown, MD) for standard wet-chemistry analysis (data in fourth column).
- Twenty-five farms that fed flooded corn were later surveyed to determine whether their livestock experienced any negative effects.

Flood-damaged corn: completely lodged and unharvestable

RESULTS AND DISCUSSION

The nature and degree of the damage caused by floodwaters varied widely among the 28 farms. Differences included: hybrids planted; duration and depth of flooding; amount of sediment deposited on the plant; depth of sediment deposited in the field; plant maturity at the time of flooding; moisture level at harvest; and time elapsed between flooding and harvest. While the nutritive characteristics of flooded and unflooded corn silage were similar in many ways, important differences were also noted. Ash levels were on average 5% higher for flooded corn silage. The maximum ash content among the flooded corn silage samples was 28% of sample dry-matter. The NDFd was lower for flood-damaged corn samples, presumably due to a wider range of harvest dates. Net energy for lactation (NEL) is calculated from several nutritional parameters including ash and NDFd. The lower NEL of the flooded corn silage is attributed to its higher ash and lower NDFd content.

Flooded corn silage samples had significantly ($p \leq 0.10$) higher levels of Fe, Mn, Al, Cd, Cr, and Co. The striking level of Fe in the flooded corn silage samples is less surprising given that USGS data indicated that sediment in some of the affected areas was 6% Fe by weight.

Yeast counts were higher for flooded corn silage samples. These elevated counts present the possibility of more rapid spoilage during feed-out. The fermentation product and microbe profiles and mycotoxin concentrations were similar between flooded and unflooded corn silage samples.

Of the 28 farms with flooded corn silage that were sampled, 25 were able to be contacted with survey questions regarding herd health impacts of feeding flood-damaged corn silage. Of those surveyed:

- Thirteen reported no adverse impact on animal health or lactation.
- Negative and multiple negative impacts were reported by six and three farms, respectively;
- Dry-matter intake, lactation and milk components [protein and/or butterfat] were reduced on three, six and two farms, respectively
- Five farms perceived that their choice to feed flooded corn silage was related to reproductive problems in their herd;
- Three farms reported digestive upsets.

It was not possible to correlate herd health impacts with the characteristics of the flood-damaged corn silage due to the varied characteristics of the corn silage and modes of harvest and feeding; nevertheless, these impacts are worthy of consideration when dealing with similar situations in the future.

CONCLUSIONS

Many variables affected the nutritive characteristics of flood-damaged corn silage collected from the farms in this study. The potential for extreme ash levels and the likelihood of adverse impacts on livestock warrant segregation of flood-damaged corn silage, particularly if large amounts of sediment were present on the plants at harvest. While the fermentation of flooded corn silage seemed to proceed in a relatively normal fashion, the possibility of 'hot spots' (i.e., pockets with elevated levels of ash, mineral, pathogenic microbes, and mycotoxins) warrants close involvement of veterinarians and nutritionists. Our data suggest that when the option exists, extremely contaminated corn silage should not be fed to livestock, or if fed, should be greatly diluted with uncontaminated feed.

Determining the stage of development at flooding

Nutritional Parameters of unflooded and flooded corn silage

	Corn Silage - Unflooded			Corn Silage - Flooded			P - value
Nutritional parameters	Mean	Min[1]	Max[2]	Mean	Min	Max	
DM, %	35.16	28.6	42.2	37.94	27.3	51.7	0.22
pH	3.87	3.72	4.06	4.03	3.67	5.51	0.22
CP, %	7.36	6.3	8	7.56	5.2	9.7	0.55
SP, % of CP	54.14	47.4	62.3	52.17	32.7	66.2	0.52
NE_L, mcal/kg	1.67	1.58	1.78	1.52	0.86	1.74	0.03
ADF, %	24.66	20.7	29.4	23.83	19	31.6	0.52
ADL, %	2.94	1.77	3.47	3.47	2.49	6.93	0.08
NDF[4], %	40.59	35.7	46.1	39.51	33.4	52.4	0.57
NDF-D, % of NDF	60.25	55.2	65.4	52.54	**31.5**	63.2	0.01
WSC[7], %	1.18	0.6	2.1	1.26	0.6	3	0.73
Starch, %	32.8	28	39.5	30.15	7.3	42	0.34
NFC[8], %	45.66	39.8	51.6	41.82	16.4	54.1	0.18
Ash, %	3.85	2.6	7.7	8.93	2.3	**28.2**	0.04
Minerals	**Levels of Ca, P, and Na were not significantly different**						
Mg, %	0.16	0.11	0.21	0.18	0.10	0.28	0.15
K, %	0.88	0.71	1.13	1	0.70	1.53	0.10
Fe, ppm	**281**	57	1544	**2477**	52	**12534**	0.05
Mn, ppm	30	10	94	85	13	**285**	0.04
Zn, ppm	24	19	29	28	16	40	0.11
Cu, ppm	6	5	7	7	4	14	0.07
Heavy Metals (ppm)*							
Al	237	54	1306	1344	42	**4410**	0.04
Ba	5	0.9	25	8	0.4	46	0.41
B	3	2	3	3	2	4	0.4
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
S	1026	937	1288	1022	812	1379	0.94
***Tl, Sb, As, Hg, Mo, Se, and Tl were all below the detection limits for all samples**							
Fermentation products							
Lactic acid, %	5	2.4	8.1	4.23	1.1	7.5	0.28
Acetic acid, %	2.88	1.61	5.95	2.6	0.21	5.72	0.61
Propionic acid, %	0.28	0.03	0.69	0.24	0.01	1.04	0.72
Butyric acid, %	0.2	0.2	0.2	0.47	0.03	0.91	-
Total acids, %	8.14	6.44	10.12	7.07	1.27	13.63	0.28
Lactic/acetic acid ratio	2.2	0.45	4.18	2.15	0.32	5.24	0.92
Ethanol, g/kg	8.73	1.64	16.35	6.62	0	27.05	0.3
Methanol, g/kg	0.2	0.07	0.31	0.27	0.07	1.82	0.57
1-Propanol, g/kg	3.41	0	13.06	2.61	0	8.87	0.54
2-Butanol, g/kg	0.08	0	0.17	0.09	0	0.46	0.82
Ethyl acetate, mg/kg	2193	50	10700	873	0	9000	0.19
Methyl acetate, mg/kg	924	120	3470	842	30	3980	0.86
Propyl acetate, mg/kg	--none detected--			95	0	1370	-
Ethyl lactate, mg/kg	177	40	320	113	0	400	0.08
Propyl lactate, mg/kg	43	0	110	83	0	540	0.4
Microbes (log cfu/g)							
Yeasts	3.7	3	5.6	5	3	8.6	0.08
Molds	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	-
Pathogens: -- *E.coli, Salmonella,* and *Listeria monocytogenes* were not detected							
Mycotoxins (ppm)							
Deoxynivalenol (DON)	2.2	0.8	5	3.4	0.5	15.5	0.45
15 – Acetyl DON	--none detected--			0.8	0.8	0.8	-
Zearalenone[7]	2.1	2.1	2.1	1.5	0.6	3.1	0.56