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Airborne particle generation from horse feeds depending on type and processing

Aim of the study was to analyze and compare the generation of different airborne particle fractions of diverse feed types and feed processing techniques under standardized laboratory conditions. All measurements of airborne particle generation have been effected under standardized conditions in a closed chamber (1 x 1 x 1.5 m). The airborne particle concentration has been detected in four different particle fractions using four different sampling inlets: PM_{20} (< 20 µm), PM_{10} (< 10 µm), $PM_{2.5}$ (< 2.5 µm) and $PM_{1.0}$ (< 1 µm). It could be shown that cleaning of oats and barley breed to a reduction in the PM_{20} and PM_{10} particle fraction concentration of 80 %. The different compound feeds (Pellets, Mix) generated the significantly lowest concentration of PM_{20} and PM_{10} particle fraction. However in particle fraction $PM_{1.0}$ the highest concentration could be analyzed in one of the mixes.

Keywords
Horse husbandry, feed, airborne particles

Abstract
Landtechnik 64 (2009), no. 4, pp. 242 - 245, 3 figures, 1 table, 8 references

Often non-infectious respiratory diseases in the horse, such as COPD or rhinitis, result from an increased concentration of airborne particles in the stable air [1]. In addition to the presence of gases such as ammonia and carbon dioxide, airborne particles are an important factor determining the stable air quality [2, 3]. Dust particles not only contain inanimate components but they can also be carriers of microorganisms, fungi and endotoxins which can cause numerous respiratory diseases [1, 4]. It is known, therefore, that the quality of the stable climate is one of the most important factors for maintaining the health and condition of a horse [1, 3]. Both bedding and feed have been proven in diverse studies to be unequivocal sources of airborne particles in horse stables [5, 6, 7]. The generation of airborne particles from horse feed is often ignored although this takes place directly within the breathing zone of the horse and is breathed in during feeding. At the moment, there is no information concerning how high the generation of various airborne particle fractions [mg/m³] is from horse feed. The aim of the present study was, therefore, to analyze the amount of airborne particles (PM_{20}, PM_{10}, $PM_{2.5}$, $PM_{1.0}$) generated by various feeds subjected to different processing methods (cleaning, rolling, industrial production).

Materials and Methods

A total of 13 feedstuffs were chosen to be used in the investigation. A differentiation was made between straights (oats and barley subjected to different processing methods) and compound feeds. These are summarized in **Table 1**.

The cleaning of the oats and barley was undertaken using an OPTIMA 2002 NA aspirator (ZUTHER GmbH, Karwitz, Germany). The material was injected into the machine via an auger into the inlet box. The coarse particles were sucked out by a continual flow of air. Finally, separate portions of the cereals were moved over eight fine corn sieves. After leaving these, the cereals were cleaned once again using air.

The oats and barley were rolled using the roller „Universal“ (Sommer Maschinenbau, Osnabrück, Germany), which consists of two crushing rollers set at a grinding gap of 1 mm.

The flaked barley, pellets and mixes were produced and provided by an accredited feed producer. Before they were used for the production of flakes, pellets or mixes, the raw materials were cleaned in a water bath. The materials were made more digestible by steam processing under high pressure and a temperature up to 105 °C before they were mixed, flaked or pelleted.

The dry matter content (DM in %) of each feed was analyzed before the airborne particle measurements were undertaken. In addition, the proportions of five particle fractions (9.9 mm, 5 mm, 2 mm, 1 mm, < 1 mm) of each feed were determined by

Tab. 1

Feeds used in the experiment

Feedstuff	Processing method
Herkömmliche Kraftfuttermittel ***Straights***	
Hafer *Oats*	ungequetscht, ungereinigt *whole, uncleaned*
	gequetscht, ungereinigt *rolled, uncleaned*
	ungequetscht, gereinigt *whole, cleaned*
	gequetscht, gereinigt *rolled, cleaned*
Gerste *Barley*	ungequetscht, ungereinigt *whole, uncleaned*
	gequetscht, ungereinigt *rolled, uncleaned*
	ungequetscht, gereinigt *whole, cleaned*
	gequetscht, gereinigt *rolled, cleaned*
	geflockt *flaked*
industriell hergestellte Kraftfuttermittel ***Compound feeds***	
	Pellet 5mm *pellets 5mm*
	Pellet 10mm *pellets 10mm*
	Müsli 1 (strukturarm) *mix 1 (poor in texture)*
	Müsli 2 (strukturreich) *mix 2 (rich in texture)*

sieving.

With the aid of the gravimetric online measuring particle analyzer TEOM 1400a (Rupprecht and Patashnick Company, USA), the generation of airborne particles [µg/m³] over a period of 60 minutes (one measurement per minute) was analyzed for each type of feed. The TEOM 1400a was integrated into a dust chamber (1.5 m x 1 m x 1 m), which was especially developed for this study. Two kilograms of each feedstuff were introduced in a standardized manner into the dust chamber via a funnel tube and slider plate at the back of the chamber. To differentiate the airborne particle content, four different measuring heads were used one after another, with three repetitions (n = 156).

- $PM_{20} \leq$ 20µm (total airborne particle content)
- PM_{10} < 10µm (thorax-penetrating airborne particles)
- $PM_{2,5}$ < 2,5µm (alveolar-penetrating airborne particles)
- $PM_{1,0}$ < 1,0µm (alveolar-penetrating airborne particles).

All the measurements were done under standardized conditions (relative humidity = 45%, temperature = 18°C). The statistical evaluation of the data was done using SAS 9.1 (SAS Inst. Inc., Cary, NC, USA). The mean maximum airborne particle concentration (C_{max} [µg/m³]) and the mean 60-minute airborne particle concentration (C_{mean} [µg/m³]) with their respective standard deviations (SD [µg/m³]) were calculated for each feedstuff. Significant differences ($P \leq 0.05$) were determined using the t-Test.

Results and Discussion

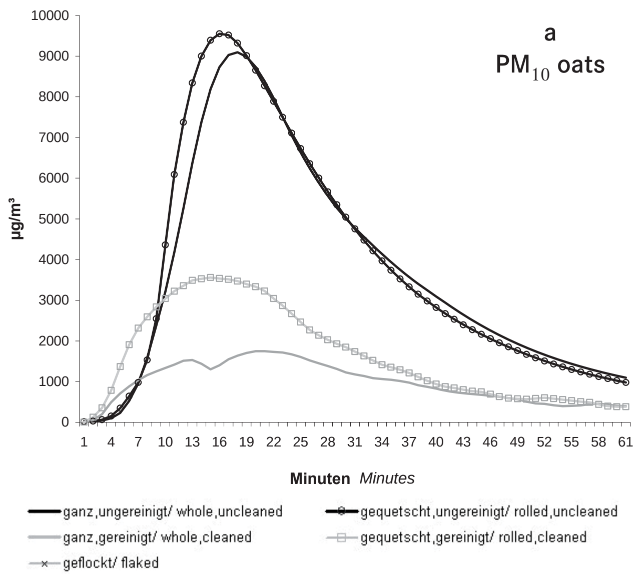
Dry matter and particle composition. The determination of the DM content of the individual feedstuffs showed values between 84.9% and 90.0%. The highest DM content (90.0%) occurred in the 5-mm pellets and the lowest in Mix 1 (84.9%). Looking at the composition of the particles of each feedstuff, Mix 1 (17.9%) and rolled, uncleaned barley (13.7%) had the highest proportion of particles < 2 mm. In comparison, the oats (rolled, cleaned; whole, cleaned), both types of pellets and Mix 2 had less 1% of these particles.

Airborne particle measurements in the straights, oats. Uncleaned oats (whole and rolled) had significantly higher PM_{20}, PM_{10} and PM_1 concentrations than cleaned oats. Cleaning led to a reduction in the PM_{20} and PM_{10} fractions by ca. 80% and the $PM_{2.5}$ and $PM_{1.0}$ fractions by ca. 30-50%. This trend could be confirmed in a field investigation, where the cleaning of oats resulted in reduction in the airborne particle load in the stable air by about 84.4% [8]. The rolling of oats (cleaned and uncleaned) led in the present investigation to a significant increase in the mean maximum PM_{20} and PM_{10} airborne particle concentration by 20% in comparison to unrolled oats. This increase could, however, not be shown for the alveolar-penetrating particle fractions $PM_{2.5}$ and $PM_{1.0}$. Significantly higher concentrations of these particles were produced by the whole, uncleaned oats.

Airborne particle measurements in the straights, barley. The rolled, uncleaned barley generated the highest PM_{20} concentration. There were no significant differences between the rolled and whole uncleaned barley with respect to the PM_{10} fraction. Significant differences were, however, found between rolled and whole cleaned barley. The rolled, cleaned barley generated significantly higher concentrations of airborne particles. The lowest generation of airborne particles was shown by the flaked barley. The effect of cleaning was similar to that found in the oats. However, in comparison to oats, the highest airborne particle concentration of the alveolar-penetrating particle fraction ($PM_{2.5}$) was not in the whole, uncleaned cereal but in the rolled, cleaned barley. **Figure 1** and **Figure 2** show the course of the mean 60-minute airborne particle concentration of the PM_{10} particle fraction in both oats (a) and barley (b) subjected to different processing techniques.

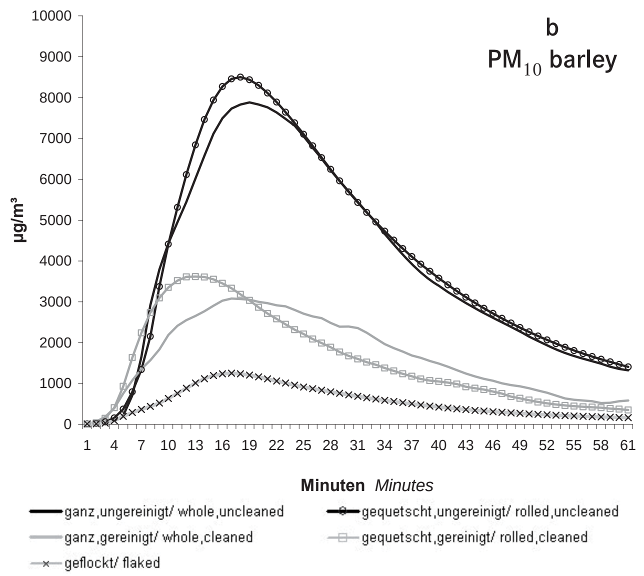
Airborne particle measurements in the compound feeds, pelleted and mixed feeds. Both types of mixes generated up to 20% less airborne particles in the fractions PM_{20} and PM_{10} than the two types of pellets. Mix 1 had the highest 60-minute concentration of the alveolar-penetrating particle fractions $PM_{2.5}$ and $PM_{1.0}$, comparable to that found in the whole, un-

Fig. 1



Generation of airborne particles (PM_{10}) of oats (a) as a function of time and processing, (n = 3)

Fig. 2



Generation of airborne particles (PM_{10}) of barley (b) as a function of time and processing, (n = 3)

cleaned oats. The cause of this could be the mix's high content of ground and dry components. A comparison of the differently sized pellets (5 mm and 10 mm) revealed no significant differences in the concentration of any of the particle fractions. The compound feeds had up to 80% less mean 60-minute concentrations of the particle fractions PM_{20}, PM_{10} and $PM_{2.5}$ (C_{mean} [µg/m³]) than the straights. **Figure 2** compares the generation of $PM_{1.0}$ by the four compound feeds with that of oats subjected to different processing methods.

Conclusions

The results of this investigation show that it is sensible to clean straights such as oats and barley. The use of compound feeds leads to a significantly lower airborne PM20 and PM10 particle contamination. The composition of mixed feeds can have an influence on the amount of alveolar-penetrating particle fractions in the air.

Literature

Books are marked with ●

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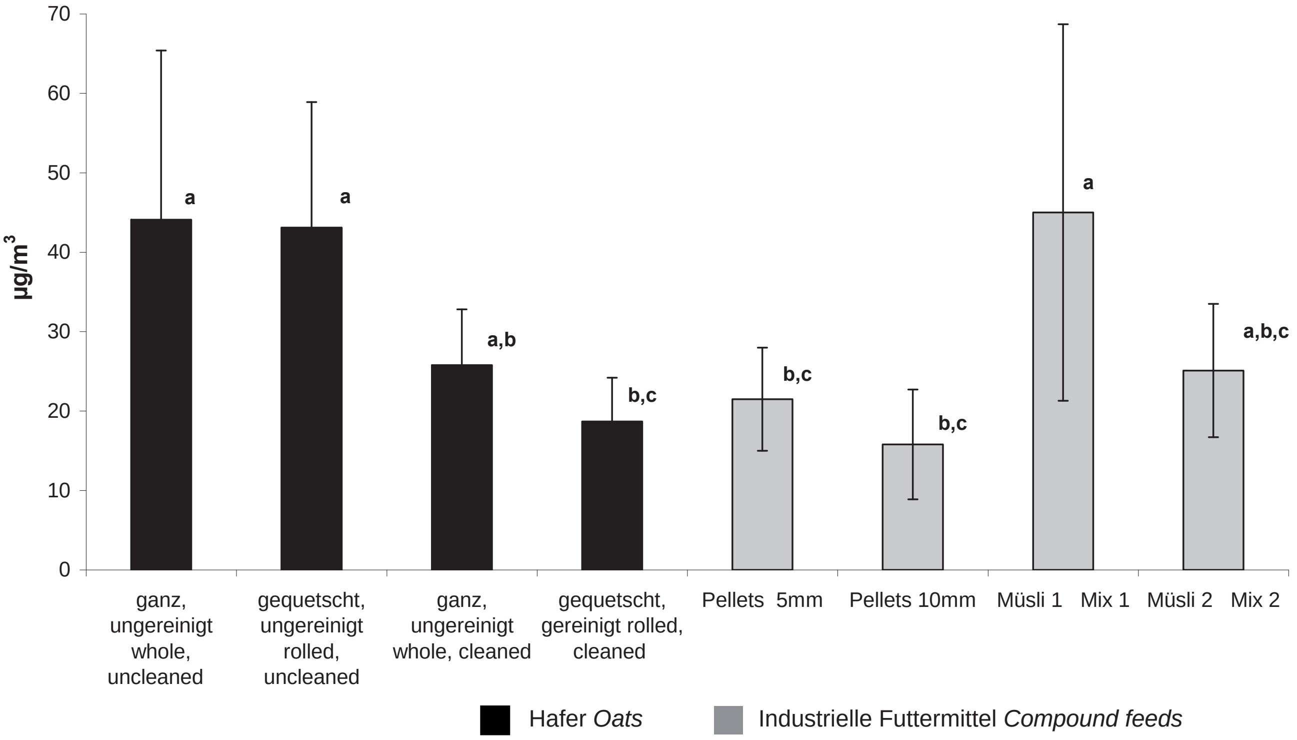
Fig. 3



Means (n = 3) of total 60-minute $PM_{1.0}$ particle fraction concentration (C_{mean} [µg/m³]) within oats after different processing and compound feeds; a,b,c = means without a common letter differ significantly ($P \leq 0.05$)