



SILKWORMS PUPAE AS PROTEIN SOURCE FOR PIGS – A REVIEW

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Keywords: pupae, silkworms, protein, feed, pigs

INTRODUCTION

The silkworm (*Bombyx mori*) is an important monophagous, lepidopteran insect due to the silk produced and its potential for human and animal food, pharmaceutical usage, biogas from substrates of mulberry silkworm (Łochyńska and Frankowski, 2018; Wu et al., 2020; Karnjanapratum et al., 2022).

Silkworms gained attention as a model in research, having characteristics such as low cost of reproduction, the large size of offspring, short generation times etc. (Zhang et al., 2012; Meng et al., 2017).

Soybean meal, as the main feed plant protein source used in monogastric animal diets, has a considerable impact on the environment (Wiedemann et al., 2016; DiGiacomo and Leury, 2019).

Furthermore, the availability of soybean meal for animal feed may be constrained because it is a component of the human diet and is not a highly productive crop.

According to the statistics (OEC; <https://oec.world/>), in 2020, Romania became the 32nd largest importer of soybean meal in the world (about \$204M).

Soybean meal was the 111th most imported product in Romania during the same year. The protein level of soybean meal range between 40-49%, while lipid content varies between 0,5-3% (Banaszkiewicz, 2011).

Due to its high protein content, SWP meal has been used to feed animals, especially for monogastric species such as poultry, pigs, and fish, as well as for ruminants (Sheikh et al., 2018).

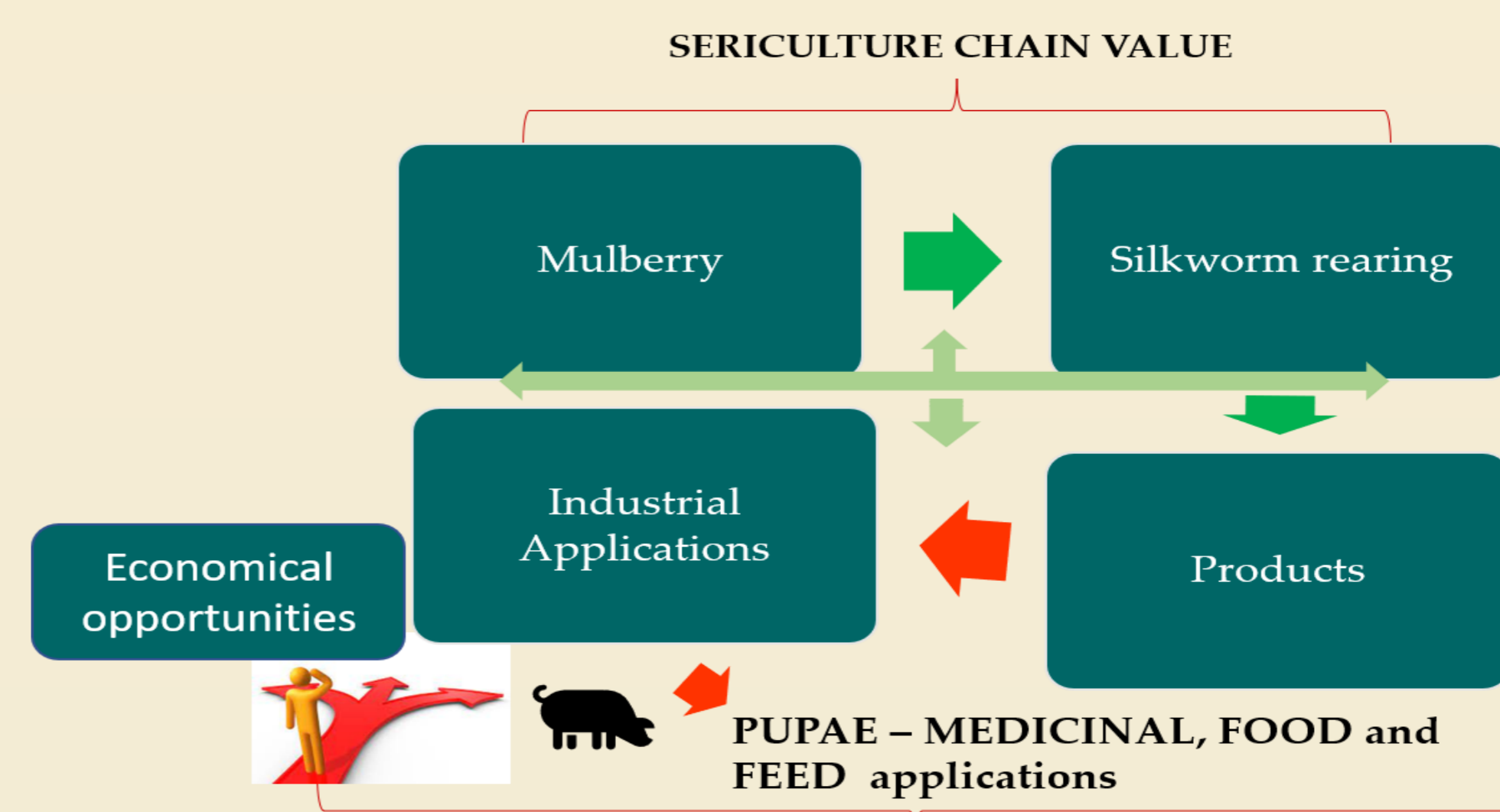
With an emphasis on pigs, this review provides an overview of the current situation regarding SWP as a sustainable source of animal feed.

MATERIALS AND METHODS

The most relevant and recently published papers available on PubMed, Elsevier, MDPI, and Research Gate, using the keywords "silkworm pupae", "composition", "protein", and "pigs" were screened.

We also used the bibliographic material regardless of the years of publication when recent papers were not available.

In this review, we tried to provide the scientific information reported about nutritional characteristics and the potential of using silkworm (*Bombyx mori* L.) pupae in animal feeding with a focus on pigs.



RESULTS AND DISCUSSIONS

Proximate composition of SWP

Specification	%, DM bases	%, fresh	References
Dry matter (DM)	-	23.2-25.9 81-97.5	Lamberty et al. (2019) Feedpedia
Protein	48-60	-	Herman et al. (2022)
	49-54	21.5	Wu et al. (2021)
	59.52-94.98	13.81-16.83	Lamberty et al. (2019)
	60.7	-	Sheikh et al. (2018)
	51.6-70.6	-	Feedpedia
Lipid	30	-	Herman et al. (2022)
	-	13	Wu et al. (2021)
	6.2-37.1	-	Feedpedia
	25.7	-	Sheikh et al. (2018)
Fiber	2.5-5.8	-	Feedpedia
	3.9	-	Sheikh et al. (2018)
Ash	5.8	-	Sheikh et al. (2018)
	-	1.16-1.33	Lamberty et al. (2019)
	-	3.3-10.6	Feedpedia
Chitin	3-4	-	Herman et al. (2022)
	-	-	Lamberty et al. (2019)
Gross Energy - (MJ/kg) - (MJ/kg DM)	-	5.09-6.82	Lamberty et al. (2019)
	25.8	-	Feedpedia

Effects of dietary addition of SWP in pigs' diet compared to classical fish meal protein rich source

References	SWP level	Pigs' category and breed	Period	Performances
Ramamoorthi and Mercy (2003)	0, 3% and 4% and 6.7% (substitute for FM protein 0, 50 and 100%)	Growing-finishing Large White Yorkshire ♀	90 days	- weight gain (kg): 45.9 and 44.6 vs. 43.3 kg; - average daily gain (g/day): 510.1 and 495.7 vs. 481.4 g; - feed conversion ratio (kg feed to kg gain): 3.63 and 3.62 vs. 3.78.
Medhi et al., (2018)	0, 3% and 7% (0, 50 and 100% replacement of FM, with or without enzymes supplementation at the rate of 65 g/100 kg feed).	Growing crossbred (Hampshire Ā— Assam local pigs)	70 days	No significant differences were observed for average daily gain, dry matter intake, digestibility of nutrients as well as balance of energy and nitrogen, except that the digestibility of ether extract increased by supplementation of enzyme in the diet.
Choudhury et al. (2021)	SWP muga, 0, 2% and 4% as substitute for FM	Grower pigs Large White Yorkshire	45 days	- average daily gain (g/day): 127 and 146 vs 125; - feed conversion ratio (kg feed to kg gain): 3.16 and 2.87 vs 3.45.

CONCLUSIONS

This review revealed the various applications of one of the main silkworm by-products for the livestock industry, emphasising pig feeding.

While looking through more than 60 papers online, there are few comprehensive scientific studies on using SWP in pig diets.

Mulberry leaves, the single component of the diet of silkworms *Bombyx mori*, have a strong correlation with the SWP composition.

All authors agree that SWP is a remarkable source of nutrients for animal feeding, with protein constituting the predominant compound which provides a valuable amino acid composition.

The structure of the lipids of the SWP is advantageous to health due to their high content of essential fatty acids, particularly n-3.

The vitamins, minerals, and other bioactive compounds complete this nutritional value of SWP.

Due to the SWP composition, this could be an important ingredient for animal feed.

ACKNOWLEDGEMENTS

This study was funded by the Ministry of Agriculture and Rural Development and supported by the Academy of Agricultural and Forestry Sciences, Romania.

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ARTIFICIAL DIET AS AN ALTERNATIVE IN SILKWORM (*BOMBYX MORI* L.) FEEDING – A REVIEW

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Keywords: artificial diet, nutrients, mulberry, silkworm (*Bombyx mori* L.).

INTRODUCTION

Silkworm (*Bombyx mori* L.) is an important monophagous insect in the sericulture industry. The mulberry leaves (*Morus alba* L.) are known as valuable plants rich in nutrients and nutraceuticals due to the presence of chemofactors (morin, β -sitosterol) and antioxidants (flavonoids, anthocyanin and alkaloids), the traditional feed in the rearing of silkworm larvae. The mulberry is also used in pharmaceutical, food, beverage and healthcare industries, being considered a suitable plant for sustainable development. Over time, research on using the artificial diet in silkworms has been focused on different topics: i) rearing silkworms in the season when mulberry leaves are insufficient or not available and ii) as an organism model for human diseases (i.e., tumour, degenerative and metabolic diseases) due to the low breeding cost, short generation time, genetic background, large progeny size and numerous genes homologous to humans.

OBJECTIVE: This review summarized the literature information about the impact of nutrition as a key factor in silkworm rearing and the effectiveness of using artificial diet based on different ingredients in silkworm productivity and health.

RESULTS AND DISCUSSIONS



Chemical composition of mulberry leaves (*Morus alba*)¹

Items	Mulberry leaves	
	fresh	meal
Dry matter (DM, % as fed)	30.2	90.5
Crude protein (% DM)	19.1	18.0
Crude fat (% DM)	5.6	3.5
Crude fibre (% DM)	13.5	13.7
Neutral detergent fibre (% DM)	30.9	37.0
Acid detergent fibre (% DM)	22.3	25.1
Ash (% DM)	12.3	12.8
Lignin (% DM)	5.4	6.1
Condensed tannins (% DM)	7.0	30.0
Gross energy (MJ/kg DM)	18.2	17.5
Calcium (% DM)	2.23	4.23
Phosphorus (% DM)	0.32	0.42
Potassium (% DM)	1.75	2.17
Sodium (% DM)	0.20	0.12
Magnesium (% DM)	0.49	0.47

Examples of artificial diet composition for *B. mori* silkworms

Ingredients	Reference
30% mulberry leaves powder, 28% defatted soybean meal, 15% cellulose powder, 6.1% corn starch, 3.7% citrate, 4% salt mixture, 4% sucrose, 7% agar, 0.4% ascorbic acid, 0.4% vitamin B mixture, 0.3% phytosterol, 1.3% soybean oil refined, 1.3, and 1% antiseptic.	Shinbo and Yanagaw (1994)
54.6% dried tofu cake, 25% defatted soy bean powder, 15% dried mulberry leaf, 2% citric acid, 1% ascorbic acid, and 2.4% others.	Sasaki et al. (2000)
25 g dried mulberry leaf powder, 36 g defatted soybean meal, 15 g wheat meal, 4 g corn starch, 5 g soybean fibre, 4 g citric acid, 2 g ascorbic acid, 3 g salt mixture, 4.2 g agar, 399 mg vitamin mixture, 200 mg sorbic acid, 691 mg propionic acid, 10 mg chloramphenicol, and 500 mg β -sitosterol per 100 g dry weight.	Cappelozza et al. (2005)
28% mulberry powder, 25% soya powder, 4% salt mixture, 0.3% sterol, 3% sugar, 3% cellular power, 7% jellifying agent, and 3% preservative.	Rajaram et al. (2012)
36 g dried mulberry leaf, 30 g defatted soybean meal, 4 g wheat meal, 4 g rice meal, 4 g corn starch, 4 g citric acid, 2 g ascorbic acid, 3 g salt mixture, 8 g agar, 1 g aloe vera gel, 4 g potato starch and water.	Bhattacharyya et al. (2016)
35% mulberry leaf powder, 35% soybean powder, 15% green twig powder, 9.4% starch, 1.5% vitamin C, 1.5% vitamin B complex, 2% citric acid, 0.4% crotonic acid, and 0.2% choline chloride.	Dong et al. (2017) Dong et al. (2018)
20 g mulberry powder, 0 g soybean flour, 2.5 g agar/100 ml water. 16 g mulberry powder, 4 g soybean flour, 2.5 g agar/100 ml water. 10 g mulberry powder, 10 g soybean flour, 2.5 g agar/100 ml water. 4 g mulberry powder, 16 g soybean flour, 2.5 g agar/100 ml water. 0 g mulberry powder, 20 g soybean flour, 2.5 g agar/100 ml water.	Paudel et al. (2020)

CONCLUSIONS

- Nutrition plays an essential role in silkworm and mulberry leaves, as traditional silkworm feed sources are valuable plants rich in nutrients (carbohydrates, protein, amino acids, fatty acids, minerals, vitamins), as well as nutraceuticals (morin, β -sitosterol) and antioxidants (flavonoids, anthocyanin and alkaloids).
- The present review highlighted that the effectiveness of an artificial diet on silkworms' productivity and health depends on the diet composition (especially the % of mulberry leaves and other protein sources).
- Even there is debate regarding the artificial diet's efficacy, it nevertheless attracts interest, particularly for research using models from the medical field. The artificial diets must give essential nutrients to meet the needs of the silkworms' larvae to have better-suited qualities. Due to the employment of silkworms as research models, it is necessary to include various compounds in artificial diets to explore specific mechanisms.

ACKNOWLEDGEMENTS

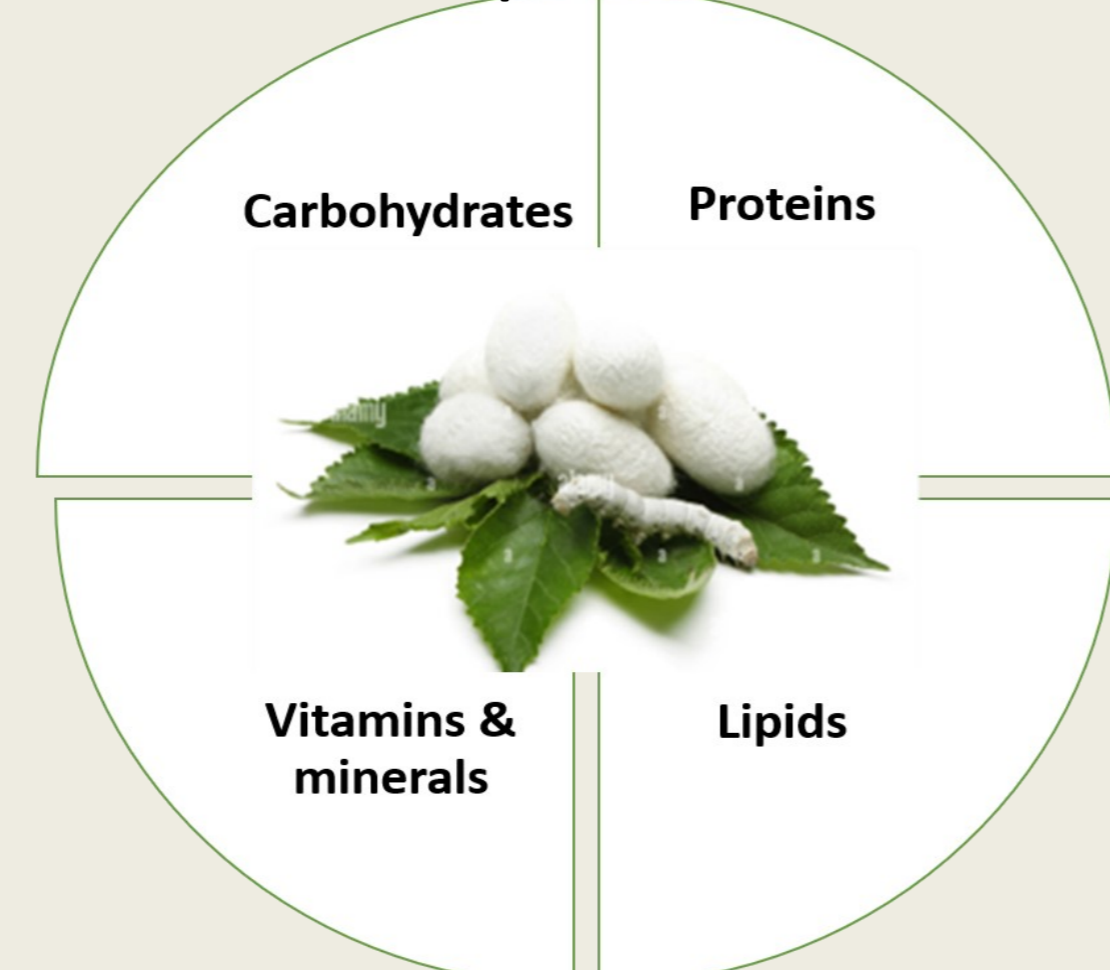
This research study was funded by the Ministry of Agriculture and Rural Development and carried out with the support of the Academy of Agricultural and Forestry Sciences, Romania.

MATERIALS AND METHODS

For this review study, the relevant scientific articles with full-text available in English were searched in databases such as Web of Science, PubMed, ScienceDirect, Google Scholar, MDPI, Springer, and Elsevier by using the following keywords: "Artificial diet", "Bombyx mori L.", "Morus alba L.", "Mulberry leaf", "Nutrients", "Silkworm". We reviewed the relevant articles published over the last 20 years. References of included studies were also consulted as additional bibliographic sources.



Nutrient requirements of silkworm



Vitamins and bioactive compounds of mulberry leaves (*Morus alba*)

Items (mg/100 g)	Mulberry leaves fresh
Vitamins	
β -carotene	13.0–14.0
Vitamin C	11.30–24.42
Vitamin B2	0.36–0.58
Vitamin B3	0.04–0.88
Bioactive compounds	
Alkaloids	660
Rutin	226
Quercetin	763
Catechins	432
Total flavonoids	33.89
Total phenols	12.26
Hemicellulose	0.2

Amino acids profile of mulberry leaves (*Morus alba*)

Source: ¹Heuze et al., (2019) - www.feedipedia.org; Olteanu et al., (2015); ²Calculated values

Items	Mulberry leaves	
	fresh ¹ (g/16g N)	meal ² (% DM)
Lysine	4.2	1.68
Methionine	1.9	0.34
Threonine	3.9	1.53
Arginine	7.4	1.13
Valine	5.6	0.85
Phenylalanine	3.8	0.98
Isoleucine	3.6	0.91
Leucine	7.6	1.73
Essential AA ³	38.0	9.15
Aspartic acid	8.8	3.27
Glutamic acid	8.9	2.93
Alanine	5.1	1.39
Glycine	4.8	0.86
Histidine	2.2	-
Proline	4.4	-
Serine	4.6	1.14
Tyrosine	3.8	0.69
Non-essential AA ³	42.6	10.28
Total AA ³	80.6	19.43
EAA/NEAA ratio ³	0.89	0.85
Essential/Total AA ratio ³	0.47	0.47

Fatty acids profile of mulberry leaves (*Morus alba*)¹

Source: ¹Olteanu et al., (2015); ²Calculated values.

Items (% fat)	Mulberry leaves meal
Myristic acid (C14:0)	1.37
Pentadecanoic acid (C15:0)	2.42
Palmitic acid (C16:0)	25.22
Heptadecanoic acid (C17:0)	0.44
Stearic acid (C18:0)	5.36
Arachidic acid (C20:0)	1.87
Saturated FA (SFA) ²	36.68
Myristoleic acid (C14:1)	0.64
Pentadecenoic acid (C15:1)	7.24
Palmitoleic acid (C16:1)	2.35
Oleic acid (C18:1n-9)	3.37
Monounsaturated FA (MUFA) ²	13.60
Linoleic acid (C18:2n-6)	13.50
α -linolenic acid (C18:3n-3)	29.07
Octadecatetraenoic acid (C18:4n-3)	0.20
Eicosatrienoic acid (C20:3n-6)	0.81
Arachidonic acid (C20:4n-6)	0.53
Polyunsaturated FA (PUFA) ²	44.11
Σ n-6 PUFA ²	14.84
Σ n-3 PUFA ²	29.27
n-6:n-3 ratio ²	0.51

Effect of using the artificial diet in silkworm *B. mori* on production parameters

Reference	Diet	Main results
Sasaki et al. (2000)	artificial diet (AD) vs mulberry leaves (ML)	- higher sericin levels, higher dye uptake and slower dyeing rate in raw silk samples, while silk fibroin exhibited similar equilibrium dye absorption and dyeing speed as effect of fed AD than ML.
Cappelozza et al. (2005)	AD without or with 2% vitamin C	- complete vitamin C deprivation during the larval cycle affects larval growth and cocoon production. Vitamin C deprivation from the diet during the first and last larval instars has positively affected cocoon production without influencing the mortality rate or delaying the larval cycle.
Tzenov & Georgiev (2010), cited by Avramova et al. (2020)	AD (with 38% ML content) vs ML	- shorter the silkworm larvae period during the fifth instar of the whole rearing period without altering the other production characteristics.
Rajaram et al. (2012)	semi-synthetic AD (SeriNutrid)	- feeding SeriNutrid in silkworm larvae up to chawki level did not affect the economical parameters of silkworm (Rajaram et al., 2012), or even increased the cocoon and shell weights, or shell ratio, thus obtaining a higher price (5-10%) for premium quality cocoons (Mondal et al., 2018).
Mondal et al. (2018)		
Bhattacharyya et al., (2016)	AD antioxidant activity (i.e., defatted soybean meal, rice meal, wheat meal, corn starch, potato starch and Aloe vera gel) vs ML	- soybean has a higher impact on increasing cocoon shell weight and silk quality than ML.
Avramova et al. (2020)	AD 1 to 3 instars ML 4 to 5 instars vs ML 1 to 5 instars	- silkworms reared on AD during the summer season in 1 to 3 instars, and ML in the 4 and 5 instars obtained similar technological characteristics and optimal sanitary conditions compared to silkworms reared only on ML.
Moise et al. (2020)	AD with 1% or 5% bee pollen addition	- fed different silkworm breed with an AD with addition of 1% or 5% bee pollen noticed an insignificant improvement in biological parameters, especially in the case of 5% bee pollen.

Effect of using the artificial diet in silkworm *B. mori* on intestinal microbiota

Reference	Diet	Main results
Dong et al. (2017)	AD vs ML	- silkworms reared on AD faced a severe deficiency of certain vitamins and experienced downregulation of glycolysis, the TCA cycle, and lipid metabolism; these larvae showed increased levels of various amino acids and amino acid-related metabolites. The authors stated that focusing on the balance of amino acids and developing a more efficient method for vitamin supplements in AD could result in significant advancements.
Dong et al., (2017); Dong et al., (2018)	AD vs ML	- the diversity of gut microbiota and the primary bacteria present in silkworms raised on AD exhibited significant variations as compared to those raised on ML, that could be associated with factors such as growth, metabolic processes, and the ability to resist diseases in silkworms fed AD. Moreover, the alterations in the gut microbiota could also affect the silkworms' nutrient metabolism and immune resistance, which may be attributed to their adaptation to the long-standing evolutionary practice of consuming ML.
Paudel et al. (2020)	AD	- tested five simple artificial diets based on different amounts of soybean flour and ML powder and the same agar content to screen drug candidates in silkworm hyperglycaemic and infection models. The authors concluded that using silkworms for biological, biotechnological, and pharmacological investigations depends on the accessibility of a simple AD for feeding trials.
Qin et al. (2020)	AD vs ML	- comparing the fecal metabolome of silkworms fed ML versus AD, have shown that the silkworms raised on ML increased the concentration of amino acids, carbohydrates, and lipids, which are essential for physical growth and silk protein synthesis. Conversely, the silkworms fed on AD had a relatively higher level of urea, citric acid, D-pinitol, D-(+)-cellobiose, and N-acetyl glucosamine.

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RESEARCH ON THE USE OF BIOFERTILIZERS IN MULBERRY CULTURE AND SILKWORM REARING

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CONTEXT

- One of the main objective of the sericultural research has been focused on the reduction of chemical fertilizers quantity by applying some ecological agricultural practices, among which can be mentioned the use extra-radicular fertilizing, also the biofertilizers of vesicular-arbuscular mycorrhizae (VAM) type, in the form of commercial products obtained by biotechnologies of high biological performance.
- The biofertilization of VAM type aims to reduce or eliminate chemical fertilization, the mulberry being a plant with increased consumption of mineral elements.
- Also, this type of mycorrhizae stimulates the plants growing and development, having a role in soil remediation and nutrition improvement from the soil-plant system.

OBJECTIVE

The aim of study was:

- i). to test the use of biofertilizer (Endorize SOL) and its influence on technological parameters in mulberry plants (saplings and adult plants) – Experiment 1.**
- ii). the effect of using these mulberry leaves in silkworm feeding on technological parameters of silkworms – Experiment 2.**

MATERIAL AND METHODS

ENDORIZE SOL ...???

Biofertilizer that contains the beneficial flora of vesicular-arbuscular mycorrhize (VAM) from *Glomus* genus: *Glomus mosseae*, *Glomus fasciculatum*, *Glomus occulatum*, *Glomus heterogama*, *Glomus microcarpum* and *Sclerocystis* sp.

BIOLOGICAL MATERIAL

- ✓ **Vegetal - Cuttings and mature mulberry plants**
- ✓ **Silkworms *B. mori***



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EXPERIMENTAL DESIGN – EXPERIMENT 1

V0 CONTROL - UNFERTILIZED



versus

**V1 – Chemical fertilization (NPK)
Dose: N240:P120:K120 kg a.s./ha**

**V2 – Biofertilizer (Endorize SOL)
Dose: 25 mg/plant**



EXPERIMENTAL DESIGN – EXPERIMENT 2

**2 SERIES OF TRIAL ON *B. mori* SILKWORMS –
FED MULBERRY LEAVES *AD LIBITUM*
V0 – CONTROL – UNFERTILIZED
V1 – Chemical fertilization (NPK)
V2 – Biofertilizer (Endorize SOL)**

June-July

August-September

**Hybrid SELECT
(n=3 replicates)**

**RASE B75
(n=3 replicates)**

**Hybrid SELECT
(n=3 replicates)**

SAMPLING AND ANALYSIS

EXPERIMENT 1

Agro-productive parameters:

- whole mulberry leaves/tree (n=3 per each experimental variant) = **mulberry leaves production/tree**;
- **25 leaves with/without petiole**, as average sample for each variant.

EXPERIMENT 2

Technological parameters of silk cocoons:

- individual weighing of **25 raw silk cocoons for each variant** of rearing for determinations of the **average value of raw silk cocoon weight and shell cocoon weight (after extraction of the chrysalis)**.

Silkworms health status analysis:

- virological, mycological and parasitological examination of larvae sampled in 3 and 5 instars.



RESULTS



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EXPERIMENT 1 – USE OF VAM IN PRODUCING MULBERRY CUTTINGS

Table 1. Biotechnological data in mulberry cuttings

Mulberry variety	Standard stem length (cm)	Standard roots no./ length (cm)	Experiment results Stem length (cm)	Experiment results roots no./ length (cm)
Kokuso 21 mycorrhize	50	5 /10	131.33	5.55/13.00
Kokuso 21 NPK fertilized	50	5 /10	172.00	5.00/16.67
Ucraina 107 mycorrhize	50	5 /10	175.33	6.67 /18.50
Ucraina 107 NPK fertilized	50	5 /10	160.00	2.33/13.50
Ichinose mycorrhize	50	5 /10	158.67	7.67/15.00
Ichinose NPK fertilized	50	5 /10	186.67	4.33 / 8.00
China 32 mycorrhize	50	5 /10	148.67	4.40/18.00
China 32 NPK fertilized	50	5/10	142.67	5.00/14.50
Olteni mycorrhize	50	5 /10	170.00	4.33/16.00
Olteni NPK fertilized	50	5 /10	171.67	5.67/20.00
Ken Mochi - Control	50	5 /10	160.33	3.00/21.33

- **The use of biofertilizer Endorize SOL for mulberry cuttings' inoculation increased the rooting percentage, in Ucraina 107, China 32 and Olteni varieties, in proportion of 64.5-76%, compared to the control, fertilized according to the traditional technology.**
- **The results also shown an improvement of cuttings' quality parameters regarding the number of issued roots, the length of issued roots, the length of cuttings stems and the thickness at bundle, compared to the control.**

EXPERIMENT 1 – USE OF VAM IN PRODUCING MULBERRY CUTTINGS

Table 2. Development of cuttings radicular system

Mulberry variety	Length of cutting (cm)	Length of main root (cm)	Number of secondary roots	Total number of active roots	Total weight of active roots (g)
Kokuso 21 mycorrhize	131.33	13.00	5.55	45.00	0.74
Kokuso 21 NPK fertilized	172.00	18.67	5.00	74.33	3.75
Ucraina 107 mycorrhize	175.33	18.50	6.67	73.33	0.89
Ucraina 107 NPK fertilized	160.00	13.50	2.33	34.00	1.16
Ichinose mycorrhize	158.67	15.00	7.67	53.00	0.55
Ichinose NPK fertilized	186.67	8.00	4.33	50.00	0.71
China 32 mycorrhize	148.33	18.00	4.40	32.00	0.88
China 32 NPK fertilized	142.67	14.50	5.00	47.67	1.30
Olteni mycorrhize	170.00	16.00	4.33	53.00	1.27
Olteni NPK fertilized	171.67	20.00	5.67	53.33	1.25
Ken Mochi - Control	163.33	21.33	3.00	71.00	1.27

- The values of inoculated cuttings length exceed the standard length of cuttings for Ucraina 107 and Olteni varieties.
- However, the varieties China 32 and Olteni presented values below the standard for the number of roots. The control used to compare varieties, Ken Mochi, does not meet the standard for the number of roots, such that the cuttings of this variety, along with the 2 others mentioned varieties, will be replanted in the replanted field, to develop at standard parameters.

EXPERIMENT 1 – USE OF VAM IN MATURE MULBERRY PLANTS FOR SILKWORM REARING

Table 3. The agroproductive parameters specific to mulberry plantations for silkworm rearing

Groups	Leaves production (g/bush)	Difference to the control (g/bush)	Weight of 25 mulberry leaves without petiole (g)	Difference from the control (g)	The unitary production of mulberry leaves (kg/ha)	Difference from the control (kg/ha)
V_0 unfertilized control	1466	-	59.0	-	11728	-
V_1 chemical fertilization	1770	+304	60.0	+1.0	14160	+2432
V_2 Endorize SOL fertilization	1873	+407	60.0	+1.0	14984	+3256

- The results shown the improvement of the agroproductive parameters specific to mulberry plantations exploited for silkworm rearings as effect of using biofertilizer.
- Production of leaves per bush has the maximum value of 1873 g/bush in the variant fertilized with Endorize SOL;
- Production of leaves per hectare were significantly higher in both experimental group, with 3256 kg/ha in the variant fertilized with Endorize SOL and with 2432 kg/ha in the variant with chemical fertilizers than control.

EXPERIMENT 2

Table 4. Technological parameters of silk cocoons *B. mori* L.

Groups	I st Series - Select hybrid				II nd Series - B75 race				II nd Series - Select hybrid			
	Raw cocoon weight (g)	Diff. to the control (g)	Shell cocoon weight (g)	Diff. to the control (g)	Raw cocoon weight (g)	Diff. to the control (g)	Shell cocoon weight (g)	Diff. to the control (g)	Raw cocoon weight (g)	Diff. to the control (g)	Shell cocoon weight (g)	Diff. to the control (g)
V ₀ unfertilized control	1.89	-	0.379	-	0.960	-	0.229	-	1.031	-	0.156	-
V ₁ chemical fertilization	2.01	+ 0.12	0.523	+0.144	1.184	+0.224	0.243	+0.016	1.3069	+0.275	0.371	+0.115
V ₂ Endorize SOL fertilization	1.98	+0.09	0.463	+0.084	1.148	+0.188	0.235	+0.006	1.099	+0.068	0.240	+0.084

- Comparing the data in both aspects, the cocoon weight and shell cocoon weight, in both rearing series the variant fertilized with Endorize SOL product presents positive values compared to the control, lower than chemical fertilized variant, but the differences are not significant.
- The veterinary analysis results reveals a normal health status with no anatomo-pathological changes in larval samples at 3 and 5 instars, and negative for virological, mycological and parasitological specific silkworm diseases.

CONCLUSIONS

- The fertilization with Endorize SOL bioproduct did not affect the agrop productive parameters in mature mulberry plants, compared to chemical fertilization. Additionally, that positively influences the sericultural economic results by reducing the production costs related to fertilization, having beneficial effects of ecological protection on soil.
- The use of biofertilizer Endorize SOL had a positive effect on technological parameters of the silk cocoons and on silkworms health status.
- The mycorrhizae technology has a great potential of application to improve the productivity and to reduce the environmental problems associated with the excessive use of chemical fertilizers.



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