
PhD THESIS SUMMARY

Research concerning the current structure of the sericultural value chain and identification of some development directions based on the productive performances of some silkworm breeds and hybrids from the local genetic fund

PhD student Lucia Lelia Pop

Scientific coordinator **Prof. Univ. Dr. Daniel Mierliță-Pantea**

Prof. Univ. Dr. Liviu Alexandru Mărghițaș

CLUJ-NAPOCA, 2023



1. Introduction

Sericulture is one of the oldest industries, with a tradition of at least 5000 years. Its core activity is raising silkworms (mulberry, oak and castor) and processing the cocoons into raw silk. It has an important economic character, being compatible with many rural areas, it has a bioeconomic character, but it can also generate many jobs. As many other industries, the historical evolution of sericulture was affected by many events generated by the first and second world war. Additionally, competition with newer and cheaper synthetic textiles contributed to its decline in time. The lift of commercial quotas permitted China and India to become leaders in silk industry, while most of the remaining countries are focused on production, including Romania.

The present thesis has the main goal to clearly and succinctly present the evolution of the silk industry (globally and nationally), to analyze the technological parameters of some silkworm breeds and hybrids from the Romanian Genetic Fund, as well as identifying new viable development directions, new or proposed by other past reports.

2. The structure of the thesis

The doctoral thesis, under the name of "Research concerning the current structure of the sericultural value chain and identification of some development directions based on the productive performances of some silkworm breeds and hybrids from the local genetic fund" includes two imported components, namely: The Current State of Knowledge and Personal Contribution.

The first element, "Current State of Knowledge", consists of 4 chapters.

The first chapter seeks to define sericulture as an industry and to present the diversity of sericultural products derived both from the mulberry silkworm and from the exploitation of mulberry orchards.

In the second chapter, the biological and technological traits of the mulberry silkworm are described, the rearing technique is described and the technological and biological characteristics of the breeds and hybrids of the silkworm within the native sericultural genetic fund are presented.

The third chapter describes the evolution of the sericultural industry at global and national level until 2001.

The fourth chapter defines the global value chain and describes the method of analysis proposed by Stacey Frederick.

The second part represents the own contribution and includes 5 chapters focusing on the description of the method and the material used, the description of the national sericultural value chain and its segments (2002-2019), the presentation of the results obtained from silkworm rearing (2017; 2019); and the classification of analyzed silkworm breeds/hybrids, of new events in the sericultural industry that manifest in 2020-2021. The last chapter contains the conclusions and recommendations drawn from the research carried out.

3. Research Objectives and Personal Contribution

The present thesis, under the name "Research concerning the current structure of the sericultural value chain and identification of some development directions based on the productive performances of some silkworm breeds and hybrids from the local genetic fund " aims to illustrate the current state of sericulture in Romania, using the currently available literature in the field and identifying some development directions, including the use of new productive silkworm breeds and hybrids, identified through their classification, based on their overall productivity.

The first objective is to analyze the sericultural industry using the global value chain as a reference model:

- Analysis of the segments of the value chain in sericulture and mapping of processes (primary sector - silkworm rearing and mulberry orchards exploitation; intermediate sector - raw silk processing; finished products – textiles and clothing; analysis of internal and external trade) as well as their evolution in the period 2002-2021;

The second main objective is to classify the silkworm breeds and hybrids by taking into account the following technological parameters: prophylaxy (no of eggs/laying) and percentage of hatching; the duration of the larval period; the weight of the larvae in the fifth age; technological indices of raw and dried cocoons (cocoon weight; crystal weight, silk shell weight, silk content percentage).

3.1. Methods and Materials

Chapter 5 contains the description of the material and method and comprises 2 parts: analysis of the value chain and evaluation of some breeds and hybrids of silkworms within the Romanian sericultural genetic fund.

3.1.1. Silk Value Chain

The analysis of the sericulture value chain is developed based on the global value chain model. . The stages of the silk value chain have been grouped and the map has been created according to the value chain methodology: identification of the stages of production and marketing; identification of the products segment; analysis of the governance environment and the research and development sector. The period under analysis is 2002-2021.

In addition to trade and industrial reports, statistical data from the following institutions are used and analyzed: the International Trade Center (ITC) and EUROSTAT (Statistical Office and services obtained; identification of the actors involved in each of the European Union); INSSE (National Statistical Institute of Romania) and ISC (International Sericultural Commission).

In the analysis of the evolution of trade and production, the CAGR – Compound Annual Growth Rate is used. It is defined as an index describing annual changes within the analyzed elements, for example imports or exports.

3.1.2. Evaluation Of Some Silkworm Breeds And Hybrids From The National Sericulture Genetic Fund

A number of 21 silkworm breeds and hybrids have been analyzed. Research activity took place within University of Agricultural Sciences and Veterinary Medicine, in special rooms, under the rearing guidelines described by scientific reports and guides.

The statistical classification method used is called the Evaluation Index. It is calculated for each analyzed technological and biological parameter, and the average value obtained represents the final score for the analyzed breed/hybrid, permitting a classification that takes into account multiple traits. According to researchers such as Buhroo et al (2017), who applied this index, if a race/hybrid evaluated has a score of more than 50, then it is considered a valuable breed from an economic and technological point of view.

4. Results and Discussion

First part of the 6th chapter entitled 'The Sericultural Value Chain in Romania' contains the analysis of sericulture in Romania and comprises of the following elements: analysis of the industry at regional level; presentation of the structure of the sericultural chain in Romania and analysis of its segments (research and development; silkworm rearing and exploitation of mulberry orchards; processing of raw silk into yarns and fabrics; trade and distribution; analysis of the governance environment; SWOT analysis; analysis of development directions; analysis of apparent consumption - analysis of internal demand for raw silk).

Silk, though considered a superior natural fiber, does not account for more than 2% of global trade. However, it is one of the most diverse fibers in the range of uses, from which its importance is denoted. This may be due to factors that contributed to the decline of sericulture such as competition with synthetic fibers, whose production costs are lower; increasing the degree of urbanization and/or workforce leaving sericulture in favor of other industries.

Globally, China and India are leaders in raw silk production, and overall in sericulture, due to their efforts in developing this industry, being mainly focused on research and development and financial support programs. The European area is characterized as a consumer of raw silk, thus producing yarns, fabrics and silk clothing, including Romania.

According to the obtained results, the most marketed products are:

- At export level: Woven Fabrics Silk Or Silk Waste (accounting for a share of more than 50 % in the trade), Raw Silk holds a share of more than 10 % in the trade and Silk Yarn (excluding Yarn spun from Silk Waste and put up for retail sale), the latter holding a share of more than 9 %, which after 2010 exceeds the 10 % threshold.
- At import level: there is an increase in imports of cocoons of silk and raw silk (the share of global imports exceeds 12 % each year). Next to these, the most important product is silk fabrics (the share of global imports exceeds 50% each year). Compared to export trends, imports register an upward trend.

The removal of international trade quotas, together with the modernization of Chinese and Indian sericulture, have further established countries within European Union or the United States of America as processing areas, this occurring due to their access to raw materials, obtained at low cost. This is also supported by the analysis of the structure

of the main exporters (2019), which also shows the influence of China, as the main exporter, holding a leading position in each segment (from raw silk to silk fabrics). Romania (30.28%) holds the first place as an exporter of silk yarn and Italy (18.74%) is one of the main exporters of silk fabrics. Due to this factor, a volatile environment can emerge within the industry. Romania is among the countries where imports are on the rise, with the highest share being in raw silk, accounting for 19.84% of total imports (93,493 thousand euros) in 2019.

BACSA (Black, Caspian Seas, and Central Asia Silk Associations) and ISC (International Sericultural Commission) are two international organizations responsible for supporting the development of sericulture. Romania, being a state member of these organizations, can benefit from access to information and technologies that can contribute to the development of silk industry. However, in order to implement them, an analysis of the current state of sericulture is needed.

As a result of the industry analysis, the value chain in Romania is fragmented, where the processing sector is the most developed, while the silkworm rearing sector has been in decline since 1990, the main factor being the privatization process, leading to the loss of the local sericultural agencies, the loss of mulberry orchards and the loss of Lugoj silk mill. The most affected segment was the silkworm rearing and the exploitation of mulberry orchards.

The raw silk processing sector is developed, with 11 active companies observed. The production of silk yarns is increasing, registering a value of 76.477 thousand euros in 2019,

In terms of production, an increase is observed for silk yarns, with a production of 76.477 thousand euros in 2019. The textile production is slightly declining, falling from 27.202 thousand euros in 2002 to 23.834 thousand euros in 2019. The evolution of this sector is directly influenced by the decisions China makes and will make, given that Romania is one of the countries dependent on imports of raw silk.

At the distribution level, silk is sold alongside other textile fibers, benefiting from a large distribution system.

Concerning the national silk trade, the following can be stated:

- The main exported silk products are raw silk (re-exported); woven silk fabrics silk yarn (excluding those spun from silk waste and those put up for retail sale).
- The main imported silk products are: raw silk, woven fabrics of silk and silk yarn (excluding those spun from silk waste and those put up for retail sale). Raw silk is imported as a raw

material and silk fabrics are imported under the possibility of being used in the production of clothing items, while domestic production may be destined for export (unit export prices are higher than import prices);

- China and Italy are the main trading partners.

The main national agricultural organizations are: The Global Center of Excellence for Advanced Research in Sericulture and Silk Production (GCEARS-PSP), which operates within the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca and the Baneasa Sericultural Research Center, Bucharest (created after the reorganization of SERICAROM), with the main purpose of preserving the sericultural genetic fund and supporting the development of this economic branch, objectives which are aligned with those of BACSA and ISC.

Although in decline, domestic sericulture has a number of advantages (opportunities): a diverse sericultural genetic fund, the existence of the processing industry (domestic customers), but also the possibility of development through collaborative projects, financed by European funds.

In addition to the development directions already proposed other research articles, such as the need for strategies strictly dedicated to sericulture, the development of value chains, the establishment and/or modernization of sericultural farms, it is also necessary to identify the interested groups desiring to be involved in sericulture, in the same time, an updated farm model, with current investments and operation costs. In view of both the opportunities presented by Romanian sericulture and the increase in the domestic consumption of raw silk, research has been carried out on silkworms in order to identify productive breeds and hybrids.

Second part of 6th chapter, named "Classification of studied silkworm breeds and hybrids, using the EI Rating Index", presents the results of the evaluation of 21 selected native silkworm breeds and hybrids.

At prophylaxity level, in 2017, the average number of eggs/laying is 618 ± 79.48 and in 2019 it has the value 599 ± 60.74 . The average hatching percentage varies between $93.77 \pm 2.70\%$ (2017) and $92.58 \pm 3.56\%$ (2019).

The duration of the larval stage, in 2017, lasts 31 days, and in 2019, lasts 33 days, 2 days longer compared to the results obtained in 2017. The results obtained are considered to be in line with the literature.

The average weight of the larva (recorded on day 7 of fifth age) has a value of 3,067 g in 2017, increasing to a value of 3,502 in 2019.

Research concerning the current structure of the sericultural value chain and identification of some development directions based on the productive performances of some silkworm breeds and hybrids from the local genetic fund

Table 1

Average values for raw and dried silk cocoons

| Parameter | Raw silk cocoon | | Dried Silk Cocoon | |
|-----------------------|--------------------|--------------------|--------------------|--------------------|
| | 2017 | 2019 | 2017 | 2019 |
| Cocoon weight (g) | 1,7780 (±0,341) | 1,8112 (±0,299) | 0,6688 (±0,140) | 0,6740 (±0,116) |
| Chrysalis Weight (g) | 1,4276 (±0,294) | 1,4784 (±0,256) | 0,3467 (±0,088) | 0,3613 (±0,069) |
| Silk shell weight (g) | 0,3397 (±0,062) | 0,3235 (±0,059) | 0,3117 (±0,067) | 0,3026 (±0,057) |
| Silk content (%) | 19,26 (±3,25) | 18,41 (±1,86) | 46,61 (±6,36) | 44,29 (±4,53) |

Taking into account all analyzed silkworm breeds and hybrids, the following average values were obtained, based on which the Evaluation Index (EI) is calculated and the final results are presented in the table below:

Table 2

Evaluation Index

| Nr. Crt | Breeds/Hybrids | 2017 | 2019 |
|---------|-----------------------|--------|--------|
| | | Values | Values |
| 1 | A033 (B) | 51.22 | 49.99 |
| 2 | AB (B) | 48.86 | 50.30 |
| 3 | AJ2(B) | 48.58 | 50.08 |
| 4 | AJ24(B) | 50.18 | 55.43 |
| 5 | Auriu Chinez (B) | 47.00 | 52.38 |
| 6 | B1(R) | 54.00 | 50.90 |
| 7 | BC112(B) | 50.34 | 50.74 |
| 8 | C122(B) | 48.28 | 46.54 |
| 9 | Galben de Băneasa (B) | 43.27 | 36.78 |
| 10 | J90(R) | 49.08 | 49.54 |
| 11 | Maritza IV (B) | 56.36 | 53.43 |
| 12 | P4/T (B) | 52.72 | 46.83 |
| 13 | RG90(B) | 47.07 | 46.40 |
| 14 | S17(B) | 52.25 | 42.59 |
| 15 | S8(B) | 48.08 | 48.50 |
| 16 | SK2(R) | 47.03 | 48.10 |
| 17 | X2(B) | 49.56 | 51.14 |
| 18 | AC/T (H) | 49.72 | 55.03 |
| 19 | AC29/T (H) | 57.12 | 56.97 |
| 20 | AJ5F (H) | 51.01 | 50.39 |
| 21 | CTK | 51.68 | 52.64 |

Taking into account both the Evaluation Index and the differences between its two value series (2017 and 2019), the most valuable breeds and hybrids commercially are: A033(R), AC29/T (H), B1(R), BC112(R), CTK

(H Maritza IV (R) and AJ 24 (R). Certain exceptions AB (R)-2019 (the index shows an increase compared to 2017), P4/T (R)-2017, X2(R)-2019 are breeds and hybrids present values under the Index threshold (50), but record high scores for certain traits.

Third part of the 6th chapter, New Outlook in Sericulture Industry, after 2019' summarizes new events in the agricultural industry, i.e. the negative economic effects caused by the pandemic are summarized (Covid 19).

5. Conclusions and Recommendations

5.1. The global silk industry is heavily influenced by China and India, as the main silk producers, due to the efforts made in the research and development sector, the mechanization of sectors and the creation of financing programs. The processing industry, including at European level, is dependent on imports of raw materials from these regions. Thus, the environment is volatile, due to the low number of suppliers. Other factors that contributed to the decline are: the rise of trade quotas, competition with synthetic fibers, the increase in the degree of urbanization, the orientation of silkworm reares and breeders towards other industries, higher production costs compared to those of other natural fibers. In contrast, a large majority of countries with a tradition in sericulture are focused on the production of yarn, fabrics and silk clothing, including Romania.

5.2. At national level, the fragmented value chain comprises the following segments: implementation, exploitation and development of mulberry orchards, production of silkworm eggs, silkworm rearing and commercialization of silk cocoons, primary processing of silk cocoons, spinning and finishing silk yarns(bleaching, dyeing, finishing), production of fabrics, clothing and other finished silk products; marketing and distribution. Due to the privatization process, the loss of spinning and orchards, the silk cocoons sector is in decline.

5.3. There is interest in the revitalization of sericulture, given the productivity of the indigenous gene pool and the existence of a silk processing infrastructure. One method is to develop the availability of indigenous raw materials, which requires the identification of productive

Research concerning the current structure of the sericultural value chain and identification of some development directions based on the productive performances of some silkworm breeds and hybrids from the local genetic fund

breeds and hybrids of the silkworms of mulberry. This has been initiated by analyzing some technological parameters of 21 breeds and hybrids.

5.4. According to the Evaluation Index, where several features are taken into account cumulatively, a breed/hybrid is considered economically valuable if the Index records values higher than 50. Another important aspect is also the stability over time of the breeds and hybrids of the silkworm of the mulberry. Thus, breeds and hybrids that had an $EI \geq 50$ in both experimental years (2017 and 2019) are: AO33(R), AC29/T (H), B1(R), BC112(R), CTK (H) and Maritza IV (R). Certain exceptions AB (R)-2019, P4/T (R)-2017 and X2(R) - 2019 are breeds and hybrids, that had lower scores in one of the 2 rearing stages, but proved stable over time.

5.5. In order to develop the sericulture industry, it is recommended to create development policies focused on creating value chains, modernizing farms and updating investment and operating costs. Considering also the values of the Evaluation Index for each parameter, especially those related to raw and dried cocoons: the following breeds are recommended: AO33, AJ24, B1, BC112, Maritza IV and hybrids: ACT and CTK.

6. Originality, Personal Contributions and Future Perspectives

The originality of the thesis consists of two main aspects: analysis of the sericulture value chain based on a general value chain reference model created by Stacey Frederick, being possible an analysis of the industry that can be replicated over time, thus reducing the time and costs necessary for research. The application of this method has been possible, although there have also been disadvantages such as restricted access to certain statistical data sets, with the textile chain included. Starting from this aspect, more detailed research projects can be launched by accessing statistical microdata, and having results validated within qualitative stages.

The second aspect concerns the use of a widely used Evaluation Index in India, which is used for the first time in the classification of silkworm breeds and hybrids from the Romanian gene pool. Unlike classical methods such as the Rank Method, the calculation process is simpler and takes less time. Through repeated research, one can assess its usefulness in Romania.