Jochen Mellmann, Hartmut Schemel, Christian Fürll, Ingrid Höhn and Thomas Wiesmüller, Potsdam

Quality Assurance in Forage Drying Plants Heated with Solid Fuels

In some cases, inadequate knowledge about the formation and concentration of undesirable substances during direct forage drying resulted in inadmissible concentrations of pollutants between 1995 and 2003. Therefore, official inspections were intensified, and legal regulations on quality assurance and traceability were adapted. The ATB was commissioned to analyze the causes and to carry out measurements. After the registration of drying plants had become mandatory, the ATB accumulated more experience as an accredited consultant. These experiences are presented in this paper.

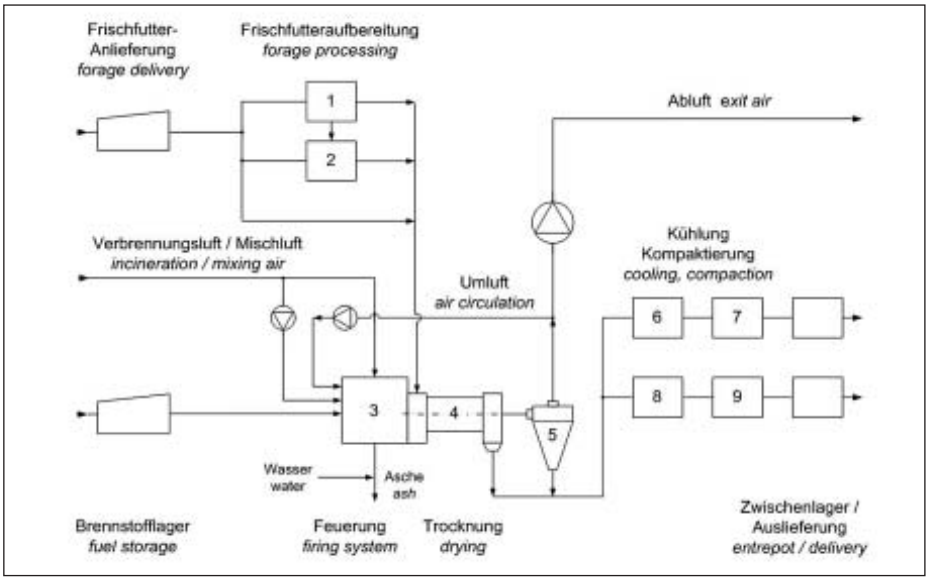

Fig. 1: Flow sheet of a forage drying plant

Dr.-Ing. Jochen Mellmann and Dr.-Ing. Hartmut Schemel are scientists working in the Department of Postharvest Technology (director: Prof. Dr.-Ing. habil. Christian Fürll) at the Leibniz Institute of Agricultural Engineering in Potsdam-Bornim, Max-Eyth-Allee 100, D-14469 Potsdam; e-mail: jmellmann@atb-potsdam.de. Dr. Ingrid Höhn works at the Ministry for Agriculture, Environmental Protection, and Regional Planning of the state of Brandenburg. Dr. rer. nat. Thomas Wiesmüller works in the Brandenburg state laboratory.

Keywords

Forage drying, solid fuel, quality assurance, traceability, forage law

Literature

Literature references can be called up under LT 07227 via internet: http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

In the years as of 1990, it was published throughout the media that limit values for harmful substances in feed were exceeded, which caused a public stir. This also affected dry forage production. In the state of Brandenburg, increased dioxin contents were first found in the dried forage of a drying plant during official feed inspections in 1999. The combustion of unsuitable fuels for dryer heating was determined as the reason for these increased emissions. Similar cases have also become known in other federal states. Therefore, the legislator has tightened the regulations for quality assurance and traceability in the production chain and in particular in forage drying in 2003. According to these regulations, producers who dry forage and food for feed production using the direct drying technique must be registered by the competent authority according to § 30 of the Forage Decree [1]. Forage drying plants which use coal or heavy heating oil as fuel must submit special certificates which prove that they fulfill the relevant requirements and duties [2].

Direct Drying Method for Forage

In Europe, approximately 4.8 million tonnes of forage are produced per year (for comparison: in Germany 2003/2004 ~ 0.26 million t/a) [3], of which the largest part is dried in plants which use mineral coal as fuel [4]. For the production of dried forage, the direct drying method in the drying drum is applied Europe-wide. *Figure 1* shows a drying plant heated with solid fuels. From the forage store, intake meterers and conveyor belts transport the freshly harvested and chopped forage to the dryer. In order to reach a certain set cutting length, the forage can optionally be re-comminuted in the chopper (1) before it is dried. This in particular applies to fibrous forage (2nd or 3rd cut). For highly moist forage, juice separators (2) are used in some operations, e.g. at moist mountainous locations in order to reduce the forage water content and to save drying energy. The exhaust air from the furnace (3) is mixed with fresh air and recirculating air (percentage of air: ~ 80 %) and reaches the drum dryer as tem-

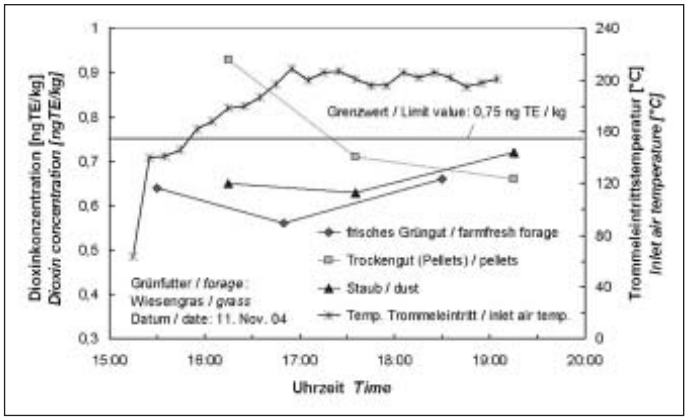

Fig. 2: Dioxin concentration in the forage and in the inlet air temperature measured during start-up phase of a forage drying plant

perate drying air (4). The forage is led through the drum in a co-current flow and in direct contact with the air. The main fan sucks the exhaust air over the cyclone (5), where dust and particles are separated. The dried forage and the dust/particles are processed into pellets or bales. For this purpose, the material is conveyed to the pellet press (6) and the pellet cooler (7) or the forage cooler (8) and the bale press (9). Afterwards, it is transported to intermediate stores or shipped.

Quality Assurance Requirements

Quality assurance- and traceability requirements during forage drying largely result from the forage- and immission protection law. According to the instructions for the registration of producer operations [2], the equipment and the control of the drying process, the suitability of the fuel, documentation during the process and traceability, the knowledge of the personnel, and other criteria must meet special requirements for dryer operation.

For quality assurance, a written plan according to HACCP principles must be drawn up and realized. As part of documentation during the process and traceability, producer operations must prove that the concentrations of undesirable substances in the forage according to the Forage Decree [5] (in particular dioxins, arsenic, lead, and cadmium) are below the limits. In addition, the regulations of the Clean Air Directive [6] apply. In addition to setting emission limits, they require the installation of a CO measuring instrument in the exhaust air flow by 30th October 2007.

Analysis of the Reasons for Dioxin Formation

As part of the analysis of the reasons for dioxin formation, the ATB was commissioned by the Ministry of Food, Environmental Protection, and Regional Planning of the state of Brandenburg to study the formation mechanisms of dioxins and their immission paths into dry forage and to carry out measurements. Based on the evaluation of numerous analyses of forage samples and the literature, the study [7] showed that the following immission sources can be considered certain:

1) Immission through fresh forage in a range from 0.06 to 0.66 ngTE/kg
2) Immission through fine dust in a range from approximately 5 to 15 ngTE/kg
3) Increase during drying by an average of 0.025 ngTE/kg (in exceptional cases up to 0.33 ngTE/kg).

According to the Forage Decree, the limit for dioxins in dry forage amounts to 0.75 ng TE/kg (TE = toxicity equivalent) given a dry matter content of 88% [5]. The immission of soil- and dust particles is considered the main reason for the contamination of the freshly harvested forage. The background contamination of soils used for agriculture currently amounts to an average of 1 ngTE per kg. Dioxins are bound in a highly adsorptive manner to the organic substance of soil- and dust particles. The reasons for the increase in dioxin concentrations during drying have not yet been determined for certain. If only approved homogeneous solid fuels are used, insufficient control of the firing- and drying system as well as unsteady processes during start-up and a change in the kind of forage are considered the main factors which are responsible for this increase.

Measurements during a Start-Up Process

In a series of measurements in November 2004, the start-up process of a forage drying system heated with coal was studied. For this trial, extreme conditions (wet and cold weather, last grass cut, fresh forage mixed with soil) were deliberately chosen. In *Figure 2*, measured dioxin concentrations in fresh forage, forage pellets, and dust, as well as the inlet air temperature were plotted over the time. After approximately two hours, a stable inlet air temperature had established itself. As the diagram shows, an excessive dioxin content in dry forage was found during the heating phase. Afterwards, the dioxin content decreases. This means that the unsteady processes during the heating phase can lead to dioxin formation. At up to 0.66 ngTE/kg, measured dioxin contents were remarkably high like in other samples of fresh forage [7]. These high dioxin contents must be attributed to high contents of ash in the fresh forage, which were caused by soil admixtures. Such high concentrations in fresh forage lead to the risk of dioxin enrichment in dry forage and, consequently, the exceeding of threshold values.

Recommendations for the Improvement of Forage Safety

After the registration of drying plants had become mandatory according to the Forage Decree, the ATB was accredited and commissioned as a consultant by the Federal Ministry of Food, Agriculture, and Consumer Protection. In 2005/2006, a total of seven forage drying plants were inspected, which were heated using solid fuels, such as mineral coal, lignite, as well as mixtures of coal and abraded briquet material. The evaluation of the collected data showed that the limits of undesirable substances were kept in the operations during the assessment period from 2003 until 2005 and that forage safety was guaranteed. Based on the experiences gained during reason analysis and consultant work, the following recommendations for the improvement of forage safety are given for the operation of forage drying plants [8]:

- Loading of the dryer drum with fresh forage only after the end of the heating phase (stationary inlet air temperature) after the forage dried during the heating phase has been removed.
- Use of homogeneous fuel piles with constant characteristics, i.e. large lots from one supplier and one bed of coal, if possible.
- Control of the combustion conditions in the combustion chamber by means of continuous measurement of the combustion chamber temperature (> 800 °C) and the CO content at the drum inlet.
- Continuous measurement of forage moisture before and after drying.
- Improvement of process control and -monitoring by means of modern measuring- and control technology as well as computer-aided measurement data collection.

The implementation of these measures and better observation of the HACCP principles allows quality assurance in drying plants to be improved step by step.