Feasibility analysis of different bedding materials for horses

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ABSTRACT
The aim of this paper is to assess the economic aspects of bedding materials for sport/recreational horses. Four materials are tested: sawdust in bulk, wood shavings, squared harvest straw, and slice-dusted straw. The process of collecting data for feasibility analysis is structured into two different trials. In Trial 1, daily observations are collected and measured to obtain data about the technical and cleaning characteristics of the four different bedding materials, and in Trial 2, the durability of the bedding materials is tested. From an economic (cost) standpoint, the most suitable bedding materials are squared harvest straw and slice-dusted straw. Unfavourable economic results are found for wood shavings and sawdust in bulk. However, the durability analysis shows wood shavings and slice-dusted straw to be the better options. Thus, the results indicate that some bedding types are better for durability reasons and others are better for economic reasons.

1. Introduction
Bedding material has ethological and technological functions within the stable. According to Werhahn et al. (2010), Garlipp et al. (2011), and Kwiatkowska-Stenzel et al. (2016), the choice of bedding material has an impact on two important factors: (i) the behaviour of horses and (ii) the quality of the air. Bedding material helps to absorb moisture and harmful gasses and helps to maintain an optimum environment in the stable. Fresh, clean air in the stable is essential in order to avoid possible health consequences for both the animals and the caretakers. Choosing the best bedding material can lead to a decision-making problem based on both an economic and a technologic assessment of the material.

While the chemical and physical properties have been analysed, there is currently no information about the different economic values of bedding materials in equine breeding. Teixeira et al. (2013) analysed bedding material for lambs, looking at four types of bedding materials and a cement floor area that were available during the lambs’ fattening period.

A basic principle of the lamb feedlot system is to reduce operative management and production costs (Miranda-de la Lama et al. 2009). With this in mind, straw may not be cost-effective in pastoral regions without arable land, and the rising costs of haulage and alternative uses for arable by-products can exacerbate this problem (Wolf et al. 2010).

Due to the lack of studies on the feasibility of using different bedding materials for sport horses, this paper assesses the economic value of four bedding materials other than straw for show jumping horses. Four different bedding materials (sawdust in bulk, wood shavings, squared harvest straw, and slice-dusted straw) are analysed in this study. The study published by Kwiatkowska-Stenzel et al. (2016) focused on the effects of different bedding materials (straw, peat moss with shavings, and crushed pellets bedding) on horse behaviour. Furthermore, Green et al. (2014) explained that assessments of bedding materials could prove to be economically attractive if the size of the dairy cattle herd is large enough to cover equipment costs. In many parts of the world, straw is the most popular bedding material for stables (Kwiatkowska-Stenzel et al. 2016). However, an understanding of the costs of bedding materials can lead to a reduction in total farm costs.

2. Material and methods
The experiment was carried out between 15 February and 25 March 2016 and consisted of two trials with the aim of collecting input data for feasibility analysis. The first trial (15 February–6 March) collected everyday quantitative measurements for information on the technical characteristics of bedding materials. The second trial (between 8 and 25 March) tested the period of durability of the bedding materials. The collective information from both trials was used as the input data for the feasibility analysis.

2.1. Bedding materials
Four different types of bedding materials are tested, where their characteristics (short description, symbol designations, and retail prices) are present in Table 1. Each type of bedding material has a symbol designation in order to avoid writing out the types in future references in this paper.

The prices for II and IV are calculated from retail prices on the market. For I and III, prices are found by summing the variable costs (taken from Jerič et al. [2011]) and transportation costs (£1 per km; approximately 10 km distance [Angelovski and Krizman, 2009] to the farm). The differences between the
bedding types used in the experiment are described by the length of the material (i.e. the length of fragments). The length of the squared harvest straw depends on the harvesting method. We have measured 50 fragments of straw from the farm that the materials came from, and the mean fragment length is presented in Table 1. The same approach is used for the wood shavings. However, the sawdust is immeasurable by nature. The measurements for the slice-dusted straw have been collected by the producing company.

### 2.2. Horse and stable characteristics

Technical specifications of the four bedding materials were analysed for eight warm-blooded horses weighing between an estimated 410 and 480 kg and housed in single stalls. For an estimate of the horses’ weight, we used the Adult Horse Weight Calculator (Carroll and Huntington 1988) (with known horse heart girth and body length). It was important that the stalls were of equivalent size (length × width = 270 cm × 270 cm). We focused on maintaining the same conditions for all stalls. For example, the floor in each stall had hydro-and thermal-insulation concrete. The time of horses spent in the stalls (20.5 h) and inside temperature (7.8°C)/outside temperature (6.7°C) temperatures were the same for all horses. The primary activity of the farm is renting out stalls for show jumping horses. Thus, the number of observations was one less than the number of days because the first day was allocated to setting up the experiment (i.e. putting the same amount [15 kg] of new bedding material into each stall) (Table 3).

The experiment was conducted on a farm in Svecina Village in the north-eastern part of Slovenia. The geographic coordinates of the farm are 46.653844 Latitude and 15.605419 Longitude, and the GPS coordinates are 46°39′13.8384″ N and 15°36′19.5084″ E. The primary activity of the farm is renting out stalls for show jumping horses. Thus, the number of horses on the farm is dependent on the number of owners who decide to board their horses there. For clarity, we used Roman numbers (from I to IV) for bedding materials and Arabic numbers (from 1 to 8) for horses. Horses numbered 1 and 2 were given bedding material I, 3 and 4 were given II, 5 and 6 were given III, and, finally, 7 and 8 were given IV. We aimed to choose horses with comparable weight (±70 kg) and with the same breeding conditions. Exercise was also controlled, and horses were ridden 3–4 times per week during intensive 45-min show jumping training sessions. Finally, horses were given the same feed ration – optimized by Prišen et al. (2013).

### 2.3. Experimental characteristics

The experiment is structured into two trials described above, supported with the combination of Tables 2 and 3, which complement each other:

**Trial 1**: The aim of the first trial was to collect data about technical and cleaning characteristics of four different bedding materials for eight warm-blooded horses. We did not consider observations of horse behaviour in stalls. Other observed units are presented in Table 2. Preparing the bedding material included the loading and unloading of the bedding material onto a wheelbarrow and its transportation from the warehouse to the stalls. While the adding of bedding material included the time needed for preparing the stall with the bedding material. The number of observations was one less than the number of days because the first day was allocated to setting up the experiment (i.e. putting the same amount [15 kg] of new bedding materials each stall) (Table 3).

**Trial 2**: The aim of the second trial was to test the durability of bedding materials. We selected four warm-blooded horses (1, 2, 3, and 4) of comparable weight (±30.7 kg) and started the second trial with the same amount of bedding material in each stall (15 kg). All types of bedding materials were rotated between horses number 1, 2, 3, and 4 with the aim of controlling for behavioural characteristics of each horse in the durability calculation of bedding materials. Werhahn et al. (2010) explained that different bedding materials could influence the behaviour of horses housed in single stalls. The durability data from the five repetitions (tested on every horse) were collected. The observed variable is time of the durability of bedding materials (Table 2). Because of the differences in the durability of each material, the duration and number of observations vary (Table 3). The stalls were cleaned by the breeder (in this case, the farm owner), who is fully responsible for the horses in the stable.

Assessing the contamination of bedding materials in the laboratory is usually done by measuring gases such as ammonia (NH₃), nitrous oxide, carbon dioxide, methane, and water vapor. However, in day-to-day operations, this is not a common practice (Garlipp et al. 2011). So, contaminated bedding materials were replaced based on visual inspection and the breeder’s opinion based on the following criteria:

1. Stall contamination divided into quarters,
2. Contamination of the centre of the stall,
3. Detection of urine smell,
4. Difficulty in separating bedding materials and horse faeces.

Despite the advantages (accuracy, reproducibility, etc.) of classic analytical methods, olfactometry methods remain the
best approach to measure odours directly and to objectively quantify the perception of odours (Brattoli et al. 2011).

2.4. The structure of cost calculation model

The feasibility analysis approach is based on the cost calculation model, which is already used in several studies: Pažek et al. (2010), Pažek and Rozman (2011), and Raineri et al. (2015). The main goals of the feasibility analysis are calculating the net return for discussion and identifying which type of bedding material is best from an economic perspective.

The calculation is structured as follows:

\[ NR = TR - C, \]  
\[ TR = NH \times MA, \]  
\[ C = \left( Q3 \times p \times \left( \frac{365}{T4} \right) \right) + \left( \left( \sum T1, T2, T3 \right) \times hp \times \left( \frac{365}{T4} \right) \right), \]

where \( NR \) is the net return (€); \( TR \) is the total revenue (€); \( NH \) is the number of horses in the stable; \( MA \) is the maintenance allowance (€/horse/month); \( C \) is the sum of costs from Trial 1 multiplied by \( T4 \) and divided by numbers of days per year (365); \( Q3, T1, T2, T3, T4 \) are input data from Trials 1 and 2 (Table 2); \( p \) is the price of bedding material (Table 1); \( hp \) is the price per hour (SI-STAT 2016).

The \( MA \) represents the cost of renting (250€/horse/month) a stall in the stable. It is multiplied by the number of horses in the stable to give the total income (2). The costs calculation is based on the total bedding material costs used per month per horse (C) multiplied by the price (p) and the sum of the time needed for cleaning, preparing, and putting bedding material into the stall (T1, T2, and T3) multiplied by the price per hour (hp). The resulting value is then multiplied by the days per year (365) and divided by durability of bedding materials (T4) (3). NR represents the difference between TR and C, and we can use it to evaluate the percentage of bedding material costs compared to labour costs. The feasibility analysis results are provided separately for Trial 1 (cost calculation No. 1) and Trial 1 + 2 (cost calculation No. 2).

3. Results and discussion

**Trial 1**: The average values of the observed data are the input parameters in cost calculation No. 1, while the average values of observed data for horses 1, 2, 3 and 4 from Trial 1 are also included in cost calculation No. 2 (Table 4).

**Trial 2**: The durability results for bedding materials are presented in Table 6, and, before it, in Table 5 there is an example of the assessment of the durability of bedding material IV. Results show that bedding material II has the longest period of durability and bedding material III has the shortest (Table 6). A, B, C, and D are the first, second, third, and fourth repetitions, respectively, of bedding material replacement (Table 6). Theoretically, this implies that bedding material II should be changed

### Table 3. Course and experimental setup of the investigation (between 15 February and 25 March 2016).

| Trial | Name of the trial | Date | Duration (days) | Number of observations (days) | Number of observed units | Number of horses | Total number of observation in period |
|-------|------------------|------|-----------------|-------------------------------|-------------------------|----------------|-------------------------------------|
| 1     | Technical and cleaning characteristics of bedding materials | From 15 February to 6 March 2016 | 21 | 20 | 8 | 8 | 1280 |
| 2     | Testing the life-long period of bedding materials | 8 and 21–25 March 2016 | 13–17 | 13–17 | 1 | 4 | 60 |

### Table 4. The sum and average values of observed data from Trial 1 over 20 days.

| Daily quantity of bedding material removed (bedding material + manure; kg/period) | Quantity of bedding material remaining (kg/period) | Quantity of new bedding material added (kg/period) | Duration of stall cleaning (h:m:s) | Time spent preparing bedding material (h:m:s) | Time spent adding bedding material (h:m:s) |
|-------------------------------|---------------------|---------------------|--------------------------|-----------------------------|----------------------------------|
| I-1 | 1048 | 31 | 153.95 | 2:01:30 | 0:20:00 | 0:22:15 |
| I-2 | 910 | 62.5 | 144 | 2:09:30 | 0:19:05 | 0:12:20 |
| II-3 | 809 | 95.5 | 107 | 1:50:00 | 0:30:20 | 0:12:20 |
| II-4 | 1134 | 92 | 112 | 2:01:20 | 0:28:10 | 0:12:10 |
| III-5 | 1202.5 | 562.5 | 280.5 | 3:14:45 | 0:38:20 | 0:12:50 |
| III-6 | 1293 | 547.5 | 294.5 | 3:02:25 | 0:44:15 | 0:13:45 |
| IV-7 | 630 | 121 | 81.5 | 1:53:40 | 0:27:10 | 0:09:00 |
| IV-8 | 861 | 99.5 | 102.5 | 2:06:30 | 0:28:35 | 0:08:50 |

### Table 5. The sum of observed data

| Average values of observed data | The combination of bedding material (I–IV) and horse numbers (1–8) | The combination of bedding material (I–IV) and horse numbers (1–8) |
|-------------------------------|------------------------------------|------------------------------------|
| I-1 | 52.4 | 1.6 | 7.7 | 0.06:04 | 0.01:03 | 0.01:10 |
| I-2 | 45.5 | 3.1 | 7.2 | 0.06:29 | 0.01:00 | 0.01:10 |
| II-3 | 40.5 | 4.8 | 5.4 | 0.05:30 | 0.01:36 | 0.00:39 |
| II-4 | 56.7 | 4.6 | 5.6 | 0.06:04 | 0.01:29 | 0.00:38 |
| III-5 | 60.1 | 28.1 | 14.0 | 0.09:44 | 0.02:01 | 0.00:41 |
| III-6 | 64.7 | 27.4 | 14.7 | 0.09:07 | 0.02:20 | 0.00:43 |
| IV-7 | 31.5 | 6.1 | 4.1 | 0.05:41 | 0.01:26 | 0.00:28 |
| IV-8 | 43.1 | 4.97 | 5.1 | 0.06:19 | 0.01:30 | 0.00:28 |
Table 5. Example of assessment of bedding material.

| Date                      | Number of horse | Time after the bedding material substitutions | Notes                                                                 | Exclusion status |
|---------------------------|-----------------|-----------------------------------------------|----------------------------------------------------------------------|------------------|
| 16 March 2016             | 3               | 20:45:30                                      | a) Less than ¼ stall is contaminated                                   | No               |
| First day after substitutions |                 |                                               | b) The centre of stall is clean                                        |                  |
|                           |                 |                                               | c) No smell of urine                                                  |                  |
|                           |                 |                                               | d) Easy separation between the bedding material and pure horse faeces (excluding the pure horse faeces) |                  |
| 17 March 2016             | 3               | 41:15:50                                      | a) Approx. ½ stall is contaminated                                     | No               |
| Second day after substitutions |            |                                               | b) The centre of stall is little wet but clean enough of bedding material in corners to put into the centre |                  |
|                           |                 |                                               | c) Detection of urine smell                                           |                  |
|                           |                 |                                               | d) Easy separation between the bedding material and pure horse faeces (excluding of the pure horse faeces) |                  |
| 18 March 2016             | 3               | 61:01:20                                      | a) More than ¼ stall is contaminated                                   | Yes              |
| Third day after substitutions | (day for changing the bedding material IV) |                                               | b) The centre of stall is dirty                                        |                  |
|                           |                 |                                               | c) Detection of urine smell                                           |                  |
|                           |                 |                                               | d) No separation between the bedding material and pure horse faeces   |                  |

107 times per year and bedding material III should be changed 140 times per year (last row in Table 6).

Results calculated for individual horses (Table 7) show that the highest net return is found in the stall with bedding material IV and horse number 7, while the lowest net return is found in the stall with bedding material II and horse number 4. Retail prices of straw can vary depending on the harvest methods. In some studies (such as Teixeira et al. 2013), there is no single harvesting approach. However, the selection and, consequently, the cost of bedding materials depends on the straw farm location. For example, the farm can be in less-favoured agriculture areas, such as high in the mountain-hilly region.

There are apparent differences in the cost of bedding material per horse weight (€/100 kg body weight). A comparison of horse numbers 4 (404.2 kg of body weight) and 7 (473.6 kg of body weight) shows that annual cost differences can amount to €629.49. Cost calculation No. 2 (Table 8) shows that annual savings between bedding materials II and IV is 140.02 €/per horse/year. Across the farm, the total annual savings (assuming the full capacity of 40 horses in the stable) could amount to €5600.08. Furthermore, this will save 0.3 full-time equivalents (FTE), resulting in the gross salary reductions of €1564.49 per month. An interesting result is also the relation between the bedding materials and labour costs in cost structure. Most of the costs in the cases of bedding materials II and IV have been saved with the labour costs, while in the case of bedding material II it was only 29.8%. The inverse is seen in the case of bedding material III: the proportion between bedding material costs and labour costs is 28.6%:71.4%.

The overall ranking of bedding materials according to feasibility analysis results can be divided using three economic parameters (two types of costs and net return). Ranking the materials by bedding material costs, we see that II > IV > I > III, meaning that bedding material costs are highest in case of bedding material II and lowest in bedding material III. The exact opposite is seen ranking by the labour costs (III > I > IV > II). Ranking by the net return, we see that IV > I > III > II, where bedding material IV has the highest net return.

Table 6. Results of testing the durability of bedding materials (Trial 2).

| Date              | Numbers of bedding material and horses in stalls | I          | II         | III        | IV         | Notes                                                                 |
|-------------------|-------------------------------------------------|------------|------------|------------|------------|----------------------------------------------------------------------|
| 8 March 2016      | Starting day (15 kg of bedding materials)       |            |            |            |            |                                                                      |
| 9 March 2016      | 1-A                                             | 3-A        | 4-A        | 2-A        |            |                                                                      |
| 10 March 2016     | 1-A                                             | 3-A        | 4-A        | 2-A        |            |                                                                      |
| 11 March 2016     | 1-A                                             | 3-A        | 4-A        | 2-A        |            |                                                                      |
| 12 March 2016     | 1-B                                             | 3-A        | 4-B        | 2-A        |            |                                                                      |
| 13 March 2016     | 1-B                                             | 3-B        | 4-B        | 2-B        |            |                                                                      |
| 14 March 2016     | 1-B                                             | 3-B        | 4-B        | 2-B        |            |                                                                      |
| 15 March 2016     | 4-C                                             | 3-B        | 1-C        | 2-B        |            |                                                                      |
| 16 March 2016     | 4-C                                             | 2-C        | 1-C        | 3-C        |            |                                                                      |
| 17 March 2016     | 4-C                                             | 2-C        | 3-D        | 3-C        |            |                                                                      |
| 18 March 2016     | 2-D                                             | 2-C        | 3-D        | 3-C        |            |                                                                      |
| 19 March 2016     | 2-D                                             | 4-D        | 3-D        | 1-D        |            |                                                                      |
| 20 March 2016     | 3-E                                             | 4-D        | 2-E        | 1-D        |            |                                                                      |
| 21 March 2016     | 3-E                                             | 4-D        | 2-E        | 4-E        |            |                                                                      |
| 22 March 2016     | 3-E                                             | 4-D        | 4-E        | 4-E        |            |                                                                      |
| 23 March 2016     | 3-E                                             | 4-D        | 4-E        | 4-E        |            |                                                                      |
| 24 March 2016     | 1-E                                             | 1-E        | 4-E        | 4-E        |            |                                                                      |
| 25 March 2016     | 1-E                                             | 1-E        | 4-E        | 4-E        |            |                                                                      |
| Average duration of life-long period (days) | (3 + 3 + 3)/(4 + 3 + 3) = 8/10 = 0.8 | (4 + 3 + 3)/(4 + 3 + 3) = 7/10 = 0.7 | (3 + 3 + 2)/(4 + 3 + 3) = 5/10 = 0.5 | (4 + 3 + 3)/(4 + 3 + 3) = 8/10 = 0.8 | 0.8 |

4. Conclusion

The feasibility analysis based on trial results shows the highest net return for slice-dusted straw and the lowest net return for wood shavings. The squared harvest straw gave a lower net return when compared to slice-dusted straw. The observed results give a clear indication that the highest net return is achieved when the costs of bedding material and labour costs are in equal proportions. According to our results, bedding material costs account for 9–14% of total costs. From an economic point of view, it is possible to enhance the research with a decision-making programme in order to eliminate as many subjective factors as possible in the assessment of the durability.

Slice-dusted straw is currently the best option economically for bedding materials for horses, but alternative bedding
Table 7. Results of cost calculation No. 1 (Trial 1).

| Horse | Unit   | I     | II    | III   | IV    |
|-------|--------|-------|-------|-------|-------|
| TR    | €      | 8.33  | 8.33  | 8.33  | 8.33  |
| NR    | €      | 5.94  | 5.96  | 4.50  | 4.31  |
| Costs of bedding material per horse weight €/100 kg body weight | 0.24 | 0.28 | 0.82 | 0.59 | 0.16 | 0.18 | 0.35 | 0.39 |

Table 8. Results of cost calculation No. 2 (Trial 1 + Trial 2).

| Horse | Unit   | I     | II    | III   | IV    |
|-------|--------|-------|-------|-------|-------|
| TR    | €      | 250.00| 250.00| 250.00| 250.00|
| NR    | €      | 178.27| 178.84| 135.02| 129.34|
| Costs of bedding material per horse weight €/100 kg body weight | 7.08 | 8.40 | 24.62 | 17.74 | 4.91 | 5.43 | 10.63 | 11.60 |

Disclosure statement

No potential conflict of interest was reported by the authors.

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materials (such as cellulose and rice husk) may become more sustainable options in the future as they become more available on the market. However, as we have already discussed in the introduction during the discussion of feasibility, the bedding material farmers should also take into account the equine welfare as an important factor when picking a bedding material.

The results are based on observations made during daily stall management. Therefore, we can assume that they reflect a solution that can be applied to real horse breeding practice. To conclude, we provide some restrictions and recommendations for improving on this experiment:

- for assessing the durability of bedding materials, some chemical and microbiological assessment approaches should be used;
- the ethology of the horses (Kwiatkowska-Stenzel et al. 2016) should also be included in future studies.

In conclusion, the potential limitations of the results presented in this paper can be the differing seasonal availabilities of the material on the market (i.e. sawdust in bulk is easy to obtain in the summer) and differing economic results due to transportation costs being different from farm to farm. In this research, we tried to avoid subjective factors as much as possible with the inclusion of an independent and knowledgeable person in the field (breeder-owner). The equations presented in the study can be used by all horse owners if calculations are modified according to the price and amount of bedding materials and labour costs.
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