10th BACSA INTERNATIONAL CONFERENCE

"Regeneration of sericultural industries in 21st century"

"REGESERI" 2023

PROCEEDINGS

Soufli, Greece

April 24th – 27th 2023

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The 10th BACSA international conference **"Regeneration of sericultural industries in 21st century" "REGESERI" 2023** will be held at Soufli, Greece, from 24th to 27th April 2023.

The Regional Government of Eastern Macedonia and Thrace, the Silk House company in Soufli, Greece and ASSOCIATON OF FRIENDS OF SILK 'CHRYSALLIS', GREECE are hosting the meeting in collaboration with the Black, Caspian Seas and Central Asia Silk Association (BACSA).

In the recent decade the international price of raw silk began to rise rapidly, reaching levels of about US$ 55–60/kg mostly because of the industrialization of China. Simultaneously a new interest was expressed by the European silk industry for countries alternative to China where silk might be produced. A sign of this interest was the BACSA conference of 2013, which was held in Italy with the economic support and commitment of the Italian silk industry in collaboration with CREA.

Another sign of interest was the progressive association to BACSA of countries from Western Europe: Italy, Germany, Spain, Portugal, Slovenia, Switzerland, UK which are currently members of BACSA.

However, the restoration of the sericulture chain in Europe and BACSA countries is a very huge goal that cannot be sustained by the industry alone, thus a public-private partnership should be envisaged, and the governmental and EC support should be provided to make it a realistic goal, which, however, needs long term investments.

According to the recent trend for a rising demand of natural fibers from the final consumers, who look for comfortable wearing and sustainability of clothes, an increase of the silk price is expected and this phenomenon might give opportunities to more countries to become competitive.

In addition to this exciting opportunity, the forecasts for the future represent that the demand of non-textile silk as constitutive proteins will increase at a steady rate, due to the new utilizations of silk as a versatile polymer for different aims (cosmetics, pharmaceuticals, biomedicals).

Sericulture might be an organic agricultural practice because the mulberry is environmentally useful to protect soil from erosion, to adsorb carbon dioxide, to prevent desertification in marginal areas. If it is exploited in a non-intensive way it requires limited fertilization and irrigation and no pesticides at all. The moriculture can also be practiced in polluted or salty soils to accelerate their recovery to production. The silkworm is an environmental sentinel especially informative on the abuse of pesticides on agricultural crops cultivated nearby the rearing places. Furthermore, sericulture and moriculture can be exploited for circular economies where by-products of some processes can become raw materials for others.

According to BACSA's aims, it has been strengthening links and sharing knowledge among sericultural countries, by giving a wide support to many actions dedicated to the revival of sericulture. Although this revival has not been possible yet on a large scale there are many hints about possible future development.

Organizing committee:

President: Prof. Dr P. Tzenov, President of BACSA and Director of Scientific Center on Sericulture under the Bulgarian Agricultural Academy.

Vice-president: Dr. Skarlatos Dedos, Associate Professor, National & Kapodistrian University of Athens, Greece

Members:

Mr. George Tsiakiris, Silk house, Soufli, Greece

Dr. Evripidis Kipriotis, BACSA vice president for Europe, Greece

Dr. Silvia Cappellozza, Director, Council for Agricultural Research and Economics, Research Center for Agriculture and Environment, Padua Seat, Padua, Italy

Assoc. Prof. Dr. Yusif Shukurlu, Director, Regional Scientific Center of Sheki, Sheki, Azerbaijan

Prof. Dr. Dimitar Grekov, Agricultural University, Plovdiv, Bulgaria

Dr. Paschalis Charizanis, Emeritus Prof. Agricultural University of Athens, Greece

Scientific committee

Dr. S. Cappellozza

Prof. Dr. D. Grekov

Prof. Dr. P. Tzenov

PROGRAMME

21st, 22nd and 23rd of April (Friday, Saturday and Sunday) Participants' arrival. Meeting with conference organisers. Transfers to hotels and check-in.

24th April (Monday)

9:00 – 9:30 Registration;

9:30 – 10:30 Opening Ceremony:
9:30 – 9:40 Opening by Prof. Dr P. Tzenov, President of BACSA;
9:40 – 10:30 Welcoming remarks from the hosting country's official representatives

10:30 – 12:30 Session: "Regeneration of the sericultural industries" Chairperson: Prof. Dr Panomir Tzenov

10:30 – 11:00 LEAD PAPER: The role of BACSA in sericulture regeneration in Europe and Central Asia, by Prof. Dr Panomir Tzenov, President of BACSA;

11:00 – 11:30 The ARACNE project: Advocating the Role of Silk Art and Cultural Heritage at National and European Level, by Dr Alessio Saviane, Council for Agricultural Research and Economics – Research Centre for Agriculture and Environment, Padua, Italy;

Coffee Break (30 minutes)

12:00 – 12:30 The recent sericultural situation in Romania (country report), by Dr Maria Ichim, BACSA national coordinator in Romania;

12:30 – 13:00 Labor saving technology for silkworm rearing in Bulgaria, by Dr Krasimira Avramova, Agricultural University, Plovdiv, Bulgaria

13:00 – 13:30 The silk niche production in Italy, by Dr Alessio Saviane, Council for Agricultural Research and Economics – Research Centre for Agriculture and Environment, Padua, Italy;

13:30 – 14:00 Discussion on the topic "Regeneration of the sericultural industries"

14:15 – 16:00 Lunch

16:00 – 16:45 Exhibition

17:00 - 17:20 Silk, Soufli and local architecture: a fascinating story, by Athanassios I. Gouridis, civil engineer-archaeologist, director of the Technical Department of the Municipality of Soufli

17:20 - 17:40 Education on sericulture in Soufli throughout time, by Kostas G. Doulias Agronomist Sericulturist, Institute of Vocational Training in Sericulture and Silk Production, Soufli, Greece

18:00 - 19:30 Free Time in Soufli

19:30 - Welcome Dinner with Greek Music and Dancing Programme

25 th April (Tuesday) FIELD TRIP TO THE REGION OF SOUFLI

09:30 – 10:30 Guided tour of the silk industry "Silk Line - Mouxtaridis"

10:30 – 11:30 Guided tour of the silk industry "Silk House - Tsiakiris"

11:30 – 12:30 Tour to the lake of Tychero

12:30 – 13:30 Guided tour of the handicraft centre of Fylakto

13:30 – 16:00 Lunch at the village of Dadia

16:30 – 17:30 Guided tour of the sericultural unit of Mr Manavis

17:30 – 18:30 Guided tour of the sericultural unit of Mr Badianidis

19:00 Dinner

26 th April (Wednesday)

9:30 –13:30 Scientific – technical reports session and Posters session Chairperson: Dr Skarlatos Dedos, Associate Professor, National & Kapodistrian University of Athens, Greece

9:30 – 9:50 State-of-the-art in mulberry propagation at the Global Center of Excellence for Advanced Research in Sericulture and Promotion of Silk Production, by Ecaterina-Daniela Baciu, University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Cluj-Napoca, Romania

9:50 – 10:10 Protein content of mulberry leaves as Related to the rearing performance of silkworm (Bombyx mori), by Paschalis Harizanis, Agricultural University of Athens, Athens, Greece

10:10 – 10:30 Increasing the value of the biological and productive parameters of silkworms (Bombyx mori) by adding a natural compound to their natural diet, by Adela Ramona Moise, University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Cluj-Napoca, Romania

Coffee Break (20 minutes)

10:50 – 11:10 Consumers' attitudes towards silk products: An expert's perspective, by Panagiotis Eleftheriadis, Department of Agricultural Development, Democritus University of Thrace, Orestiada, Greece

11:10 – 11:30 Bombyx mori as a model organism for biomedical research: A recommended alternative for animal experimental models, by Gabriela-Maria Baci, University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Cluj-Napoca, Romania

11:30 – 11:50 Effect of "Violet K" antiseptic on eggs, caterpillar and butterfly of mulberry silkworm, by Gulnar Baghirova, Department of Plant And Plant Protection, Azerbaijan StateAgricultural University, Ganja, Azerbaijan

Coffee Break (20 minutes)

12:10 – 12:30 The pupae of the wild European silkworm Saturniapyri (Leptoptera: Saturnidae) area new and essential nutritional supplement in all aspects, by Yusif Hacibala Shukurlu, Department of Sheki Regional Scientific Center of Azerbaijan, Republic of Azerbaijan

12:30 – 12:50 Extraction of natural silk fiber from cocoons of Saturniapyri (Lepidoptera: Saturniidae), by Zarintaj Shukurova, Sheki Regional Scientific Center, National Academy of Sciences of Azerbaijan, Republic of Azerbaijan

13:00 – 15:00 Lunch Poster Sessions: Five minutes of poster presentation and five minutes for Q&A

15:00 – 15:10 Genetic transformation of the silkworm (Bombyx mori) using Piggybac methodology, by Denise Pérez Almazán, Center of Research on Proteins Plans and Bionatural Products, Cuba

15:10 – 15:20 Trends in using nutrient supplements in silkworm (Bombyx mori L.) nutrition, by Gheorghe Anca, Research Station for Sericulture Baneasa, Bucharest, Romania

15:20 – 15:30 An insight on pharmacological functions of silkworm pupae (Bombyx mori L.), by Habeanu Mihaela, Research Station for Sericulture Baneasa, Bucharest, Romania 6

15:30 – 15:40 Recent progress in the synthesis of silk fibroin nanoparticles, by Osmani Chacón Chacón, Centre for Research on Protein Plants and Bionatural Products, Cuba

15:40 – 15:50 The contribution of sericulture to the pharma-farming industry, by Gabriela-Maria Baci, University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Cluj-Napoca, Romania

15:50 – 16:00 The effects of feeding with old Slovenian and Hungarian mulberry varieties on silkworm's growth and silk quality, by Andreja Urbanek Krajnc, Faculty of Agriculture and Life Sciences, University of Maribor, Pivola, Slovenia

16:00 – 16:10 Preservation of cultural heritage: Sericulture in Brandenburg/Germany by Ines Rönnefahrt, Initiative Zernikowe.V., Zemikow, Germany

16:10 – 17:00 Closing Ceremony

16:10 - 16:30 A silk fairytale, a narrative by Ann-Marie Koustrup, Jyderup, Denmark

16:30 - 17:00 Closing remarks from the hosting organisation, Chrysalis

17:00 - 19:00 Free Time in Soufli

19:30 Dinner

27 th April (Thursday) COMPREHENSIVE TOUR OF SOUFLI

10:00 – 11:00 Guided tour of the municipal historical museum "Brika" and exhibition space of the "Chrysallida" association

11:00 – 12:00 Guided tour of the Art of Silk museum "Tsiakiris"

12:30 – 13:30 Visit to the Information Centre of Dadia Forest

13:30 – 15:30 Lunch at the village of Dadia

15:30 – 17:30 Guided tour of the Folklore Museum of Soufli "Gnafala" and the traditional cocoon house
17:30 - 19:00 Guided tour of the Silk Museum of Piraeus Bank Group Cultural Foundation with Regional Folklore Music and Dancing Programme 19:00 Farewell Barbeque Din

THE LIST OF PARTICIPANTS

OF THE 10th BACSA INTERNATIONAL CONFERENCE

"REGENERATION OF THE SERICULTURAL INDUSTRIES IN THE 21ST CENTURY"

"REGESERI" 2023

SOUFLI, GREECE

APRIL 24th -27th, 2023

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45	Asterios Tetos	Greece	sericulturist	6977747664	katervarn@gmail.com
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47	Georgios Tatarakis	Greece	Regional Adm. of Eastern Macedonia & Thrace		
48	Anna Laskareli	Greece	Regional Adm. of Eastern Macedonia & Thrace		
49	Nikolaos Denikouros	Greece	Sericulture farmer		
50	Thodoris Tsiamitas	Greece			
51	Christodoulou Christos	Greece	Munisipality Gen. Secretery		
52	Knavas Ioannis	Greece			
53	Kakalis Ioannis	Greece			

54	Kaloudis Alexoudis	Greece			
55	Sofia Kasapidou	Greece	Student, REGESERI General Secretary		
56	Amalia Terzi	Greece	General Secretary of Chrysallis		
57	Stamatia Leka	Greece	Member of Chrysallis		
58	Apostolos Alexoudis	Greece	Koukouli hotel owner, Treasurer of Chrysallis		
59	Theodoros Paschalis	Greece	Volunteer, Student		
60	Ioannis Tsiakiris	Greece	Volunteer, Student		
61	Sara Lamprinoudi	Greece	Volunteer, Sericulture Student		
62	Evangelos Bakaloudis	Greece	Volunteer, Sericulture Student		
63	Athina Ketsitzi	Greece	Volunteer, graduate of textile school		

OPENING SPEECH

By

Prof. Dr. P. Tzenov, President of BACSA

Ladies and gentlemen, Sericulturists and Distinguished delegates,

It is a privilege and an honor to meet all of you here and I am very pleased to be in the company of fellow sericulturists in this important gathering for the purpose of sharing information and experiences in the sericulture development.

I would also like to express my gratitude to our Greek hosts for their tremendous efforts in organizing the present conference.

You will recall that in the early 1990s, some companies from China and some other East Asian countries damaged the image of silk with the mass production of low - quality silk fabrics and wide circulation of the low quality products in the world markets. By the same time the manufacture of super fine synthetic fibers and the improved quality of other natural fibers increased their competitiveness at the market. This "strike" on the World sericultural industries led to a long period of too low silk prices, which reflected in destroy of sericulture in many countries.

The fluctuation of silk price and unstable supply of high quality silk have impacted negatively on silk industry promotion particularly in Europe which led some silk-fabrics and garments manufacturing private companies to shift their major products from silk to other synthetic fibers or close.

In the recent years however the raw silk price went up, reaching over US$ 55/kg which gave optimistic expectations for cocoon production revival in many countries whose sericulture activities had been declining dramatically during the previous two decades.

The silk is a natural fiber, which has been the center of our attention for many years. It is so unique that it can be mixed or twisted with other fibers for improved fabric production and diversification of products, but it can never be substituted in any of its uses.

The silk has many excellent properties and it may be the most environmentally positive crop, actually improving the condition of the soil.

In Europe for example mulberry requires no any pesticides and is naturally resistant to most of insects, fungus, and other pests, that's why mulberry could be easily grown as an organic crop.

On the other hand, the specific climatic conditions in the BACSA region countries require mulberry to have high cold and drought tolerance and the silkworm strains to possess a good tolerance to adverse rearing conditions like high temperature, daily temperature fluctuations and coarse mulberry leaves feeding. The not well controlled use of insecticides can easily harm the silkworm rearings and even to destroy completely the whole sericulture value chains in some regions or countries.

In the countries, having comparatively high costs of production in order to survive in the present sericulture business, producers should not make cheap products with low quality to compete for the prices, but to produce more sophisticated products, natural and environmentally friendly which satisfy consumers even though they are more expensive.

At present the trend for World silk prices increase, the availability of European and national subsidies, long tradition and farmer's experience, the need of European silk industry of raw materials etc. give some new opportunities for the regional sericulture revival.

Finally, I wish you all pleasant stay in Soufli and Greece, a successful participation in this conference to the end, and a safe trip back to your home countries, bringing with you some work plans and business ideas to be put into practice for further development of sericulture in your respective countries and for further progressive international collaboration.

Believing that the work of the present international meeting will be successful and useful for the regional and world sericulture industry development I open the International conference "Regeneration of sericultural industries in 21st century" "REGESERI" 2023

Thank you very much for your kind attention!

LEAD PAPER!

The role of BACSA in sericulture regeneration in Europe and Central Asia

By

Panomir Tzenov [1], Silvia Cappellozza [2] and Alessio Saviane [2]
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Considering the constraints facing the silk industry in Eastern Europe, Caucasus and Central Asia as well as the long traditions and high potential of sericulture for income generation, an "International Workshop on Revival and Promotion of Sericultural Industries and Small Enterprise Development in the Black, Caspian Seas and Central Asia Region" was organized by the AGST, Food and Agriculture Organization of the UN (FAO) in collaboration with the Government of Republic of Uzbekistan in April 2005 at Tashkent, Uzbekistan.

At the workshop a common institution was created to facilitate and expedite regional collaboration, in an effort to realize the recommendations to be made. The institution had been named as The Black, Caspian Seas and Central Asia Silk Association (BACSA), it was registered as a legal entity in Bulgaria and unified most of the sericultural countries in Eastern Europe, Caucasus and Central Asia.

When established in 2005 BACSA included 9 countries—Azerbaijan, Bulgaria, Georgia, Greece, Kazakhstan, Tajikistan, Turkey, Ukraine and Uzbekistan. Later on, and gradually, BACSA attracted for membership new countries—Albania, Armenia, Iran, Poland, Romania, Switzerland, Italy, Spain, Germany, Portugal, Slovenia, Russia, UK so that currently the association includes 22 countries and has also ьфдкш 70 individual members and 4 institutional members.

Until the end of 2019 BACSA organized 9 international conferences. Each conference was on a specific subject, connected with the problems of regional sericulture development.

The BACSA activity to prepare project proposals was very intense between 2006 and 2010 when 10 proposals were made, however out of them only 3 were approved for financing then after many failures, these kinds of attempts ceased in terms of projects studied for the whole area and focused mostly on more limited projects or bilateral agreements between members of BACSA.

BACSA makes all the efforts to establish connections among the producers, sellers and buyers of different sericultural products such as mulberry saplings, silkworm eggs, dry cocoons, raw silk,

silk yarn, fabrics, and garments. These activities are performed mainly by responding in real time to all the enquiries from possible sellers and buyers, connecting stakeholders together and giving a chance to exhibit sericultural products by organizing international workshops, conferences, etc. During the last 10 years a new interest was expressed by the European silk industry, especially from Italy and Switzerland for countries alternative to China where silk might be produced and on this basis the silk industry may re-consider establishing part of the cocoon production they need in Europe, Caucasus and/or Central Asia. A sign of this interest was the BACSA conference of 2013, which was held in Italy with the economic support and commitment of the Italian silk industry in collaboration with CREA. A delegation of the executive board was hosted in Como and visited "Ratti", one of the most important silk Italian companies belonging to the Marzotto group. Another sign of interest was the progressive association to BACSA of countries from Western Europe: Italy, Germany, Spain, Portugal, Slovenia, Switzerland, UK which are currently members of BACSA

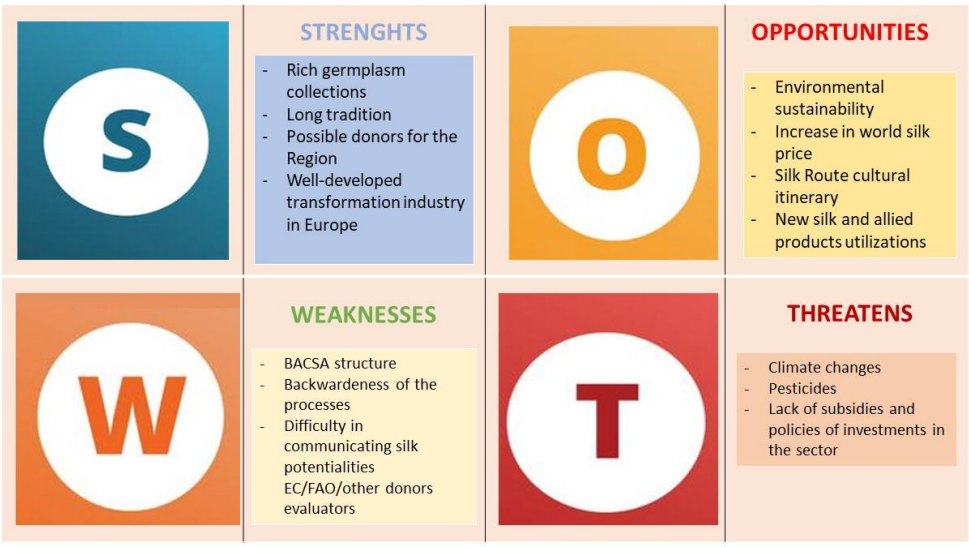

Figure 1. SWOT analysis representing criticalities and qualities of BACSA examined with respect to the possibilities of success in revitalizing the sericultural activity in the area.

Common problems

The global raw silk production was around 91,945 t in 2020, but out of them 53,359 t were produced by China and 33 770 t by India, while all the other countries produced only about 4,816 t of raw silk (see Fig. 2).

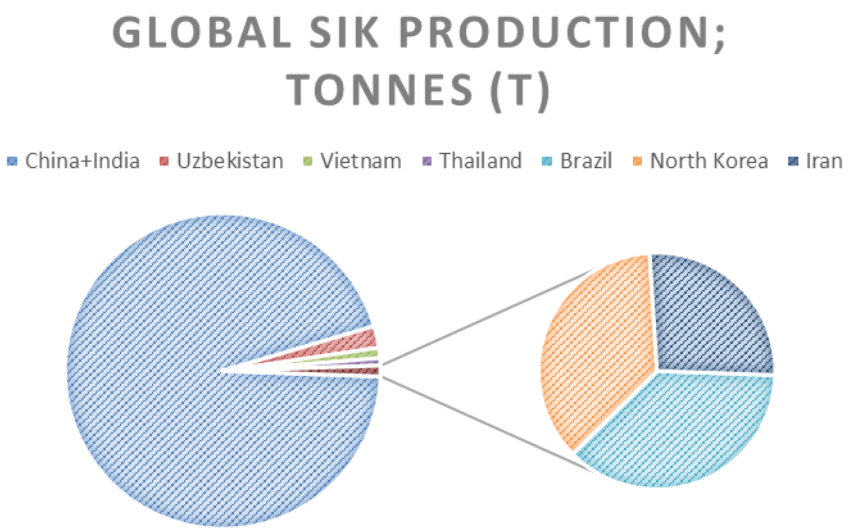

Figure 2: Pie-chart and relative shares of the eight main silk producers (data from https://inserco.org/en/statistics) in 2020; data from China and India collapsed to highlight how they cover more than 90 % of the worldwide production (94.8 %).

That means almost 95% of the total world silk production is from only two countries - China and India. On the other hand, although many countries in the World dealt with sericulture in the past or are still dealing nowadays, the majority of them only make efforts to preserve this activity and only few of them to revive the sericultural industry.
Silk production volumes more than doubled from 1990 to 2019 but it saw a decrease over the last several years. Even in those countries that are the biggest World cocoon and silk producers, there are presently entire regions where the sericultural activities have been partly or even completely stopped and the sericultural expertise may be lost.
Among these, BACSA associated countries, face problems typical of nations with history of long tradition and scarce current production. The first problem for them is how to preserve their mulberry and silkworm germplasms, which usually constitute public genetic resources, mostly located in research Institutes. The preservation activity is quite expensive, governments, in consideration of the present scarce economical revenues from the sericultural agribusiness, tend to restrict funds destinated to conservation.
Any hypothesis to concentrate the germplasm in one center only, preserving accessions for all the region, is quite unrealistic and in addition dangerous for the possible losses of genetic material in case of diseases or unforeseen accidents. The best way to preserve genetic resources is their spreading ex-situ however, this proved to be very difficult because of intellectual properties on the selected strains and varieties and could be done only for the genetic material that does not have any economic significance.
Therefore, encouraging the use of these resources and restarting an economically viable sericulture is certainly the best way to guarantee their preservation. In fact, even a partial sericultural revival will favor bilateral exchanges and commercial exploitation agreements among different countries, which might be regulated internally within the BACSA framework.
To recover the technological gap of sericulture with respect to other agricultural crops or agro-industrial chains, more competitive in terms of economic revenues for farmers or investors, is not easy and requires many funds to develop innovations. This is one of the main reasons why sericulture is a niche production in several developed countries.

This technological gap in sericulture became more evident in the last decades when the effect of climatic changes and environmental pollution began to seriously affect agriculture. For example, dramatic climatic changes began to negatively affect silkworm rearing with serious fluctuations in the average temperatures even in the seasons traditionally favorable to sericulture.
Climatic abnormalities such as heavy droughts, late frosts, excessive rains compromise mulberry leaf harvests. High temperatures and humidity favor spreading of insect pests, which are also more invasive due to the increased globalization of the transport of goods around the world, which works as involuntary carrier. Fighting against these new insect pests with insecticides, on turn, affects sericulture. To solve these problems a lot of technology and research related to the environmental management of sericulture would be necessary.
With regard to structural funding for research, training, dissemination, demonstration and other activities related to the sericulture revival, as mentioned above, some BACSA associated countries are members of EU, therefore, they should have access to EU funding for research institution and SMEs (Small and Medium Enterprises). Probably, the correct manner to attract financing is to enclose sericulture as a small part of wide projects focusing on other activities and where sericulture represents a study-case more than the central research or investment attractor.
On the other hand, non-EU BACSA countries can have access to FAO funds or to those of other NGOs. However, the lack of experts at world level in the specific branch of sericulture often results in a minor attention to this theme. It is not a case that two Korean experts gave a great personal contribution (Dr Hoo Zoo Lea, FAO Senior officer and Dr Jong Sung Lim, FAO consultant) to the BACSA creation, because of their knowledge and in-depth expertise in this sector. Unfortunately, FAO now is missing these professional officers specialized in sericulture.
With regard to subsidies of governments to silk production, what occurred was that both in the EU and in the other BACSA countries, where they were applied, they did not prevent sericulture from the decline and, in some cases, they triggered frauds from farmer associations or other organizations. Therefore, it is clear enough that this instrument to guide the market might be useful only if coupled with a general policy of industrial and technological development of this sector.

Prospects for the future

China, India, Brazil have probably already reached their maximum level of silk production and are not going to increase further their quote in the world market. On the other hand, silk consumption, so far, has been a very small quote of total world fiber production (less than 1%), but very stable in the years, although with a diminishing trend in the last several years.
This stability of silk for the textile market is due to the general buyers' identification of silk with a luxury fiber, which is a part of human civilization. In many countries it is intrinsically connected with local culture, and it has a long-standing tradition. Silk is considered as "Queen of textiles" because it has some unique and important characteristics, such as its ability to keep the body warm when it is cool, and cool when it is warm, or being a healthy fiber because it breathes easily and naturally keeps away moisture from the skin or being actually soothing to the skin diseases and itches.
Therefore, according to the recent trend for a rising demand of natural fibers from the final consumers, who look for comfortable wearing and sustainability of clothes, an increase of the silk price is expected. This phenomenon might give opportunities to BACSA countries to be competitive with China, even considering that the top world quality silk fabrics and garment producing industries are concentrated in Europe (Italy, France, Switzerland, England).
Regarding the fresh cocoon purchasing prices in the main producing countries, they were as follows in 2021:
China: US$ 5.54/kg
India: US$ 5.09/kg

Uzbekistan: US$ 2.31/kg
Vietnam: US$ 4.2/kg
Thailand: US$ 4.7/kg
Brazil: US$/4.05/kg

Many BACSA countries might develop even more than currently their artisanal and handicrafts production, especially by linking it to the tradition of their territories, countryside landscapes, culture. This idea gave birth to a project promoted by the Venice Municipality and the Council of Europe through the creation of a cultural itinerary “The European Silk Route”; it aims to be a local cultural network and infrastructure linking cities, regions, sites, museums and universities in order to enhance knowledge of a shared European cultural heritage, both tangible and intangible, and to promote new relationships within Europe and between Europe and the East through sharing of best practices and cultural tourism activities.

The Project "Advocating the Role of silk Art and Cultural heritage at National and European scale" ARACNE is one of the three projects funded by the European Commission that emerged victorious over a fierce competition with 55 projects in the framework of the call "Research and innovation on cultural heritage and Cultural and Creative Industries" (HORIZON-CL2-2022-HERITAGE-01-02). The coordinator of this project is CREA Agriculture and Environment, Italy.

The project started on 1st March 2023 and has the ambition to contribute to the creation of a broad and connected innovation ecosystem related to silk in Europe, including the industrial sector, and intended as a tool for expressing cultural and landscape heritage, thus, connecting culture, tradition, and new industrial production within an ideal network of exchanges and visions. ARACNE has a duration of 36 months and involves 11 partners and 3 associated partners from 7 EU member and non-EU member countries.

In addition to this exciting opportunity, the forecasts for the future represent that the demand of non-textile silk as constitutive proteins will increase at a steady rate, due to the new utilizations of silk as a versatile polymer for different aims (cosmetics, pharmaceuticals, biomedicals). Recently a bio-technological sericulture has been developing. For the first time in the world, in 2017, the legitimated rearing of genetically modified silkworms in conventional sericulture farms started in Japan. Functional silk is a promising material for medical applications.

Using the methods of genetic engineering, absolutely new silks that have unprecedented functions were developed. These are transgenic spider silk, hyperfine silk of small diameter, artificial blood vessels, fluorescent silk. Some of the BACSA countries are ready to face this biotechnological challenge. Silk regenerative medical materials like silk sponge, silk hernia mesh, wound dressing, silk surgical tape, hydrogel, films and 3D scaffolds for wound healing and tissue regeneration and reconstruction gels, powders, enzyme immobilization matrices were also created. Transgenic sericin is used for several medical reagents, like blood test drugs, biomatrix for tissue engineering and cosmetics.

Therefore, new kind of applications are likely to offer new opportunities; the interesting consideration is that, in this case, it is not necessary to produce silk in a huge quantity and it is not necessary to possess big reeling plants or transformation industries. This event might allow BACSA countries to increase their production slowly and steadily.

The region possesses some of the richest silkworm and mulberry germplasm collections. Several of the commercial silkworm hybrids, produced in the BACSA area manifest comparatively high productivity, namely single cocoon weight 2.2 – 2.5 g, shell ratio 23-24 %, shell weight 0.500 – 0.600 g, filament length 1300 – 1500 m under laboratory conditions. This might help in making the member countries attractive for this production. The level of sericultural science and technology in the region countries is comparatively high at a world level. This expertise might be particularly useful because new technological properties might be required for such a kind of silk production for innovative aims.

The EC green deal might also play a great role in promoting the development of sericulture in the BACSA countries: as recalled before, sericulture might be an organic agricultural practice; the mulberry is environmentally useful to protect soil from erosion, to adsorb carbon dioxide, to prevent desertification in marginal areas; if it is exploited in a non-intensive way it requires limited fertilization and irrigation and no pesticides at all; moriculture can also be practiced in polluted or salty soils to accelerate their recovery to production.
The silkworm is an environmental sentinel especially informative on the abuse of pesticides on agricultural crops cultivated nearby the rearing places. Furthermore, sericulture and moriculture can be exploited for circular economies where by-products of some processes can become raw materials for others. Mulberry fruit can be consumed fresh, dry or employed for production of juice, wine, jam and food additives. Pharmaceuticals can be extracted from mulberry branches, roots, leaves (for example, 1-deoxynojirimycin (DNJ) with antidiabetic aims).

Conclusions

BACSA, being established only 18 years ago, is a rather young international organization, for example in comparison to another one in the same sector, the International Sericultural Commission (1960). BACSA is basically managed on a voluntary basis thanks to the work and support of individual members, mostly belonging to scientific institutions.
According to its aims, it has been strengthening links and sharing knowledge among sericultural member countries, by giving a wide support to many actions dedicated to the revival of sericulture in Europe, Caucasus and Central Asia. Although this revival has not been possible yet on a large scale there are many hints about possible future developments, so that the support action of this Association continues to be fundamental and would deserve more attention by the sector stakeholders.

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The ARACNE project: Advocating the Role of silk Art and Cultural heritage at National and European level

By

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(Abstract)

The name ARACNE refers to a tale of Greek mythology in which the main character – ARACNE – was transformed into a spider after challenging the goddess Athena to a weaving contest. In our case, however, the acronym stands for "Advocating the Role of silk Art and Cultural heritage at National and European level" and it describes the main targets of this project funded by the EU. The international partnership engaged in this project is committed to the preservation and valorisation of cultural values and traditional skills linked to the silk world and the legacy it has

left. In the past, silk greatly contributed to the development of European economy and arts; therefore, in the framework of the ARACNE project the silk sector can represent again the common basis for a future European silk route intended as a cultural itinerary across Europe. The project was split into 6 work packages (WP). The objectives of WP1 are the collection of local data about silk's cultural heritage and the recreation of a silkworm and mulberry European heritage through the identification and selection of old mulberry varieties and *Bombyx mori* strains to build the base for typical/local productions. The WP2 leader group will use the information collected through the implementation of WP1 to build virtual maps of silk museums and points of interest connected with the silk cultural heritage while, at the same time, other partners will develop new production chains based on non-woven silk, on "zero km" silk and on silk as raw material for biotech applications. WP3 will address all those issues regarding business, governance, and financing models to improve the silk built cultural heritage. Strategies to support companies and start-ups involved in the project will be a task in this WP as well. In WP 4 all partners will take advantage of the experience of a French local silk route to develop their own itineraries that will be subsequently unified under a unique European silk route. WP5 will cover topics regarding communication, dissemination and exploitation involving the partners themselves, local communities, and stakeholders for a medium-long term impact. WP6 concerns the management of the ARACNE project. Overall, the aim of the project is to build a resilient silk innovation ecosystem based on traditions, architecture and both tangible and intangible heritage by involving museums, local communities, and general stakeholders. The project will also meet the New Green Deal and the New Bauhaus macro-objectives.

Keywords: cultural heritage, silk, mulberry, silk route, local

The recent Sericultural situation in Romania (country report)

By

Maria Ichim, BACSA national coordinator in Romania

ABSTRACT

For millennia, the Silk Road was the world's most important trade route. It was a link between culture and civilizations that were often antagonistic. If we think about it, it was
a first form of globalization, as well as a real way of development and communication of human civilization as a whole. Beyond its commercial, historical and cultural attributes,
the Silk Road remains a fascinating road for those who want to experience the charm and adventure of the route that once united two worlds. The Silk Road was a means for the exchange of goods and culture, benefiting the inhabitants of the cities on this route who in turn improved and developed science, arts and other fields. From the 14th century, silk began to be produced in European countries, which is why its reduction took place. Noticing this decline, the European Commission decided to relaunch this activity and launched the European Global Gateway project aimed at strengthening commercial relations with partners from around the world. The project will benefit from €300 billion in funding and has been developed as an alternative to China's New Silk Road. I think it is an opportunity for many countries, to strengthen relations through strong partnerships. The presentation will analyze the own method of recovery and organization for the revitalization of the sericulture field in Romania.

Keywords: Silk Road, sericulture, revitalization, culture, partenerships.

For millennia, the Silk Road was the world's most important trade route. It was a link between culture and civilizations that were often antagonistic. If we think about it, it was a first form of globalization, as well as a real way of development and communication of human civilization as a whole. Beyond its commercial, historical and cultural attributes, the Silk Road remains a fascinating road for those who want to experience the charm and adventure of the route that once united two worlds. The Silk Road was a means for the exchange of goods and culture, benefiting the inhabitants of the cities on this route who in turn improved and developed science, arts and other fields. From the 14th century, silk began to be produced in European countries, which is why its reduction took place. Noticing this decline, the European Commission decided to relaunch this activity and launched the European Global Gateway project aimed at strengthening commercial relations with partners from around the world. The project will benefit from €300 billion in funding and has been developed as an alternative to China's New Silk Road. I think it is an opportunity for many countries, to strengthen relations through strong partnerships. The presentation will analyze the own method of recovery and organization for the revitalization of the sericulture field in Romania**.**

Keywords – Silk Road, sericulture, revitalization, culture, partenerships.

The contemporary Romanian craft is a complex field in which the popular artistic tradition is located, the heritage meets an activity of an old craft tradition still alive in many regions of Romania. Contemporary popular creation enriches and diversifies the genres of creation and the range of products, using traditional elements, respecting the specifics of the region, on the territory of Romania. However, the local silk handicraft industries were not oriented towards the market, but to satisfy the personal needs of the farmer's family, so with the urbanization and industrialization of the country in the second half of the 20th century and the gradual disappearance of local traditions in the port and national costumes, there was the disappearance of the silk winding and weaving industry at home. After the transition from the centralized system to the market economic system, many people, especially in the rural and semi-urban areas, remained unemployed, many are working abroad, so the revival of the silk handicraft cottage industries nowadays would provide a very good chance of create job opportunities and additional income. Sericulture is a traditional activity in Romania, being one of the oldest branches of agriculture, with good and bad periods of development over time. Its importance at a given moment in the country's economy is also attested by the fact that Romania is one of the founding members of the International Sericulture Commission (1959). The serum research activity, as well as the production of biological material, was organized within the Sericarom Trading Company. Although Romania has the material and human resources that allow obtaining over 500 t of fresh silk cocoons annually, in recent years production has continuously decreased, both in terms of silk production and mulberry areas. Many reasons caused the production of cocoons to decrease: the economic instability characteristic of the period of transition to the market economy, the low purchase prices of cocoons, the import of cocoons at lower prices than those existing in the country. All this led to the closure of the Sericarom company.

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winding and weaving industry at home. After the transition from the centralized system to the market economic system, many people, especially in the rural and semi-urban areas, remained unemployed, many are working abroad, so the revival of the silk handicraft cottage industries nowadays would provide a very good chance of create job opportunities and additional income. Sericulture is a traditional activity in Romania, being one of the oldest branches of agriculture, with good and bad periods of development over time. Its importance at a given moment in the country's economy is also attested by the fact that Romania is one of the founding members of the International Sericulture Commission (1959). The serum research activity, as well as the production of biological material, was organized within the Sericarom Trading Company. Although Romania has the material and human resources that allow obtaining over 500 t of fresh silk cocoons annually, in recent years production has continuously decreased, both in terms of silk production and mulberry areas. Many reasons caused the production of cocoons to decrease: the economic instability characteristic of the period of transition to the market economy, the low purchase prices of cocoons, the import of cocoons at lower prices than those existing in the country. All this led to the closure of the Sericarom company. For a community to grow and develop, to be sustainable requires a local development strategy that meets real needs identified. And as we are European country, all this development should reflect and identify with EU requirements. Romania has great development potential in sericulture, but must take measures to restore the field Currently measures are necessary for the development of the private sector by attracting private farmers in sericultural activity

Below I will identify some recent changes in the sericulture field in Romania

I) In 2022, the Băneasa-București Sericole Research Station was established, through the reorganization of the Sericarom company, being a public institution with legal personality operating under the Ministry of Agriculture and Rural Development (M.A.D.R.) and under the scientific coordination of the Academy of Agricultural and Forestry Sciences " Gheorghe Ionescu-Sișești (A.S.A.S) taking over heritage and the 85 breeds of silkworms and 59 varieties of mulberry. Having as activities

at the genetics, breeding and pathology laboratory of silkworms

• Conservation of the silkworm gene pool, production of silkworm material, production of elite and industrial silkworm eggs.

• Selection of biological material by macroscopic control to eliminate plants with various defects and by microscopic control to detect diseases specific to silkworms.

• Elaboration of programs for the conservation and improvement of the genetic background of silkworms.

• Development of new or improved methods, techniques, procedures and technologies in silkworm rearing.

• The study of diseases and pests in order to develop their prevention and treatment measures.

And at the mulberry culture laboratory

• Research on obtaining mulberry planting material.

• Development of new or improved mulberry culture technologies.

• Creation by hybridization of new varieties of mulberry resistant to diseases and pests.

The newly established Băneasa Sericulture Research Station in the field will collaborate with silkworm breeders, proposing to revive the silk industry in Romania.

II) Within the Cluj Napoca University of Agricultural Sciences and Veterinary Medicine, the Global Center of Excellence for Advanced Research in Sericulture and the Promotion of Silk Production (CGECAS-PPM) was formed, which was recognized and operates under the auspices of the International Sericulture Commission. He was authorized sanitary-veterinary in 2019 for the purchase, breeding of silkworms, delivery of biological material and sericulture secondary products. This center collaborates with the Baneasa Sericulture Research Station Bucharest;

- Makes reserves for the Romanian sericulture genetic fund; - - Elaborates plans for improvement, multiplication and control of biological silkworm material (larvae of silkworms from native breeds and those belonging to the national silkworm gene pool); - Organizes the breeding of silkworms, - Distributes and sells silkworm biological material.

III) One of the great advantages for the future development of Romania's sericulture is the comparatively rich availability of its own mulberry and silkworm genetic resources and their possible development using modern genetic and breeding methods to provide farmers with high quality mulberry seedlings and eggs of silkworms and silk textile industry with superior quality cocoons/raw silk... We know that sericulture is one of the branches of agro-industry, which involves labor force and serves as an effective means for the development of traditional crafts/handicrafts. It creates job opportunities for alternative jobs and additional income for the rural population. Lately I have noticed that the tradition of silk crafts in Romania has survived and even flourished, continuing in the family the making of handmade accessories and traditional clothing. I noticed that the knowledge of craftsmanship was passed down from one generation to another. In this way, the silk textile industry was successful, obtaining prestigious, culturally significant silk clothes. I mention the company NICULESCU SRL, a private company, which developed by its own forces, taking over the art from their grandparents. The Niculescu company has a closed circuit of production, from the mulberry plantations, the raising of silkworms, the making of silk, the making of textile articles and the sale of the products, by selling the production in its own stores and online sales have developed. I will show some images of the traditional products made by Niculescu SRL ROMANIA.

Conclusions
Romania has great possibilities for the development of sericulture, but I believe that the government must adopt some measures to restore this field of activity. It is necessary to develop the private sector by
- attracting private farmers in the sericulture activity.
- the provision of government credits, partially subsidized by the state
- the improvement of mulberry and silkworm cultivation technologies, adapted to the new forms of private sericulture,
- the development of new technologies for the use of sericulture by-products and their capitalization in the market economy system,
- carrying out complex collaboration programs in the field of sericulture with traditional sericulture countries interested in such actions.

The silk niche production in Italy

By

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(Abstract)

The present summary is based on data covering the year 2022 regarding both the agricultural and the industrial part of the silk supply chain. During the last rearing season about 120 boxes were reared for different purposes by rearers belonging to CREA-AA's network: around 32 boxes by Italian farmers, 30 boxes by French farmers belonging to the Sericyne's network, 8.5 boxes by farmers belonging to the Swiss Silk's network and 18 boxes were sent to Greece; the remaining amount was employed for various purposes (science, education, analysis, cocoon production, etc.). The fresh cocoon production that refers to the CREA-AA network and can be directly monitored by the aforementioned institution amounts to around 600 kilograms. Among these, a small part was used for reeling (only 8 kg of silk were reeled in Southern Italy and 7 kg in Northern Italy) for industrial niche production, while the remaining part was used for the cosmetic and biomedical industry in Italy or abroad, and to obtain pupae for different purposes. As a general remark, it must be considered that throughout the rearing season the egg requests were higher than expected and thus, for the 2023 season, the production was increased. Production was tripled and amounts to 356 egg boxes for the Spring season and to 43 for the Autumn season. Data as a whole indicates that despite being still a niche, the sector is growing. Moving to the industrial silk textile sector (downstream of the reeling sector and importing silk or silk tissues from abroad), based on data provided by the Italian Silk Office (Sistema Moda Italia – Italy Fashion System), the overall picture about year 2022 is fairly positive with growing trends for both quantity and market value; the same applies to thread and fabrics import. Export has grown and almost reached pre-Covid

thresholds. Relative to these data, a few countries showed a clear growing trend while China slightly decreased the value of imported silk goods.

Keywords: silk supply chain, boxes, production, niche, industrial silk textile sector

The pupae of the wild European silkworm *Saturnia pyri* (Leptoptera: Saturnidae) are a new and essential nutritional supplement in all aspects

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ABSTRACT

The article presents the results of the content of the chemical and biochemical composition of the pupa of the wild silkworm *Saturnia pyri* belonging to the family *Saturniidae*, species of Lepidoptera. The nutritional value of silkworm *Saturnia pyri* pupae was evaluated, which contained 51% dry matter, 52.50% crude protein, 27.89% fat, 10.50% chitin fibers, 2.5% ash, 27 macro-, and microelements, and 25 mg alpha tocopherols in 100 g oil. The X-ray fluorescence method was used to determine the content of mineral elements in the pupa of the silkworm *Saturnia pyri*. It was revealed that the pupa of this type of silkworm contains 25 elements, of which the relative amount of K, Mg, Na, Ca, Al is much higher than other elements.

Keywords: Giant peacock moth, Aristotle's silkworm, mineral elements, proteins, fat, chitin fiber, ash, vitamin E

Introduction

Modern sericulture is an activity in which the products obtained at each stage of silkworm cultivation can be used for different directions of the consumer market. From the experience of world achievements, it is known that after obtaining silk from a cocoon, the remaining pupa is also of industrial interest and serves as a raw material for the manufacture of various medicinal and cosmetic products, food products (oils, seasonings) and is used as feed additives for pets, poultry (Buhroo *et al.*, 2018).

Currently, the most common is the traditional silkworm (*Bombyx mori*). But also, in many

countries, non-mulberry species are bred, such as the Chinese oak silkworm (*Antheraea pernyi*), the Japanese oak silkworm (*Antheraea yamamai*), Indian wild species of silkworms (*Samia ricini, Antheraea mylitta, Antheraea roylei*), which belong to the family *Saturniidae* andare primarily used as wild silk producers (Sharma and Gurjar,1987).

The giant peacock moth or Aristotle's silkworm (*Saturniapyri*) from the genus *Saturnia*, also belonging to the family *Saturniidae*, has been experimentally hatched by us since 2019at the Sheki Regional Scientific Center at the National Academyof Sciences of Azerbaijan, in order to study the possibility of breeding these species in laboratory conditions and prospects for use in the silk industry (Shukurlu *et al.*, 2019). In parallel with our study of specific silk of this type, some biochemical components of other by-products were also studied (Shukurlu *etal.*,2021).

The silkworm pupae are used in many sectors of the economy,such as agronomy, pharmacology, cosmetology, as well as thefood industry, where pupae are used as a source of protein (Li*et al.*, 2017). According to approximate calculations, 1 kg offeed additives from silkworm pupae replaces 2.5 kg of meat.They have long been included in the diet of the population indifferent countries of the world (Mishra *et al.* 2003; Paul and Dey, 2014) According to some authors, the increased recognition of silkworms as an alternative and useful source of nutritionthat does not require large costs can also contribute to the socio-economic development of local peoples, whose main occupation is silkworm breeding (Heuzé *et al.*, 2017; Sheikh *et al*., 2018).Different types of wild silkworms feed on different fodder plantsin different conditions, thus, the index of the content of the chemical composition of their pupae is different (Chieco *et al.*,2019).

Basic preparations

The pupae of giant pēacock moth - *Saturnia pyri* were acquiredby cutting off fresh *Saturnia pyri* cocoons obtained in our laboratory as a result of the spring and summer feeding season of2020, which were visually identified a year earlier by associateprofessor Aliyev Khalid Ali Agha oglu (employee of the Instituteof Zoology of the National Academy of Sciences of Azerbaijanand associate professor Baku State University).

The characteristics of the pupae meet the standard criteria.No preliminary killing of chrysalis and drying of cocoons wascarried out. After the pupae were freed from their cocoons, theywere washed with distilled water and transferred to a thermostatat 105°C until constant weight. After drying, the samples were placed for 30-45 min in a desiccator for cooling, before weighingthey were ground into a fine powder in an agate mortar.

Measurement and characterization

The moisture content in the pupae was determined to the last weight by drying them at a temperature of (105 ± 2) °C,according to the given method (Bradley, 2010). The percentageof ash and fat was calculated by the method of Marshall (2010). The method of Min and Ellefson (2010) was used to determine thepercentage of fatty oil in pupae.

The protein content in the pupae of *Saturnia pyri* was determinedaccording to the Kjeldahl method — by multiplying a certainnitrogen content by the Jones coefficient — the conversion ofnitrogen into protein (Mariotti *et al.*, 2008). It is known that thetotal organic nitrogen in food will represent nitrogen mainlyfrom proteins and to a lesser extent from all organic nitrogen-containing non-protein substances. In the Kjeldahl procedure,proteins and other organic food components in a sample are digested with sulfuric acid in the presence of catalysts. Total organic nitrogen is converted to ammonium sulfate. The digestis neutralized with alkali and distilled into a boric acid solution.The formed borate anions are titrated with a standardized acid,which is converted into nitrogen in the sample. The result of theanalysis is the content of *chitin* protein in food since nitrogenalso comes from non-protein components (Chang, 2010).

Vitamin E was determined by thin-layer chromatography on"Silufol" (Czech Republic) plates with a fixed layer of silica gel(Interstate standard 30417-2018, 2020; Hodisan *et al.*, 2008).

The determination of *chitin fiber* was carried out according to themethod of Kurschner and Haneck (1930) and Kozina (2012).The content of mineral elements was analyzed at the National

Center for Nuclear Research CJSC (Baku, Azerbaijan) by the X-ray fluorescence method for Omega 4000 ("Innov-X," headoffice: Massachusetts, U.S.A., CEO: Don Sackett) (Hutton *et al.*,2014).

Results and Discussion

The Eri silkworm (*Samia ricinii*) is a traditional food sourcein northeastern India, where it is grown primarily for silk and food production. Nutrient analysis showed that the approximate composition of mature silkworm larvae and pupae reared on castorbean and tapioca was comparable and provided a good sourceof protein (16%), fat (8%) and minerals (Longvah *et al.*, 2011).Therefore, the biochemical parameters of the pupa of the Eri silkworm (*Samia ricinii* (Longvah *et al.*, 2011) or *Pilosamia ricini*(Mazumdar, 2019)) were taken for comparison with the pupae of theGiant peacock silkworm (*Saturnia pyri*).

For comparison, let's pay attention to theoretical calculations, the component composition of Bombyx mori silkworm pupae.Calculations show that the mass content of lipids in the compositionof the silkworm pupa is about 12.1-27.4, proteins - 59.8-75.1, chitin - 3.5-4.7, ash - 2.7-5.6 and humidity ~10 percent (Avazova *et al.*,2020).

Table 1. Chemical composition of the pupa of *Saturnia pyri* silkworm grown on cherry leaves, silkworm *Samia ricini* grownon castor bean leaves (Longvah et al., 2011), and silkworm *Bombyx mori* grown on mulberry leaves (Avazova et al., 2020).

Items, %	Pupae (Dry weight) *Saturnia pyri*	Pupae (Dry weight) *Samia ricinii* (Longvah *et al.*, 2011)	Pupae (Dry weight) *Bombyx mori* (Avazova *et al.*,2020)
Moisture	5.50 ± 0.28	8.50 ± 0.21	~10,00
Protein	52.50 ± 0.63	54.60 ± 0.56	59,8-75,1
Fat	27.89 ± 0.32	26.20 ± 0.35	12,1-27,4
Ash	2.50 ± 0.05	3.80 ± 0.67	2,7-5,6
Chitin fiber	10.50 ± 0.03	3.45 ± 0.06	3,5-4,7

Table 1 shows the quantitative content of certain biochemical values in the silkworm pupa of *Samia ricini*, *Saturnia pyri*, and *Bombyx mori*. As can be seen from this table, the dry solids content of raw protein is high enough to make the wild silkwormpupa *Saturnia pyri* - a good addition to protein food.

The fat content in the pupa of *Saturnia pyri* is 27.89%, which is mostly unsaturated fatty acids, which have importantphysiological functions according to previous studies by scientists(Rao, 1994).

In Fig. 1 shows the oil from 4 batches of pupae (pupa oil) ofthe silkworm *Saturnia pyri*, obtained by us, which has a darkyellow color and a specific odor. Experiments have shown that the oil obtained from a female (sample 1), a male (sample2), larger (sample 3), and smaller (sample 4) pupae do notparticularly differ in color or smell. The average melting point ofthe chrysalis oil is 26.0°C, the density is 930 kg/m.

Vitamin E (or *tocopherol*) is a fat-soluble vitamin, meaning itdissolves in fats. In nature, there are 8 different compounds thatrepresent vitamin E (alpha, beta, gamma, and delta tocopherols). Themost commonly known form is alpha tocopherol. In addition, itis the most active vitamin.

Vitamin E is a physiological antioxidant, the intake of which is directly related to the consumption of polyunsaturated fats. These lipids are involved in the formation of cell membranes and proteins that carry fats into the blood. They are very sensitive to the effects of oxygen, and vitamin E is a reliable protection for them. Since fat must be supplied to our bodies with food on a daily basis, it is important that the diet also contains a sufficient amount of vitamin E (Nielsen *et al.*, 2001).

Vitamin E is an antioxidant that protects cells from free radicals and carcinogens. It is also necessary for the normal functioning of the immune system, and the cardiovascular system, promotes vasodilation, strengthens the walls of capillaries, and prevents thrombus formation. Vitamin E plays an important role in the process of regeneration and reproduction (Eiichi, 2002).

Fig. 1. The oil from the pupae (*chrysalis oil*) of the silkworm *Saturnia pyri:*
1 – female; 2 – male; 3 – larger; 4 - smaller

To determine vitamin E in the oil of the pupa of the *Saturnia pyri* silkworm, the amount of tocopherol was calculated. To establish the mass fraction of this vitamin, the content of α-tocopherol was calculated according to the calibration graph using the method of thin-layer chromatography. Fig. 2 shows the chromatography of tocopherol in oil of the pupa of *Saturnia pyri* on a silica gel plate. This chromatography shows that only alpha-tocopherol is present in the oil - the natural and most biologically active form of all tocopherols.

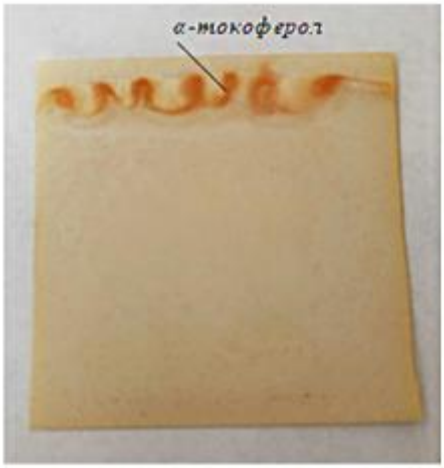

Fig. 2. Chromatography of vitamin E in oil of the pupae of the wild silkworm *Saturnia pyri* on a plate with silicogel

Thus, we calculated the content of natural vitamin E in the form of acetate – 25 mg per 100 g of oil.

Minerals play a key role in the life of living organisms. They are found in food as organic and inorganic compounds.

As can be seen from Table 2, pupae of the silkworm *Saturnia pyri* mostly accumulate mineral substances, containing elements K, Mg, Na, Ca, and Al. It is known that sodium and potassium regulate water-salt metabolism. In addition, the Na/K ratio in the pupae of *Saturnia pyri* is low (0.08). This is interesting from a nutritional point of view since the consumption of sodium chloride and food with a high Na/K ratio can cause an increase in blood pressure. The magnesium ion plays a huge role in the life of a living organism, participating in the metabolism of proteins, carbohydrates, and phosphorus (Zhou and Han, 2006b).

Calcium (Ca) is a plastic material for bones, a blood coagulation factor, normalizes the activity of the heart and muscles, is a part of the nucleus and membranes of cells, cellular and tissue fluids, and activates a number of enzymes and hormones (Pravina *et al.*, 2013).

Table 2. Mineral contents of *Saturnia pyri* pupae

Micro- and macro elements in pupae		e relative number to the mass of a dry weight of pupae, mg/g
Kalium	K	3.761
Natrium	Na	3.113

Magnesium	Mg	7.019
Calcium	Ca	1.016
Aluminum	Al	1.564
Siliceous	Si	0.611
Phosphorus	P	0.342
Sulfur	S	0.076
Barium	Ba	0.031
Lead	Pb	0.003
Iron	Fe	0.036
Copper	Cu	0.032
Zinc	Zi	0.042
Titanium	Ti	0.045
Vanadium	V	0.003
Chromium	Cr	0.009
Manganese	Mn	0.013
Nickel	Ni	0.022
Gallium	Ga	0.001
Zirconium	Zr	0.011
Tin	Sn	0.001
Strontium	Sr	0.006
Yttrium	Y	0.003
Niobium	Nb	0.011
Rubidium	Rb	0.002

The muscular and mental activity of a person depends on the intake of phosphorus (P) (Takeda *et al.*, 2004), iron (Fe) (Abbaspour *et al.*, 2014) in the human body, which are important elements for almost all living organisms, since they are involved in a wide range of metabolic processes, including oxygen transport, synthesis of deoxyribonucleic acid (DNA) and transport electrons.

Manganese (Mn) is an essential nutrient for intracellular activity; it acts as a cofactor for various enzymes including arginase, glutamine synthetase (GS), pyruvate carboxylase, and Mn superoxide dismutase (Mn-SOD). Through these metalloproteins, Mn plays a critical role in development, digestion, reproduction, antioxidant defense, energy production, immune response, and regulation of neuronal activity (Chen *et al.*, 2018).

Cobalt and molybdenum increase the intensity of bioenergetic processes and protective reactions of the body. Cobalt (Co) is an essential trace mineral for the human body and can be present in organic and inorganic forms. The organic form is an essential component of vitamin B12 and plays a very important role in the formation of amino acids and some proteins in nerve cells, as well as in the creation of neurotransmitters, which are necessary for the proper functioning of the body (Czarnek *et al.*, 2015).

Molybdenum (Mo) is a trace element that acts as a cofactor for at least four enzymes: sulfite oxidase, xanthine oxidase, aldehyde oxidase, and a component that reduces mitochondrial amidoxime (Novotny, 2011); it also participates in the synthesis of amino acids.

Zinc (Zn) is part of a number of enzymes and insulin. That is why zinc plays a central role in cell growth, differentiation, and metabolism (Brown *et al.*, 2001).

Sulfur (S) is a part of some amino acids (cystine, methionine) that form proteins - methionine, cysteine, cystine, homocysteine, homocystine, and taurine (Parcell, 2002).

Lead (Pb) levels do not exceed the maximum lead levels (0.5 mg/kg) set for a number of foods in world standards (Suldina, 2016).

Realizing the extent to which silkworm cocoon byproducts are used through appropriate methods is an immediate pursuit of income optimization. In terms of nutritional value, pupae are suitable for human consumption, and food for poultry, fish, rabbits, pigs, and dogs. In recent years, the *Bombyx mori* silkworm pupae have been listed by the Chinese Ministry of Health as a "new food resource used as common food" (Zhou and Han, 2006a).

The preliminary results presented in this article show that the pupae of the silkworm *Saturnia pyri* have great potential for obtaining various types of active dietary supplements, and medicinal components that can be useful in dietetics, cosmetologists, pharmacologists, etc. in our country. Considering that our planned volume of industrial feeding of *Saturnia pyri* does not give us the opportunity to talk about such large-scale production of feed additives yet, at this stage, we need to conduct a detailed analysis of the pupae of *Saturnia pyri* for the presence of specific, valuable nutrients and

non-nutrients, secondary metabolites with medicinal potential. This will allow us to expand the boundaries of research in the field of national nutritional science and biomedicine, which is a crucial task of modern science.

The pupae of the silkworm (*Bombyx mori*) were studied, which, after unwinding the cocoons, are sent to the waste processing workshop, are processed raw with a moisture content of up to 200% and contain various impurities that must be removed. Such raw pupae are squeezed out of excess water in a centrifuge at a temperature of 85-95 C. After drying, the pupae are sorted to remove rotten and moldy pupae and worms do not turn into pupae. Removes fibers and other contaminants. After that, the dried pupae are crushed and poured through the holes of the sieve, and the pulp remaining in the sieve is presented in the form of entangled fibers and this is removed. Shredded pupae with a moisture content of 9% or less are packed in paper bags. Measurements carried out on samples of these bags show that dry silkworm pupae contain ~60% crude protein and ~29% fat and are a high-quality source of insect protein with a rich balanced content of essential amino acids: valine, phenylalanine, and sulfur-containing methionine and cysteine. It was found that fat contains the most acids such as oleic (34.9%), palmitic (29.6%), linolenic (11.4%), linoleic (11.8%), and stearic (10.5 %). So far, in our region, *Bombyx mori* pupae are a waste material often discarded in the open environment or used as fertilizer and mainly used in poultry and fish farming. But we know that it can be extracted to yield valuable oil used in industrial products such as paints, varnishes, pharmaceuticals, soaps, candles, plastic, and biofuels (Trivedy *et al*., 2008). The extracted meal is sometimes used for the production of chitin, the long-chain polymer of N-acetylglucosamine which is the main component of the exoskeleton (Suresh *et al.*, 2012). Silkworm pupae have long been eaten by humans in Asian silk-producing countries and are considered a delicacy in regions of China (Luo, 1997), Japan (Mitsuhashi, 1997), Thailand (Yhoung-Aree *et al.*, 1997), India (Longvah *et al.*, 2011), and elsewhere. Due to its high protein content, silkworm pupae meal has been found suitable as livestock feed, notably for monogastric species (poultry, pigs, and fish), but also for ruminants (*Trivedy et al.*, 2008).

Conclusions

It was found that the pupae of the silkworm *Saturnia pyri* contain 51,0% dry matter, 52.5% crude protein, 27.9% fat, 10.5% chitin fiber, and 2.5% ash. It has been established that the oil of the pupae (*chrysalis oil*) of the silkworm *Saturnia pyri* contains 25 mg of α-tocopherol per 100 g of oil, the natural and most biologically active form of all tocopherols. It was revealed that pupae of the silkworm *Saturnia pyri* accumulate K, Mg, Na, Ca, and Al to a large extent, and the *Al* content is within the normal range, not higher than 2 *mg* per 100 *g* of pupa. The accumulation of Ti, Fe, Cu, Ba, and Zn in the pupa is evenly distributed.

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Extraction of Natural Silk Fiber from Cocoons of *Saturnia pyri* (Lepidoptera: Saturniidae)

By

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(Abstract)

Wild silkworm the Giant peacock *Saturnia pyri* (Den. & Schiff., 1775), a moth from the family Saturniidae, is one of the wild silk-producing forest insects native to Azerbaijan. However, there is a need for definite procedures for extracting silk fiber from its cocoons. This study evaluated the physical characteristics of *S. pyri* cocoons and outlined a process for extracting silk fiber for use in the silk industry. Cocoons of the *S. pyri* were grown from our mulberry breeding laboratory Sheki RSC of ANAS: the first pair of butterflies were collected from the forest of Bash Shabalud, Sheki, Azerbaijan (41°18′12′N – 47°07′1′E), and others obtained by semi-captive rearing of the silkworm larvae. The cocoon of *S. pyri* was described as brownish and rough with a prominently open side-eclosion hole with brush-like filaments at one end. The study recorded 20 minutes of boiling and 45 minutes of steaming as the optimum softening time for the cocoons to yield silvery brown silk floss using 10 g sodium carbonate and 10 g sodium bicarbonate per liter of pure water as the degumming agent. During the experiment, a shell ratio of the *S. pyri* cocoon (11.43%) and silk fiber fibroin (77%) was calculated. The data obtained suggest that *S. pyri* cocoons can be processed to produce natural silk fiber and give the population living in the settlements adjacent to the forest an excellent opportunity to engage in the production of wild silk.

Keywords: wild silkworm, *S. pyri,* cocoons, degumming, silk fiber.

Effect of "Violet K" antiseptic on eggs, caterpillar and butterfly of mulberry silkworm

By

Gulnar Baghirova

Abstract

Scientific research was conducted in 3 variants. According to the results obtained from the research, in the control (dry) version treated with 0.001 % solution of "Violet K" (C24 H28 N3 Cl), the mortality rate due to disease agents was 51.28 %, in the caterpillars of the "Azad" breed, while in the "Us " breed it was 42.66 %, and in the "Azerbaijan" breed it was 16.28 %. The mortality rate of the first experimental variant was 14.30 % in the "Azad" breed, 16.48 % in the "Us" breed, and 7.20 % in the "Azerbaijan" breed. In the second control (aqueous) variant, 24.10 % mortality was observed in the “Us” breed, and 7.30 % in the “Azerbaijan” breed, but no mortality occurred in the "Azad" breed.

According to the weight of the silk coat, the weight of the cocoon of the "Azad" breed in the control (dry) variant was 256,3 mg, 145,1 mg in the " Us" breed, and 226 mg in the "Azerbaijan" breed. The amount of the control (aqueous) variant was 360,3 mg in the "Azad" breed, 186,4 mg in the " Us" breed, and 160.0 mg in the "Azerbaijan" breed. In the experimental version, the weight of the silk coat of the "Azad" breed was 481,0 mg, 177,2 mg in " Us", and 181 mg in "Azerbaijan".

In the productivity of butterflies, the number of eggs in the " Azad" breed was 348 in the control (dry) version, 295 in the control (aqueous) version, and 1,324 in the experimental version. In the "Us " breed, there were 294 eggs in the control (dry) variant, 373 eggs in the control (aqueous) breed, and 1290 eggs in the experimental breed. In the "Azerbaijan" breed, the number of eggs was 257 in the control (dry) variant, 681 in the control (aqueous) variant, and 647 in the experimental variant.

Keywords: mulberry silkworm, bio-stimulants, physiological response, yield prediction, etc.

Introduction. Like any living organism, the survival of the mulberry silkworm depends on the influence of environmental factors. As a result of the exogenous influence of various origins, the body of the mulberry silkworm undergoes changes in its physiological state as a response, and the body is directed to continue its development in the direction of the normalization of life activity even after the impact phase. However, the intervention has such consequences that it is difficult for the body to eliminate them. In this regard, the effect of the "Violet K" antiseptic against the diseases caused by pathogenic microorganisms in different breeds of mulberry silkworms was studied in the present research.

In sericulture, for many years, there was an opinion that the technology of producing cocoons by an industrial method, in order to obtain high productivity during the feeding period of mulberry silkworm caterpillars, adding different ingredients to the feed is not appropriate. Therefore, in order to obtain a positive result in the biological indicators of the mulberry silkworm, the influence with ingredients was carried out only in the egg stage in silkworm-breeding farms. However, it has been proven with the actual material obtained experimentally that the processing of mulberry leaves with the ingredients - "Biovit-80" and sodium bicarbonate causes both a decrease in the percentage of diseases of caterpillars and an increase in productivity (Salimjanov S. 2011, p. 10).

It should be noted that modern diagnosis of mulberry silkworm diseases does not deal with the identification of microorganisms located on eggs (Salimjanov S. 2011. p.128). However, the bacterial layer formed on the overwintering eggs poses a threat during the feeding period of the caterpillars. This is explained by the difficulties in conducting microanalysis of butterflies and state control of prepared eggs. For example, the protection of mulberry silkworm eggs from the pebrine epidemic was carried out by exposure to high temperature (46^0C) and sulfuric acid for 30 minutes immediately after egg laying for 36-48 hours. It has been found that the caterpillars hatching from the eggs become infected by ingesting small particles of the eggshell, i.e., self-infection occurs.

The main goal of the scientific direction of the current research is the development of cocoon farms and the improvement of storage conditions of the mulberry silkworm, which is the primary guarantee of a high-quality cocoon product, and the development of a new, economically profitable, ecologically clean method for high biotechnological indicators.

"Violet K" ($C_{24}H_{28}N_3Cl$) as a bacteriostatic compound does not directly destroy the fungus and any other negative culture, it simply destroys the conditions necessary for the development of microorganisms (Ch. A. Mamedov, 2001, p. 342) and caterpillars' treatment of fodder leaves with a 0.001% aqueous solution of K-violet under feeding conditions has a dual effect (H.F. Guliyeva, G.D. Baghirova, 2021, pp. 260-263). These detected effects of the drug are of great importance in solving problems in sericulture. The analysis of the experimental results proved that the "Violet K" antiseptic, which can be considered the most effective ingredient, can be successfully used in the breeding centers of the local and introduced breeds of the mulberry silkworm in the breeding centers of Azerbaijan during the wintering period, during the storage of eggs and the feeding of the caterpillars.

Noteworthy that the treatment of thousands of eggs with K-violet in breeding centers during the wintering period is accompanied by some technical difficulties, but the expected effect is quite high. Also, processing the leaves by spraying the preparation and feeding the caterpillars (0.001% aqueous solution and spraying with water only in subsequent feedings) is a process that can be carried out at the farm level and will ensure the achievement of high indicators.

Research material and methodology. The research was carried out in 2020-2022 at the newly established Cocoon Training Centre under the Faculty of Soil Science and Agro-chemistry of the Azerbaijan State Agrarian University. The selection and processing of the research material were carried out according to the previously developed methodology [9], [10]. The study of the physiological response of mulberry silkworm eggs to changes in storage conditions was carried

out on local "Azad" and introduced "Hesa 2/1", and "Us" breeds. In the experiments, 5 pairs (1♀+1♂) were used in each series, with 100% diapause (dark-coloured, sunken) eggs.

Processing with the preparation (A.Z. Zlotin, V.N. Kirichenko, 1980, patent JJ 2895218/30-15/037103/; A.Z. Zlotin et al., 1974, pp. 75-82; A.Z. Zlotin et al., 1976, p. 46-49) was applied based on the methodology.

Statistical analysis of results [Q.F. Lakin, 1990] was carried out, and the arithmetic mean (x), the error of the mean (sx), and the precision index of the difference from the test (tf) were determined.

Discussions. On the eve of the end of diapause, processing with 0.001% aqueous solution of "Violet-K" ($C_{24}H_{28}N_3Cl$), which we determined as the optimal dose, was carried out, experiments (1 experiment and 2 checks - placed on dry paper and treated with distilled aqueous) in 3 series was conducted. The effect of the preparation on eggs was carried out in knots made of paper and gauze under the conditions of +20 -25^{0}C and 60% relative humidity. The processing, that is, the effect, was realized in 2 series: a) after the darkening of the laid eggs and b) directly when the eggs were put into incubation.

In each series, the duration of development of caterpillars, the thickness of the silk layer, the date of flight of butterflies and the fertility per female butterfly, and the date of the beginning of diapause in laid eggs were recorded. Survival of caterpillars was determined by counting their number at the beginning and end of the experiment and was expressed as a % relative to the initial amount.

The presented experimental results prove that the exogenous intervention in the egg and caterpillar stages of the mulberry silkworm with the optimal dose of "Violet K" significantly increases the most important physiological indicators in addition to the pathogenic manifestation. Thus, tests with the optimal dose of "Violet K" that we conducted in local "Azad" and introduced ("Hesa 2/1", "Us") breeds were recorded with positive results in the elimination of both physiological and pathogenic manifestations.

The results of the analysis proved that the "Violet K" antiseptic not only increases the viability of caterpillars but also leads to an additional increase of the effect of economic importance - the number of healthy caterpillars.

As the most important effect of the tests, the effect of the drug on the weight of the silk cover of the cocoons can be shown. It was found that the preoral effect with the optimal dose of the drug during the feeding period of the caterpillars (2 times: feeding with leaves sprayed with the drug at the age of II-III and age V) has a significant effect on the formation and weight of the silk cover in the cocoons. It was determined that the local breed of mulberry silkworm "Azad" has a more clear and sharp response in this regard: the difference compared to the control options was 52.0% (dry) and 74.1% (aqueous), respectively.

Visually, it can be seen that the local breed is significantly different in terms of experience compared to those introduced to Azerbaijan. Thus, after exogenous intervention with the drug during the feeding period, the weight of the silk cover of the cocoons obtained in the local breed ("Azad") was 2.9 ("Hesa 2/1") and 3.1 ("Us") times more than the introduced ones.

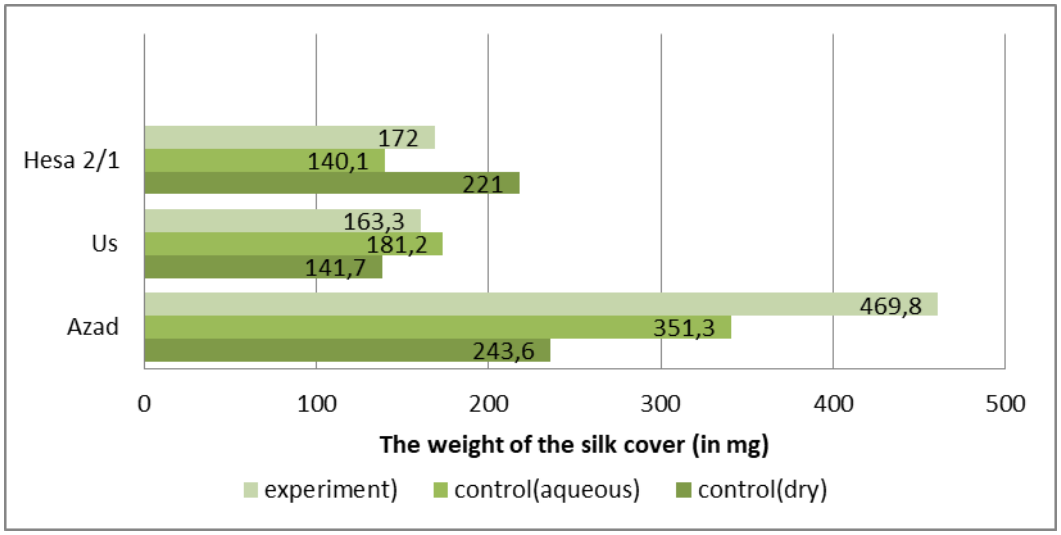

Figure 1. The effect of the optimal dose of "Violet K" antiseptic (0.001% aqueous solution) on the weight of the silk coat in native and introduced breeds of the mulberry silkworm.

One of the most interesting and important physiological effects is the effect of the "Violet K" antiseptic on the productivity of butterflies.

The treatment of eggs with this antiseptic and the appearance of the response effect in the butterflies of the generation created from them are insufficient, as can be seen from the experimental data shown in Figure 3 and the trend stated according to the experimental choice. In other words, the production of butterflies from the "Us" breed shows the strongest response. It's important to note that while the productivity of butterflies was characterized by a mild response, the stimulating effect of the "Violet K" antiseptic on the survivability of caterpillars and the dynamics of the weight of the silk cover is more clearly exhibited in the local "Azad" breed. The average number of deaths in this series decreased by 1.7–2.0 times after drug exposure.

It was discovered that the responses shown in the butterfly productivity following the administration of the medicine "Violet K" among the introduced breeds are different. The study's findings unmistakably demonstrated that this antiseptic has a maximum stimulating impact when it comes to increasing the productivity of butterflies and the viability of caterpillars of the "Us" breed. In general, more variations are evident when comparing the physiological response of the "Us" breed to external influences that have similar effects in other breeds ("Azad" and "Hesa 2/1"), and this is noted both in the experimental version and among the checks. This is a very strong positive response of the preparation to the solvent's effect.

It was discovered that the newly introduced "Hesa 2/1" breed of mulberry silkworm had no significant response to the drug's external intervention. Therefore, neither the viability of caterpillars nor the productivity of butterflies were stimulated by this antiseptic.

The mulberry silkworm is well recognized to have an embryonic diapause type (Kuliyeva H.F. 2005, pp. 65–70). Our study revealed that monovoltine breeds of mulberry silkworms in Azerbaijan create the state of physiological quiescence in their eggs throughout the summer (July–August). Hybrid breeds are an exception to the rule that diapause eggs do not hatch into caterpillars. As a result, caterpillars appear and eat when one of the parent lines is bivoltine or polyvoltine (introduced breed).

It was discovered that when the eggs of both native and exotic species of mulberry silkworm are treated with the "Violet K" antiseptic, not only are the pathogenic microorganisms found in the covering layer destroyed, but also the different dates and percentages of diapause formation are revealed. The results of the investigation, however, clearly demonstrated that gender

differences exist in the way that antiseptic exposure affects the development of diapause. It's intriguing that the hydrothermal conditions are not significantly different at this time; in other words, embryonic diapause takes place in settings with high average daily temperatures and relative humidity, which are not essential for the mulberry silkworm (Guliyeva 2003, p. 120).

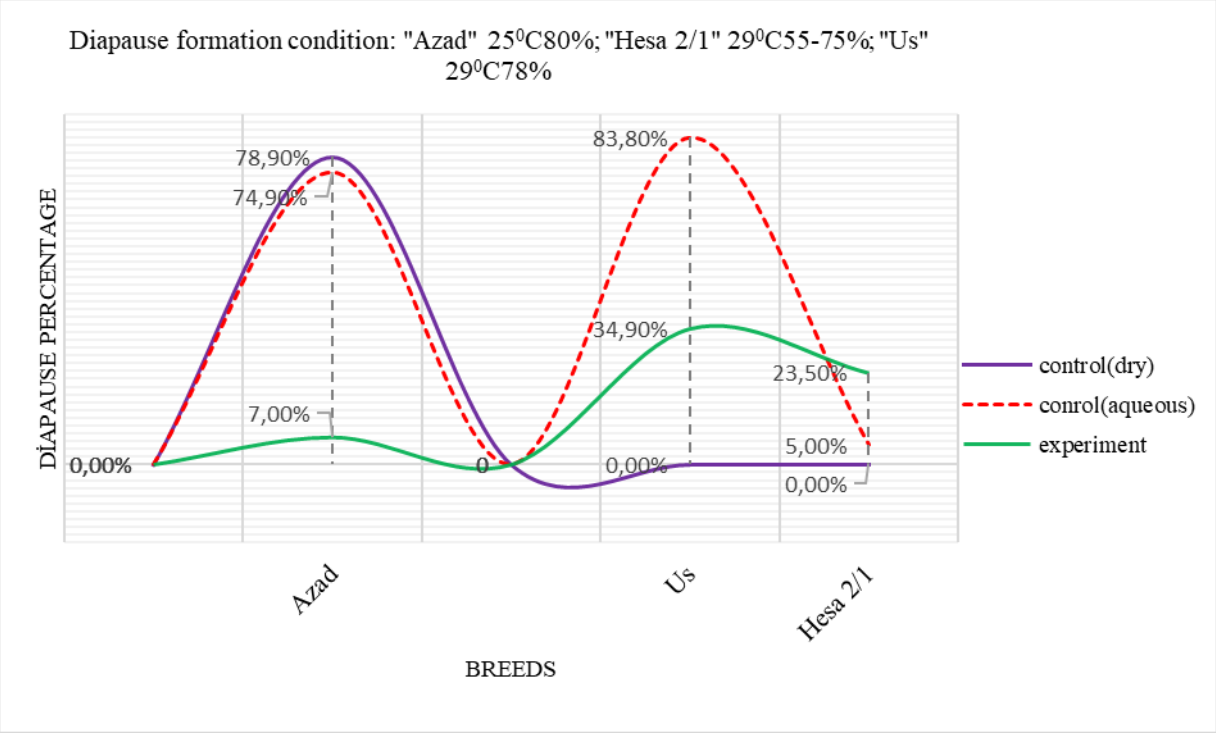

Figure 2. The impact of the ideal concentration of the "Violet K" antiseptic (0.001% aqueous solution) on the development of diapause in native and exotic mulberry silkworm breeds.

Conclusion and recommendations. According to the data, the percentage of eggs in diapause is generally significantly smaller in the experimental version than in either of the control versions because the drug prevents the emergence of a physiological quiescent state and the inhibition of the activity of exchange processes.

The percentage of embryonic diapause in the "Azad" breed was found to be decreased by 67.9% (water) and 72.90% (dry) compared to the control versions, but no differences were found in the way the introduced breeds responded to the antiseptic's effects. However, the reaction to the influence of the solvent varied between the imported breeds, with the experimental version having a 3.98 ("Hesa 2/1") - 1.2 ("Us") times higher percentage of diapause eggs, however, the way that the introduced breeds responded to the solvent's effects varied: the "Hesa 2/1" variation had the highest proportion of diapause, with 85.4% being reported (Fig. 2).

As a result, according to the experiment's findings, the death rate for caterpillars of the "Azad" breed in the control (dry) version was 51.28%, compared to 40.20% for those of the "Hesa 2/1" type and 15.90% for those of the "Us" breed. The experimental variety had mortality rates of 11.00% in the "Azad" breed, 13.00% in the "Hesa 2/1" breed, and 5.00% in the "Us" breed. In the control (aqueous) variety, mortality was recorded in the "Hesa 2/1" breed at a rate of 23.5% and the "Us" breed at a rate of 6.98%, while in the "Azad" breed there was no mortality.

According to the weight of the silk coat, the "Azad" breed cocoon in the control (dry) version weighed 227.6 mg, "Hesa 2/1" breed cocoons weighed 125.4 mg, and "Us" breed cocoons weighed 204 mg. The amounts of the control (aqueous) variety in the "Azad" breed, "Hesa 2/1" breed, and "Us" breed were 329.8, 167.9, and 125.0 mg, respectively. The silk coat of the "Azad"

breed weighed 451.0 mg in the experimental version, 147.9 mg in the "Hesa 2/1" breed, and 151 mg in the "US" breed.

In terms of butterfly productivity, there were 289 eggs in the control (dry) variation, 250 in the control (aqueous), and 1471 in the experimental variant for the "Azad" breed. There were 259 eggs in the control (dry) variation, 298 eggs in the control (aqueous), and 1212 eggs in the experimental variation in the "Hesa 2/1" breed. In the "Us" breed, the control (dry) version produced 223 eggs, the control (aqueous) version 597, and the experimental variant 556.

The current study's findings can be applied to problems like finding more sustainable and promising mulberry silkworm breeds in Azerbaijan, which is a requirement for foreseeing the success of their introduction.

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PROTEIN CONTENT OF MULBERRY LEAVES AS RELATED TO THE REARING PERFORMANCE OF SILKWORM (*Bombyx mori*)

By

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ABSTRACT

The development and growth of silkworms as well as the cocoon and raw silk quality depends upon the quality of mulberry leaves. The quality of mulberry leaves is closely related to the mulberry tree varieties, environmental conditions and cultivation practices. Most of the time, mulberry leaf quality is determined by its chemical contents (protein, carbohydrate, minerals, water content etc.). This paper describes a study on the development of silkworms and cocoon production as related to protein content of mulberry leaves. For the experiment, eggs of the Greek hybrid X1xK1 were hatched under controlled conditions of temperature (25˚C), relative humidity

(75%) and photoperiod (16L:8D). Eight hundred newly hatched larvae (200 X 4) were reared on the leaves of each of the two mulberry varieties (Tang10x Lang109and Heyebai). Leaf analysis was performed by Kjeldahl method to determine leaf composition in terms of nitrogen and protein contents. After completion of the rearing, post-cocooning parameters such as effective rate of rearing (ERR%), cocoon weight, shell weight and shell/ cocoon ratio (SCR%) were estimated.

Keywords: Silkworm, *Bombyx mori*, mulberry leaves, protein content, cocoon rearing

INTRODUCTION

Silkworm (*Bombyx mori* L.) is a monophagous insect which feeds solely on mulberry leaves. The development of the silkworm depends on many factors which can be controlled and regulated. Factors affecting silkworm rearing performance are feed by 38.2%, climatic conditions by 37%, rearing techniques by 18.2% and breed by 6.6% (Kumar et al., 1994 and Shankar et al., 1994).

Leaf quality is an important parameter used for evaluation of genotypes aimed at selection of superior varieties for rearing performance (Bongale et. al.,1997). This parameter has been the subject of research investigations for many years and many reports published on the matter (Machii and Katagiri, 1990; Das et. al., 1993; Sarkar and Fujita, 1994; Aruga, 1994; Minamizawa, 1997; Bongale et. al., 1997). It is a confirmed fact that leaf quality differs among mulberry varieties. What are not well known are the contents of specific components of the mulberry leaves which are responsible for the difference in rearing performances of the silkworm (Aruga, 1994; Bongale et. al., 1997). The present study aims to investigate leaf quality of two mulberry varieties as related to their protein content and cocoon production.

MATERIAL AND METHODS

A one cycle experiment took place at the Sericultural Laboratory of the Agricultural University of Athens during May and June. The experiment design was complete randomized with four replications.

a. Leaf protein analysis

Leaf analysis for protein content was performed on 7 varieties (Incinose, Kokuso21, Proussis, Kokerka, Fengchisang, Heyebai and the hybrid Tang10xLang109) in the same field. These varieties is part of the Laboratory's collection. Thirty leaves of each variety were selected and analyzed by Kheldahl method (In et al., 2005) 4 times (4 samples). Fresh leaves collected from position 5 to 10 of each shoot. Silkworm rearing performed using leaves of the two selected varieties (Heyebai and the hybrid Tang10xLang109).

b. Silkworm rearing

Silkworm eggs of the Greek hybrid X1xK1 were reared under controlled conditions of temperature (25ºC), relative humidity (75%) and photoperiod (16L:8D). Two hundred larvae with four replications for each variety reared on equal quantities of leaves. A total of 1600 larvae (800 + 800) were reared. Leaf samples collected from 10 randomly selected plants for each variety. The larvae fed on fresh leaves collected from position 5 to 10 of each shoot because the quality of leaves varies at different leaf maturity levels.

c. Post-cocooning parameters

After completion of the rearing, post-cocooning parameters such as effective rate of rearing (ERR%), cocoon weight, shell weight and shell/cocoon ratio (SCR%) were evaluated. EER and SCR calculated by the following formulas:

ERR= (number of cocoons yielded / initial number of larvae) X 100

SCR= (shell weight / cocoon weight) X 100

The experiment was carried out on the basis of the randomized complete block design. We considered variety as the treatment and the sample as the group on this design.

RESULTS

a. Leaf protein analysis

The results are shown in Figure 1. The two varieties, Tang10xLang109 and Heyebai, were selected as the best taking in consideration other botanical and environmental factors too. Silkworm rearing performed using leaves of these two varieties.

The average value of protein content was 13.191%, for all varieties. The lower protein percentage measured at variety Fengchisang (11.856%) and the highest at hybrid Tang10xLang109 (14.243%). At the three varieties (Kokerka, Kokuso21, and Incinose) were similar content of protein in leaves (13.7%). Even there are differences in leaf protein among varieties, these are not statistically different.

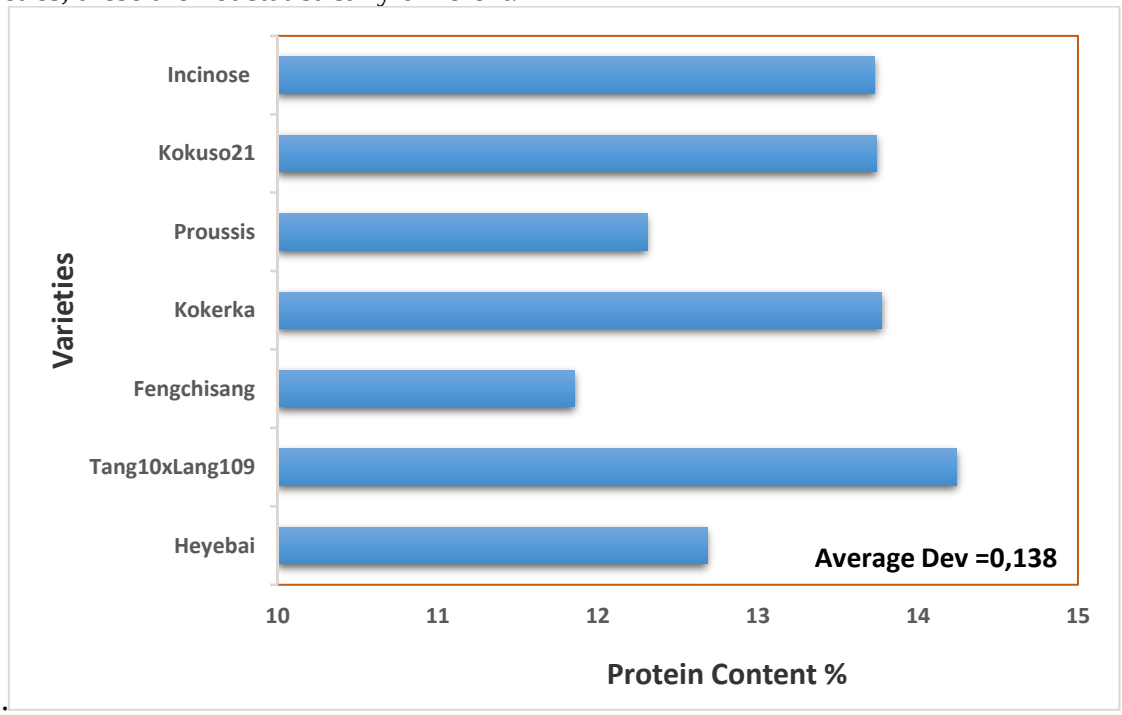

Figure 1. Protein content (% dry weight) of 7 varieties grown on the same mulberry field.

b. Silkworm rearing and post-cocooning parameters

Cocoon weight (g), cocoon shell weight (g) and shell/cocoon ratio

In Figures 2 a, b, & c the weight (g) of cocoon, cocoon shell and shell/cocoon ratio of Tang10xLang109 & Heyebai varieties is shown. The analysis of Variance showed that the two varieties differ significantly on cocoon weight at $p<0.005$ ($p_{value}= 0.0065$, Table 1 & figure 3).

On the other hand the two varieties marginally, do not differ significantly on shell weight, for significant level 5% ($p_{value} =0.0587$, Table 2 & figure 4). For variety Tang10xLang109 the mean value of shell weight was 0.5125 g and for Heyebai 0.455 g respectively.

The two varieties marginally, do not differ significantly on SCR (shell/cocoon ratio), for significant level 5% ($p_{value} =0.2223$, Table 3 & figure 5).

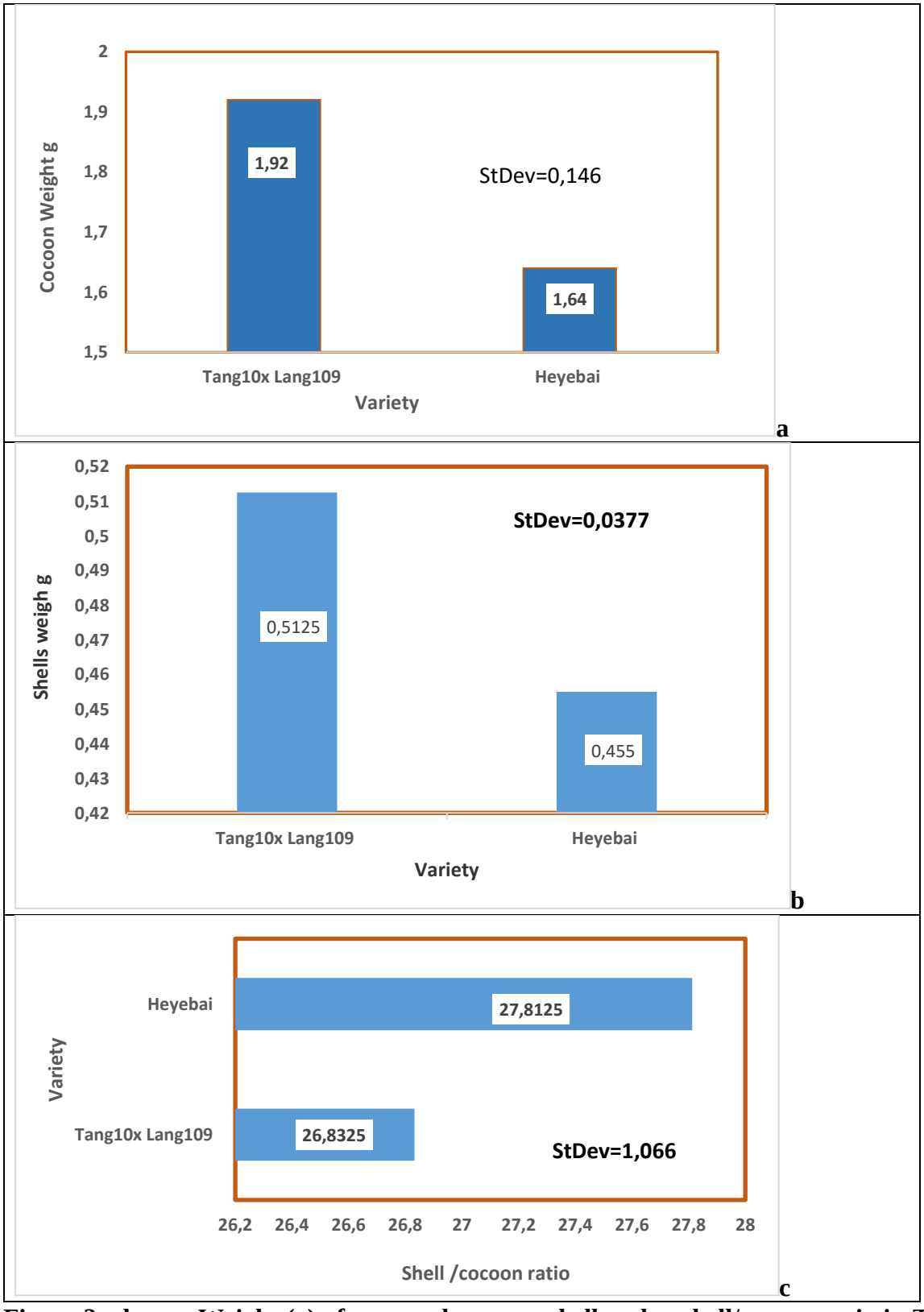

Figure 2a, b, c. a:Weight (g) of cocoon, b:cocoon shell and c: shell/cocoon ratio in Tang10x Lang109 and Heyebai variety.

As far as the effect of the variety on cocoon weight is concerned, analysis of variance was carried out, as it is shown on table 1 and figure 3:

Table 1. Analysis of variance concerning the effect of the variety on cocoon weight.

Source of diversity	Degrees of freedom	Sum of squares	Mean square	F	Pr>F
Variety	1	0.15680	0.156800	*48*	***0.0062***
Sample	3	0.00420	0.001400	0.4286	0.7477
Error	3	0.00980	0.003267		
Sum	7	0.17080			

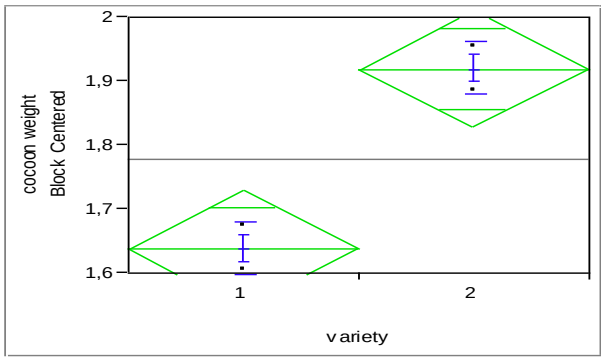

Figure 3. One way analysis of cocoon weight (g) by variety, 1:Heyebai, 2: Tang10x Lang109.

As far as the effect of variance to the shell weight is concerned, analysis of the diversity was carried out, as it is shown in table 2 and figure 4:

Table 2. Analysis of variance concerning the effect of the variety on the shell weight.

Source of Diversity	Degrees of freedom	Sum of squares	Mean square	F	Pr>F
Variety	1	0.0066125	0.006612	8.8659	0.0587
Sample	3	0.0025375	0.000846	1.1341	0.4600
Error	3	0.0022375	0.000746		
Sum	7	0.0113875			

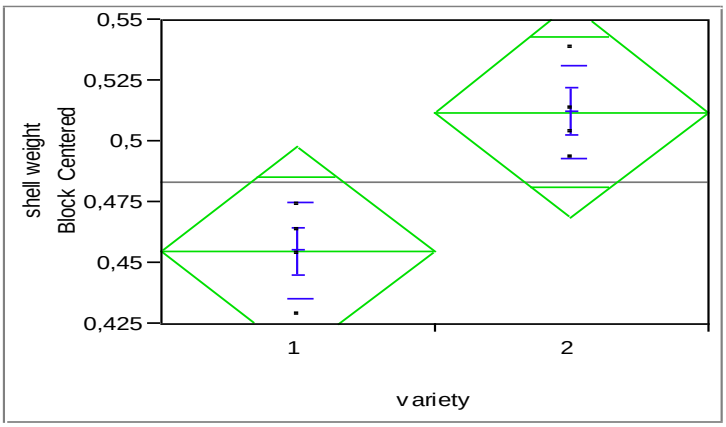

Figure 4. One way analysis of shell weight by variety, 1: Heyebai, 2:Tang10x Lang109.

There is no significant difference between the two varieties. As far as the effect of variety to shell/cocoon ratio is concerned, analysis of the diversity was carried out, as it is shown in table 3 and figure 5:

Table 3. Analysis of variance concerning the effect of the variety on shell/cocoon ratio.

Source of Diversity	Grades of Freedom	Sum of Squares	Mean Square	F	Pr>F
Variety	1	1.5138	1.51380	2.3568	0.2223
Sample	3	5.5675	1.85583	2.8894	0.2034
Error	3	1.9269	0.64230		
Sum	7	9.0082			

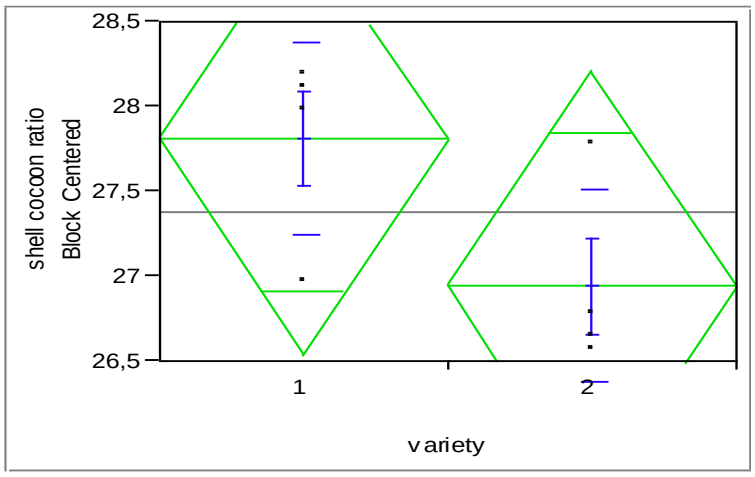

Figure 5. One way analysis of shell/cocoon ratio by variety, 1: Heyebai, 2: Tang10x Lang109.

Effective rate of rearing (ERR%)

The Effective rate of rearing (ERR%) is shown in table 4. The higher percentage estimated at Tang10xLang109 (92.4%). No significant difference was found among the two varieties.

Table 4. Effective rate of rearing (ERR %) for the two mulberry varieties.

Variety	Total number of cocoons yielded	Initial number of larvae	ERR %
Tang10xLang109	739	800	**92.4**
Heyebai	729	800	**91.1**

DISCUSSION - CONCLUSION

Leaf quality differs among mulberry varieties and the contents of specific components of the mulberry leaves which are responsible for the difference in rearing performances of the silkworm. In order to have comparable results of protein content of seven varieties in this study, it was necessary to collect fresh leaves from position 5 to 10 of each shoot of the above varieties, two of which were selected for further study. The hybrid Tang10xLang109 had the highest protein content and the Heyebai with low protein content, but widely used in many countries. It was necessary to rear the silkworm in the same room under controlled conditions to minimize environmental factors.

Comparing the protein content of the two varieties Tang10xLang109 and Heyebai, there was higher in Tang10xLang109 and we would expect to have dereferences on post-cocooning parameters. From the obtained results we conclude that differences in leaf protein content among two varieties can result differences on the cocoon weight when silkworms are reared from their leaves. Cocoon weight is directly related to production and is the way that the cocoon producer

increases his income. Shell weight (cocoon after the pupa is removed) is related to the amount of silk that each cocoon has. Since shell weight did not differ significantly between the two varieties, this means that other factors also involve in silk production besides protein content in silkworm's food.

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LABOR SAVING TECHNOLOGY FOR SILKWORM REARING IN BULGARIA

By

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ABSTRACT

During the period 2019 – 2022, at the Scientific Center on Sericulture, Vratsa, Bulgaria a 4-year field testing, using 3 Bulgarian hybrids, tolerant to adverse rearing conditions in a volume of 9 silkworm egg boxes has been conducted. The silkworm rearing was performed during the spring season. During the 1st and 2nd instars the larvae were reared in cartoon boxes and covered by nylon. After the beginning of 3rd instar the silkworm larvae were moved to constructions with movable trays. The feeding was 1 time per day up to the 2nd day of 5th instar and two times per day after that. The bed was not cleaned during the larval feeding. It was detected that the labor saving

technology tested provided obtaining of comparatively high cocoon yield and percentage of cocoons with alive pupae, by the same time at 2 times less labor expenditures, compared with the standard technology.

Key words: sericulture, rearing technology, labor, cocoons

INTRODUCTION

The favourable climatic conditions in Bulgaria and the existing rich national traditions are fundamental prerequisites for sericulture development. It could be an economically effective sub-sector of agriculture, as it can supply incomes for silkworm farmers in a significantly short period of time, as well as new working places and raw material for textile industry. The following factors influence significantly the silkworm development and productivity: the breed /hybrid/, the used rearing technology and environmental conditions (temperature and air humidity; ventilation in the room; quantity and quality of mulberry leaves).

In recent years there have been developed improved technologies of silkworm rearing aiming at lowering the electricity expenses and using less labour force in the process. Vasta et.al (2023) have proposed to automatize the process of sorting out cocoons by quality as they have developed the first prototype of the machine.

Ohura (2003) has developed a system for automatized insect breeding aiming at industrial production. The technology has a control program. After evaluation of the machine functionality, it has been established that its vibration and noise do not affect the silkworm growth and productivity. Henceforth, the process of larvae rearing in the fifth age can be completely automatized.

One of the main problems in sericulture is the maintenance of a relevant temperature-humidity regime during the period of silkworm feeding and cocoon spinning (Rahmathulla 2012). The success in sericulture depends on the environmental conditions, especially the biotic and abiotic factors. With relation to abiotic factors, temperature plays a main role for larval growth and productivity (Ueda 1975, Benchamin 1986). According to some research studies, high-quality cocoons are obtained at temperatures between 22–27°C. The presence of higher temperature values leads to lower-quality cocoons (Krishanswami 1973). The optimum temperature for silkworm rearing is between 20°C and 28°C, depending on the larval age. On the other hand, humidity is a factor influencing larval physiological functions and mulberry leaf drying rate.

According to Sodiqov (2023), the use of cloth and polyethylene foil for humidity preservation shortens the larval period with 2.7-4.0 days and leads to considerable growth of larva weight.

The silkworm rearing at the farmer's level in Bulgaria is mostly based on the traditional technology, namely feeding 3 – 4 times per day in the young ages and 2 – 3 times daily in the 4^{th} and 5^{th} instars by leaves and/or shoots, which requires higher labour expenses.

The present study purpose was to develop a labour saving technology in order to reduce the cocoon production costs and make the sericulture more profitable for the farmers.

MATERIALS AND METHODS

The study has been carried out during the period 2019 – 2022 at the Scientific Center of Sericulture – Vratsa. The experiment included 3 silkworm hybrids, which were tolerant to unfavourable rearing conditions, in 9 boxes of silkworm eggs each year. The silkworm rearing was performed in the spring season. During the first and second instars the silkworms were reared in cardboard boxes sizing 100 cm/60 cm/20 cm, arranged on a cross one over another. During both instars the silkworms were covered with polyethylene. During the young ages the mulberry leaves were cut by a cutting machine. The machine was designed and made at the Ukrainian Sericulture

Research Institute, Merefa, Kharkov district in early 90's. The machine capacity is 65 kg of fresh mulberry leaves per 1 hour.

After the beginning of 3rd instar the silkworm larvae were moved to constructions with movable trays. The rearing was performed at one level, on the floor. The pipes are installed on the floor by putting them into bigger pipes, welded on the floor. There's a wheel tray for feeding by mulberry branches/shoots and nylon net around the rearing bed in order to prevent larvae, leaf, remnants of excrement's dropping. The feeding was 1 time per day up to the 2nd day of 5th instar and two times per day after that.

From the third instar the silkworm rearing was done with whole mulberry branches, on deep unchangeable bedding, the mountages used for cocoon spinning were laid directly on the bedding, which was cleaned after the cocoons were harvested. The cocoons were deflossed by a deflossing machine, designed and made in Uzbekistan in 80's. The machine capacity is 60 kg of fresh cocoon per hour.

In the period from the beginning of fifth instar age to the cocoon harvesting the rearing room was not heated or cooled because the natural air temperature varied from 17 – 30 º C and the silkworm hybrids reared were tolerant to adverse rearing conditions.

The following character values were detected: yield of cocoons from one box of silkworm eggs, % of cocoons with live pupa, average cocoon weight, silk shell weight and silk shell %. The data obtained were mathematically processed (Lidanski, 1988).

RESULTS AND DISCUSSION

The results obtained are presented in Tables 1, 2, 3 and 4.

During the four experimental years for the hybrid Nova 2 x HB2 it was observed that cocoon yield from one box of silkworm eggs gradually grew, as in 2019 the values were from 31.23 kg, and in 2022 the values were 33.15 kg. The highest value of yield was reported in 2021 – 34.95 kg. In the three-year period – from 2019 to 2021 there was an increase with 3.72 kg, and after that in 2022 there was a slight decrease in yields up to 33.15 kg. Taking into account the same hybrid, the % of cocoons with alive pupa had preserved its comparatively high values - over 90% during the four experimental years. Cocoon weight gradually decreased during the years of silkworm rearing. In 2019 it had values from 1972 mg and in the last experimental year it reached 1596 mg, which was 376 mg less. The same tendency was observed regarding the silk shell weight – in 2019 it was 390 mg, and in 2022 – 307 mg, which was 83 mg less. In the four years the cocoon silkiness was within the bounds of 19-20%. Only in 2020 it was 20.58%.

The other hybrid - SN1xIva1 was reported with lowest values of cocoon yield already in the first year of study compared to the three tested hybrids. These values were preserved in the period 2019-2022, when the yield was within the bounds between 26-28 kg, and in 2021 there were reported extremely low values – 23.95 kg. In the same year there were reported low values of the other characters – cocoon weight, silk shell weight, silkiness. In the year 2021 all hybrids were established with lower values of the characters in comparison to the rest three experimental years. It could be due to a worse mulberry leaf quality. The hybrid SN1xIva1 showed high values of cocoon weight in 2019 – from 2038 mg, as this value was the highest among the three hybrids for the whole experimental period. After that this value started steadily decreasing, as in 2021 it reached the critical low value of 1623 mg, which was 415 mg less than in 2019. The next year these values were slightly increased up to 1752 mg, or 129 mg more than in 2021 and 286 mg less than in 2019. The same tendency was observed regarding the silk shell weight, where at the beginning of the experiment the values were 405 mg, in 2021 they went down to 286 mg, followed by a slight growth in 2022. The difference in silk shell weight values from 2019 to 2022 was 119 mg for the hybrid SN1xIva1. At the same time, in 2019 when the experiment started, the hybrid SN1xIva1 was reported with the highest values of cocoon weight and silk shell weight compared

to all hybrids tested. With relation to the silkiness character, the same tendency was observed – in 2019 it started with the highest value of silkiness compared to all hybrids – 19.87%, after that there was a decrease to 17.62% in 2021 followed by an increase up to 19.52 % in the last experimental year, which was the highest value compared to all tested hybrids. The percent of cocoons with alive pupa varied – from 85% in 2020, which was the lowest value for all years of study, to 96% in 2022.

The last tested hybrid Iva1 x VB1 was established with similar values of cocoon yield from one box of silkworm eggs in the first and fourth years of study – at the beginning of 2019 the yield was 34.27 kg, and in the last year – 34.80 kg. It made an impression that in 2021 there were reported extremely low values of 30 kg compared to the rest years of rearing. The hybrid Iva1 x VB1 showed the highest values of the cocoon yield from one box of silkworm eggs trait, as these values were comparatively high during the whole experimental period – 30 kg or above 30 kg. With relation to the percent of cocoons with alive pupa, in 2020 and 2022 there were equal values of 98%, and in the other two years, 2019 and 2021, the values were 90% for both years. The cocoon weight character showed a stable increase in values, as at the beginning of the experimental period the hybrid started with values of 1480 mg and in the last year there were values of 1972 mg. It was the highest value for this trait compared to all hybrids tested.

The silk shell weight trait for the hybrid Iva1 x VB1 showed a significant increase in values during the period – in 2019 the hybrid had values of 253 mg, which was the lowest value regarding this experimental year and this trait. The following year these values grew up to 344 mg, and in 2022 they reached 343 mg. The value in 2022 was the highest one taking into account the three hybrids, only the hybrid SN1xIva1 had similar values of 342 mg. Cocoon silkiness for the hybrid Iva1 x VB1 varied from 17.09% in 2019 to 18.49 % in 2021, as there was a slight decrease in 2022 – 17.39%.

Table 1. Industrial testing of the labour-saving technology for silkworm rearing in 2019

Hybrid	**Cocoon yield by one box of silkworm eggs, kg**	**% cocoons with alive pupa**	**Fresh cocoon weight, mg**	**Silk shell weight, mg**	**Silk shell percentage %**
Nova2 xHB2	31.23	93.00	1972	390	19.78
SN1xIva1	26.46***	92.00	2038**	405*	19.87
Iva1x VB1	34.27**	90.00*	1480	253***	17.09**

*The data were processed statistically towards the hybrid Nova2 x HB2
***P < 0.05; **P < 0.01; ***P < 0.001**

Table 2. Industrial testing of the labour-saving technology for silkworm rearing in 2020

Hybrid	**Cocoon yield by one box of silkworm eggs, kg**	**% cocoons with alive pupa**	**Fresh cocoon weight, mg**	**Silk shell weight, mg**	**Silk shell percentage %**

Nova2 xHB2	32.25	90.00	1764	363	20.58
SN1xIva1	26.55***	85.00***	1940***	376	19.38*
Iva1x VB1	32.45	98.00**	1863**	344*	18.46**

*The data were processed statistically towards the hybrid Nova2 x HB2
***P < 0.05; **P < 0.01; ***P < 0.001**

Table 3. Industrial testing of the labour-saving technology for silkworm rearing in 2021

Hybrid	**Cocoon yield by one box of silkworm eggs, kg**	**% cocoons with alive pupa**	**Fresh cocoon weight, mg**	**Silk shell weight, mg**	**Silk shell percentage %**
Nova2 xHB2	34.95	98.00	1875	338	18.03
SN1x Iva1	23.95***	90.00***	1623***	286***	17.62*
Iva1x VB1	30.00	90.00***	1693***	313	18.49

*The data were processed statistically towards the hybrid Nova2 x HB2
***P < 0.05; **P < 0.01; ***P < 0.001**

Table 4. Industrial testing of the labour-saving technology for silkworm rearing in 2022

Hybrid	**Cocoon yield by one box of silkworm eggs, kg**	**% cocoons with alive pupa**	**Fresh cocoon weight, mg**	**Silk shell weight, mg**	**Silk shell percentage %**
Nova2 xHB2	33.15	93.00	1596	307	19.24
SN1x Iva1	28.00***	96.00*	1752***	342*	19.52
Iva1x VB1	34.80*	98.00**	1972***	343*	17.39***

*The data were processed statistically towards the hybrid Nova2 x HB2
***P < 0.05; **P < 0.01; ***P < 0.001**

The developed labour-saving technology allowed that the premises were not heated during silkworm feeding. It reduced the energy costs, preserved the freshness of mulberry leaf for longer time, which led to longer period of leaf consumption and to higher yields of cocoons from one box of silkworm eggs.

On the other hand, the labor expenditures estimated were 1.8 hours per 1 kg of fresh cocoons produced while the labor expenditure at the standard rearing technology were 3.7 hours/kg of fresh cocoons. Until the beginning of 5th instar 9 boxes of silkworm eggs were fed by only one worker and after that 3 workers fed the larvae until mounting.

CONCLUSIONS:

From the results obtained we may conclude that the labor saving technology tested provides obtaining of comparatively high cocoon yield and percentage of cocoons with alive pupae, by the same time at 2 times less labor expenditures, compared with the standard technology.

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State-of-the-art in mulberry propagation at the Global Center of Excellence for Advanced Research in Sericulture and Promotion of Silk Production

By

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(Abstract)

Mulberry trees, belonging to the *Morus* genus, are long-lived, perennial plants with high economic value that grow in temperate and tropical climates, both spontaneously and in crops. The most common varieties include *M. indica*, *M. alba*, and *M. latifolia*, and it plays a critical role in the silk industry. More than that, mulberry is a polyvalent plant, due to its potential to produce functional foods and pharmaceutical supplements, making its cultivation a profitable venture. The objective of this paper is to explore alternative methods of multiplying biological material to increase the production of top-quality mulberry leaves and fruits. This research is conducted as part of the ongoing project, DUDFOOD, which aims to establish and revive mulberry nurseries and plantations using conventional culture, micropropagation techniques and alternative production systems such as aquaponics, hydroponics, aeroponics for the Kokuso 21 variety. To start, conventional culture has been initiated and maintained in greenhouse conditions, where the seedlings' growth has been accelerated by exposing them to purple LED Grow Light. Micropropagation, using MS as culture medium and different growth regulators, has been shown to be the most common method in the literature, and we have successfully initiated organogenesis and callus formation from seeds and buds as explants. Exploiting the potential for growing mulberry in hydroponics, aeroponics, or aquaponics systems is the final part of the research, representing a solution for year-round propagation when land is not available for conventional cultivation, when the climate is not favorable or when there is not enough water to ensure daily plant growth. Quality parameters are constantly monitored, especially the protein content which is desired to be higher than in conventional culture. Threfore, mulberry has high exploitation potential due to the prospects of using alternative multiplication techniques such as micropropagation and ponics systems to produce leaves throughout the year and his could be used in sericultural practice, food, or pharmaceutical industries.

Keywords: mulberry, micropropagation, alternative farming systems

Bombyx mori as a model organism for biomedical research: A recommended alternative for animal experimental models

By

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(Abstract)

In recent years, animal models have been extensively used in life sciences-related domains in order to address a wide range of biomedical issues, such as the development of novel treatments, but also for a better and more comprehensive understanding of certain genetic and molecular mechanisms. However, the widespread usage of animals involves certain drawbacks including high breeding costs, long generation time, and most importantly, great bioethical issues.

Consequently, the scientific community is constantly trying to replace or limit the usage of animals as experimental models. In the past few years, numerous studies reported the successful use of certain insects as model organisms, for instance, to investigate various human diseases or examine drug pharmacokinetics. One of the most used insects as a model organism is the silkworm, *Bombyx mori*. Its usage does not involve any ethical issues, furthermore, its whole sequenced genome has been published. *B. mori* has 28 pairs of chromosomes, being a valuable rich genetic source. One of the most important advantages of using the silkworm as a model organism is the short reproduction time and great progeny size. Furthermore, *B. mori* displays a moderate body size, this aspect represents a great benefit for experiments that involve oral administration or intravenous injection. On top of that, its breeding involves low costs. Nowadays, in a wide range of studies, the silkworm is used as a bacterial infection model for numerous bacterial strains, including *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Vibrio cholera*, but also as fungi and virus infection model. In addition, B. mori was used for diabetes and drug screening models, just to mention a few.

Keywords: animal models, *Bombyx mori*, insect, silkworms.

INCREASING THE VALUE OF THE BIOLOGICAL AND PRODUCTIVE PARAMETERS OF SILKWORMS (BOMBYX MORI) BY ADDING A NATURAL COMPOUND TO THEIR NATURAL DIET

By

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(Abstract)

Spiruline platensis is a photosynthetic prokaryote recognized by the United Nations World Food Conference as nutritious food, due to its high amount of nutritive ingredients. Its general chemical composition includes proteins (50-70%), essential fatty acids (1.5-2 % of 5-6% of total lipid), vitamins and minerals and it is worldwide used in animal breeding (Habib et al., 2008). The effect of three concentrations of spiruline was tested on four silkworm's breeds (C122, JH3, AO33 and B1). The followed parameters were larvae length (mm) and weight (g), silk gland weight (g), chrysalides and total cocoons weight (g), silk weight (g) and longitudinal and transversal cocoon's axes (mm). The technological and microclimate parameters in the rearing room were strictly respected, according to Dezmirean and Moise (2018), Dezmirean D. (2013) and Mărghitaş et al. (2003). Randomly, ten larvae were choose from every experimental group for further measurements. All data were collected and compared with those of the control group, which was ad libitum fed with mulberry leaves.The experiment generated data comparable with those of other researchers (Agam et al., 2018). The results demonstrate the positive effect of food supplementation with spiruline 1% on the majority of the studied parameters, especially on silk

weight. The differences obtained between different concentrations of spiruline are not statistically significant. For this reason, the supplementation with 3% or 5% of spiruline are not economically justified.

Keywords: Spiruline, silkworms, biological parameters, development

Recent progress in the synthesis of silk fibroin nanoparticles

By

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(Abstract)

Silk fibroin-based nanoparticles are a promising carrier for drug delivery purposes due to their biocompatibility and biodegradability. The present investigation aims to set up the synthesis method based on phase separation of silk fibroin and polyvinyl alcohol (PVA). Silk skein was boiled for 30 min in an aqueous solution of 0.02 M sodium carbonate, and then rinsed thoroughly with distilled water. After air-drying, the extracted silk fibroin was dissolved in 9.3 M LiBr solution at 60°C for 4 hours. The solution was dialyzed against distilled water using Snake Skin Dialysis Tubing (3.5K MWCO, 35 mm dry I.D., 35 feet) for 72 hours to remove the salt and centrifuged to remove silk aggregates as well as debris from skein. The final concentration of silk fibroin aqueous solution was approximately 5.3 % (w/v). The blend solution, prepared by mixing fibroin and PVA starting solutions, was stirred at room temperature and subjected to sonication using an IKA T25 digital ULTRA-TURRAX homogenizer. The solution was immediately transferred to open polystyrene petri dishes to dry until form a dried film. The dried fibroin/PVA blend film was dissolved in ultrapure water with gentle shaking at room temperature and centrifuged twice in a Sorvall high speed centrifuge. The final pellet was suspended in ultrapure water and sonicated to disperse the clustered fibroin nanoparticles. The characterization by Scanning Electron Microscopy (SEM) and Dynamic Light Scattering (DLS) showed a suspension of porous fibroin nanoparticle with a size ranging between 300 nm and 500 nm.

Keywords: silk fibroin, polyvinyl alcohol, nanoparticles

Genetic transformation of the silkworm (*Bombyx mori*) using *Piggybac* methodology

By

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(Abstract)

The silkworm (*Bombyx mori*) is a silk-secreting domestic insect that has been used in sericulture for thousands of years. Since 2008 it has been used as a protein bioreactor of great interest in the pharmaceutical field. Taking advantage of the cellular capacity of *Bombyx mori* to efficiently perform post-translational modifications in complex proteins, the *piggyBac* transposon methodology has been used as an attractive model for transgenesis, having as an advantage integration in the genome and stable expression to obtain heterologous proteins. The aim of this research is to obtain a line of transgenic silkworms that express the green fluorescent protein GFP (in vivo marker of transgenic organisms) under the fibroin heavy chain promoter. A microinjection protocol was applied to eggs of the pure multivoltine breed *Pure Mysore (PM)*, of tropical origin, using the pBac(3xP3-DsRadaf)R3 vector that contains the gene that encodes the GFP protein and pHA3PIG (plasmid helper) containing the transposase under the BmA3 promoter. Transgenic worms were identified, indicating the presence of the GFP protein in the cocoons, by irradiation with ultra-blue light with a 530 nm scanning filter, followed by PCR control, carrying out their reproduction and breeding until generation 17. The above is a useful background for the establishment of a methodology for obtaining future lines of transgenic silkworms that express more complex proteins of pharmacological interest in the cocoon.

Keywords: silkworm, transgenic, *piggybac*, *Bombyx mori*, proteins, green fluorescent.

Trends in using nutrient supplements in silkworm (*Bombyx mori* L.) nutrition

By

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(Abstract)

The *Bombyx mori* L. silkworm is an economically important lepidopteran insect for silk production. It is known that silkworm, as a monophagous insect, require certain nutrients for their growth and production (i.e., proteins, amino acids, essential sugars, fatty acids, vitamins and micronutrients) that are provided by the mulberry (*Morus* spp.) leaves due to the unique morin content. The quality of mulberry leaves depends on environmental conditions and affects the cocoons production and silk quality. The nutrition and health status of silkworm larvae are the

main factors influencing silk production. Over time, researchers searched alternatives to enrich the mulberry leaves with nutrient supplements such as amino acids (glycine, asparagine, arginine, serine), vitamins (vitamin B-complex, vitamin C) and minerals (calcium, phosphorus, zinc, magnesium, potassium, copper, selenium) to improve its quality and to increase the silkworm productivity and health. This review highlighted the recent trends in silkworm nutrition by using natural feed supplements. Effects of various probiotics such as *Lactobacillus* spp. (*L. acidophilus*, *L. plantarum*), *Bacillus* spp. (*B. licheniformis, B. subtilis*), yeast (*Saccharomyces cerevisiae*), and algae (*Spirulina*) as ways to fortify the mulberry leaves to modulate the larval and cocoon economic traits of silkworm were discussed. Moreover, the health benefits of probiotics on intestinal microflora of silkworm and disease resistance are presented. The enrichment of mulberry leaves with probiotics represents an eco-friendly strategy to improve the growth performance, cocoon productivity and silk quality.

Keywords: *Bombyx mori*, nutrition, probiotics, productivity.

An Insight on Pharmacological Functions of Silkworm Pupae (*Bombyx mori* L.)

By

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(Abstract)

Sericulture, the science of raising silkworms and producing cocoons, investigates ways to utilize of silk-based materials in a variety of fields, including cosmeceuticals, food additives, tissue engineering, medicine, and drug delivery systems. The silkworm (*Bombyx mori L.)* is the only insect currently known as a natural source of food and fiber. Industrialization, pollution, diseases (pebrine) and the higher cost of silk caused problems that led to the decline of the sector, although wide varieties of valorizations were studied. Besides uses of silk in the textile industry, and application of silkworm by-products (pupae particularly) for animal feeding and as nutritious-rich food for humans, multiple functionalities in the pharmaceutical industry were subjected to scientific investigations and emphasized over time. This paper highlights silkworm pupae's (SP) therapeutic value and functional characteristics, attracting interest their high-quality proteins and lipids concentration, as well phospholipids, sugars, polyphenols and flavonoids, vitamins, five tocopherols, 25 different types of minerals and other bioactive compounds. Such as, the SP functional compounds can impact beneficial human physiological process. Oiled and de-oiled SP have a protein level ranging from 51.6% to 70.6%, an excellent amino acids composition (mainly methionine), and a lipid content between 6.2 and 37.1% (dry matter bases) with an excellent fatty acids (FA) profile. The previous data have shown a significant concentration of polyunsaturated FA (PUFA, ~44% of total FA), respectively omega-3 (including α-linolenic acid, ~36-38%), omega-6 (including linoleic acid, 6-8%), traces of docosahexaenoic and eicosapentaenoic acids. SP compounds have a variety of pharmacological functions and can play significant therapeutic role on many diseases. Blood glucose, blood pressure, and increased cellular oxidation have been

associated with a variety of metabolic disorders. The intracellular reactive oxygen species (ROS) control inflammation by regulation of signaling pathways. Cardiovascular disease can develop as a result of an imbalance in ROS. The amount of PUFA is strongly associated with the release of ROS. The surface of stomach ulcer and secretion decrease when SP oil is added to the diet, while the gastric pH is raised, oxidative damage is mitigated, and inflammation is decreased. A few peptides and amino acids have antioxidant properties. By the stimulation of antioxidant enzymes and the cholinergic system, SP may have neuroprotective effects. Due to the presence of polyphenolic groups and FA-like linoleic acid, SP may have antigenotoxic properties. Around 4% of the dry matter in SP skin is chitin, which can be converted into chitosan, chitin sulfate, chitin nitrate, chitin xanthate, and sodium carboxymethyl chitin, among other useful compounds. Immunomodulatory, antibacterial, anticancer, antioxidant, hepatoprotective, antifatigue, and anti-apoptotic actions were among the numerous and complex medicinal impacts identified. Furthermore, the SP compounds decrease plasma triglycerides, prevent fatty livers, prevent arteriosclerosis and thrombosis, increase cell vitality, strengthen the body's defenses system, and can act as wound dressing material. We conclude that SP allows valorizing its active compounds for health. From a perspective, new medical ways of valorization can be researched: possible solutions for chemotherapy in the treatment of tumors, SP could be a source of anticancer drugs, act as natural antioxidants or for prevention and treatment of human cardiovascular disease.

Keywords: silkworm, pupae, functional compounds, pharmacological, health

SILK MATERIALS FOR DESIGN OF ADVANCED MEDICINES AND BIOMEDICAL APPLICATION

By

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ABSTRACT

The use of silk proteins, fibroin and sericin in medicine and pharmaceuticals production is one of promising and high-tech ways of their application. These proteins were originally used as raw materials for the production of protein hydrolysates that possess a wide range of physiological, prophylactic, and therapeutic effects. But these proteins will find a more effective application in their natural polymeric form characterized by high mechanical, sanitary and crowding properties, biocompatibility, biodegradability and self-assembly which are much-needed in stabilization, capsulation, shaperoning of proteins and enzymes, in 3D printing, designing and modulation of dosage drugs and their properties, in cellular and tissue engineering, etc.

The fibroin property of interconversion from the soluble to the gel and crystalline state allows to create on its basis and, especially, with the participation of sericin, a large variety of drugs with modified properties. This is important in the creation of low-toxic pharmaceuticals and in the treatment of metabolic and neurodegenerative diseases, especially, in personalized therapy. In field of biomedical application - allergy-free nutrition, for the elderly, various bioprotheses, implantable biosensors, tissue and cellular engineering, hemostatic and regenerative therapy and others.

The research and development strategy in this area is focused on the selection of suitable raw materials and wastes of the silk industry, on their inexpensive processing into universal initial semi-products for bio- and nanotechnology, on the development and selection of attainable methods for conversion the initial semi-products into bio-sorbents and composites as well as on the methods of incorporating the samples of effective local and foreign medicines.

The use of these methods allowed us to obtain samples for testing dosage forms with the inclusion of polyphenolics: quercetin, curcumin, gossypol and its derivatives, proteins (insulin, lysozyme, lipases, phospholipase A_2, phospholipase D), protein hydrolysates (different peptides and amino acids), allapinin and other drugs.

We have examined EM-structure and FTIR spectra of the obtained samples, there solubility, cumulative releasing of drugs, antioxidantal, antimicrobial, enzymatic and other properties. The rate of ligands release varied in accordance with its concentration, temperature, pH, content of extragent. As shown by the results obtained silk proteins can be used in creation of large variety of drugs with modified properties.

Keywords: silk proteins, matrix material, drugs design, biomedical application.

Introduction: Silk is a national treasure of the Republic, a source of affordable, unique biomaterial for modern medicine, bio- and nanotechnology. Uzbekistan ranks third in the world in the production of silkworm cocoons. Such a volume of production with the development of the latest scientific and technological approaches will allow not only to achieve import substitution in the field of silk bioproducts, but also to come to the production of completely new products for export, obtained from local raw materials and even silk production waste. Compared with the leaders of sericulture (China, India) Uzbekistan has a large proportion of sericulture waste and cocoon processing. The excess waste part of silk production can be directed to a non-textile direction, to obtain new biotechnological products, while at the same time increasing the profitability of the industry and employment of the population. In addition, the utilization and rational use of protein-based biopolymers, unique in their properties, in high technologies of Uzbekistan is still in its infancy. Among the scientific studies of scientists in the non-textile field of sericulture (the so-called functional sericulture) from biotechnologically developed countries (USA, Japan, South Korea, Germany, France, Italy etc.) [1-9] there are also works of Uzbek scientists using silk materials to produce high-tech products based on this unique biopolymer [10 -20].

Recently, fibroin has been used as various biomaterials, including tissue engineering (bioprostheses), as allergen-free nutrition, for the treatment of wounds and burns, for targeted drug delivery with their micro- and nanodosing and controlled release, in permeable biosensor membranes, for the proliferation of animal cell cultures, as well as for many other biotechnological goals. Biosorbents with different porosity were obtained from silk fibroin in parallel for the surface immobilization of various medicinal ligands, as well as their inclusion in a porous matrix of regenerated fibroin. Soft encapsulation of peptides, proteins, enzymes, inhibitors, hormones, genetic material, organelles, and even living cells, allows them to preserve their nativity and possibility of their activity directed modification (like polyhedrin and peritrophins). When combined with liposomal technology, the possibilities of targeted delivery of fibroin-based drugs

will increase significantly. Fibroin, which is prone to sorption of some poorly soluble substances, may prove to be an indispensable material in study and use of transported polyphenols and other poorly soluble substances

Materials and methods: As a source of fibroin and sericin raw materials and waste of silk production were selected: cocoons, raw silk, defective cocoons, cut and "perse"cocoons, etc. fibrous and woven waste of silk-winding and weaving production. To remove sericin, etc. water-soluble components from the cocoon shell and other sources of fibroin were extracted with aqueous solutions of alkali, soda and some detergents. [10, 13, 16]. After the transfer of fibrous fibroin to water-soluble by these methods, the obtained fibroin solutions were dialyzed against distilled H_2O, 2 days before the complete disappearance of the dissolving salt (and alcohol) [13, 16].

The dialysate was concentrated to a concentration of 60-80 mg/ml and left in the refrigerator at 0-4^oC for use. With such storage, the fibroin solution retains a liquid state for 16-20 days. This period was used for planning and conducting experiments to obtain composites with medicinal products with peptide, protein, phenolics and other effective physiologically active substances and medicines. Subsequently we studied various approaches for accelerated gelling of the material using various methods, including ultra sonical and liposomal methods [14, 15, 17, 18].

Results and discussion: Regenerated silk fibroin obtained by a previously developed technique was used in the work [10, 13, 16]. This made it possible to obtain experimental samples according to previously selected optimal conditions for obtaining various physico-chemical states of fibroin: from soluble to gel-like and completely insoluble. Preliminary calculations of the costs of obtaining a unit of regenerated fibroin biopreparation in comparison with the costs of obtaining one described in the literature have been made. Various fibroin and mixed with other (bio) polymer including sericin and chitosan matrices and guest composites were also obtained. In total, more than 60 samples obtained on the basis of regenerated fibroin were accumulated, of which 20 were selected the most promising for detailed study in the *Center* for A*dvanced Technologies*, where preliminary characterization and analysis were carried out by methods of IR spectroscopy with Fourier transform and electron microscopy with magnification from 50 to 3000 times. These samples also used to study the release of "guests" and fibroin from composites and for other investigation. Antioxidantal, antimicrobial, enzymatic and other properties was also studied/. The rate of ligands release varied in accordance with its concentration, temperature, pH, content of extragent. IR spectra with Fourier expansion were obtained for samples of the initial regenerated fibroin (2) and gossypol, megosin, ragosin and insulin composites obtained on its basis with a ratio of fibroin : guest 1:1 and 1:2. The results of such study are presented in Fig. 7,8. A detailed discussion of the results obtained will be conducted after receiving additional studies of the spectra of polyphenolic compounds purified samples before increasing the resolution of micrographs of samples 1-13 to 20-50 nm and obtaining IR spectra of purified initial polyphenols and insulin.

As shown obtained results silk fibroin and sericin can be used in creation of large variety of drugs with modified properties.

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APPLICATION

Образцы стабильных и долгосохраняемых растворимой (слева) и нерастворимой частичной (справа) форм регенерированного фиброина шелка для био- и нанотехнологических целей.

Fig. 1.

Образцы нагруженных пленочных (А) и гелевых (Б) форм композитов фиброина и госсипола (F-Gos) - 1, ацетата госсипола (F –GosAc) - 2, мегосина (F-Meg) – 3 и аллапенина (F-Alla) - 4 для лабораторных испытаний *in vitro* и *in vivo*

Fig. 2.

Выход полифенолов и белка из пленочных

КОМПОЗИТОВ 1- **F –Gos,** 2- **F –GosAc** и 3- **F-Meg**

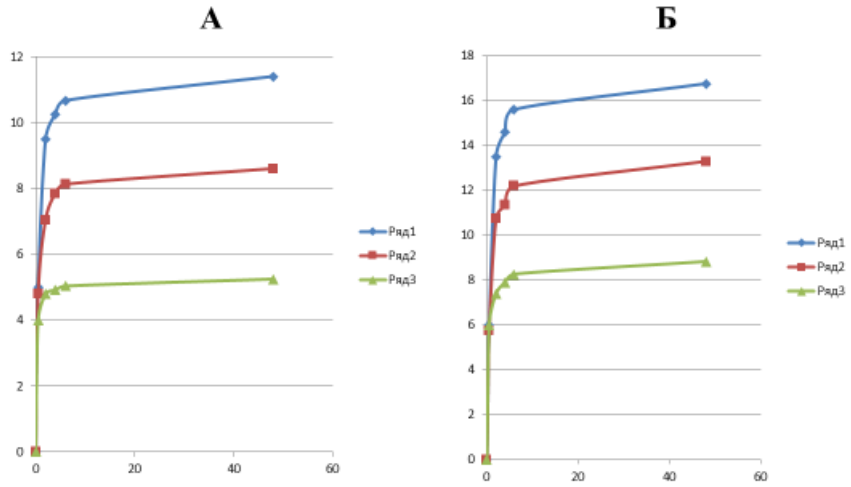


Fig. 3.

Высвобождение аллапинина и белка из фиброиновой матрицы F-Meg-композита

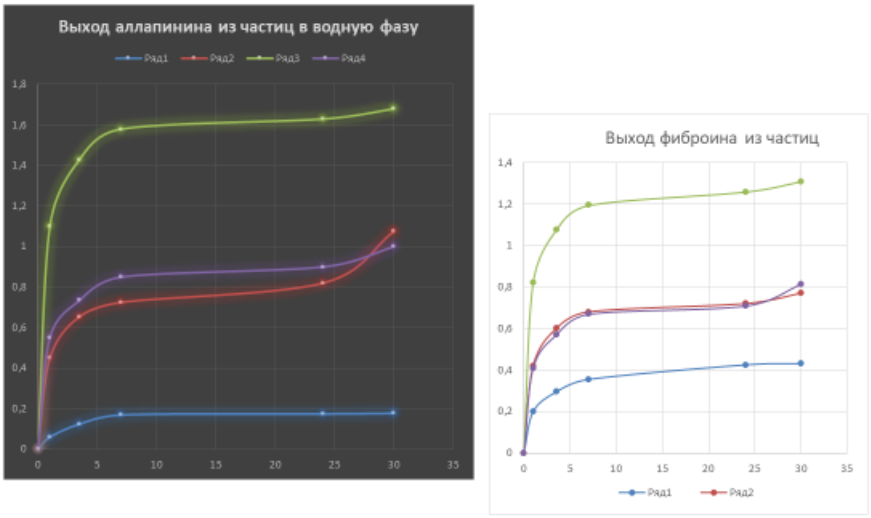
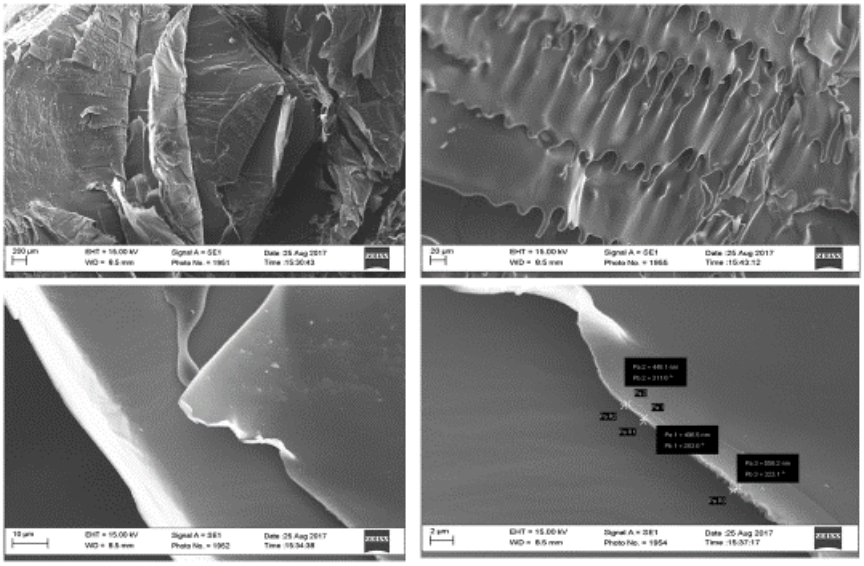


Fig. 4.

Лиофилизированный, растворимый препарат фиброина для нужд био- и нанотехнологии



Fug. 5.

Порошковая нерастворимая форма фиброина с бета-складчатой структурой

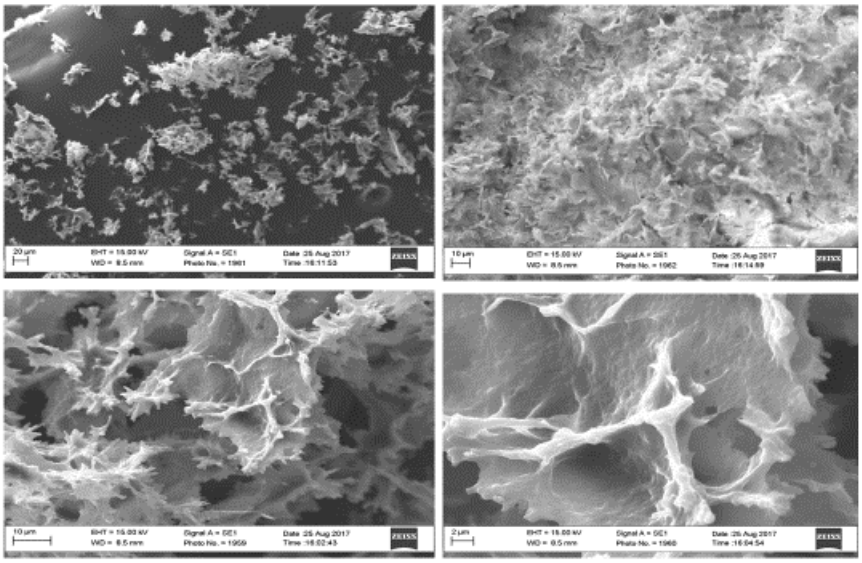


Fig. 6.

Спектры FTIR альфа-фиброина без (1) и с добавками мегасина в соотношении 1:1 (2) и 2:1 (3)

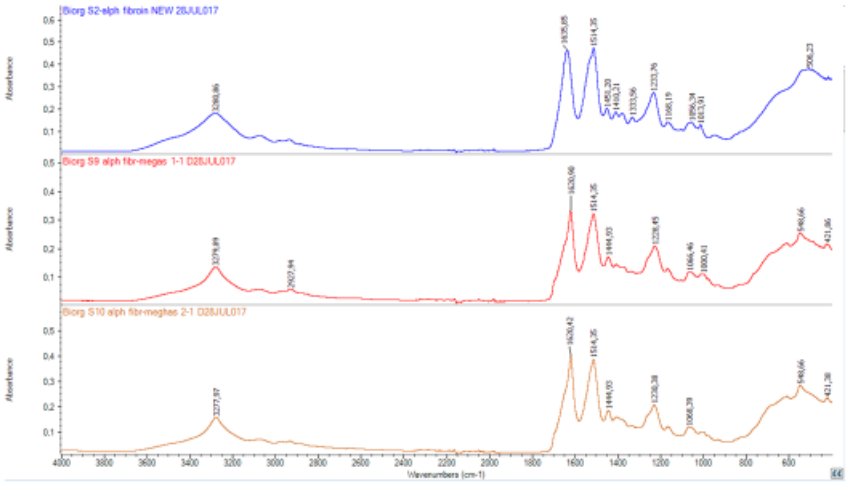


Fig. 7.

Спектры FTIR альфа-фиброина без (1) и с добавкой инсулина в соотношении 2:1 (2)

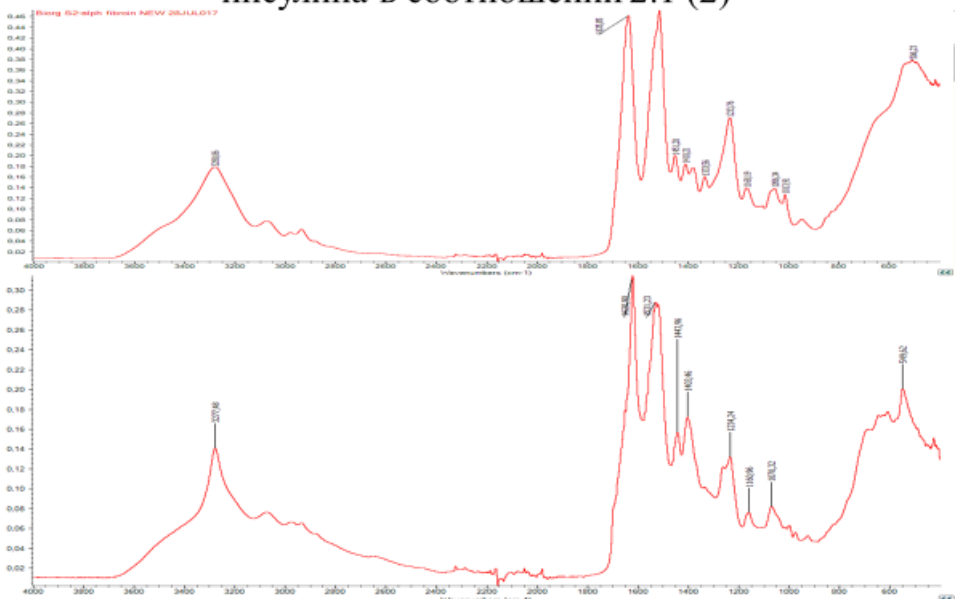
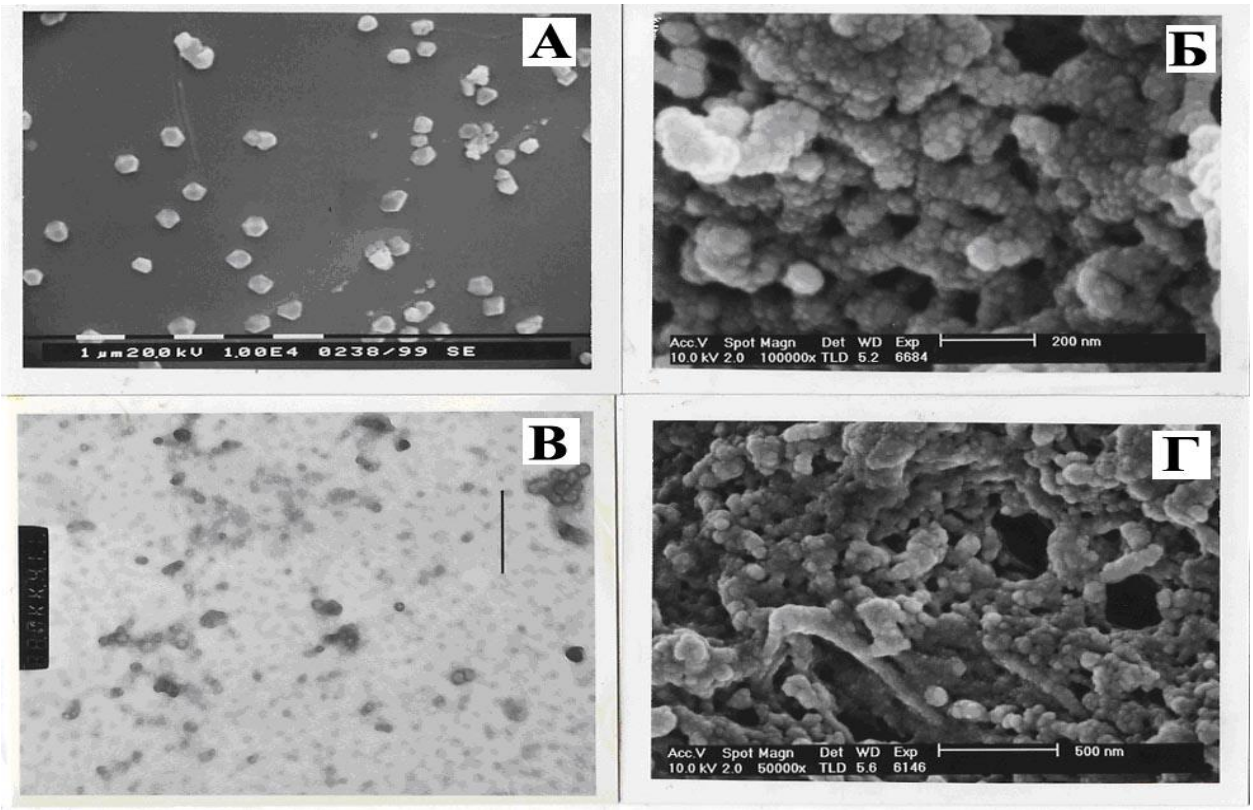


Fig. 8.


А
1 µm 20.0 kV 1.00E4 0238/99 SE
Б
Acc.V Spot Magn Det WD Exp
10.0 kV 2.0 100000x TLD 5.2 6684
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500 nm

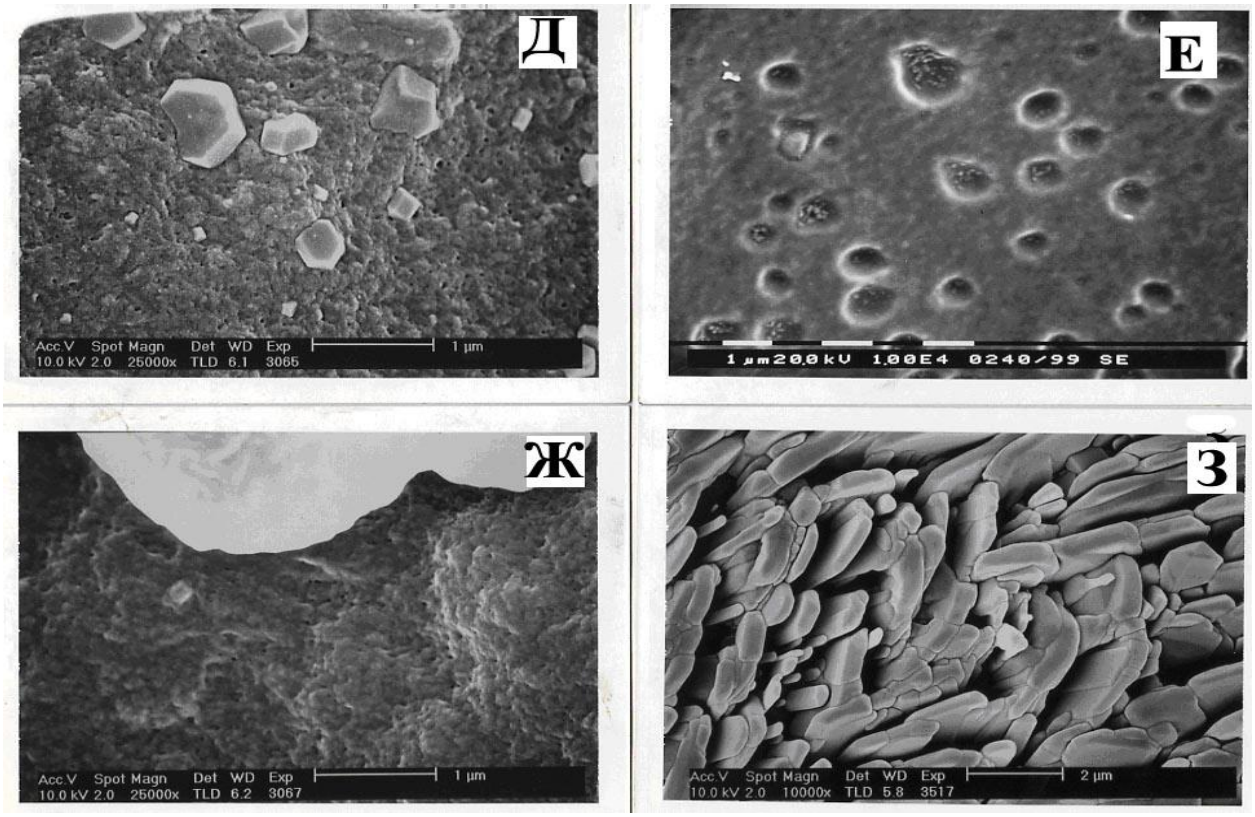

Fig. 9.

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Fig. 7. FTIR spectra of fibroin without additives (1) and with additives of megasin in a ratio of 1 : 1 (2) and 2 ; 1 (3).
Fig. 8. FTIR spectra of fibroin without additives (1) and with insulin additives in a ratio of 2 : 1 (2).
Fig. 9. Electron microscopic images of fibroin-guest composites: fibroin-PAA-Lipase (F-PAA-CRL, (A) **и** F- Dextran blue (Б), F - PLD (B), F- lysozyme (Г), F- *E.coli* cell (Д), F- vitamin B_{12} (E); F- *Saccharomyces cerevisiae* cell (Ж), F- cytochrome C (З) composites.

DEVELOPMENT OF ARTIFICIAL DIET FOR SILKWORMS BASED ON LOKAL CELLULOSE COMPONENTS

By

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ABSTRACT
Uzbekistan is a long-standing and significant global producer of cocoons, raw silk, silk goods and products. Sericulture based on the mass breeding of the silkworm (SW) using artificial diet (AD) can be attributed to large-scale biotechnology. The basis of such cocoon production is AD prepared according to specially developed formulas. The development of such recipes began in Japan in the 70s of the XX century. Similar studies have been started in Uzbekistan since 1981.

The composition of the developed AD for SW among the main components includes: mulberry leaf powder (10% - 55%), protein-containing (20% - 50%) and cellulose-containing (8% - 40%) components. The samples of cellulose-containing components previously used in the AD, presented by the Research Institute of Chemistry and Technology of Cotton Cellulose and the Central Research Institute of Cotton Industry, were obtained using acid treatment of cotton lint and also from the waste of bandages (Institute of General Chemistry, Kyrgyzstan).

In this study, we tested samples of microcrystalline cellulose (MCC) and nanocellulose (NC) powder presented by the Institute of Chemistry and Physics of Polymer, Uzbek Academy of Sciences. These are samples of MCC from cotton lint, straw and waste of glycyrrhizinic acid production in comparison with samples of powdered cellulose and MCC of American and Italian production. In the experiments, the attractiveness of diets based on these samples was evaluated, as well as the growth and development of SW. The larvae were fed AD until the III – IV age.

It is known that mulberry SW is a monophagus, very sensitive to the components added to the AD, including cellulose preparations. Our studies have shown that foreign-produced cellulose samples had a greater attractiveness and a better SW development at younger ages, while increased indicators for local cellulose preparations were found only for some hybrids. The best results of these data were obtained for a NC sample.

Study on the search for cellulose samples with increased data of attractiveness and stimulation of growth and development on AD for silkworm eggs of local and foreign eggs plants are continued.

Keywords: Silkworm, nutrition, artificial diet, microcrystalline and nanocellulose.

Introduction. Uzbekistan is a long-standing and significant global producer of cocoons, raw silk, silk goods and products. Uzbekistan accounted for more than 60% of sericulture products and their processing in the former USSR.

Sericulture based on the mass breeding of the silkworm (MW) using artificial diet (AD) can rightfully be attributed to large-scale biotechnology. The basis of such cocoon production is compound feeds prepared according to specially developed recipes. The development of such recipes began in Japan in the 70s of the XX century. Similar studies have been started in Uzbekistan since 1981 [1, 2].

The composition of the developed AD for SW among the main components includes: mulberry leaf powder (10% - 50%), protein-containing (20% - 50%) and cellulose-containing (8% - 40%) components. The samples of cellulose-containing components previously used in the AD, presented by the Research Institute of Chemistry and Technology of Cotton Cellulose and the Central Research Institute of Cotton Industry, were obtained using acid treatment of cotton lint and also from the waste of bandages with the help of Lewis acids (Institute of General Chemistry, Kyrgyzstan) [1, 3].

Our work has shown that cellulose is not an inert component that stimulates peristalsis in the digestive system of the silkworm, but also a source of glucose produced by symbiotic yeast-like fungi [2, 4].

Pretreatment of cellulose-containing raw materials and AD with industrial enzyme preparations of the cellulose complex led to an increase in MS productivity [5-7].

In this study we tested samples of microcrystalline cellulose (MCC) and nanocellulose (NC) powder presented by the Institute of Polymer Chemistry and Physics, Uzbek Academy of Sciences and provided by experts from . These are samples of MCC from cotton lint, straw and liquorice production woody waste [8] in comparison with samples of powdered cellulose and MCC of American, Japanese and Italian productions. Attractiveness of diets based on these samples, as well as SW growth and development were evaluated in the experiments . The larvae It is unprofitable to feed older ages larvae on AD in agricultural production. due to the high cost of AD. Although currently in such developed countries as Japan, the Republic of Korea, the USA MS is fed on entire larva period for production of peptide, protein dosage forms and vaccines in special centers with automatic agrotechnical and microbiological control.
were fed up to age III or IV and then they were transferred to mulberry leaves (in a combined. technology).

Materials and methods. The cellulose-containing materials obtained from NIIHTC and the Institute of Organic Chemistry of the Kyrgyz Academy of Sciences, as well as samples of microcrystalline cellulose (MCC) and nanocellulose (NC) powder presented by the Institute of Polymer Chemistry and Physics, Uzbek Academy of Sciences and MCC of foreign production. These samples were added (20%) to AD recipes of domestic and Japanese inventions. Studies of the attractiveness, growth and development of MS were carried out in Petri dishes, in which samples of artificial feed were placed around the perimeter, and hatched were placed in the center of Petri dishes and incubated at 27.5°C and humidity 80-90%.

Determination of the attractiveness and development of MS larvae on AD at certain times was recorded by photographs, counting the number and weighing of larvae. After the transition of the larvae to the age of 3 or 4, they were transferred to feeding mulberry leaves up to curling cocoons.

The diets were tested on breeds, hybrids and partenclones from the collection of the Institute, Laboratory of Genetics and Breeding (Partenoclones 29, 113 and APC, breeds IP1, IP2, as well as hybrids IP1 x IP2 and APC x MG) and from the Lab. Breeding NIISH (L-27 L-28, L-500, L-501, Parvoz 1, Parvoz 2, Guzal, Marvarid, Uzbekisistan 5, Uzbekistan 6, Marhamat and Asaka, hybrid with Ferghana Plem-silk station IP2 x IP1, as well as industrial hybrids from China ("Liongguong x Forliao" and "Jingsong x Haoyue") were also tested with AD containing MCC.

Results and discussion. The table shows data on the degree of polymerization and the degree of crystallinity of the cellulose preparations studied. As can be seen from the results of the analysis, the tested samples are relatively close in degree of crystallinity, and differ significantly in degree of polymerization.

Table

Polymerization degree (PD) and crystallinity degree (CD)
of domestic and imported cellulose samples

№		Samples	PD	CD

1		MCC (cotton lint)	254	90.20
2		MCC (straw)	202	80.86
3		MCC(licorice root)	224	88.50
4		PC- Kyrgyzstan	145	88.31
5		FCC, USA	810	-
6		MCC-Italy	271	79.96
7		MCC-Diets, USA	175	85.93

As can be seen from the results of the analysis, the tested samples are relatively close in degree of crystallinity, and differ significantly in degree of polymerization.

In the work, much more attention was paid to the selection and procedures for the pre-preparation of the initial components for the preparation of AD, since MS, being a monophage, is very sensitive to substances that are not characteristic of its traditional feed substrate and related substances, even in standard feed ingredients. So, for example, soy meal and fish meal containing protein, excellent ingredients for most animals, require additional preparation to become components of AD for MS. In this regard, it was necessary to conduct preliminary testing for MS not only of MCC samples. To compare and adjust the prepared MCC, those of Japanese and Italian production were used. In addition, it is necessary to take into account the different sensitivity of different breeds and hybrids to the artificial prepared feed substrate. Therefore, a diverse and extensive experimental work was carried out to approximate the results actually observed by specialized manufacturers.

Next, we have preliminarily evaluated the attractiveness of the tested preparations of MCC, the Fig. 1. As can be seen, the most attractive is the preparation of DIETS company (USA). Increased attractiveness is also characteristic of Japanese-made powdered MCC.

Fig. 2. shows the same preparations in the composition of AD for MS according to a local prescription.

Fig. 1. Selection method of one of the samples of the cellulose component for AD for MS. At the bottom - the MCC DIETS , at the top – the MCC of domestic product from straw, on the left – from cotton lint, on the right –

from the of licorice.

Fig. 2. The study of the attractiveness of AD of different composition containing the same amounts of cellulose powders. Notation, as in Fig. 1.

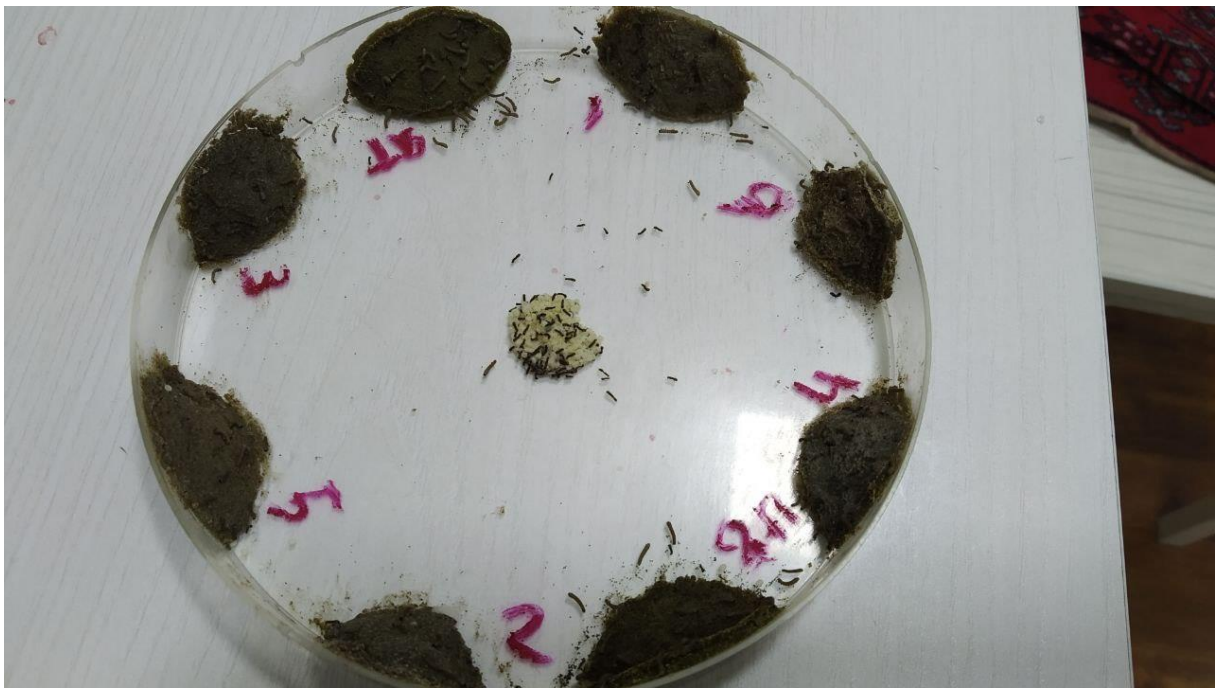

Figure 3. shows one of the serial experiments using the Line 500 MS from the Breeding Department. 1 - MCC from cotton lint, 2 - from straw, 3 - from licorice root, 4 - from cotton nanocellulose, 5 - from MCC DIETS, 6 - MCC of Japanese production. For comparison, 7 is a commercial AD follows from the results of numerous experiments that the most attractive MGC preparations for the creation of IC are samples of foreign production, although local preparations, especially nanocellulose from cotton lint, are also outstanding for some TS breeds. 1 and 8 is a Japanese-made commercial AD 2.

Figure 4. Distribution of tracks of MS parthenoclone PK-113 on AD of various composition.

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Studies were carried out on monophagous MS which is very sensitive to components added to AD, including cellulose preparations. They showed that imported cellulose samples had a greater attractiveness and a better influence on development at younger ages, while increased indicators for domestic cellulose preparations were only for some breeds and hybrids.

Studies on search for cellulose samples with increased indicators of attractiveness, growth and development stimulation in AD for domestic and foreign silkworm eggs production plants are continued.

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The contribution of sericulture to the pharma-farming industry

By

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(Abstract)

Sericulture has been a traditional practice in many countries for centuries; however, in the recent years, it has gained attention in the pharma-farming field. The concept of pharma-farming implies the adaptation of silkworm breeding technologies to obtain target pharmaceutical products and beyond. In this direction, sericulture offers a unique advantage in obtaining target recombinant proteins on a large scale by using *Bombyx mori* as a bioreactor. This approach exhibits the benefit of lower costs and a reduced environmental footprint compared to traditional manufacturing methods. Moreover, silkworms can be genetically modified to produce silk proteins with specific therapeutic properties, such as antimicrobial or anticoagulant activity. Sericulture also contributes to the development of new drugs and therapies. Silk-based drug delivery systems display several advantages over conventional systems, including biocompatibility, biodegradability, and controlled release properties. These systems offer a promising solution for the delivery of difficult-to-administer drugs, such as proteins and peptides. The unique properties of silk enable the sustained release of these drugs over an extended period, improving their efficacy and reducing the need for frequent dosing. With further research and development, silk-based drug delivery systems could offer a cost-effective, sustainable, and customizable solution for drug delivery in the pharmaceutical industry.

Keywords: *Bombyx mori*, pharma-farming, recombinant proteins, drug delivery.

The Effects of Feeding with old Slovenian and Hungarian Mulberry Varieties on Silkworm's Growth and Silk Quality

By

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(Abstract)

In the former sericulture regions of Europe, there are still a number of centuries-old trees of the white mulberry (*Morus alba* L.), which represent both a valuable natural heritage and outstanding monuments of the past sericultural activities. In Slovenia and Hungary, attempts are currently being made to reintroduce the sustainable cultivation of mulberry trees. The aim of the research was to collect data on the ecogeographical locations of historical mulberry trees in both countries and to investigate the content of key metabolites in the leaves in order to determine genotypes of local origin that are superior in terms of individual compounds defined as feed markers for silkworm larvae (*Bombyx mori* L.). Local mulberry genotypes maintained in the mulberry gene-bank were selected based on previous determinations of primary and secondary metabolites in leaves sampled at the tree's place of origin. The major phenolic compounds in mulberry leaves were identified as caffeoylquinic acid derivatives with chlorogenic acid predominating. The flavonol fraction contained rutin, quercetin malonyl hexoside, isoquercetin, quercetin acetyl hexoside and quercetin dirhamnosyl hexoside, while the predominant kaempferol glycoside was kaempferol acetyl hexoside. The Slovenian and Hungarian mulberry genotypes had significantly higher total protein contents, lower total phenolic contents and differed significantly in some individual phenolics compared to the reference sericultural and fruit varieties. Significant differences were also found in macro- and microelement contents. We can conclude that proteins, some specific phenolics and elements have a positive influence on larval growth, cocoon size and silk thread parameters. The results of the study indicate that the local mulberry varieties are suitable for the production of high quality silk cocoons and raw silk.

Keywords: chemical composition, feeding experiment, mulberry leaves, silkworm

Preservation of Cultural Heritage: Sericulture in Brandenburg/Germany

By

Ines Rönnefahrt

Initiative Zernikow e.V. (non-profit association)

(Abstract)

The Mulberry alley in Zernikow in the north of the Mark Brandenburg goes back to silkworm breeding and raw silk production, which was intensively promoted in Prussia in the mid-18th century. Until the middle of the 20th century, there were repeated phases in which silkworm breeding was practiced in the region, but only with limited economic success. The non-profit association 'Initiaitve Zernikow e.V.' works to preserve the cultural landscape and its history and organises various cultural events at the Zernikow estate every year. For many years, the association has also been working to preserve the mulberry alley, both by caring for the remaining old trees and by planting new ones. In addition, a small exhibition and the annual Mulberry Festival draw attention to the history of the alley. In this way, an almost forgotten part of the region's cultural history is preserved.

Keywords: cultural heritage, preservation

Cocoon Jewellery - a creative way to explore a silk cocoon

By

Bourouliti Dimitra

Hello! I welcome you all to our small city! Soufli is famous of the silk production and I grow up on a totally silky environment. Our family business working on silk handicrafts made me creative and easy to move from one artwork to another. My family background was full of embroidery, meters of laces, patrons and sewing cloths, jewellery making, build houses. All these working hands lead me easily to become an artist. First I became painter and drawer, photographer and video maker at the next step. I moved rapidly from one way of expression to the other. I made studies on fashion and jewellery making and then back to digital art. Anyway an artists.

My first attempt to create something from cocoons was the famous souvenir of Soufli the Cocoon Komboloi. A different version of praying rizario made of cocoon beeds and I learn how to make it as a small kid. I didn't paint them on that time, I just use it whole or create colours with the matching materials that I used. Then in 2004 I started my first cocoon jewellery and I started to sell them in exhibitions in Greece.

Then I started observe cocoons on old frames. In all places that we used to have silk production in Greece you could see hundreds of cocoon frames on the wall. They usually hold some family

images in the middle and give us the certainty that few years ago all these beautiful frames on the walls were made of the small or big family silk production.
Many representation of nature like flowers and birds made of pieces of cocoons. Plain background, sometimes embroidered and cutted cocoons in small pieces that create a new cocoon image. I saw cocoons used as décor on clothing and as layers on embroidery.
Around 2004 these small flowers made of cocoons became my new material on my jewelleries. Beads and white flowers and lot of experiments. In 2009 we started use cocoons also for cleaning our faces from dirty and black spots. So we clean them and keep them for that reason. After some years of creating white and natural colored jewelleries I started colored them with natural dyes as tea, beetroot, hibiscus and egg colors for Easter time.
In 2011, I started making wedding wreaths that Orthodox wore on their wedding day. Wreaths that made of the same cocoon flowers! For many years our wedding wreaths became in fashion and many people wanted to wear this natural, amazing silk material on their heads, hairs and body. Unique as the wedding day.
Then after a nice jewellery workshop that my mother had she noticed that they used dyed cocoons cutted in shapes and as we had many kilos of cocoons we decide to create our first colored collection of Greek cocoons made especially for crafts in 2012. All these cocoons take place in my creations rapidly and I just fall in love! Of course all this new material that was new in the Greek market made us very quick to give many workshops in all Greece in term to create new customers and learn about this amazing material with all these fantastic potentials.
I create a huge collection of different shades of colours, bride, dark, lighter and started to cut them in different shapes, even in flowers and leaves. Customers were thrilled, they just feel amazed of our creations and they wanted to make their own. This is how we made a whole collection of silk materials for crafts.
After all this years I notice that cocoons has amazing abilities and a creative mind can make thousands of ideas with them. They are so flexi as material because you can change shape when you wet it, you can cut it, you can dye it, you can saw it, you can glue it, you can use it in many ways. My creative journey as the daughter of the silkworm (that was a joke that we used to make as kids) is not finished! I never stop feeling surprised of what I discover under all these silky layers of the lovely house of the silkworm!
All these ideas make me work more on the idea of change shape, forget what you know and experiment. We get the knowledge of Macrame and needlework and create smaller motifs so we can use them in jelleries and smaller creations fordable for more costumers. That is how we get the folk art and we made jewelleries with fresh and modern ideas. This is our aim, to make workshops for people to learn our local crafts and keep them alive. This is how you can make a creation influenced from the past, from local artisans and transform it to modern image with future and presence in nowerdays.

Brief information on the state of sericulture science in Azerbaijan

By

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Silk farming is a very profitable branch of agriculture. The history of sericulture has its roots in the depths of centuries. The secret of making silk was discovered by the Chinese more than four thousand years ago. However, some researchers postpone this period for another thousand years. Fava and Witt, famous Western European silkworm growers of the last century, argue that silk obtained from silkworm cocoons has been known in China for 7000 years.

According to N.N. Shavrov, the silkworm was brought to Azerbaijan in the 5th century. In the Middle Ages, Azerbaijani silk was exported along the Great Silk Road to Iran, Asia Minor, Syria and Venice. In the XV-XVII centuries, Azerbaijani silk was highly valued in the markets of Italy, France, Russia, Turkey, Iran and other countries of Europe and Asia.

The most powerful and steadily growing development of sericulture in Azerbaijan was achieved during the period of Soviet power, thanks to the conduct of the industry on a broad scientific basis. According to N.N. Shavrov, the silkworm was brought to Azerbaijan in the 5th century. In the Middle Ages, Azerbaijani silk was exported along the Great Silk Road to Iran, Asia Minor, Syria and Venice. In the XV-XVII centuries, Azerbaijani silk was highly valued in the markets of Italy, France, Russia, Turkey, Iran and other countries of Europe and Asia.

The Sericulture Research Institute of Azerbaijan has played a significant role in the development of sericulture in Azerbaijan. Here, many highly productive varieties of mulberries, white-stone breeds and hybrids of silkworms were created, which have high productivity and the best technological indicators of cocoons, a number of effective technologies were developed for feeding silkworms, for growing the exploitation of mulberries, for the primary processing of cocoons, measures to combat silkworm and mulberry diseases. As a result of the widespread introduction of all these scientific developments into the practice of sericulture, the volume of production of live cocoons in the republic began to increase in ascending lines and amounted to 3113 tons in 1960, 3664 tons in 1970, 4981 tons in 1980 and finally in 1993 the highest level of cocoon production in the history of sericulture of Azerbaijan was reached - 5924 tons. During this period, there were 2 breeding sericulture stations and 7 grenage plants in the republic, producing a total of 3.6-4.3 tons of grena of various categories annually. More than 150,000 peasant families (families of collective farmers and state farm workers) were engaged in feeding the silkworm.

The development of sericulture and the increase in the production of cocoons in the republic stimulated the development of the silk industry. 3 large silk processing enterprises were established in the republic: Sheki silk processing plant, Ordubad and Khankendi cocoon winding factories. These enterprises annually produced 250-350 tons of raw silk, more than 30 million square meters of finished fabric and various final products. 10-15% of the products were consumed within our republic of the former USSR. At that time, more than 7,000 people worked in the Sheki Silk Combine alone. The government of the republic planned to bring the volume of production of cocoons by 2000 to 10 thousand tons.

However, this plan was not destined to come true. In 1991, Azerbaijan, the first among all the Union republics, officially announced its secession from the Soviet Union. Following him, other union republics began to secede from the USSR. In 1992, the Soviet Union collapsed. Since that time, the production of cocoons and raw silk in the republic began to decline annually. So, if in 1992 the republic produced 5220 tons of live cocoons and 185.6 tons of raw silk, then in 1994 these figures were respectively 1431 tons and 177.7 tons, and in 1996, respectively, 762 tons and 9.9 tons. After 1996, the production of cocoons and raw silk in the republic practically ceased.

The reason for this decline in sericulture and the silk industry was many factors, the main of which, in our opinion, are as follows:

1) After the collapse of the Soviet Union, all economic ties between the former Soviet republics, which had been well established until that time, were severed. As a result, the products produced by the Sheki Silk Mill (raw silk and other products), 85-90% of which in Soviet times were sent for sale to other Union republics, began to accumulate in the warehouses of the plant. The ineptitude of the then leaders of the silk mill and the lack of control by government organizations to find foreign markets for the sale of accumulated goods, led the Sheki Silk Mill to insolvency. The plant could not pay off the district offices for sericulture (the so-called head coco dryers) for the dry cocoons purchased from them. In turn, the district offices for sericulture could not pay with silkworm farmers for the purchased (hybrid) grena. Grenage factories could not pay off the breeding sericulture stations for elite grena. As a result of all this, all the above-mentioned links of the sericulture system of the republic were forced to suspend their production activities;

2) Occupation of 20% of the territory of Azerbaijan by Armenian invaders since 1988. In the occupied zone, such large sericulture areas as Zangilan, Gubadli, Dzhabrail, Fizuli and Aghdam districts remained, which in total annually produced more than 1,000 tons of cocoons. The Khankendy cocoon-winding factory also remained in the occupied zone.

3) A deep economic crisis in the period 1990-1995 and unprecedented inflation rates in the republic, reaching several hundred, and sometimes up to a thousand percent. Silk-growers handed over the live cocoons they produced to procurement organizations in June, and received money for products (live cocoons) in 5-6 months, at the end of the year. During this time, as a result of strong inflation, the purchasing power of money was significantly reduced. This greatly reduced the interest of farmers in the breeding of silkworms.

4) A strong weakening of the fodder base of sericulture in the republic. The crisis phenomena occurring in the early 90s also affected the energy supply system in the republic. There was an acute shortage of electricity, natural gas and coal. The population during this period cut down a significant part of the mulberry plantations.

It should be noted that despite all the drama of the situation, Azerbaijan still has great potential opportunities and all the necessary prerequisites for the revival and development of sericulture and silk industry. The country has very favorable natural and climatic conditions for the rotation of mulberries and the breeding of silkworms. The most important prerequisite for the revival of sericulture is the transformation of the Sheki Silk Mill into an open joint-stock company (JSC), "Sheki-Ipak". The government allocated millions of US dollars to this JSC for recreational production activities. Currently, the potential annual production capacity of Sheki-Ipak JSC, subject to the organization of two-shift work, is 150-200 tons of raw silk, which requires more than 1000 tons of live cocoons as raw materials.

The highly respected President of Azerbaijan, Mr. Ilham Heydar oghlu Aliyev himself personally occupies, if I may say so, leads the sericulture of the republic. We have a "State Program" on silkworm breeding. In 2019, the production of live cocoons in Azerbaijan was 619.0 tons. The "State Program" on sericulture notes that, in 2025, the production of live cocoons in the republic will be 6.0 thousand tons.

Due to the lack of scientific personnel, candidate and doctor of sciences, postgraduate students in 2015, AzSRIS was liquidated. Despite this, AzSRIS had very good scientific ties, agreements with Georgia, Ukraine and Bulgaria, with the aim of conducting joint selection work on silkworm mulberry and mulberry breeding, as well as on the organization of gene pool exchange.

In addition, in 2005, the Black Sea, Caspian Sea and Central Asian Silk Association (BACSA) was established within FAO with the aim of coordinating ongoing research on sericulture and mulberry growing countries, i.e., Azerbaijan, Bulgaria, Georgia, Greece, Iran, Kazakhstan, Kyrgyzstan, Tajikistan, Turkiye, Ukraine and Uzbekistan, to coordinate ongoing research on sericulture and mulberry breeding, to exchange genetic resources of both mulberry and silkworm, to facilitate the exchange of information, to organize the conclusion of bilateral and

multilateral agreements, etc. Actually, certain works have already been carrying out in these areas. Since new international hybrids were obtained, including Mayak 5 x Hesa 2/1 and reverse combinations, Ganja 8 x Vratsa 35/2 and reverse combinations, Veten x Karabakh, Karabakh x Veten, Sultan x Zefer and Zefer x Sultan, these hybrids were presented to the State Commission. Finally, since 2005, the BACSA Executive Committee from the CIS countries, i.e., in Azerbaijan, Uzbekistan and Georgia, has carried out research work on the basis of the situation of the Executive Committee. Since, 2 new breeding lines were bred in the 12th generation (F_{12}). They were named Ordubad-1 and Ordubad-2. These breeds and the hybrid Namazly 3xMizuri 1 were presented to the State Commission. In addition, in recent years new varieties of mulberries have been created Nizami- tut, Ilyas-tut, Fakhraly - tut, etc.

According to the State Statistics of the Republic for 2022, the number of mulberries in our country reached 7.0 million pieces. Of these, 4.5 million pieces were brought from China. According to the State Statistics, now in the republic the area of mulberries was reached on 3256.0 hectares, of which 1924.0 hectares are old, 1332.0 hectares are intensive and super-intensive mulberry plantations.

After independence, new breeds of silkworms Namazly 1, Namazly 2, Namazly 3, Veten, Karabakh, Sultan, Zefer, Ughur, Khayal, Ganja-8, GE-143, ŞZEM-4, Yagub, Chingiz, Mughan-1, Mughan-2 were introduced in the Republic of Azerbaijan. Of these, Mughan-1, Mughan-2 are regionalized in the republic.

In the republic, more precisely in our institute of animal husbandry, it has a gene pool of silkworm (62 breeds), and mulberries (100 varieties and 1000 forms).

In addition, new breeds of silkworm GE-143 x ŞZEM-4, ŞZEM-4 x GE-143, Yagub x Chingiz, Chingiz x Yagub were introduced at the Sheki Regional Center.

Currently, industrial grena is brought from China. Since, our tribal stations (Gakh tribal station) are not yet fully operational. And this creates some problems for the state. Therefore, we are trying to finally get rid of the dependence on the import of grena from the PRC.

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My Silk Fairytale
My name is Rie Koustrup – come from Denmark. I would like to tell you a fairytale – a silk fairytale

I will tell you something about the life with my husband Ole Zethner.
Ole and I were together for about 30 years – he died last June in an age of 86. We were both widow people.

Ole was an entomologist (insect expert) – he worked almost all over the world. I was a primary school teacher.
In the year 2005 we decided to stop working – we wanted to do something interesting TOGETHER
Insects give much work and pain all over the world – there are bad insects, but also good ones. Ole used to fight against the bad ones without using too many pesticides. He was even known as the IPM grandfather in Cambodia (Integrated Pest Management).
We now looked forward to study the good insects together.
Already in 1980 Ole had written a book on silk - at that time he lived and worked in Pakistan. He wrote the book in Danish language.
We both knew that people in Denmark did not know much about silk.
So in the year 2005, after Ole was fired from his job, we decided to make a travel by car through Europe all the way through Polen, Bulgaria, Romania and Greece into Bursa in Turkey. Already in the Spring we had learned that Soufli was an interesting place for silk, and we met some very special people there who have since been a part of our big family. We have been here many times and we have loved it every time. It is a part of our silk family.
During our visit in Romania, we visited a silk institute near Bukarest (Sericarom). Here I received my first silk eggs and mulberry seed ever. "Try it" the very nice people there told me – and I did when I returned to our home. Since then I have grown many White Mulberry trees and all our 14 grandchildren have tried to be silk farmers in a small scale, and we have told many people how to make silk.
February 2007 our first book was "born". We called it Silkens Veje in Danish, it is "Ways of Silk" in English. It became a rather well sold success in Denmark. We started to give lectures in schools, universities and at many private meetings. We made during the next years more than 50 lectures – in Denmark – European countries, Afrika and India, Nepal, Bhutan and Burma.

Ole and I loved to travel together – to meet people - to teach people and to learn from them. When you teach you yourself also learn. It is very important to share your knowledge with other persons.
During many years Ole had worked in Africa and I had joined him many times. A thought came to us: Do they make silk in Africa?
We will write our next book on African Ways of Silk. So we had to prepare a travel in countries in Africa.
After having studied the internet and Ole had corresponded with colleagues and friends, we decided to make an Africa – travel. 7 African countries in 7 weeks. Uganda, Kenya, South Africa, Madagascar, Ghana, Burkina Faso and The Gambia.
We learned that UGANDA produced silk, they sent people to be educated in India, but at that time in Uganda they had no plans for the use of the cocoons.
KENYA educated silk farmers and they researched also with help from India. Now adays they are doing more education through ICIPE. They made 2nd Edition on the book.
SOUTH AFRICA is well known for their Mulberry Silk (duvets) as well as their Eri silk (Ricinus or castor).

In MADAGASCAR we saw beautiful scarves and shawls made for funerals and tourists. Wild silk and spider silk. Yellow.

GHANA has a tradition for Kente . The Kente pattern was used for silk shawls many years back among the kings – and is very popular today but in artificial silk. In GHANA we met some Mulberry plantations and a small production of cocoons.

In BURKINA FASO there was a small production of wild silk. Gorom Gorom.

From our travel in Africa we learned that people wanted to produce cocoons but many did not know what to do with them. We made contact between countries - and heard later that Ghana for instance started selling cocoons to SA for producing of duvets.

Our book "African Ways of Silk" was first published 2008 by CASAS in Cape Town and later by icipe 2017. Book for education.

Ole worked for many years in India and the countries round India. So we had to go to India to collect information for "Indian Ways of Silk". We visited a gigantic cocoon market in Karnataka (open 365 days) and the Hanuman Weaving Factory in Bengaluru, plus small family factories where only few people worked. This was all Mulberry Silk.

But silk is not only made from larvae eating Mulberry leaves. There are many other larvae from other Moths spinning silk and we wanted to know about them also. In Odisha we found people making tasar silk from the beautiful Tasar silk Moth, the lovely and very expensive Muga which looks like golden threads, and the popular Eri silk made from Ricinus or Castor. Piece Silk. (Ghandi)
In Assam we met a very ambitious and friendly man, Dilip Barooah, manager of the company Fabric Plus. He became our very good friend. Together with Dilip we wrote "Indian Ways of Silk"2012 and "South Asian Ways of Silk" (2015). Ole and I visited Guwahati in Assam many times until Dilip died 2020.

"South Asian Ways of silk" is on silk in India and the surrounding countries: Pakistan, Nepal, Bhutan, Bangladesh, Myanmar and Shri Lanka. Ole asked scientists from those countries and they gave wonderful help without payment. The book was published in Nepal 2015.

It is always interesting to visit people who have the same interest and almost the same knowledge as you have.

We have met many interesting people on our travels and our feeling was, that people who work with silk are very kind and full of hospitality.

During the latest years we have unfortunately lost some of our best silk friends (I will call them silk family) Nikos Bouroulitis, Dilip Barooua and my dear husband Ole Zethner, who has taught me so much.
The day before Ole died my daughter told him that the baby girl she and her husband had adopted was going to be called Silk. He smiled!
Rie Koustrup

Consumers' attitudes toward silk products: an experts' perspective

By

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(Abstract)

During the last two decades, there is an apparent shift in marketing and branding toward a more integrated approach focusing on locality and sustainability. In the case of Soufli city in Northern Greece, the revival of the silk industry and the originality recognition of its traditional silk products have played a crucial role in the regeneration of the local economy and the tourism promotion of the destination. The present study sought to explore consumers' preferences and attitudes toward silk products and the brand identity of the local silk industry. It also investigated producers' perceptions toward the sericulture's contribution in regional development and the silk sector's challenges in the meta COVID-19 era. Qualitative data were selected from 20 in-depth interviews with silk experts and local entrepreneurs, and content analysis provided the main dimensions that seem to have a critical influence on the silk industry, and the promotion of silk products in the domestic and global market. More specifically, the main findings showed that i) consumers have a strong preference for silk products, especially local silk textiles and luxury silk-based cosmetics, and they seem willing to pay a premium price for the products' quality, ii) local silk businesses have gained intense brand recognition and consumer loyalty, and there is also a noticeable demand increase for local silk products, iii) sericulture is a dynamic sector with a substantial contribution to regional economy, social development, and cultural identity formation, iv) there are several obstacles in sericulture production due to the lack of inputs (sufficient food for the silkworms, sufficient number of mulberry trees) and the disease risk in the silkworm breeding, v) the business installation and operation costs are quite high, especially in turbulent economies.

Keywords: silk industry, local products consumer attitudes, experts' perceptions

CONTENTS

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