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THE IMPACT OF SHEEP WASTE WOOL ON THE ENVIRONMENT

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Abstract

The present study focuses on the impact of sheeps' wool on the environment if it becomes waste. Wool is a keratin-rich by-product that is resistant to degradation, and appropriate management plans for this type of waste should be carefully considered. Some studies consider hydrolyzation of wool, but these processes are implying the use of harsh chemicals for the environment. Therefore, different methods for the valorization of wool waste refer to composting, obtaining fertilizers for using them in agriculture, producing cosmetics, or for thermally-isolating of houses. Special attention is paid to the extraction of keratin from wool, as this is the most valuable by-product resulting from the process of sheep shearing.

***Key words**: waste wool, environmental pollution, valorisation, wool keratin, extraction.*

INTRODUCTION

The agricultural economy, today, includes a variety of applied fields, with considerable overlap with the conventional economy, and have an important role in the optimization of the production of food and fiber, as well as in their distribution.

Recently, this research area has registered substantial contributions in economics, econometrics, development economics, and environmental economics while influencing food policy, agricultural policy, and environmental policy.

Scientists in this field have shown that meat consumption is an important source of protein in the human diet, and the prefered is poultry and pig meats, followed by bovine and sheep meats (Montossi et al., 2013).

Compared to other animal species, the costs associated with raising sheep are not necessarily related to the price of fodder crops, such as maize, soybeans, and cereals.

Therefore, independent producers, including family businesses with limited resources, can focus on sheep production. These small businesses are advantageous for raising sheep, as the sheep industry is one of the few types of animal economic agriculture that has not been included in the vertical agro-industry (Montossi et al., 2013; Petek & Marinšek Logar, 2020).

From ancient times, all over the world, the sheep were grown for multiple resources, such as meat, milk, wool, as well as for the obtaining of leather goods. Therefore, it can be considered that the existing species of sheep are multipurpose animals (Erdogan, Seki & Selli, 2020). Sheep also play an important role in many local economies, some of which are focused on organic or sustainable agriculture (Erdogan et al., 2020; Väntsi & Kärki, 2013).

Domestic sheep are relatively small ruminants, which offer a wide range of raw materials, wool being the most widely used and widespread since old times. Especially in developing countries, such herds can become part of subsistence farming.

The life expectancy of a domestic sheep is about 12 years, but only about half of its life can be considered productive because a sheep's productivity usually reaches its peak between the ages of 3 and 6 and begins to decrease after the age of seven (Allafi et al., 2020; Väntsi & Kärki, 2013).

As mentioned previously, wool represents a resource that can be further exploited during the growth of the sheep. This is produced by the small cells located in the skin, called follicles. These cells are located in the upper layer of the skin called the epidermis and push down into the second layer of skin called the dermis, as the wool fibers grow.

Annually, a sheep produces 900 grams to 13.5 kilograms of wool, but this amount depends on breed, genetics, nutrition, and sheer range.

Globally, wool is collected from about 90% of raw wool-producing sheep.
Lambs produce less wool than mature animals. On the other hand, due to their larger size, the amount of wool produced by rams is higher than of the sheep of the same breed or type (Maier, Rajabinejad, & Buciscanu, 2019).
Merino sheep produce most of the world's wool and makeup about a third of the sheep population. Their wool is of high quality, whose fibers are so fine that five strands of them are equal to the width of a human hair.
Nowadays, wool is considered as a by-product of the sheep farm, not only because of its low quality but also because of low prices. As a consequence, wool is incinerated, dumped or sent to landfills. All these practices are impacting the environment and are not sustainable (Montossi et al., 2013).
Recently, several scientific studies are focusing on the improvement of the properties of wool (Assefi Pour et al., 2020; Wang, Shen, & Xu, 2012; Zhang, Millington, & Wang, 2009; Zhou et al., 2020), or on the valorization of this keratin-rich waste (Perta-Crisan, Ursachi, Gavrilas, Oancea, & Munteanu, 2021).
The present study has in attention the evaluation of the impact on the environment of wool, as a by-product, and to identify possibilities of valorization of wool waste.

MATERIALS AND METHODS

For the purpose of the paper, the collected data from the statistical program on the Knoema website (https://knoema.com/) was analysed for evaluating the impact of sheep waste wool on the environment.
The data refers to information on global, European, and Romanian sheep and wool production.
After data collection, the analysis was performed and the impact on the environment was evaluated.
The data analysis and graphs preparation were performed using Microsoft Excel software.

RESULTS AND DISCUSSIONS

European Union has the second-highest world population of sheep. According to the recent statistics collected, it is shown that in 2019 the global sheep production was 1,238,719,591 (Figure 1).

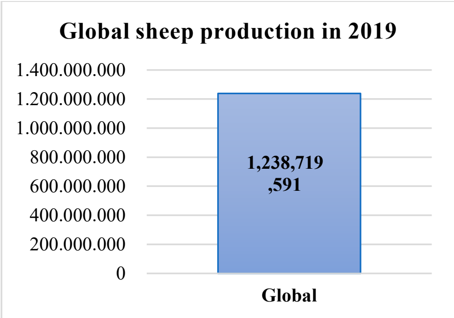

Figure 1. Global sheep production 2019

Table 1 presents the global sheep production from 2019 in comparison to the one in Europe. As observed from the data in Table 1, European sheep production is about 10% of the global sheep production.

Table 1. Global sheep production in 2019

Country	Unit	2019
Global	Global sheep production	1,238,719,591
Europe	Sheep production	127,912,209

Figure 2, presents the sheep production in 2019, and the percentage for European countries.
As shown in Table 2, it can be concluded that the Romanian sheep production stands for about 8% compared to the European one.
Besides the sheep production, the data for the production of wool were also collected and are shown in Table 3. The amount is expressed in tons and is representative for the year 2019, except for Romania, for which the latest reported information on wool is from 2012 (marked with an asterisk,*), in Table 3.

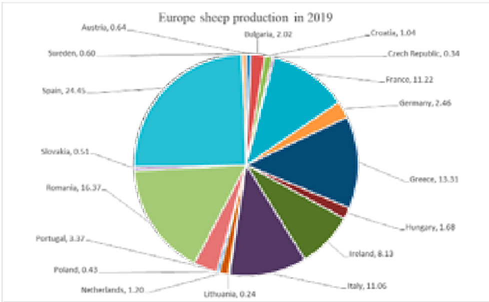

Figure 2. Europe sheep production in 2019

Table 2. Romania sheep production in 2019

Country	Unit	2019
Romania	Sheep production	10,358,700

Table 3. Global, European and Romanian wool production

Country	Amount, Tons
Global	1,719,876
Europe	138,161
Romania	19,713*

Figure 3 shows the percentage of wool produced in different European countries in 2019. Spain ranks first, with 22.87% of the wool produced, followed by Ireland with 14.48%, France 14.33%, Germany 12.45%, Greece 7.42%, Italy 7.28%.

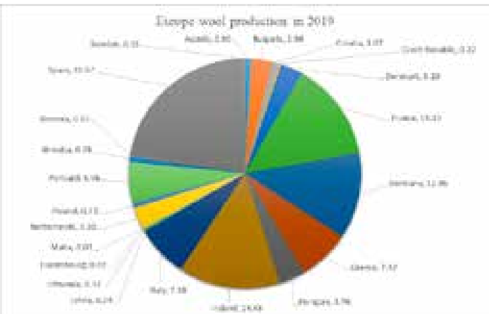

Figure 3. Europe wool production in 2019

As already mentioned, unfortunately, the latest statistics for wool production in Romania were recorded until 2012, because only until that year was the wool production in Romania registered on the Knoema website, but we are convinced that the wool production in the country remained almost unchanged and from 2012 to the present.

The sheep wool as waste

Wool waste management is a problem related to sheep farming, as the main role of sheep is meat production, sheep are cross-bred that are not classified for the production of fine wool (Petek & Marinšek Logar, 2020).

Every year, huge amounts of unused wool are thrown away, incinerated, or simply due to poor legislation, remains on the ground, becoming an environmental pollutant.

Among other solid wastes, wool waste is of growing concern due to the huge volumes accumulated and the difficulties in finding solutions for their efficient management.

Raw wool is sheared wool from sheep, which is the most problematic waste. World crude wool production can only be estimated based on the number of sheep.

Following the waste management terminology, some comments should be made on terms such as by-product, co-product, waste, all of them referring to sheared wool (Eslahi, Dadashian, & Nejad, 2013).

Recent studies on major agro-ecological areas have shown significant differences depending on sheep breed and wool grade.

Table 4. Relationships between the sheep and wool production, data for 2019

Country	Unit	2019
Global	Global sheep production	1,238,719,591
	Total wool produced	1,719,876
	Wool - used	1,032,000
	Wool - waste	688,000

For example, in 2019, the world sheep production was 1,238,719,591 pieces, and the world wool production was 1,719,876 tons, as shown in Table 4.

Huge amounts of organic waste and by-products are generated every year. Waste from the wool textile industry (poor quality raw wool, unsuitable for spinning), is rich in collagen, elastin, and keratin and must be properly managed.

From recent scientific studies, the world wool production annually records enormous amounts of wool fiber (Erdogan et al., 2020; Johnson, Wood, Ingham, McNeil, & McFarlane, 2003; Petek & Marinšek Logar, 2020; Väntsi & Kärki, 2013).

Of this total, between 50-60% is used in the textile industry, depending on the needs and requirements of each factory. The remaining wool is waste.
This problem has become more and more serious for the environment, as sheep wool has become an increasingly serious environmental pollutant (Johnson et al., 2003).

Figure 4. Produced, used and wasted wool, in 2019

This aspect must be taken into account by as many people as possible because the pollution of the environment with wool has become an increasingly worrying aspect, as it pollutes the water, the soil, and the natural decomposition of wool is very difficult to accomplish.
Taking action without consulting a legal basis can have considerable consequences, as in the absence of essential information on how to protect the environment from certain factors that pollute nature, the taken consequences can lead to very complicated situations.
To help minimize the degree of pollution of the three main components of the environment, soil, water, air, there are regulations of the European Commission, which specify in detail the procedures for disposal and use of Category 3 materials, wool being one of the materials of the category specified above.
The current situation is in the context of European regulations with EC Regulation 1069 (2009), ("Commission Regulation (EU) No 142/2011 of 25 February 2011 implementing Regulation (EC) No 1069/2009 of the European Parliament and of the Council Laying Down Health Rules as Regards Animal by Products and Derived Products not Intended for Human Consumption and Implementing Council Directive 97/78/EC as Regards Certain Samples and Items Exempt from Veterinary Checks at the Border under that Directive Text with EEA relevance. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32011R0142," ; "European Commission. Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 Laying down Health Rules as Regards Animal by-Products and Derived Products not Intended for Human Consumption and Repealing Regulation (EC) No 1774/2002 (Animal by-Products Regulation); European Commission: Brussels, Belgium, 2009. Available online: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009R1069,").
According to EC Regulation 1069 (2009) Category 3 materials, including wool, must be disposed of as follows:

(a) considered for incineration;

(b) thrown away or renewed by co-incineration;

(c) dumped in an approved landfill after processing;

(d) processed, unless the Category 3 material has been altered by decomposition or deterioration to present an unacceptable risk to public or animal health, through the product concerned, and used:

(e) converted to compost or biogas;

(f) processing to make fertilizers;

(g) field application as fertilizer;

(h) cosmetics.

Following the regulations on safe disposal, wool can not be buried in a farm warehouse or incinerated without authorities' permission.
If unused wool does not become waste according to Regulation (EU) NO. Commission Regulation (EC) No 142/2011 ("Commission Regulation (EU) No 142/2011 of 25 February 2011 implementing Regulation (EC) No 1069/2009 of the European Parliament and of the Council Laying Down Health Rules as Regards Animal by Products and Derived Products not Intended for Human Consumption and Implementing Council Directive 97/78/EC as Regards Certain Samples and Items Exempt from Veterinary Checks at the Border under that Directive Text with EEA relevance. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32011R0142,"), the wool may be transited under the following conditions:

(a) enclosed in safe and dry packaging and

(b) sent directly to a plant producing derived used outside the food chain, animal, or to a facility carrying out intermediate operations, under conditions that prevent the spread of pathogens.

If the necessary measures are not taken this situation is a significant problem for the environment because in the long-term affects the ecosystem, the animals, the air, the ground, and all the important structures (Allafi et al., 2020).

Our future studies will focus on the valorization of wool, for the extraction of the keratin. Keratin is the most valuable by-product of sheep shearing. According to the etymology, keratin comes from the Greek language, from the word, *"Keras"* (genitive *Keratos*) which means *"horn"* and the meaning of this word refers to the hard tissues in animals, and the first spelling and formulations were around in the 1850s (Chaitanya Reddy et al., 2021).

Regarding the structure of the wool fiber, the basic substance contained in defatted wool of about 95% keratin and 5% water (Perta-Crisan et al., 2021).

With such a high content of keratin, it is necessary to point out that the dumping of wool will finally lead to the dermatophytes development that has an impact on human health (Anbu, Hilda, & Gopinath, 2004).

Keratin is seen as three-dimensional polymers interconnected by the intermolecular bonds of the amino acid cysteine disulfide and the inter- and intramolecular bonds of nonpolar and polar amino acids, which are responsible for their high stability and distinctive physical properties.

Two main directions have been developed to add value to wool waste, in applications that exploit the properties of the native fiber and in applications that use the keratin biopolymer, extracted from fibers through different methods, but the most valuable should be considered the ones with minimal impact on the environment.

Protein waste, from by-products of the wool textile industry, agricultural sources, poor quality raw wool, hair, and feathers unsuitable for spinning, are important sustainable resources.

Due to their biodegradability and biocompatibility, the recovery of these extremely accessible and inexpensive protein sources, as well as the development of methods for extracting keratin from this waste have been the focus of many studies (Allafi et al., 2020).

Therefore, in recent years, there has been great interest in developing new applications of keratin extract in various fields such as innovative products, biomedical applications, getting and use of fertilizers, environmental applications, cosmetics, biodegradable composites, compostable packaging, medical membranes, and agricultural films, etc.

CONCLUSIONS

Every year, the amount of unused wool is very high, resulting in it being dumped, burned, buried or simply left on the ground, water or landfills, polluting the environment due to inefficient legislation.

Among other solid waste, wool waste has attracted more and more attention due to the accumulation and difficulties in finding efficient management solutions. As it is impossible to avoid waste and is improbable to be minimized considering the population growth, reuse and recycling are still the most viable options for keratinous waste management.

Wool waste will inevitably be produced, which demands the search for a reasonable and cost-effective solution for the management and recycling of solid waste, with social and environmental benefits.

A promising alternative for the valorization of wool is keratin extraction, but of major importance is the use of eco-friendly methods for its extraction. The development of such methods for the valorisation of keratin might open new perspectives for the obtaining of new materials with applications in different industries.

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