

Article

Economic Viability of Alternative Bedding Material in Broiler Chicken Farming

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Abstract: The aim of this paper is to assess the economic viability of two different bedding materials used in broiler chicken farming processes. The materials considered are wood shavings and slice-dedusted straw. The slice-dedusted straw is considered an alternative type of bedding material produced by a company from Slovenia. While the technological and economic assessment of this type of bedding material has already been researched in the case of horse breeding, it is something new in the case of broiler chicken farming. Data collection is structured from two trials. Trial one (T1) is also known as daily observations, and trial two (T2) involves obtaining input data at the end of the fattening period. During T1, daily observations are focused on collecting data from technical characteristics, and in T2, the percentage of death proportions and average increments are observed, calculated, and considered as economic input data. The cost calculation model is used for the calculation of several different technical-economic indicators, which denote the influence of different bedding materials on economic production viability. Favorable economic results were found for slice-dedusted straw, which shows that this kind of alternative bedding material could be the better option.

Keywords: bedding materials; feasibility analysis; broiler chicken; cost calculation model



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1. Introduction

Bedding material has ethological and technological functions within all farming breeding processes, regardless of the type of production. Choosing the best bedding material can lead to a decision-making problem based on both an economic and technological assessment of the material. Many studies have been completed by the veterinary sector, while agricultural and economic aspects remain unexplored. The rapid growth rate in broiler production and the gradual ban of the cage system for layers will mean more litter materials for the poultry industry. Several factors, including unavailability, increased cost, and possible health and safety risks of conventional materials have been the major forces driving research into new bedding materials for commercial poultry [1]. Wood shavings and sawdust are becoming scarce and expensive [2]. In recent decades, we have seen increased research in alternative bedding materials for poultry. Several alternatives to wood by-products have been used with varying outcomes on bird welfare and performance. In view of the differences in the availability of substrates used for bedding materials among regions, reviews summarizing the characteristics of alternative materials, their effectiveness, and major issues would benefit the poultry industry [3]. Several alternative materials have been studied. Rice hulls have been identified as an appropriate litter alternative and are rapidly gaining space in the broiler litter market [3]. Soft wheat straw and rice straw can be used successfully as poultry litter without apparent adverse effects on bird performance or litter quality [4]. Sand has been considered a suitable litter material, resulting in increased body weight and lower coliform and aerobic plate counts [5]. Chopped corn cobs [6], shredded and processed newspaper [7], pelleted newspaper [8], coconut husk [9], coir dust [10],

and refused tea [11] have all been tested and produced results similar to wood or pine shavings. All analyzed bedding materials have similar limitations related to geographic limitation of the origin of raw materials, complex production processes, or economically unjustified usage.

Soft- and hardwood shavings have become increasingly expensive and difficult to obtain as the broiler industry is expanding worldwide, and they are unavailable in some production areas, encouraging researchers to evaluate other litter sources. The purpose of this study is set out in the statement written by authors [3], where they explain that identifying suitable and affordable alternative litter sources is of particular importance in developing countries, as broiler production makes a significant contribution to the livelihoods of small-scale farmers. The objective of the study was to assess the economic viability of sliced and dedusted straw as one of the alternative bedding materials in broiler farming. It is a relatively new material developed by a Slovenian company and is commonly used as bedding material for horses by several big stables in Europe. A more detailed description of this material is set out in the subsection under Material and Methods. The feasibility analysis of this new industry product used in horse breeding has already been discussed in one published paper [12]. The results indicate relevant positive economic reasons of slice-dedusted straw as bedding material for horses. Part of the research [12], which was described as a new and provocative methodology for assessing the durability of bedding material in horse breeding (based on breeders' visual assessments), is also the same approach used in this study for assessing the quality of bedding material in the production of the broiler chickens, based on relevant assessment criteria. The efficiency of a particular bedding substrate is influenced by factors such as particle size, moisture content and build-up, rate of caking, and other physical characteristics [13]. This assessment approach can be very useful in everyday real-life situations when farmers do not use quantitative measurement units.

According to these statements, the relevant research question for this paper pertains to whether this bedding material could be useful in broiler housing and management because the costs of bedding materials present the second-highest cost percentage in the structure of total costs (the first one being feeding costs). We decided to use the same economic methodology (cost calculation model) as in [12], as it is recognized as suitable for the wider applicability of economic analyses. During the literature review [1,14–16], we identified that a common trait of all the alternative options is that their production processes are too expensive and influence the high final price. An understanding of the costs of bedding materials can lead to a reduction in total farm costs.

This paper is structured through several sections, which range from describing the materials and methods to a discussion section, where the authors present important results, which can lead to further research ideas. These results are based on a survey of data collected from a scientific project, which was supported by the Slovenian Agency for Agricultural Markets and Rural Development.

2. Materials and Methods

The experiment was carried out between November 2019 and October 2021. It was part of a research project entitled *“Technological and economic analysis of slice-dedusted straw as bedding material use in different animal production processes”*, financed by the Agency for Agricultural Markets and Rural Development in Slovenia. Two farms were taken into consideration. For a clearer interpretation and to avoid any ambiguity, we named them Farm 1 and Farm 2. The GPS coordinates of Farm 1 are 46°37'57.3" N 15°27'04.2" E and for Farm 2 are 46°17'20.5" N 15°25'26.0" E. The production capacity of Farm 1 is between 100 and 130 broiler chickens, and on Farm 2, the total capacity is between 10,800 and 11,000 broiler chickens during one production/fattening period. To calculate the economic results, it was crucial to take into account different costs (variable costs—such as material costs, costs of purchasing animals, feeding costs, and manual labor costs. The part of fixed costs due to regulating microclimatic conditions was incorporated into material costs),

which can influence the calculation and depend on the level of production (extensive or intensive). We stated the same cost structure for both variants and took into account the factors that could be easily measured by breeders/farmers, which were crucial for creating the cost calculation model.

2.1. Bedding Materials

Two different types of bedding materials were tested. Their characteristics are presented in Table 1. Furthermore, throughout the paper, we use the symbol “I” for wood shavings and “II” for slice-dedusted straw.

Table 1. Characteristics of tested bedding materials.

Type of Bedding Material	Short Description	The Length of Pieces (cm)	Symbol of Bedding Material Use in Article	Price (p) (EUR/kg)
Wood shavings	Transported from a local sawmill	Not relevant	I	0.09
Slice-dedusted straw	Slice-dedusted straw in 25 packages	2.5	II	0.25

The production process for slice-dedusted straw allows for different lengths of fragments. We selected the most common or “standard” length. This type of length does not need additional processing and it is the optimal choice from an economic point of view. All other types, where the lengths of fragments were shorter, were more expensive than EUR 0.25/kg. The input data for slice-dedusted straw were collected by the producing company. The price of bedding material II was calculated from retail prices on the market, while for the bedding material I, the price was calculated as a product between variable costs (taken from [17]) and transportation costs (EUR 1 per km; approximately 10 km distance [18] to the farm). This was the average calculation of transportation costs, which depended on actual fuel prices, type of transportation, and manual labor costs. These costs may vary between countries.

2.2. Broiler Chickens

Broiler chickens of the ROSS 308 provenance were included in the litter testing. The estimated density of inhabited animals did not exceed the norms on minimum conditions for farm animals [19–22]. The animals were bred using technology on deep bedding. Feed and water were available ad libitum. All the animals in the experiment had a complete feed mixture prepared according to the recommendations for the selected Ross 308 provenance [23]. Microclimatic conditions were monitored daily according to recommendations for animal provenance [23,24] (a thermoneutral zone was also provided by [25]). We used a variable program of illumination in hours, ratios of light-L, and darkness-D (23L: 1D, 20L: 4D, 23L: 1D) in accordance with existing legislation [19,20,22]. The weighing of 10% of animals took place at the end of the experiment. During the experiment, we assessed the birth growth, and the final results are presented in Table 2.

Table 2. Growth characteristics of broiler chickens.

Bedding Material	Parameter	Production Type		Sig.
		Intensive (Farm 2)	Extensive (Farm 1)	
Wood shavings (I)	Age (day)	41.00 ± 0.83	43.39 ± 2.42	0.000
	Live weight (g)	2573.50 ± 215.19	2997.44 ± 222.01	0.000
	Carcass weight (slaughtered) (g)	2073.63 ± 140.21	2431.11 ± 202.89	0.000
Slice-dedusted straw (II)	Age (day)	39.33 ± 2.40	44.72 ± 0.70	0.000
	Live weight (g)	2413.33 ± 226.13	3073.43 ± 239.30	0.000
	Carcass weight (slaughtered) (g)	1989.67 ± 142.57	2513.25 ± 239.80	0.000

2.3. Experimental Characteristics

The experiment was structured from two trials, which are separately described in this subsection. The thermo-neutral zone followed the age of the animals so that the temperature at the housing was 30 °C (day 1) and gradually decreased to 21 °C on the 27th day of rearing and remained until the end of the experiment. The relative moisture was 60%.

In total, 11 repetitions of the experiment were performed (6 on Farm 1 and 5 on Farm 2). Three repetitions of the experiment with bedding material I and three repetitions of the experiment with bedding material II were performed on Farm 1. On Farm 2, bedding material I was used three times, and bedding material II was used two times. Considering the same breeding technology and environmental conditions, we tried to provide the same conditions on both farms. Table 3 presents the experimental overall setup data of the investigation. The significant differences between observed animals on Farm 1 and Farm 2 were in the type of intensive production. One of the unique research questions we wanted to address in this research was the difference between the use of tested bedding materials between extensive (Farm 1) and intensive (Farm 2) production types of broiler chickens. Consequently, the number of animals differed between them.

Table 3. Course and experimental setup of the investigation (between November 2019–October 2021).

Trial		No. of Repetitions	Average Daily Observations	No. of Observed Units	Total No. of Observation in Period
1	FARM 1	6	44	6	1584
	FARM 2	5	40	6	1200
No. of Observed Broilers					
2	FARM 1	6	28	4	672
	FARM 2	5	2750	4	55,000

Trial 1: The aim of the first trial was to collect data about technical and cleaning characteristics. These data are described in detail in Table 4. It included collecting data such as the capacity of manual work (measured in time—minutes) connected to preparing bedding material at the start of the experiment, carrying out the mixed bedding material, and preparing/adding the clean bedding material during the experiment. In all repetitions, we started the experiment with the same amount (weight) of new bedding material, which was put into the stall; approximately 5–7 cm of bedding material (Figure 1). Accordingly, we obtained the exact capacity of bedding material, which was used at the start of the experiment (in kg).



Figure 1. The set of wood shavings at the start of the experiment (photo: own source).

Table 4. Observed units through trial 1 and trial 2.

Observed Unit	Number of Trials	Symbol of Units	Unit
Quantity of bedding material used at the beginning of the experiment	1	Q1	Kilograms (kg)
Quantity of new bedding material added during the experiment	1	Q2	Kilograms (kg)
Time spent in preparing the stall for the experiment	1	T1	Minutes (min)
Time spent in mixing the bedding material	1	T2	Minutes (min)
Time spent in adding bedding material	1	T3	Minutes (min)
Amount of feed consumed throughout the experiment	1	F1	Kilograms (kg)
The number of broiler chickens at the start of the experiment	2	A1	No. of animals
The number of broiler chickens at the end of the experiment	2	A2	No. of animals
The average live weight of the broilers at the end of the experiment *	2	W1	Kilograms (kg)
The average weight of the slaughtered broilers at the end of the experiment *	2	W2	Kilograms (kg)

* Data were collected from approximately one-quarter of the population.

Daily observations also included the assessment of bedding materials, which was in the domain of the breeder. During the experiment, researchers developed the assessment protocol (Table 5) and their standards (criteria), which were taken into consideration by the breeders. The protocol assessment tool was a new approach based on choosing the criteria from several literature reviews [26–28]. The protocol provided four quality classes of bedding material dependent on its contamination level. Class 0 was identified at the start of the experiment when the bedding material was uncontaminated (usually started on day 1). Then, classes 1–3 followed, which were dependent on the notes (column 2 in Table 5) about the contamination of the bedding material. When breeders assessed the quality of the bedding material with number 3, a new quantity of bedding material was added, and the assessment of the quality class fell to number 2. This assessment protocol was used in all the repetitions and repeated until the end of the experiment.

Table 5. Example of assessment of bedding material.

Number of Class/Asses	Notes	Status
0	At the start of the experiment (usually stated as day 1)—new bedding material	No activity is needed
1	(a) The mixture process of bedding material can be easily performed (b) The surface of bedding materials is soft (c) No smell of contamination in the bedding material	Daily mixture process
2	(a) The mixture process of bedding material cannot be easily done (b) The surface of bedding materials is soft (c) No smell of contamination in the bedding material	Daily mixture process
3	(a) The mixture process of bedding material cannot be easily performed (b) The epidermis of the bedding material is compacted (c) Detection of the smell of contamination of the bedding material	Add new bedding material

Trial 2: The aim of the second trial was to collect data about the average live weight of the broilers at the end of the experiment and the average body weight of the slaughtered broilers at the end of the experiment. The last one was obtained by the breeders on Farm 1 and from the slaughterhouse in the case of Farm 2. The number of observed animals represented approximately one-quarter of the whole population, and the average amount was calculated for every repetition. Very important input data for additional economic analyses were also provided by the death rate (which was the difference between the number of broiler chickens at the start of the experiment and at the end of it). This will be further discussed in the Results and Discussion section.

2.4. The Structure of the Cost Calculation Model

The economic analysis approach was based on the cost calculation model, which had already been used in a similar study on horses [4] and several other studies [29,30]. The aim of the feasibility analysis was to calculate the economic parameters for identifying which type of bedding material was best from an economic perspective. The calculation was structured from the total income (TI) and total costs (TC). The calculation of TI is presented by Equation (1) and TC with Equation (2). When TI and TC were calculated, we could then calculate the economic parameters such as financial results (FR)—Equation (3) and economic coefficient (EC)—Equation (4).

$$TI = A2 * W2 * MC \quad (1)$$

$$TC = BC + ML + AC + FC \quad (2)$$

where MC is meat price (EUR/kg); BC is bedding material costs (EUR) calculated as “ $(Q1 + SUM(Q2)) * p$ ” (p is the price of bedding material; ML is manual labor costs (EUR) calculated as “ $(T1 + T2 + T3) * hp$ ” (hp is the price per hour [31]); AC is animal costs (EUR) calculated as “ $A1 * ac$ ” (ac is the price of one broiler chicken), and; FC is the feed costs consumed through the experiment (EUR) calculated as “ $F1 * fc$ ” (fc is feed costs). For an explanation of the symbols, see also Table 1.

Finally, two economic parameters were calculated for estimating the economic analysis:

$$FR = TI - TC \quad (3)$$

$$EC = \frac{FR}{TC} \quad (4)$$

The main difference between Farms 1 and 2 was in the stated selling price of meat because Farm 1 presents extensive production and Farm 2 presents intensive production. On Farm 1, all producing capacity was sold locally or through direct food chains, while for Farm 2, the marketing process was more dispersed across multiple marketing channels (local markets, medium and long food chains, direct transport sales, etc.). Accordingly, on Farm 1, the selling price was EUR 3.8/kg meat, while on Farm 2 it was EUR 2/kg meat. It was assumed that, with the lower selling price on Farm 2, some additional costs, which were necessary for successful processing and marketing, were included (e.g., transportation costs; processing costs such as slaughtering costs, packaging costs, and reproduction material costs; promotion costs and others, which have a potential impact on reducing selling costs). Type and costs values were taken from farm cost notes. The calculated selling price from Farm 2 was comparable to other purchase prices in the poultry industry in Slovenia.

3. Results and Discussion

In this section, the final economic calculation results are presented. Table 6 contains the results from Farm 1 and Table 7 contains the results from Farm 2. Economic parameters (such as FR —financial results and EC —economic coefficient) show important data in terms of higher economic justification for the use of slice-dedusted straw (II) in the breeding of broilers. Financial results express the economic viability of production in a dollar value (EUR currency). In the case of Farm 1, it was between EUR 521.81 and EUR 936.27, while in the case of Farm 2, it varied between EUR 15,394.36 and 27,106.42. The economic coefficient expresses the economic justification of production in number values. If the number is below 1, it means that production costs are higher compared to total income (i.e., the farmer has losses). If the number is under 1, it means that production costs are lower compared to total income (i.e., the farmer has a profit). If the EC is 1, it means that production costs are equivalent to the total income (farmers are on “zero”). In the case of Farm 1, the higher value of EC (2.61) was calculated in repetition 5, when sliced-dedusted straw was used. The same sample was recognized in the case of Farm 2—repetition 3, where the EC for

the sliced and dedusted straw was 1.62. This value of *EC* was the higher value for all the repetitions on Farm 2.

Table 6. Calculated economic results for Farm 1.

Farm 1												
	1. Repetition		2. Repetition		3. Repetition		4. Repetition		5. Repetition		6. Repetition	
Bedding material	I		I		II		II		II		I	
Cost calculation structure												
1. Material costs		%		%		%		%		%		%
Bedding material	10.35	2.92	8.64	1.93	12.00	2.77	9.38	2.48	8.63	2.45	3.78	0.97
2. Costs of purchasing animals	67.00	18.87	93.80	20.92	93.80	21.64	80.40	21.24	87.10	24.74	93.80	24.16
4. Feeding costs	167.95	47.30	242.20	54.01	243.96	56.29	209.64	55.38	176.53	50.14	214.55	55.26
5. Manual labor	109.76	30.91	103.79	23.14	83.63	19.30	79.12	20.90	79.83	22.67	76.16	19.61
Total costs (TC)	355.06	100.00	448.42	100.00	433.39	100.00	378.53	100.00	352.09	100.00	388.29	100.00
Economic parameters												
Total income (TI)	876.87		1292.13		1281.63		1109.342		1271.936		1324.566	
Financial results (FR)	521.81		843.71		848.24		730.81		919.84		936.27	
Economic coefficient (EC)	1.47		1.88		1.96		1.93		2.61		2.41	
Death rate	−5.00		−2.14		−1.43		−1.67		−1.54		−3.57	

Table 7. Calculated economic results for Farm 2.

Farm 2											
	1. Repetition		2. Repetition		3. Repetition		4. Repetition		5. Repetition		
Bedding material	I		I		II		II		I		
Cost calculation structure											
1. Material costs											
Bedding material	206.24	1.17	198.18	1.11	520.00	3.12	520.00	3.05	198.00	1.15	
2. Costs of purchasing animals	4280.00	24.36	4480.00	25.20	4352.00	26.08	4480	26.31	4480	25.93	
4. Feeding costs	12,992.00	73.95	13,015.20	73.21	11,727.60	70.29	11,948	70.17	12,516.4	72.45	
5. Manual labor	89.60	0.51	84.37	0.47	85.12	0.51	79.89	0.47	82.43	0.48	
Total costs (TC)	17,567.84	100.00	17,777.75	100.00	16,684.72	100.00	17,027.89	100.00	17,230.69	100.00	
Economic parameters											
Total income (TI)	36,939.24		33,172.12		43,791.14		43,522.82		42,811.69		
Financial results (FR)	19,371.40		15,394.36		27,106.42		26,494.93		25534		
Economic coefficient (EC)	1.10		0.87		1.62		1.56		1.48		
Death rate	−18.04		−30.08		−3.06		−3.96		−4.29		

Although the feeding costs and material costs in most of the analyzed cases are on the side of bedding material I, the costs of manual labor and the proportion of deaths are on the side of bedding material II. If we check the values of the economic coefficient, we find that it's higher in the case of bedding material II. Moreover, an interesting finding is that the volume of production has an impact on the economic results. Higher economic parameters were calculated in the case of a higher animal population. The calculated feeding costs are lower in the intensive production type and the calculated manual labor costs are lower in the case of the extensive production type, both apply in the case of using the sliced-dedusted straw. Other production data investigated that are part of the cost structure are stated in Tables 6 and 7 (first column). The proportion of animal deaths is similar, deviating in a negative direction (in practice, this means a positive economic result) when using bedding material II. The key items show that the use of bedding material II is economically more justified compared to wood shavings.

Table 8 presents the calculated proportions between different types of costs.

The calculated proportion results presented in Table 8 depended on the positive or negative proportion between bedding materials I and II. It can be seen that the costs of bedding material II are higher on both farms (32.33% on Farm 1 and 169.23% on Farm 2). The same calculations were performed for feeding costs, manual labor, and the death rate. If we compare the calculated average values of the economic coefficient, we can see that on Farm 1, it is higher for 13% and in the case of Farm 2, for 38.16% (the positive proportion goes to bedding material II). According to the calculated proportions between the cost structure (Tables 6 and 7), we can see that total income is a crucially important factor in the calculation of the differences between economic coefficients of bedding materials. Furthermore, the crucial component in the calculation of total income is the death rate, which is higher in the case of bedding material I (Table 8). These differences are not so relevant in the case of Farm 1, where the death rate for bedding material I is −3.57%, and in the case of bedding material II, is −1.54%. However, it is enough that the calculated economic coefficient results are higher in the case of bedding material II compared to I.

An interesting finding from the obtained results is the expression of the higher positive economic results in the case of intensive farming processes. The maneuvering space for improving economic results can be recognized in achieving the higher selling price in the case of Farm 2. By changing the selling price in the cost calculation model, we can create numerous simulations. Some of them express that if farmers can improve the selling price to EUR 2.5/kg, then the economic coefficient will be higher by approximately 0.5 points. Moreover, it will be higher by approximately 1 point in the case of the selling price being EUR 3/kg.

Table 8. Calculated proportions between different types of costs on Farms 1 and 2.

Type of the Costs	Farm 1		Farm 2	
	Average Value (Express in %)	Proportion (%)	Average Value (Express in %)	Proportion (%)
Costs of bedding material				
I	1.94		1.15	
II	2.57	32.33	3.09	169.23
Feeding costs				
I	52.19		73.27	
II	53.93	3.35	70.23	−4.33
Manual labor				
I	24.55		0.40	
II	20.95	−17.18	0.49	22.91
Death rate				
I	−3.57		−17.47	
II	−1.54	−131	−3.51	398

4. Conclusions

The results of this survey presented the economic findings, while the technological investigation is still in progress. A future avenue should include the quality of meat in economic assessments. According to these preliminary results of the research project, we can derive some soft but well-stated conclusions connected to economic results. The results demonstrated that using slice-dedusted straw as one of the options of alternative bedding material could have some positive economic influences on extensive and intensive production types of broiler chickens, depending on breeders' assessment techniques (the subjective factor of the breeder is included). The positive options for improving the economic results of the farms also exist in exploiting the lower death rate of animals in the case of slice-dedusted straw, while it depends on various aspects, such as housing, management, and chicken strain.

According to the statements from the last paragraph in the Results and Discussion section, a further challenge for investigation also exists in introducing a new methodological approach, such as an econometric modeling approach, with the aim of calculating elasticities values. With these kinds of calculations, researchers can investigate the movements of profit related to the change in cost values. The same methodological approach was already used by [32].

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References

1. Diarra, S.; Lameta, S.; Amosa, F.; Anand, S. Alternative Bedding materials for poultry: Availability, efficacy and major constraints. *Front. Vet. Sci.* **2021**, *8*, 669504. [\[CrossRef\]](#) [\[PubMed\]](#)
2. Garcês, A.; Afonso, S.M.S.; Chilundo, A.; Jairoce, C.T.S. Evaluation of different litter materials for broiler production in a hot and humid environment: Litter characteristics and quality. *J. Appl. Poult. Res.* **2013**, *22*, 168–176. [\[CrossRef\]](#)
3. Paz, I.C.L.A.; Garcia, R.G.; Bernardi, R.; Nääs, I.A.; Caldara, F.R.; Freitas, L.W. Selecting appropriate bedding to reduce locomotion problems in broilers. *Brazil. J. Poult. Sci.* **2010**, *12*, 189–195.
4. Benabdeljelil, K.; Ayachi, A. Evaluation of alternative litter material for poultry. *J. Appl. Poult. Res.* **1996**, *5*, 203–205. [\[CrossRef\]](#)
5. Bilgili, S.E.; Montenegro, G.I.; Hess, J.B.; Eckman, M.K. Sand as litter for rearing broiler chickens. *J. Appl. Poult. Res.* **1999**, *8*, 345–351. [\[CrossRef\]](#)
6. Avila, V.S.; Oliveira, U.; Figueiredo, E.A.P.; Costa, C.A.F.; Abreu, V.M.N.; Rosa, P.S. Avaliação de materiais alternativos em substituição à maravalha como cama de aviário. *Bras. J. Anim. Sci.* **2008**, *37*, 273–277. [\[CrossRef\]](#)
7. Malone, G.W.; Allen, P.H.; Chaloupa, G.W.; Ritter, W.F. Recycled paper products as broiler litter. *Poult. Sci.* **1982**, *61*, 2161–2165. [\[CrossRef\]](#)
8. Malone, G.W.; Gedamu, N. Pelleted newspaper as a broiler litter material. *J. Appl. Poult. Res.* **1995**, *4*, 49–54. [\[CrossRef\]](#)
9. Huang, Y.; Yoo, J.S.; Kim, H.J.; Wang, Y.; Chen, Y.J.; Cho, J.H.; Kim, H. Effect of bedding types and different nutrient densities on growth performance, visceral organ weight, and blood characteristics in broiler chickens. *J. Appl. Poult. Res.* **2009**, *18*, 1–7. [\[CrossRef\]](#)
10. Swain, B.K.; Sundaram, R.N.S. Effect of different types of litter material for rearing broilers. *Br. Poult. Sci.* **2000**, *41*, 261–262. [\[CrossRef\]](#) [\[PubMed\]](#)
11. Atapattu, N.S.B.M.; Wickramasinghe, K.P. The use of refused tea as a litter material for broiler chickens. *Poult. Sci.* **2007**, *86*, 968–972. [\[CrossRef\]](#) [\[PubMed\]](#)
12. Prišenk, J.; Turk, J.; Rozman, Č.; Pažek, K.; Janžekovič, M. Feasibility analysis of different bedding materials for horses. *J. Appl. Anim. Res.* **2017**, *46*, 798–803. [\[CrossRef\]](#)
13. Brake, J.D.; Boyle, C.R.; Chamblee, T.N.; Schultz, C.D.; Peebles, E.D. Evaluation of the chemical and physical properties of hardwood bark used as a broiler litter material. *Poult. Sci.* **1992**, *71*, 467–472. [\[CrossRef\]](#)
14. Teixeira, A.S.; de Oliveira, M.C.; Menezes, J.F.; Gouvea, B.M.; Teixeira, S.R.; Gomes, A.R. Poultry litter of wood shavings and/or sugarcane bagasse: Animal performance and bed quality. *Rev. Colomb. Cienc. Pecu.* **2015**, *28*, 238–246. [\[CrossRef\]](#)
15. Burke, G.B.; Pescatore, A.J.; Cantor, A.H.; Straw, M.L.; Xiangbai, H.; Johnson, T.H. Newspaper as litter material and its effects on the performance of broilers. *J. Appl. Poult. Res.* **1993**, *2*, 154–158. [\[CrossRef\]](#)
16. Lien, R.J.; Hess, J.B.; Conner, D.E.; Wood, C.W.; Shelby, R.A. Peanut hulls as a litter source for broiler breeder replacement pullets. *Poult. Sci.* **1998**, *77*, 41–46. [\[CrossRef\]](#) [\[PubMed\]](#)
17. Jerič, D. *Calculations Catalogue for Management Planning on Farms in Slovenia (CMPS)*; Jerič, D., Ed.; Chamber of Agriculture and Forestry of Slovenia: Ljubljana, Slovenia, 2011.
18. Angelovski, B.; Križman, A. *Tariff System and Calculations*; Ministry for Education and Sport, Republic of Slovenia: Ljubljana, Slovenia, 2009; p. 113.
19. Directive/43/ES; Directive Laying Down Minimum Rules for the Protection of Chickens Kept for Meat Production. Council directive 2007/43/ES. EU: Brussels, Belgium, 2007; pp. 19–28.
20. UL RS št 51/2010; Rules on the Protection of Livestock. Regulation. Ministry of Agriculture, Forestry and Food: Ljubljana, Slovenia, 2010; pp. 1–18.
21. UL RS, št 37/2013; Rules on the Conditions for Conducting Experiments on Animals. Regulation. Ministry of Agriculture, Forestry and Food: Ljubljana, Slovenia, 2013; pp. 1–22.
22. UL RS, št 38/2013; Animal Protection Act (Official Consolidated Text) (ZZZiv-UPB3). Ministry of Agriculture, Forestry and Food: Ljubljana, Slovenia, 2013; pp. 1–12.
23. Aviagen. *Broiler Management Handbook*; ROSS Aviagen: Huntsville, AL, USA, 2014; pp. 1–132.
24. De Jong, I.; Van Harn, J. *Management Tools to Reduce Footpad Dermatitis in Broilers*; Aviagen, V., Ed.; AviaTech, Wageningen Livestock Research: Wageningen, The Netherlands, 2012; pp. 1–26.
25. Purswell, J.L.; Dozier, I.I.I.W.A.; Olanrewaju, H.A.; Davis, J.D.; Xin, H.; Gates, R.S. Effect of temperature-humidity index on live performance in broiler chickens grown from 49 to 63 days of age. In Proceedings of the 2012 IX International Livestock Environment Symposium (ILES IX), Valencia, Spain, 8–12 July 2012; pp. 1–9.
26. Snell, W.; Atherton, N. *The Economic Value of Applying Broiler Litter in the Fall*; Economic & Policy Update, USA: Lexington, KY, USA, 2020; p. 20.

27. Jeswani, H.K.; Whiting, A.; Martin, A.; Azapagic, A. Environmental and economic sustainability of poultry litter gasification for electricity and heat generation. *Waste Manag.* **2019**, *95*, 182–191. [[CrossRef](#)] [[PubMed](#)]
28. Van Horne, P.L.M. Economics of Broiler Production Systems in The Netherlands. Available online: <https://www.wur.nl/en/show/Report-Economics-of-broiler-production-systems-in-the-Netherlands.htm> (accessed on 10 January 2022).
29. Pažek, K.; Rozman, Č. Business opportunity assessment in Slovene organic spelt processing: Application of real options model. *Renew. Agric. Food Syst.* **2011**, *26*, 179–184. [[CrossRef](#)]
30. Raineri, C.; Stivari, T.S.S.; Gameiro, A.H. Development of a cost calculation model and cost index for sheep production. *Rev. Bras. Zootec.* **2015**, *44*, 443–455. [[CrossRef](#)]
31. SI-STAT. Statistical Office of Republica of Slovenia. 2022. Available online: <https://www.stat.si/StatWeb/Field/Index/15/74> (accessed on 4 January 2022).
32. Heidari, M.D.; Omid, M.; Akram, A. Energy efficiency and econometric analysis of broiler production farms. *Energy* **2011**, *36*, 6536–6541. [[CrossRef](#)]