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Comparison between different types of bedding materials for horses

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Abstract. The sports horse lives a large part of the time inside the pen in constant contact with the bedding. Therefore the bedding material can deeply affect the welfare and health of horses kept in pens. The materials have to ensure the realization of a double aim: to create a comfortable and soft surface on which the animal can stand and relax; to give appropriate hygienic and sanitary conditions. Other important factors influence the choice, such as: the material must not be appetizing for the horse; the litter has to maintain a proper level of moisture, so that the hoof is kept healthy, elastic and hydrated. Also the costs for material and litter management have to be taken into account. In the present study, different organic materials are compared: wood chips, hemp, rice, flax and coconut. The trials took place in five box stalls, with square plan of 3 x 3 m. Environmental data were collected during the trials (air temperature and humidity, ammonia concentration, litter moisture). Management data were also collected, regarding the use of bedding materials, working time, costs. In the paper the main results of the comparison between the different litter materials used in horses pens are presented.

Key words: horse husbandry, bedding material, housing, sanitary and hygienic conditions.

INTRODUCTION

In the housing of the sport horse inside stables, the use of litter has always played a fundamental role on the physical wellbeing of the animal. The horse's foot, more if shod, can pose serious problems if the litter used inside the pen is not suitable. Over the years there have been many attempts with different materials such as cereal straw, flax straw, paper, cardboard, sawdust, pine shavings and other types of wood, peat, sand, rice husks, cobs of corn, hemp and coconut.

The continuous increase in the cost of litter in wood chip pellets and the lowering of the average quality (often derived from the shredding of waste products from sawmills and wood industries) has favoured the entry of alternative types of litter into the market.

Many types of natural litter arrived on the market, some ones very popular years ago and others discovered more recently (like the coconut). New producers and importers, who sell different litter materials on the market, exalt their products that often have no practical confirmation in reality.

It is therefore necessary to understand what makes one litter better from another. This research aimed to find an answer to this question, analysing factors that concern the welfare of the horse and the practical and economic aspects of the human activities.

The litter must have the following characteristics for the horse: not to be wet to avoid foot infections; not to be edible; to be free of detrimental substances (chemical and bacteriological); not to be dusty; to ensure physical comfort; to reduce the gaseous emissions.

For the man the litter has to present the following characteristics: to reduce the daily management time; to have a low price; to be easy to dispose of; to be easy to transport and storage; to be easily available.

The horse husbandry usually takes place in box stalls (3 x 3 m or 3.5 x 3.5 m), arranged in two rows with a central lane, where the horse is kept for much of its time stopped, getting out only for training and/or grazing in the paddock. It is therefore essential for the health of a horse that the litter in the box stall, on which the animal spends most of the day, is kept clean and in the best hygienic-sanitary conditions (Fig. 1). To reach this goal there are at least two different ways to manage the litter, which generally depend on the type of litter used:

- with daily aeration of the whole litter and continuous removal of urine and solid dejections;
- with permanence of a bottom layer of the litter (mixed urine) and daily removals of the superficial solid faeces.

Figure 1. Horse lying in the resting phase (left); detail of the horse's foot in contact with the litter (right).

The environmental factors that most influence the physical condition of the horse, and on which the study has focused, are detrimental gases, air humidity and litter moisture.

Air quality is a fundamental environmental condition not only for humans, but also for animals kept inside a barn. A significant accumulation of gases occurs inside the box stall, with some heavy (carbon dioxide, nitrous oxide and hydrogen sulphide) and other light (methane, carbon monoxide and ammonia), detrimental both for man and for animals.

To guarantee good conditions inside a barn the ventilation is really important. The quality of the air is influenced by the ventilation rate. Ventilation system is the most effective airborne particle clearance action (Woods et al., 1993; Curtis et al., 1996). For

horse health it is necessary to have enough fresh air distributed to the areas inside the barn where horses are kept (Lundval, 2013). However, when the horses are kept in stall boxes in open paddocks this requirement is less impressive.

Usually in horse sport husbandry, the horses exercise outdoors usually for 1 to 2 h and, consequently, spend the major part of the day (often up to 23 h) indoors. Because of this, stable air quality is of considerable importance. Furthermore the respiratory disorders are common problems, and respiratory allergy is commonly diagnosed as a condition affecting the equine lung (Saastamoinen et al., 2015). When the condition becomes protracted it is referred to as chronic obstructive pulmonary disease (COPD) or heaves (or RAO, recurrent airway obstruction), an animal model of asthma. Some reports suggest that the condition is rare in climates where animals are outside all year around but is common in climates where horses are stabled indoors (Derksen, 1991). Clinical signs in horses with this chronic lung disease include poor athletic performance, chronic couching, purulent nasal discharge, and ultimately difficulties in breathing (Elfman et al., 2011).

People working in and visiting horse stables may also be exposed to the effects of the stable air. Causes of chronic airway disease both in horses and humans usually involve exposure to excessive concentrations of airborne dust, moulds, viruses, bacteria, spores, aeroallergens, and endotoxins which mostly originate from bedding and feed (Tanner, 1998). Furthermore, the inhalation of gaseous irritants such as ammonia may initiate airway obstruction and exacerbate or prolong the clinical signs of COPD in affected horses (Saastamoinen et al., 2015) as well as humans (Elfman et al., 2011).

The ammonia, resulting from the catabolism of nitrogenous substances, has 10 ppm as a limit recommended by the Scientific Committee of the CE Commission (for cattle and pigs, the reference for horses is missing). Ammonia derives from the biological degradation of nitrogenous organic substances: about 85% comes from the demolition of urea and uric acid contained in the urine, the remaining part comes from various compounds present in the faeces (Curtis et al., 1996). The factors that determine the atmospheric concentration of ammonia are mainly temperature, humidity, ventilation, animal load, flooring, debris removal systems and frequency of cleaning and washing (Kwiatkowska-Stenzel et al., 2016).

High concentrations of air humidity, besides favouring the onset of bacteria, parasites and moulds, cause respiratory problems for the horse and the man who must operate inside the stall. Unlike low levels of humidity when combined with high concentrations of dust cause cough and allergies. Optimal relative humidity values are between 50% and 75% and the maximum level of RH has not to exceed 80% in uninsulated stables (Lundval, 2013). An excessive moisture of the litter causes problems related to the hoof, such as the ‘worm’ (a fungus) and rotting (a bacterium) which, if neglected, become ‘cancer’ and irreparably compromise the horse. Otherwise a too dry litter tends to dry the nail which will lose elasticity and become more fragile.

Also the role of bedding material in recycling the nutrients of horse manure represents an important issue to take into account during the choice of a proper material. The manure should be efficiently recycled in agriculture avoiding any uncontrollable loss of its nutrients into the environment (Nikama et al., 2014). Keskinen et al. (2017) assessing the nutrient cycling properties of three bedding materials (peat, wood shavings and pelleted straw) in horse manure found that manure with pelleted straw bedding had

superior composting characteristics, which favoured an increase of the nutrient concentrations and a decrease of the C:N ratios.

MATERIALS AND METHODS

During the trials the following bedding materials were tested: flax straw, hemp litter, rice husk, coconut litter, wood chips.

Flax straw is a completely vegetable product, very spread in Italy around ten years ago, absolutely free of dust and pests. The tested flax comes from organic farming in Flanders, an area between Belgium and France. A de-dusting system guarantees the absolute absence of any form of powders and substances that create allergies. Usually the flax straw is healthy and convenient, completely vegetable litter. Furthermore, the manure is removed perfectly compostable, thanks to the absolutely neutral pH value.

Hemp litter, obtained from the central and soft part of the hemp stalk, is completely biodegradable. It consists mainly of cellulose and lignin and is highly absorbent. The hemp stalk is also rich in silica, a chemical that in nature is found in sand or flints. It is well accepted by farmers and easy to store and distribute.

Rice husk has a brown/beige colour and a hard consistency, much more resistant than that of wheat. It is lightweight and voluminous and is virtually rot-proof and resistant to insects. It contains silica, has low absorption and is often dusty. It is cheap in areas suitable for rice cultivation and is not easy to dispose of.

Coconut litter is an extremely natural and ecological product, it has a very pleasant appearance (soft, homogeneous, easy to distribute). Due to its high absorption capacity, the litter is always very dry on the surface. It guarantees the total elimination of bad smells. It is characterized by total absence of dust and is not appetizing for the horse. It maintains optimal hygienic conditions and prevents the onset of serious diseases. The use of coconut allows you to reduce the amount of manure to be disposed of, which is still of excellent quality and acceptable for agronomic uses such as fertilizer simple or composted.

Wood chips have been the most used litter in Italy for the housing of horses until recently. Wood chips have a medium-high cost, are easy to store and process and produce an acid material that is not liked by farmers. There are different types of wood chips depending on the type of tree from which they are produced. The two large groups are: fir wood chips and wood chips of other species. In this study two kinds of wood chips were tested, one of only fir and one of beech and another fir.

Fir wood chips (wood chip A), produced exclusively with fir curls, free from toxic substances and impurities. They are de-dusted, dried and ventilated. The chemical-bacteriological analyses attest to the quality and certify the total absence of streptococci, colibacteria, tetanus, fungal moulds, etc. The fir fibre develops considerable hygroscopic values, has good resistance to foot traffic and high thermal insulating effects. It is the litter most used for keeping purebred horses.

Beech and fir wood chips (wood chip AF): contains only selected beech curl with the addition of a large fir leaf dried and de-dusted. Chemical analysis attest the absence of pesticides, fertilizers, aflatoxins, etc. It is a specific horse litter with high hygroscopic power and excellent resistance to wear. It guarantees a valid thermal coefficient and an excellent softness, reducing the moisture and the acute smell of urine.

Table 1 shows the costs of the tested litters, including transport, for the trials.

Table 1. The costs of the tested litter, including transport carried out in the province of Arezzo, site of the study

Litter	Bale size	Bale added/week	Cost/kg (€)
Hemp	7 kg – 80 L	2	0.64 + vat 10%
Flax straw	21 kg – 120 L	1	0.34 + vat 10%
Rice husk	20 kg – 200 L	1	0.18 + vat 10%
Coconut	15 kg – 250 L	1/3	0.80 + vat 4%
Wood chip A	23 kg – 145 L	1	-
Wood chip A/F	23 kg – 145 L	1	-

Instrumentation used and parameters detected

For the trials 5 box stalls (3 x 3 m) arranged in line, with in front a roof (3 m) and walls of 2 cm thick fir wood were used. The base is made in concrete with a central grid and 2% inclination. The roof is a sandwich panel, 2.70 m high at the ridge and 2.20 m in the eaves. The stalls between them are not communicating, not even in the upper part, in order to reduce the exchange of air between adjacent boxes. The horse boxes are all the same and in the same conditions. The air exchange is guaranteed by the upper part of the entrance door to the facility.

The horses examined are of the same body size. They all follow the same diet as type and quantity, with feeding of the food at scheduled times.

Several parameters were monitored during the whole trials. Among them, the parameters taken into account for the present study are the following: relative humidity of the air; moisture of the litter (surface and background layer); amount of ammonia in the air (ppm); quantity of waste; degree of fatigue and perception of smell by the operator; operating times for the daily cleaning of the box.

For the study, the following instrumentation was used: portable data-logger (DO9847 of Delta OHM) with probes for air temperature and humidity and contact temperature; moisture analyser (Rad Radwag Mac50) with heating at 160 °C; ammonia detector (Dräger X-am® 5000). A digital video recording system with five infrared CCTV cameras (Proeye Bullet AHD Multistandard 1.0 Mpixel) was installed with the only purpose to check the state of the horses inside the stalls during the trials.

The data were not collected to provide a statistical analysis most likely due to a limited number of samples and variability in used source materials.

The measured parameters were marked on specific tables. All measurements were taken regularly, in order to cover 2–3 days per week, in the morning before redoing the box stalls and following this method:

- the air temperature and humidity were obtained through measurements taken in five points of the stalls (vertices of a square 2 x 2 m and in the middle) and averaged;
- the measurement of the quantity of ammonia in the air, carried out with the Dräger meter, respectively at the top of a 2 x 2 m square and in the middle;
- the moisture survey was carried out by taking five small points (with the same pattern as in the previous surveys) with a small quantity of litter both from the bottom layer and from the surface layer, mixed separately, and brought to the Radwag analyser for the measurement of moisture.

In this research both of the box stalls management techniques were tested (daily airing of entire litter, layer permanently cross and daily manure removal of surface), for a period of about five weeks; the horses were kept in boxes and sent out to the paddock for 2–3 hours a day in order to simulate the most common horse keeping conditions.

Data on the practical use of the different litters were obtained thanks to the experience of an operator who has been working with horses and cleaning the boxes for years. A table was prepared on which the operator, at the end of the cleaning of the stall box, could express a value in units (U) related to the perception of odours (odours: 1 not detectable, 2 barely perceptible, 3 perceptible, 4 strongly perceptible), express a value in units (U) related to fatigue (fatigue: 1 little, 2 normal, 3 more than normal, 4 a lot), and sign the time employed (in minutes).

Before starting the trials an analysis of the moisture of the different types of litter was conducted (Table 2).

Table 2. Litter moisture in the respective bales (%)

Coconut	Flax Straw	Rice husk	Hemp	W.ch. A	W.ch. A/F
20.0	14.0	9.5	14.1	11.0	13.3

The trials began on 06/04/16 and the box stalls were filled with the quantities of bedding recommended and reported in each pack (Table 3). Subsequently the boxes were cleaned every day in the morning and, until 26/04/16, with the technique of turning the litter completely; from 26/04 regarding the litter of coconut, flax and hemp, leaving a layer at the bottom and removing only the solid superficial faeces (for the litter in wood chips, instead, it continued as usual). The trials of the rice husk, which started later, were carried out with the technique of 'surface removal'.

Table 3. Amounts of litter used for the beginning and for the renewal (number of bales)

Date	Coconut	Flax Straw	Rice husk	Hemp	Wood chips A	Wood chips A/F
06-04	7	4	4	11	3	3
13-04	1/3	1	1	2	1	1
20-04	2/3	1	1	2	1	1
27-04	-	1	1	2	1	1
04-05	1/3	1	1	1	1	1

RESULTS AND DISCUSSION

During the trials a significant amount of data was collected. In this study, the main results regard the analysis of litter moisture and air humidity parameters (Table 4) and ammonia concentration (Table 5). Results related to ergonomic aspects and to the costs of single litters are shown as well. The values concerning the production of manure, the level of smell, the time consumed for the daily work, and the level of fatigue, expressed by the operator during the cleaning and renewal of every single bedding, are summarized in Table 6.

The moisture is related to the depth of the litter, as shown in Table 4. With a relative humidity inside the stable more or less constant (minimum 70.7% and maximum 82.5%) and a total average RH of 77.61%, the lowest values of moisture were reached by beech and fir wood chips (wood chip AF), which presented little differences between moisture

at surface and ground levels (26.32 and 29.85% respectively). Also hemp litter showed low values of moisture at surface level (26.00 %), but at the ground level the moisture value increased till 43,01% on average. The highest values were reached by fir wood chips (wood chip A) at surface level (50.21%) and by coconut litter at ground level (55.30%).

Table 4. Litter moisture values (%) at ground and surface level, and air relative humidity (%)

Date	Level	Coconut	Flax Straw	Rice husk	Hemp	W.ch. A	W.ch. A/F
12-04	Ground	51.6	35.8	-	41.8	42.7	29.5
	Surface	40.0	25.6	-	17.8	41.1	20.9
	Air	75.0	76.5	-	76.8	80.6	79.2
14-04	Ground	52.8	33.8	-	43.5	51.7	28.5
	Surface	42.6	27.6	-	18.6	46.8	20.8
	Air	74.8	70.7	-	74.0	71.0	73.8
17-04	Ground	53.6	50.6	-	45.8	54.3	29.7
	Surface	41.3	37.9	-	18.1	50.5	21.0
	Air	73.0	74.0	-	75.0	75.0	74.8
19-04	Ground	58.2	47.6	-	33.9	58.4	32.4
	Surface	44.5	38.7	-	28.8	51.9	31.6
	Air	76.5	75.0	-	77.0	71.8	73.9
23-04	Ground	56.5	43.0	-	45.6	55.1	28.0
	Surface	40.3	37.5	-	29.9	52.2	24.9
	Air	79.0	76.5	-	80.7	82.0	75.0
26-04	Ground	59.1	44.5	-	47.8	56.4	31.0
	Surface	43.2	38.4	-	31.1	52.8	28.2
	Air	77.8	78.4	-	78.7	79.4	76.4
30-04	Surface	56.0	40.1	29.4	31.9	56.2	29.8
	Air	79.0	79.8	80.9	80.6	80.5	76.0
04-05	Surface	53.7	43.7	38.6	33.3	-	34.3
	Air	82.3	80.8	82.1	80.4	-	81.9
06-05	Surface	50.9	48.6	38.5	24.3	-	25.4
	Air	82.5	81.0	80.2	82.0	-	79.8

The highest ammonia concentrations were recorded in flax and hemp litter, and then in the wood chip litter. The coconut litter is the one that recorded the lowest ammonia concentration values. In the first week it presented values of 1 ppm and subsequently higher, with a maximum of 5 ppm. The rice husk litter, even though it does not have great absorbent capacity, recorded very low values in the first week, probably due to the high amount of litter on the first implant (20–30 cm in height). From 26/04/16 the technique of maintaining the ground layer (hemp, flax, coconut and husk) was adopted and, as can be seen in the Table 5, the values lowered.

Generally, the litter ground layer, within one or two months, must be completely renewed. This operation must be carried out with extreme caution: the ammonia detected at the removal of the flax straw after a month of trials was almost 30 ppm.

Concerning the moisture of the litter, in particular concerning the surface layer, which can influence horse's hoof state, the lowest values were recorded in the fir-beech (AF), while the highest in the chip of only fir (A), in the coconut and in the flax. An explanation of this may be that the horse with wood chips (A) recorded an intense

walking activity inside the stall box compared to the one with the fir-beech shavings (AF), spreading faeces and urine in all parts of the pen. High moisture values of the litter, i.e. over 50%, must be carefully evaluated, also according to the seasonal period, as they can be a predisposing index to the onset of diseases.

Table 5. Ammonia concentrations (ppm) measured in box stalls with different types of litter

Date	Coconut	Flax Straw	Rice husk	Hemp	Wch. A	Wch. A/F
06-04	Beginning of trials					
09-04	1	8		8	5	8
12-04	1	8		8	7	8
13-04	Added weekly litter					
14-04	3	7		7	3	7
17-04	1	8		5	2	3
19-04	5	6		5	6	5
20-04	Added weekly litter					
23-04	5	7		8	3	3
26-04	4	7		6	6	8
27-04	Added weekly litter					
30-04	3	4	2	6	2	2
04-05	2	6	1.5	6	3	3
04-05	Added weekly litter					
06-05	2	6	2	6	3	3

The hemp litter remained dry and smooth on the surface after just a week, providing an excellent comfort and an excellent filtering function: the urine is filtered by the hemp and ends up at the bottom of the stall box. It is therefore necessary to distribute a certain thickness of litter on the bottom so as to allow the surface to always remain perfectly dry. Daily litter care is also easy.

Flax straw recorded high values of surface moisture and high ammonia concentrations with the drying technique. The wood chips showed good absorption and in particular the fir wood chips (A) presented very high values of surface and background moisture, while the wood chips (AF) were the driest.

Horses never ingested the litter used in the trials, except in rare cases at the beginning of the rice husk and hemp plant.

From the point of view of the work for the man (saving time and fatigue), the technique of total litter aeration has appeared more expensive than the removal of only the surface layer, in particular in the litter of coconut given its height (20–30 cm). The rice husk appeared to be the lightest to be turned over and managed even if, to guarantee low ammonia values, a height of over 20 cm must always be achieved. The rice husk has the advantage of lower costs than other litters and a good availability especially in northern Italy. The coconut used at 20% moisture appears at first glance not convenient considering the high cost and the long preparation during planting and addition due to the necessary shattering of the clods. However, it has low ammonia values in the box and is favourable from the point of view of the work: low labour costs per day thanks to the fact that the care of the litter can be carried out once every two days.

Table 6. Values of manure, smell, time and fatigue expressed by the operator during the cleaning and renewal of every single litter

	Date								
	10-04	12-04	14-04	17-04	19-04	23-04	27-04	30-04	06-05
Manure Kg									
Coconut	5	6	7	4	7	5	5	7	6
Flax	8	8	8	6	6	7	6	6	6
Rice husk								4	5
Hemp	5	3	3	2	2	1	2	4	4
W.ch. A	4		4	1	5	4	4	5	
W.ch. AF	5	7	6	7	6	6	7	6	8
Time min									
Coconut	12	13	12	10	10	14	12	7	7
Flax	5	10	8	10	10	10	10	6	7
Rice husk								8	8
Hemp	5	6	7	8	8	10	8	9	7
W.ch. A	10		12	12	10	12	10	10	
W.ch. AF	10	10	10	10	10	10	10	10	10
Smell U									
Coconut	1	1	1	1	1	1	1	1	2
Flax	4	4	4	4	4	3	3	3	4
Rice husk								3	2
Hemp	3	3	2	2	2	2	2	2	3
W.ch. A	4		3	4	3	3	3	3	
W.ch. AF	3	4	3	2	3	3	3	2	2
Fatigue U									
Coconut	2	2	3	3	3	3	3	1	1
Flax	2	2	2	2	2	2	2	1	1
Rice husk								1	1
Hemp	2	2	2	2	2	2	2	1	1
W.ch. A	1		2	2	2	2	2	3	
W.ch. AF	1	2	2	2	2	2	3	2	2

CONCLUSIONS

The comparison of six different types of litter produced interesting results about the convenience or not to use one or the other litter from an environmental, as well as a commercial perspective.

The coconut litter recorded the lowest values of ammonia concentrations in all the phases of the experiments and, even if it presents high purchase prices, is favourable from the point of view of the work with low labour costs.

Beech and fir wood chips presented very good results in terms of litter moisture, also at ground level, showing to be an excellent product for bedding. Anyway, wood chips have medium-high cost and produce an acid material that is not liked by farmers.

The rice husk, although tested for a short period, showed to have some advantages, such as the acceptable ammonia and moisture values when used with a minimum height of 20 cm, besides the low cost and the good availability especially in northern Italy.

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