Development of an Improved Technology to Increase Production Efficiency in the Sericulture Farm

Vasilică Savu[1]*, Agripina Şapcaliu[1], Melania Andrei[1], Adela Ramona Moise[2], Silvia Pătruică[3]

[1]*Research Station for Sericulture Băneasa-București, 013685 Bucharest, Romania*
[2]*University of Agricultural Sciences and Veterinary Medicine, 400372 Cluj-Napoca, Romania*
[3]*University of Life Sciences from Timișoara, 300645, Timișoara, Romania*

Abstract
The developing process of a technology with the potential to increase efficiency in a sericulture farm represents one of the most important levers in the efficient exploitation of silkworms and mulberry (*Bombyx mori*). The development of an optimized technology, with the aim of making the activities carried out in a sericulture farm more efficient, is the main objective of this study. At the same time, the concept of "*Pharma-Farming*" is being explored, which promotes an integrated and sustainable approach in the management of sericulture farms by integrating sericulture and moriculture products and by-products. The use of the principles underlying the "*Pharma-Farming*" system could contribute to optimizing integrated processes and increasing the performance and sustainability of this agricultural sector. The integration of by-products obtained during the rearing of silkworms can represent a valuable opportunity not only to increase farmers' incomes through product diversification, but also to improve the quality of life. Exploring this concept facilitates the integration of by-products obtained from the sericulture farm into the pharmaceutical production chain, contributing to the creation of an additional source of raw materials and promoting a circular and sustainable economy. This research is carried out in a collaboration between three partners with expertise in the field of sericulture, and uses the resources of each to successfully address the development and implementation of the technology in different areas of Romania.

Keywords: sericulture technology, *Bombyx mori*, *Pharma-Farming*

1. Introduction

The rearing of silkworms can be done throughout the mulberry vegetation if the appropriate technology is applied to the intensive plantation [1] in order to obtain good quality leaf for the larvae's food throughout the season and if the appropriate environmental conditions are ensured in the growing spaces for all series of silkworms [2, 3]. The most favourable conditions for the growth of silkworms in the conditions of our country is the end of spring, and in the summer-autumn season greater attention is required in terms of procuring quality leaves and achieving the temperature and humidity necessary for the development of the larvae in the growing spaces. At the beginning of spring, a generally rainy season in the last part of the growth, is unfavourable for the larvae, because the air humidity in the growth rooms increases too much, and in the summer season [4], the drought with temperatures above 25°C and the humidity below 60% predispose the larvae to disease. Obtaining large productions of donuts depends primarily on the conditions in which the larvae were raised in the first instars [5], so that they enter vigorous in the old ages and resist in the event of the intervention of less favourable conditions [6, 7].
Rearing silkworms is a complex process and requires a deep understanding of the needs and

*Corresponding author: Sapcaliu Agripina, 0755115819, sapcaliuagripina@yahoo.com

behavior of these insects, but also of environmental factors and available technologies [3]. Silkworm rearing has been practiced for millennia and continues to be a particularly important activity in the textile industry and economies of many countries around the world [8]. This is due not only to the quality of the silk produced, but also to the positive impact it has on local communities, providing jobs and supporting cultural traditions [9]. That is why the technology of growing larvae in the first three ages (L1-L3) and their growth in the last two ages (L4-L5) will be treated separately [2].

The technology of rearing silkworms differs depending on the stage of development in the biological cycle (eggs, larvae, chrysalis, adult). Silkworm eggs are incubated centrally in specially designed rooms [10], where optimal temperature and humidity conditions are ensured in order to obtain vigorous larvae (https://fzb.usamvcluj.ro). The hatched larvae are transported in specially designed places, where temperature, humidity and darkness conditions are ensured to avoid stressing the larvae [11]. Silkworm breeders must have the grow room ready, ensuring temperatures of 25-26°C at the time of receiving the seed. Immediately after receiving the incubation boxes, the litter is removed, and chopped leaves are sprinkled on top of the perforated paper in the incubation box, so that the larvae then settle on the growth racks [12, 13].

The aim of this work is to explore an improved silkworm rearing technology starting with the 2024 season. The focus is especially on the initial stages of their life cycle, from eggs to young larvae (L1-L3), then to adult larvae (L4-L5) and to adults (butterflies), accompanied by hygiene measures and examinations specific sanitary-veterinary measures for each growth cycle, with the aim of ensuring the health of the silkworms. At these critical stages, proper care is essential for healthy development of silkworms, obtaining healthy genetic material and production of high-quality silk [14]. Through this paper, some essential aspects of an improved technology for rearing young silkworm larvae are specified (care environment, food and nutrition, space and disease management [15, 16] also analysing the importance of each aspect in the rearing process of silkworms and their impact on the final silk production. Through a deep understanding of these aspects and the associated technologies, researchers and producers involved can contribute to optimizing the silkworm rearing process and improving existing practices, thus leading to more efficient and sustainable silk production on silkworm farms.

The evolutionary cycle and morpho-physiology of the silkworm [Figure 1]

The mulberry silkworm (*Bombyx mori L.*) is part of the class of insects, order *Lepidoptera*, being the only domestic species in the large family of *Bombycidae*, which counts over 70 species. The development cycle is characteristic of insects with complete metamorphosis, successively passing through the 4 typical stages: egg, larva (caterpillar), chrysalis (cocoon) and butterfly. Each developmental stage has specific peculiarities, dependent both on the influences from the external environment and on the functioning of the neuroendocrine systems, which trigger and regulate all these processes [17]. Silkworms with only one complete development cycle per year are called monovoltine, and those in which this biological cycle repeats 2-3 times or even more times a year are called: bi-, tri-or polyvoltine [18, 19].

The fertilized egg or seed represents the first stage in the evolutionary cycle of the butterfly. It has an oval shape, being slightly flattened, of variable size and weight, depending on the species, the feeding method of the parental generation as well as the period in which they were deposited. The weight of an egg is 0.5-0.8 mg and the longitudinal diameter is 1.5 mm. One gram of seed can contain up to 2000-2500 eggs. After fertilization, the colour of the eggs becomes yellow-orange, then pink, and in an interval of 3-4 days it becomes grey, of different shades depending on the breed. Immediately after laying by the female butterfly, the colour of the egg is light yellow (lemon yellow) [20, 21, 22, 23, 24].

The larva - the silkworm, has 5 growth phases of certain ages - which are separated by 4 sleep periods at the end of which the larva changes its integument, i.e. it moults. Upon hatching, the larvae are black and covered with fine and numerous hairs. In relation to the length of the body, the head is small and has some shine [25, 26]. Although the newly hatched larvae can live without food for 2-3 days [27], it is much better that when they emerge, they find fresh mulberry leaves nearby; the smell of these leaves quickly attracts their attention. Usually, newly hatched

larvae are agile, move easily and have a large appetite. [5]. If they are well fed, they grow quickly and in a period of 30-32 days they become about 10,000 times larger than at hatching, being able to have a length of 9-10 cm [5].
The chrysalis (nymph or pupa) is the third stage of the silkworm's biological cycle. Its formation begins 3 days after the mature larva spun the cocoon. In this phase, it gradually loses its mobility, remaining motionless, with its body reduced and tight near the insertion of the rings, causing a spindle-shaped appearance. A fifth moult is produced, which takes place right inside the cocoon. The chrysalis reaches full maturity in about 10-15 days. At low temperature, the moth formation process takes place more slowly, prolonging the chrysalis stage. A chrysalis weighs on average 1.5-2g, and contains nutrients (proteins, lipids, carbohydrates), so it can be attacked by mice, domestic animals, etc. [25, 26].
The butterfly represents the last evolutionary stage of the silkworm, being short-lived, but of vital importance, because it is the period when the female is fertilized and lays eggs, so that the seed appears, which will perpetuate the species. Immediately after emerging from the cocoons, differences can be observed: some move faster, are livelier, have a thinner body and are always moving their wings, these are the male butterflies. Females are more voluminous, have larger abdomens, have slower movements or almost do not move at all. The presence of eggs in the body of the female determines the development of her abdomen [25, 26].

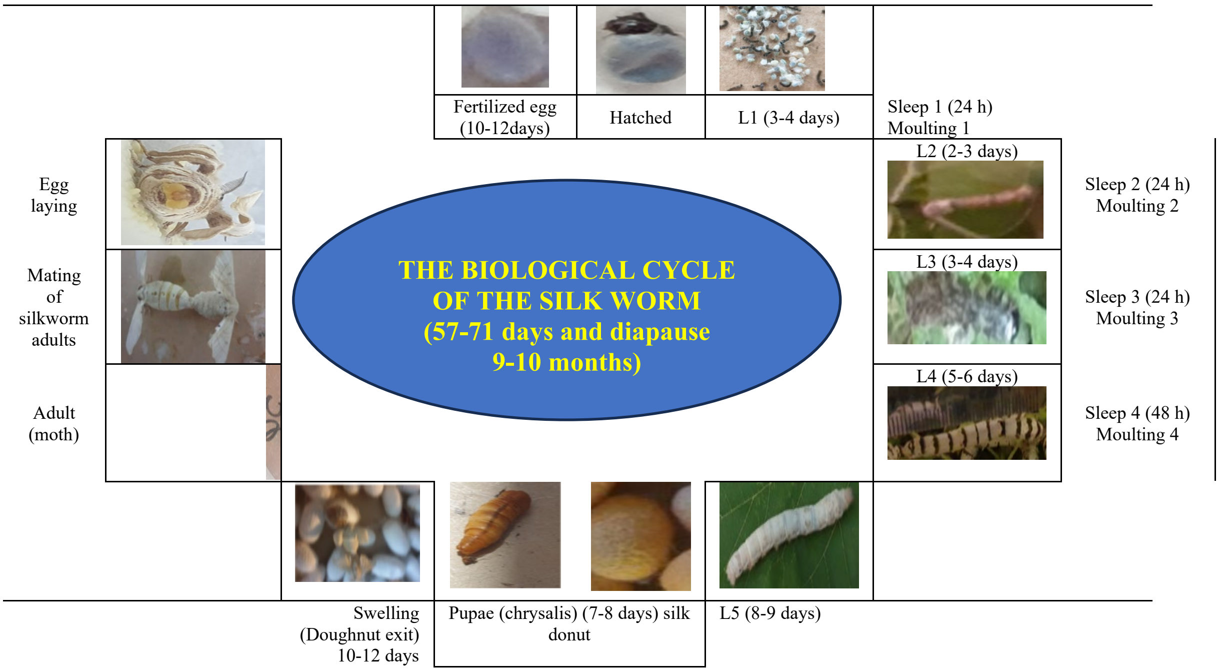

Figure 1. The biological cycle of the silkworm

2. Materials and methods

In the 2023 sericulture season, at the Sericulture Research Station in Băneasa, Bucharest, investigations were carried out in order to improve a technology aimed at increasing the efficiency of a sericulture farm, in collaboration with partners from USAMV Cluj and USAMV Timișoara.
The improved technology was tested in two strains of monovoltine silkworms (RG90, B75), selected for use in basic science research needed to elucidate the genetic, physiological and biochemical mechanisms of silk secretion, disease resistance, food utilization and physiology reproduction. The breeds included in the study were selected according to the high degree of adaptability to the environmental conditions of our country, and the technological testing involved the evaluation of performance, functionality and reliability in various scenarios and conditions of our country. The optimized technology focused in particular on the essential stages of growth, such as *Bombyx mori* egg incubation, hatching, L1-L5 larval growth, feeding, and finally silkworm

harvesting and sorting, but also on the importance of sanitary-veterinary exam in ensuring the health of silkworms.

The breeding and reproduction of silkworms was done following the specific rules of this zootechnical branch, quite demanding technology, and from a technical point of view it requires special attention. In the process of growing silkworms, there are a large number of stages, each requiring specific activities. An important stage was the organization of egg production, but also the prevention and combating of silkworm diseases [27]. The correct management of the factors that lead to obtaining an increased percentage of hatching ensured a large number of larvae with the same possibilities of going through the larval stage and of simultaneous cocoon forming.

The development of an efficient exploitation technology of the sericulture farm was based on increasing the performance and sustainability of the family sericulture farms by adopting and implementing the *Pharma-farming* concept and identifying the main secondary products of high biological value from the family sericulture farm in the Pharma-Farming system (1).

2.1. Biological material

The improved technology was tested using two strains of monovoltine silkworms (RG90 and B75), representing the biological material. The morphological characteristics of the two breeds are close, with the laying of eggs containing a large number of grey-green eggs, the yellow chorion. The larva is white, without larval markings, and the cocoon is oval, without a belt. The growth of the larvae is uniform, in the situation where optimal care conditions are ensured. The cocoon forming rate is very fast, which means that in the first 24 hours after the appearance of the first signs, more than 90% of the larvae spin the cocoon. The cocoons are oval, unbelted and has a good ability to combine with other breeds, reacting accordingly, both in the form of maternal and paternal parents.

2.1.1. RG 90 breed

The RG 90 breed comes from Romania and was obtained in 2002 by the fusion of the yellow cocoon breed "Galben Centurat Băneasa" and the white cocoon breed "S8".

2.1.2. B75 breed (Băneasa 75)

B75 (Baneasa 75) is a breed selected in Romania between 1970-1975, based on breeds from China.

2.1.3. Other breeds targeted for experimental implementation of improved technology

The improved technology is to be tested in the active 2024 breeding season on other monovoltine (AO33, GBC) and bivoltine (JH3, AJ17) breeds.

2.2. Description of the improved breeding technology applied to the breeds under study

2.2.1. Bombyx mori egg incubation technology

Egg incubation was one of the essential steps in the silk production process, having a significant impact on the quality and quantity of future silkworm production. Correct incubation of the eggs of the silkworm species of interest is crucial to obtaining an optimal number of healthy and vigorous larvae to serve as the foundation of the silkworm growth cycle. Exploring the technology and practices associated with the incubation of eggs of sericulture species focused on the essential aspects of the process and their importance to the sericulture industry and highlighting the key factors influencing the success of egg incubation. Particular importance is given to the analysis of aspects such as egg selection, incubation conditions, humidity and temperature management, as well as methods for monitoring and evaluating the incubation process [28], with innovations in the field of egg incubation and their impact on production efficiency and quality of silk [5, 29, 30].

2.2.2. The technology of growing silkworm larvae

The larva represents the second stage of metamorphosis in the insect's life. In *Bombyx mori*, depending on the breed or hybrid, the larval stage lasts 26-31 days [31, 32]. The larvae have a cylindrical body, elongated and slightly flattened ventrally, with three body regions: head, thorax and abdomen. Larvae growth technology is fundamentally influenced by the quality of food and environmental factors [Tables 1 and 2].

Table 1 The factors that influence the growth technology of young larvae (L1-L2-L3) [2, 6, 17]

Monitored parameters	AGE		
	First Age	Second Age	Third Age
Growth phase duration (days)	4	3	4
Optimum room temperature (°C)	25-26	24-25	24-25
Optimal room humidity (%)	75-80 %	75-80 %	75 %
Space management (growing area)/ race	1 m^2	2 m^2	5 m^2
Optimal light	Optimal diffused light		
Airing	every two hours		
Administered food (mulberry leaves)	leaves chopped into strands of 0.5-1 cm		uncut leaf
Leaf quality	mulberry leaves of the best quality, harvested from the upper part of the shoot		
Amount of leaf administered for 1 g hatched eggs (kg)	0.14	0.76	2.1
Amount of leaf administered per 100 g hatched eggs (kg)	14	76	210
The number of feedings per day	2-4	4-6	6-8
Entering the larvae into sleep (if all growth factors are respected)	on the 5th day	on the 8th day of the biological cycle	on the 15th day of the biological cycle
Sleep duration (h) During sleep, the larvae will not be fed and/or disturbed	24	24	24
Bedding change/ L1-L3 period	not recommended	only once, before going to sleep	twice, the last time before entering the third sleep

2.2.3. The technology of growing silkworms in the pupa stage (chrysalis)

The chrysalis (pupa or nymph) represents the third evolutionary stage in the insect's life. Towards the end of the last instar, the larvae withdraw to quiet places, stop consuming food, empty their intestines and start looking for support points for pupation, keeping the front half of the body raised [25, 26]. Their body shrinks (it reaches a third of the length of the larva's body) and, due to the content of the silk glands, acquires a bright white colour with a transparent appearance During the last three days of the larval stage, the larvae, after climbing on the cocooning materials, weave a cocoon inside which after another three or four days it undergoes a new moulting (the fifth), after which it turns into a chrysalis [33]. The chrysalis weighs 1.5-2 grams, has a fusiform body (oval, with a sharper posterior part), consisting of three weakly differentiated regions (head, thorax and abdomen). The chrysalis stage lasts 10-14 days in *Bombyx mori* [34].

Table 2. The factors that influence the growth technology in the L4 and L5 adult larval stages [2,6,17]

Factors	the fourth age	the fifth age
Lifetime (days)	6 days	7-8-9 days
Food administration	leaf or shoots	leaf or shoots
no. of feedings	4-5	permanently
Temperature (°C)	23-24	22-23
Humidity (%)	70-75%	65-70%
The light	Optimal diffused light	
Airing	permanently	
bedding change / larval period	daily and before the larvae enter the 4th sleep	daily
Sleep duration During sleep, the larvae will not be fed and/or disturbed	48 h	Sleep 4 (2 days)

2.2.4. The technology of raising silkworms in the adult stage (moths)

This adult stage is the last in the individual development of the insect. At this stage, the insect survives only on the basis of body reserves, its main purpose being the perpetuation of the species [Table 3]. After mating and laying eggs, i.e. after doing their "duty to the species", the moths die. At the end of the chrysalis stage, a new moulting takes place (the sixth and last in the insect's life), after which the moth appears. The integument of the chrysalis dries and gradually detaches from the body, releasing the moth, which attaches its legs to the internal face of the cocoon and eliminates through the mouth opening an alkaline liquid at the level of the oesophageal goitre (it contains sericinase, an enzyme that dissolves sericin, but does not affect fibroin), which will stain the cocoon at the top (above the head), thus softening the silky wall. Then, with the help of its legs, it unties the warp of the cocoon in the area where the liquid mentioned above acted, thus creating a hole through which it exits. When the moth leaves the cocoon, first it takes out its head, then its legs, and after a few efforts, the whole body. The moth emerges from the cocoon, as a rule, in the morning. After the butterfly emerges, the exuvia of the larva (from the fifth moult) and the chrysalis remain in the cocoon. In *Bombyx mori*, the duration of this stage is 8-10 days in males and 10-12 days in females. If they are kept at a temperature of 5^0C [12, 13], the life span of a moth can exceed 45 days, and if the temperature is 35^0C, the moth lives only 5-7 days. Temperatures of 75^0C kill butterflies, and it should be mentioned that, in this species, butterflies have lost their ability to fly [2, 3, 35].

Table 3. Factors influencing the adult stage (moth) (6,17,2)

Adult stage (moth)	Monitored parameters
At the end of the chrysalis stage	• 6th moult, the end of which the moth appears
Duration of adult stage (adult-chrysalis) (days)	• 8-10 days in males • 10-12 days in females
Temperature (°C)	• at a temperature of 5^0C, the life span of a moth can exceed 45 days, • if the temperature is 35^0C, the moths live only 5-7 days.
Humidity (%)	70-75%
The light	Optimal diffused light
Airing	permanently
No. of feedings	they don't feed

3. Results and discussion

The RG 90 breed, used in combination with improved technology [Figure 2], presents additional characteristics and advantages in terms of production efficiency and quality [Tables 4, 5, 6]. The use of improved technology can positively influence egg, larva, silk fibre characters, bringing improvements in silk fibre uniformity, yield and quality [36, 37].

Figure 2. RG 90 breed, cocoon formation stage (Photo: CGECAS-PPM, USAMV CN) (https://fzb.usamvcluj.ro)

Table 4. Egg stage characters (grey-green colour, zebra-like larvae, yellow, belted cocoon)

Crt. No	Characters	U.M.	Value
1.	Average prolificacy	No. eggs/laying	540
2.	Hatching percentage	%	92,30
3.	Size of the egg: length/width	mm	1.6/1.2
4.	Hatched egg's colour	-	Grey-green
5.	Chorion's colour	-	yellow

Table 5. Larval stage characteristics

Crt. No	Characters	U.M.	Value
1.	The length of the mature larva	cm	7.0
2.	Weight of the mature larva	g	5.5
3.	Larval period	days	30
4.	Larval viability	%	90.76
5.	Moulting	No.	4
6.	Larval signs	-	The integument has transverse brown stripes, giving the larva a zebra-like appearance

B75 (Băneasa 75) breed, accompanied by improved technology, brings with it additional characteristics and advantages in the efficiency and quality of silk production [Table 7, 8, 9]. The use of this improved technology can positively influence the aforementioned aspects, contributing to greater uniformity, yield and quality of the silk fibre produced [38, 39].

Table 6. The technological characteristics of the cocoon and the silk fibre

Crt. No	Characters	U.M.	Value
1	Cocoon yield / 10,000 larvae	Kg	14.53
2	Raw cocoon weight	g	♀ 2.240 ♂ 1.969
3	Shell cocoon weight	g	♀ 0.434 ♂ 0.437
4	Silk content	%	♀ 19.38 ♂ 22.19
5	Raw silk	%	38.62
6	Reeling percentage	%	83.72
7	Longitudinal axis	cm	3.88
8	Transversal axis	cm	1.72
9	Dry cocoon weight	g	0.945
10	Fiber length	m	1194
11	Filament weight	g	0.365
12	Filament size	d	2.75

Table 7. Egg stage characters (grey-green colour, zebra-like larvae, yellow cocoon, belted)

Crt. No	Characters	U.M.	Value
1	Prolificacy	No. eggs/laying	600-670
2	Weight of the laying	g	0.350
3	Hatching percentage	%	97.20
4	Hatched egg's colour	-	grey-green
5	Chorion's colour	-	yellow
6	Size of the egg: length/width	mm	1.4/1.2

Table 8. Larval stage characteristics

Crt. No	Characters	U.M.	Value
1.	Length of the mature larva	cm	6.0
2.	Weight of the mature larva	g	4.8
3.	Larval period	days	25
4.	Larval viability	%	90.0
5.	Moulting	no	4
6.	Integument colour	-	white
7	Larval signs	-	absent

The collaboration of the partners involved allowed the exploitation of the expertise and resources of the partner institutions to develop and implement an improved technology, which is to be tested in the active sericulture season of 2024 on other monovoltine (AO33, GBC) and bivoltine (JH3, AJ17) breeds, and then implemented by Romanian sericulture farmers in their own sericulture farms. By collecting feedback from these target users, valuable information is expected to be obtained for the continuous improvement of the technology [40].

Table 9. Technological characteristics of the cocoon and the silk fibre

Crt. No	Characters	U.M.	Value
1	Pupation percentage	%	90.0
2	Cocoon yield / 10000 larvae	kg	16-17
3	Raw cocoon weight	g	♀ 2.110 ♂ 1.860
4	Shell cocoon weight	g	♀ 0.470 ♂ 0.440
5	Silk content	%	♀ 22.27 ♂ 23.65
6	Raw silk	%	46.42
7	Reeling percentage	%	84.04
8	Dry cocoon weight	g	0.810
9	Longitudinal axis	cm	3.23
10	Transversal axis	cm	2.07
11	No. of cocoon/litre	pieces	73
12	Filament length	m	1150
13	Filament weight	g	0.376
14	Filament size	d	2.94

The process of developing an effective technology with the potential to increase production in a sericulture farm is one of the most important stages in the efficient exploitation of silkworms (*Bombyx mori*), an essential stage that involved several aspects (identifying the needs of farmers and their challenges, research, development, testing and validation of the developed technology, its implementation) and dissemination to potential beneficiaries from areas with potential sericulture in our country. First, it was necessary to fully understand the needs and challenges faced by sericulture farmers in their silkworm rearing process (feed management, disease and pest control, optimization of environmental conditions and reduction of production costs). After identifying the farmers' needs, the technology research and development stage followed, where specialists designed and tested innovative solutions to address the previously identified problems. This involves the use of specialized equipment, the implementation of automated monitoring and control systems or even the application of bioengineering techniques to improve the genetic performance of silkworms. The technological solutions developed are to be tested and validated in real farm conditions, a process that will allow the identification of potential problems or implementation difficulties and the adjustment of the solutions accordingly, to ensure their effectiveness in practice. The technology must be implemented in sericulture farms and farmers trained and familiar with its use. Ensuring correct implementation and appropriate use of technology is crucial to achieve the desired benefits in terms of increased efficiency and profitability in the sericulture farm [41, 42].

The development of an optimized technology for the efficiency of the activities carried out in a sericulture farm represented the essential and strategic objective of the research study. To achieve the proposed objective, several stages were involved, namely: detailed analysis of existing processes, identification of relevant technology, research, development, testing in laboratory conditions and validation in real farm conditions, implementation, integration, monitoring and continuous improvement. A detailed analysis of all the activities and processes carried out within the sericulture farm was carried out, namely the evaluation of work flows, the identification of weak points and areas with potential for improvement, as well as the understanding of the specific requirements of farmers. After the analysis of the existing technologies, it followed the identification of the potential technology that could be implemented to optimize the farm activities. The research and development stage involves the design and testing of the technological prototype in the laboratory and at the pilot level. This provides the opportunity to assess the feasibility and effectiveness of the proposed solution before implementing it on a larger scale (sericulture farms). After laboratory-scale development, the optimized technology will be tested and validated under real farm conditions to evaluate its performance in a practical environment. This stage will allow potential problems or difficulties to be identified and the solution adjusted accordingly to be integrated into the sericulture farm. This involves training sericultural staff, adapting existing infrastructure and ensuring a transition to new practices and technologies. The implementation of new technology does not end with its integration into the farm, but the performance of the technology is monitored, making continuous adjustments or improvements to ensure that it achieves its objectives and brings the expected benefits [43, 44].

Developing an optimized technology to streamline activities in a sericulture farm is essential to increase productivity and sustainability in this industry. At the same time, the "Pharma-Farming" concept was integrated, which promotes a sustainable approach in the management of sericulture farms by integrating sericulture by-products. The concept of "Pharma-Farming" aims to overcome the traditional idea of a sericulture farm, where only the main products (silk) were obtained, and to promote the full utilization of the resources available within the farm. Thus, in addition to silk production, farmers can also explore other possibilities of capitalizing resources (sericulture by-products), using mulberry leaves as animal feed [45], implementing recycling practices (organic fertilizers for agriculture) and saving of resources (washing water of cocoons or silkworm excrement for crop irrigation, waste reduction and efficient management of available natural resources), with the adoption of the concept of "*Pharma-Farming*".

The use of the principles underlying the "*Pharma-Farming*" system in the context of a sericulture farm contributes significantly to the optimization of integrated processes and to increasing the performance and sustainability of this agricultural sector. The integration of by-products obtained during the rearing of silkworms can represent a valuable opportunity not only to increase farmers' incomes through product diversification, but also to improve the quality of life. The principles of the "Pharma-Farming" system focus on the efficient and sustainable use of available resources within a farm, encouraging the integration of different processes and products in a synergistic way. Thus, the application of these principles in a sericulture farm could include: capitalizing on all available resources, diversifying incomes and products, increasing sustainability, improving quality of life and working conditions.

The exploration of the concept of "Pharma-Farming" facilitates the integration of secondary products obtained within the sericulture farm in the pharmaceutical production chain and contributes to the creation of an additional source of raw materials and to the promotion of a circular and sustainable economy. By applying this concept, by-products obtained during the silkworm rearing process can become valuable components of the pharmaceutical production chain. As a resulting by-product, silk cocoons can be used to obtain silk fibres, which, in turn, can be processed into various pharmaceutical products, due to their special properties (tear resistance and bio-compatibility), which make them suitable for use in various medical applications (surgical sutures, membranes for tissue regeneration or for drug delivery systems). By integrating these by-products into the pharmaceutical production chain, new opportunities are opened for the development of innovative and effective products in the medical field. In addition, the use of raw materials from sericulture farms can help reduce dependence on finite natural resources and promote a circular and sustainable economy. By promoting a circular economy, where products are reused, recycled and integrated into production chains, waste is reduced and the impact on the environment is minimized, contributing to the conservation of natural resources and protecting the environment for future generations.

This research represents the strategic collaboration between three partners with expertise in the field of sericulture, who use each other's resources and knowledge to successfully address the development and implementation of oppressed technology in different areas of Romania. Local sericulture farms represent other essential partners in this collaboration in the future, as they provide practical experience and the necessary resources to test and implement the technology in real conditions. Research institutions and universities bring scientific expertise and advanced research resources to this collaboration (feasibility studies, laboratory tests and statistical analyses to assess the effectiveness and impact of the proposed technology). Also, partners can provide support in the process of developing and optimizing technology to adapt to the specific needs of the Romanian sericulture industry. By combining the resources and expertise of these three partners, this collaboration can successfully address the complex challenges associated with the development and implementation of an innovative technology in the Romanian sericulture industry, namely increasing the efficiency and sustainability of the sericulture sector and promoting a competitive and sustainable economy in the country.

4. Conclusions

In the perspective of relaunching sericulture in our country and considering the value and tradition of this important field, which has had a downward evolution in recent years, the development and diversification of the production base is required.

The breeding of silkworms in family sericulture associations, small and medium sericulture farms, for which there are all the conditions for development, can become profitable under the conditions of superior utilization of production, including secondary products. Numerous geographical areas meet appropriate eco-pedological and social conditions for the relaunch of the sericulture sector.

The silk thread and finally the silk are particularly precious, as well as the secondary products (chrysalis, excreta, mulberry leaf remnants, non-reeling cocoons) are equally important and sought after on the market. They can be used for the production of medicines, food bio-stimulants, chrysalis oil used in cosmetics, protein feed additives, surgical thread, borage thread used in electronics and new types of feed used in fish farming (sturgeon and carp).

The implementation of improved technology can represent a significant change in the way sericulture farms can be managed and play a crucial role in increasing efficiency and competitiveness in this industry.

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