ARACNE

ADVOCATING THE ROLE OF SILK ART AND CULTURAL HERITAGE AT NATIONAL AND EUROPEAN SCALE

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Report on preparation of the educational kit and educational packages

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Dissemination Level

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Abstract

There is a constant demand for silkworm eggs for schools, and the distribution of these eggs is part of the regular activities carried out by ARACNE's partners, in particular the germplasm banks (SCS and CREA). Eggs are generally sent to schools when leaves are available to feed the silkworms, and as this is seasonal, it is difficult for students to observe the entire biological cycle of the silkworm, as the school year ends before the moths emerge from their cocoons and the insect's metamorphosis is complete. To overcome this limitation, a few years ago a rearing kit with including a heating system was fine-tuned thanks to the collaboration between CREA and the Silk Experiment Station in Milan (Italy). The rearing kit was assembled using components already available on the market and produced for other purposes, while the silkworms were fed with an artificial diet based on a patented recipe developed at CREA. The recipe includes mulberry leaf powder, but because it is produced and stored as a dry powder, it can be used during the winter season when the mulberry trees are leafless. This allowed greater flexibility, although the quality of the plastic components used to build the kit and their inappropriate design were sub-optimal solutions. In the ARACNE project, the idea was to design a specific device to be used as a rearing kit using the already tested artificial food. The kit and the corresponding instructions will form a package that will be sent to schools for a rearing experience that is not affected by the seasonality of the mulberry tree, as part of the communication tools of the ARACNE project. All the partners working with schools will be involved in the dissemination of the kit.

Partners involved in the document

Participant n.	Participant organisation name	Short name	Check if involved
1 Coordinator	Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria	CREA	X
2	Iniziativa Cube S.r.l.	INI	
3	Lepl State Silk Museum	SSM	X
4	Nauchen Tsentar Po Bubarstvo Vratsa	SCS	X
5	Piraeus Bank Group Cultural Foundation	PIOP	X
6	Univerza V Mariboru	UM	X
7	Ethniko Kai Kapodistriako Panepistimio Athinon	NKUA	X
8	Instituto Murciano de Investigacion y Desarrollo Agrario y Medioambiental (IMIDA)	IMIDA	X
9	D'orica S.r.l. Società Benefit	DOR	
10	Chemins De La Soie - Des Cevennes aux Alpujarras	ASSOIE	X
11	Sericyne	SER	
12	Universita degli Studi di Padova	UNIPD	X
13	Council Of Europe - Conseil de L'europe	COE	
14	Mouseio Technis Metaxiou	ASMS	X

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1. Description of the project

ARACNE project focuses on the cultural heritage of the European silk production and its preservation, protection and valorisation; it aims at reinvigorating traditional skills through the adaptive reuse of the common cultural and artistic legacy and at shaping a silk-linked European cultural identity.

The production and the past and present development of the silk sector can be again the common basis for a future European Silk Route intended as a cultural itinerary across Europe. To create a wide and well-connected network that, starting from the historical path followed by Marco Polo in his travels to East, even includes the routes of production and commercialization of silk in Europe in the following centuries, we aim to:

- Bring back silk production in vogue by reconstructing a resilient and innovative silk ecosystem that retraces the concerned European countries and promotes traditions, architecture, and both tangible and intangible heritages. The consolidation of a European Silk Route will encourage links and shared activities among European cities and regions to strengthen the preservation and protection of their culture and promote innovations in production and trade;
- Contribute to improve skills and competitiveness of silk-related European Cultural and Creative Industries through the renewal, co-development and the implementation of human-centered and place-specific silk-based cultural products, processes and service innovations, leveraging on digital applications and cutting-edge technologies, to foster the transition to more sustainable business models, and promote economic and social growth, and strengthen the reputation of European countries abroad.

1.1 ARACNE specific objectives

The overarching goal of ARACNE is to create a wide and well-connected Silk Innovation Ecosystem that, starting from the historical path followed by Marco Polo in his travels to East, also includes the routes of production and commercialization of silk in Europe in the following centuries. An innovation ecosystem is an interconnected network of quadruple helix stakeholders, including academia, industry and different levels of the public sector and civil society. This multi-level approach applies a systemic and bottom-up approach to creating research, innovation and knowledge. Silk Innovation Ecosystem includes every stakeholder and innovator in the cultural silk value chain even if not participating directly in the project activities. The production and, more in general, the past and present development of the silk sector in the ARACNE Consortium countries represent the common thread for the future "European Silk Route" as a cultural itinerary across Europe, to boost the European values in relation to the silk arts and CH for the benefit, prosperity, peace of our societies. To this aim, the project will explore the CCIs' capacities to create a cultural and artistic niche market where silk produced within EU boundaries will be valued as a distinct immaterial asset; on the other hand, the ambition is to contribute to stop the loss of technical, traditional and cultural know-how and skills that accompanied the decline of this fiber production and that is detrimental exactly to those CCIs which might be active in fashion, art, design and product

communication. In fact, the so-called "Silk Road" is generally associated to its Asian origin; however, its European ramifications were fundamental for the development of Europe as we know it today. More in general, the silk production (silkworm rearing, mulberry cultivation, silk reeling), originated from Asia but subsequently spread to Europe and developed strongly in the Mediterranean and Balkan regions. Bringing back silk production in vogue by reconstructing a resilient and innovative Silk Route that retraces the European countries and enhances traditions, architecture, tangible, and intangible heritage will demonstrate that silk, as a cultural legacy, can contribute to develop the European economy and enrich our society. In this context, ARACNE covers several sectors linked to content creation, conservation, exploitation, management, fruition, diffusion related to the silk historical, artistic and environmental resources and assets. The ambition of ARACNE will be reached through a set of specific, measurable, achievable, realistic and time-constrained (SMART) specific objectives:

Objective 1: Enhancement of knowledge and memory for the renaissance of a European Silk Innovation Ecosystem;

Objective 2: Co-creation of human-centred and place specific creative silk-based solutions leveraging on digital and cutting-edge technologies;

Objective 3: Implementation of innovative strategies and business, governance and financing models for the involved CCIs organisations and SMEs, building on previous research;

Objective 4: Support the establishment of a cultural European Silk Route, based on the tangible and intangible silk cultural heritage and landscapes;

Objective 5: Raise awareness of ARACNE results and impacts among different stakeholders of the territories and CCIs of the silk sector and raise the expectation for the constitution of a European Silk Route in support to the European silk CH and silk CCIs;

Objective 6: Enhance the European cultural identity and strengthen European competitiveness for a more resilient post-crisis society;

Objective 7: Contribution to the European Green Deal, the New European Bauhaus and the Sustainable Development Goals.

2. Introduction

Silk is a well-known natural fibre that is used to produce luxury fabrics and garments worldwide. Although it is generally recognised as a natural fibre, it is not always clear that the only possibility to obtain silk comes from Lepidoptera and mainly from the domesticated silkworm (whose scientific name is *Bombyx mori*). The objective of the CREA initiative was to increase public awareness about the origin of silk and, in particular, about the fact that it is spun by an insect that has specific requirements since it is the only animal that relies entirely on human care to survive. To this end, CREA developed a kit for rearing the silkworm in schools across the country. The objective of disseminating the kit to schools is to facilitate greater engagement with the topic of silk production and to increase awareness about the ARACNE activity among the younger population and their families. Furthermore, as the traditional rearing process utilises mulberry leaves, whereas the kit employs an artificial diet,

it is important to illustrate the evolution of sericulture over time. Despite its traditional roots, this activity has the potential to advance significantly, particularly through the integration of innovative applications of science and technology.

Based on CREA's previous experience, the objective was to design a device with characteristics of reliability, robustness and durability. The materials used to construct the system must also be compatible with the rearing of an insect that is highly sensitive to its surrounding environment. This is to ensure that a few aspects of the production procedure cannot be disregarded. Furthermore, the system must be reusable and ensure the hygienic standards required to successfully rear the silkworm.

2.1 Objective of the deliverable

The objective of this deliverable is to develop a preliminary prototype of a reusable and durable kit to rear the domesticated silkworm larvae, which will be fed an artificial diet based on mulberry leaf powder. The aforementioned kit will be accompanied by a manual of instructions containing relevant points on the usage of the rearing system, the biology of *Bombyx mori*, and a few key information about silk, its history, and how it was imported to Europe from China. The rearing kit was designed with schools as end-users in mind, and according to the age of the students and their educational level, different information can be attached to the device to provide them with a deeper knowledge of the insect's biology. This hands-on experience is supposed to have a great impact on the awareness of non-experts about the natural origin of silk and the care needed to successfully rear the silkworm. The device is designed to be safe for the end user, as it is made of plastic, has no moving parts, is lightweight, and the only electric device is a heating cable that will maintain the optimal temperature for the correct development of the silkworms. A first set of ten kits will be manufactured by the producing company (by the end of June) and used by CREA to rear the silkworm in conditions that will simulate a domestic setting. The results of this test will provide the necessary information to write a user manual. In addition, the biology of *Bombyx mori*, the history of silk, silk fabrics, new applications of silk proteins (cosmetics and biomedical), and all the by-products of sericulture will be illustrated form that is suitable for the intended users of the kit. The artificial diet will be the principal feed substrate, but information on the silkworm's natural feed (the mulberry leaves) will be included as well, given the significance of ancient mulberry trees to this project.

2.2 Document structure

The deliverable structure is divided into four main parts:

3. Design of the rearing kit
4. Production of the rearing kit
5. Rearing kit testing
6. Writing the instruction manual
7. Conclusions

Given the nature of this objective, each part can only be initiated once the previous one has been completed. However, the final part may be partially realised before its completion, provided that the general aspects have been addressed.

3. Design of the rearing kit

3.1 The experience with the previous kit

The concept of the previous kit was inspired by the illustration of early incubators used by sericulturists at the end of the 19th century and the beginning of the 20th century.

As can be observed (Figure 1), the object comprises a wooden body with removable trays located within. A system of tubes facilitates the circulation of heated air or water. The central body is supported by a wooden base, which is adjustable in height and houses the heating device.

The system of circulating water within a cavity and heating it to maintain a uniform temperature within the interior was adapted for the construction of the kit.

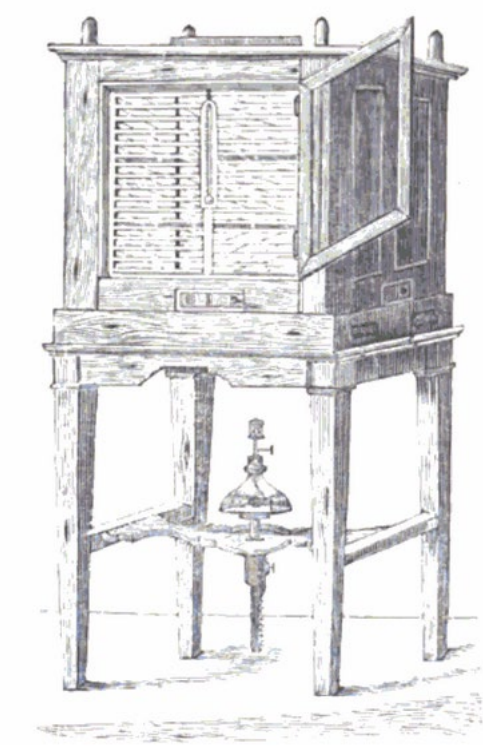

Figure 1 - Egg incubator

Subsequently, the enclosed instructions will elucidate the way the didactic-demonstrative kit was derived from the ancient concepts developed by scientists in past centuries, through the application of contemporary technologies.

The preceding kit, developed in the early 2000s, employed readily available plastic boxes and items sourced from the commercial network of a company engaged in the pet animal sector, with eggs and artificial diet provided by CREA. This item exhibited several shortcomings, namely, the substandard quality of the materials (see Figure 2) and the cumbersome assembly process (Figure 3). In particular, the plastic material of the boxes was of poor quality and prone to breakage. This was a significant issue, as the large and small boxes were separated by a water gap to ensure optimal thermal stability. Any water leakage, both inward (where the worms were placed) and outward due to breakage, made rearing difficult or impossible.

Figure 2 – Plastic boxes and other items composing the first version of CREA's silkworm rearing kit

Furthermore, the vertical plastic surfaces were easily scratched and lost transparency.

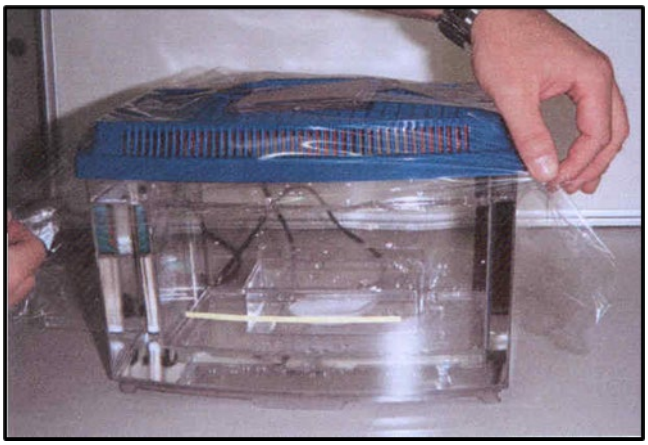

Figure 3 – The assemblage of the preceding rearing kit required the outer box to be coated with a plastic film to prevent the ingress of moisture and the lid to be employed to maintain the correct positioning of the smaller inner box

The rearing system was accompanied by a manual containing information and details pertaining to various aspects of the assembly process and sericulture. Like the current model, it was designed to be reusable.

3.2 The new rearing kit

The design of the kit was thought to be very simple, on the basis of the previous expertise. However, the process of identifying a company to undertake the design was not without its criticalities and problems.

3.2.1 Criticalities

The fundamental concept underlying the design of a new model of kit was that it should be created with the specific purpose of rearing silkworms, rather than being manufactured from materials designed for alternative applications. Consequently, a few companies specialised in the production of moulds for plastic were contacted. It was immediately apparent that the costs associated with developing a kit comprising a limited number of exemplars (compatible with the intended uses of the project and not for sale) were not within the budgetary constraints of the project. Consequently, the option of 3D printing the kit in several copies was considered. However, the associated production costs were deemed to be prohibitively high, prompting a search for companies that had previously manufactured plastic prototypes for experimental demonstrations. Following the identification of a suitable supplier through a tender on the Italian MePA (Public Administration Electronic Marketplace), an intermediate solution was sought, that is to utilise pre-printed Plexiglas tubes, cutting them and adapting them to the project in question through a customised process.

3.2.2 The choice of a collaborating company

Eri S.r.l., a company based in Padua (Italy) was selected following a discussion of the technical details and the consideration of the possibility of providing feedback to their staff during the development phase of the project, given its proximity to CREA. The concept of implementing a water gap between the room and the rearing space, as seen in the previous kit, was adopted due to the high thermal inertia of water, which protects the silkworms from sudden changes in temperature. To address assembly issues, the base was designed as a single piece to prevent the inner chamber from rising with the Archimedes' thrust. The material selected for the pieces is methyl methacrylate (trade name Plexiglas), which is lightweight and highly resistant to impacts. Additionally, it exhibits remarkable light transmission properties, high stability, and pieces can be easily joined by cyanoacrylate glue.

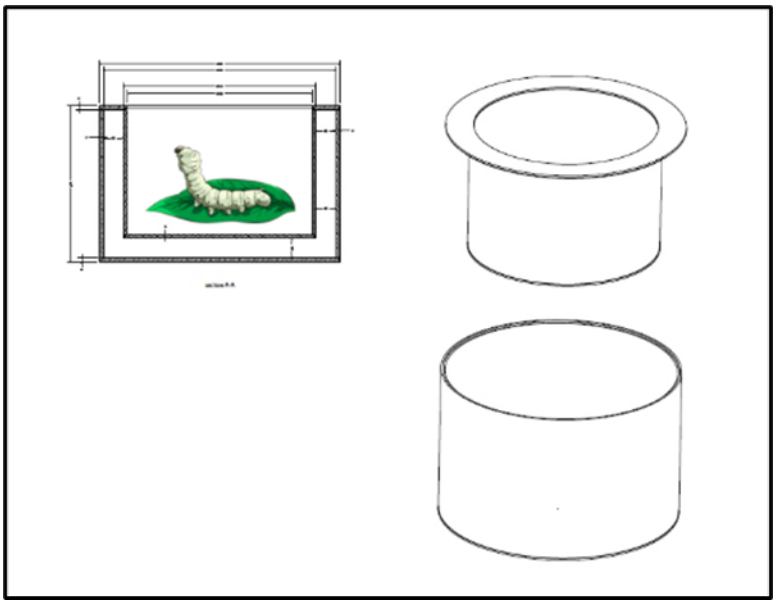

Figure 4 – An overall view of the main parts composing the kit. On the left a section of the kit's main body and on the right its exploded view. The silkworm illustration shows where the insects will be reared

Figure 4 depicts the proposed design for the rearing chamber, which is to be constructed around and under the water gap. The shape of the rearing chamber was determined in collaboration with Eri S.r.l., with the rationale that a circular design offers superior visibility of the silkworms within the chamber and allows for the construction of a smaller device by pasting together fewer parts than would be required for a square-plan rearing chamber. The project depicted in Figure 4 was proposed by CREA to the company based on the considerations set out above. These considerations included the availability of Plexiglas tubes that could be cut at fixed dimensions and used to construct the rearing chamber's main body. The diameter difference between the inner and outer tubes would determine the mass of the water gap, which would ensure thermal inertia and stable temperatures for the silkworms. Figure 5 illustrates the construction details regarding the connection point between the wall and the floor. As shown in the dimensions of the drawing, the thickness of the Plexiglas tube has been set to five millimetres in order to ensure sufficient impact resistance and the ability to perform the required processing on machine tools to generate the step (2.5 mm, namely half the thickness of the Plexiglas tube) to glue the parts together.

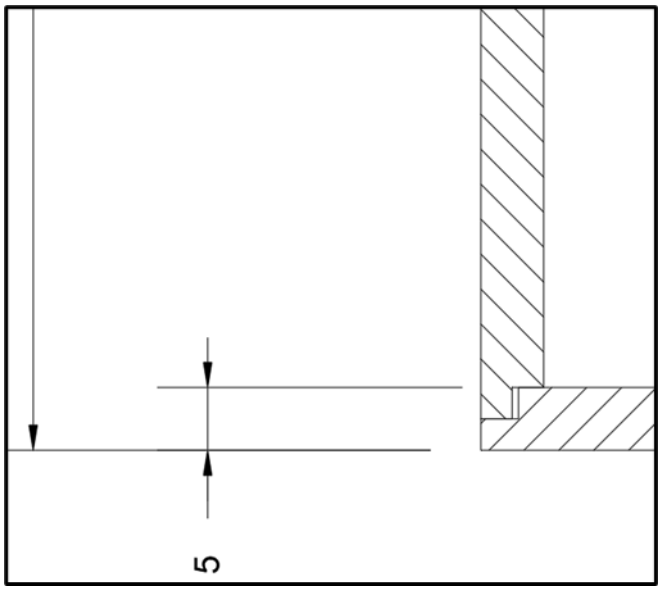

Figure 5 – Details of the junction point between pieces composing the main body of the kit. The Plexiglass tube thickness was set at 5 mm in the design stage. The step for gluing the wall and the floor together was set at 2.5 mm

The use of cyanoacrylate glue is essential in the assembly of the components. The chemical component exhibits a satisfactory stability in the rearing room temperature range (23-25 °C). The project shown in Figure 4 (without details of the lid) has undergone examination by Eri S.r.l. subsequent to CREA's proposal. The company has suggested a number of alterations to enhance the production process and reduce processing residue. The final project, which was submitted and accepted by Eri S.r.l., is outlined in Figure 6 below.

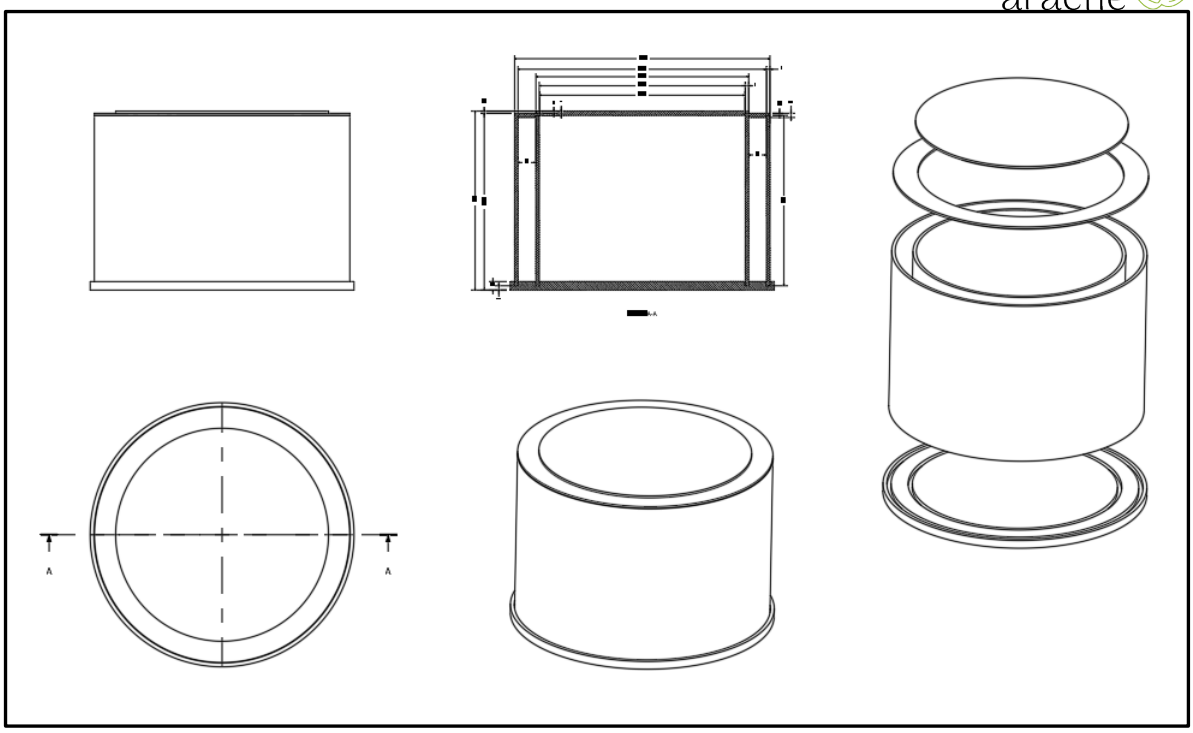

Figure 6 – General overview of the final version of the kit that was approved by the manufacturing company. In-depth details in the following pictures

The overall dimensions were maintained from the previous project, with the majority of changes being related to the free volume filled with water. As the water gap under the rearing chamber was not a critical feature, it was removed from the project, with thermal inertia being guaranteed by the water mass between the inner and outer walls. The gap between the walls has a dimension of 21 mm (Figure 7) and the mass of water that will be poured by the end-user to fill it will be determined during the tests that will be carried out by CREA. The water will be heated by a waterproof aquarium heating cable and to avoid an excessive water loss, a toroidal lid (Figure 6 and Figure 7) will be held in place by gravity. Both the inner and outer walls are fixed to the base by means of an adhesive and held in place by two grooves.

A second circular lid (Figure 6) is placed on top of the first one to cover the rearing chamber and prevents the artificial diet used to feed the silkworms from drying out. The correct lid positioning is guaranteed once again by the step between the parts (Figure 7).

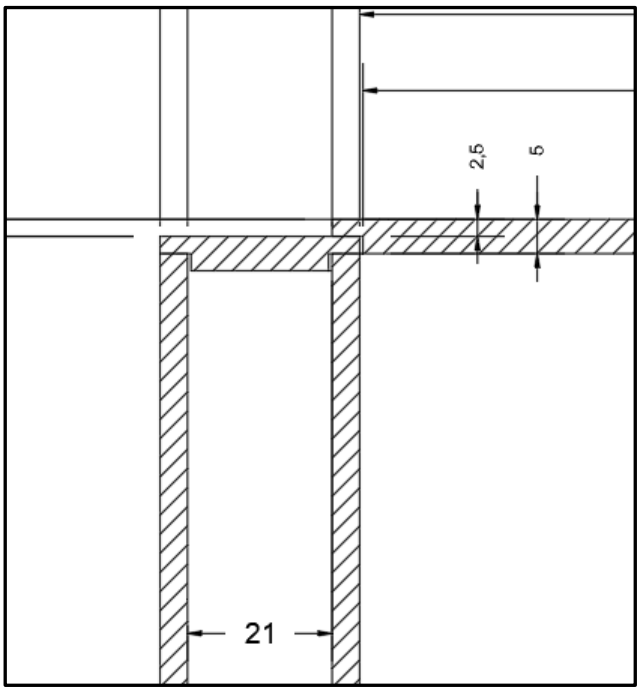

Figure 7 – Details in section: the step that holds the outer and inner lid in place. The dimension of the water gap is also visible and set to 21 mm

This part will be equipped with an aeration mechanism to be regulated by the end-user according to the size and developmental stage of the silkworm. Relevant information on this will be included in the accompanying manual.

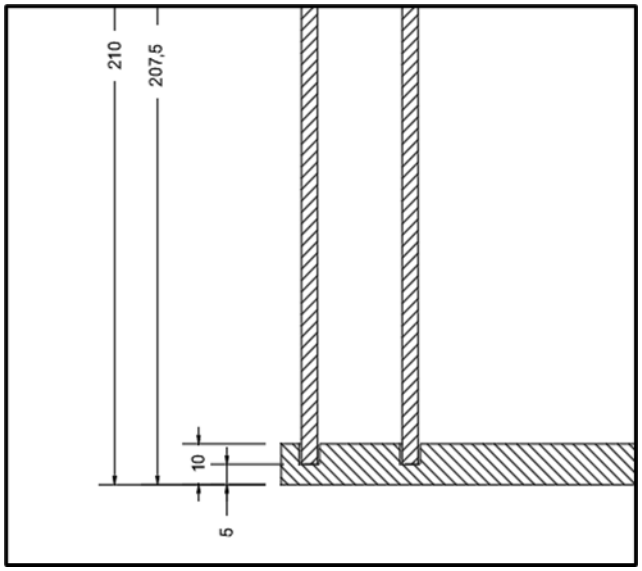

Figure 8 – Section details: dimension of the parts composing the main body of the kit and the grooves to hold the inner and outer tubes in their place. All these parts are held together by the glue

4. Production of the rearing kit

Since CREA is a Public Authority, the assignment of the order to Eri S.r.l. necessarily had to pass through a program for the rationalization of public spending (the above mentioned MePA) run by the Ministry of Economy and Finance through Consip S.p.A. This resulted in a significant delay in the awarding of the order because Eri S.r.l. was new to this e-procurement solution and it was not possible to schedule the production and assembly of the parts before the end of June. The problem was solved with the help of CREA's administrative offices, which provided support to ERI's administration. Small batches of silkworms will be reared as soon as the kit will be available.

5. Rearing kit testing

Scheduled as soon as Eri S.r.l. will provide the rearing kit prototypes.

6. Writing the instruction manual

The manual will be written in accordance with the feedback provided by the experiments conducted at CREA by using the rearing kit, which will be carried out as soon as the kit is manufactured. Considering the information included in the manual that was previously supplied with the early-conceived kit, it would be advisable to consider updating the data contained therein, particularly with regard to the new technologies based on silk proteins (cosmetics and biomedical).

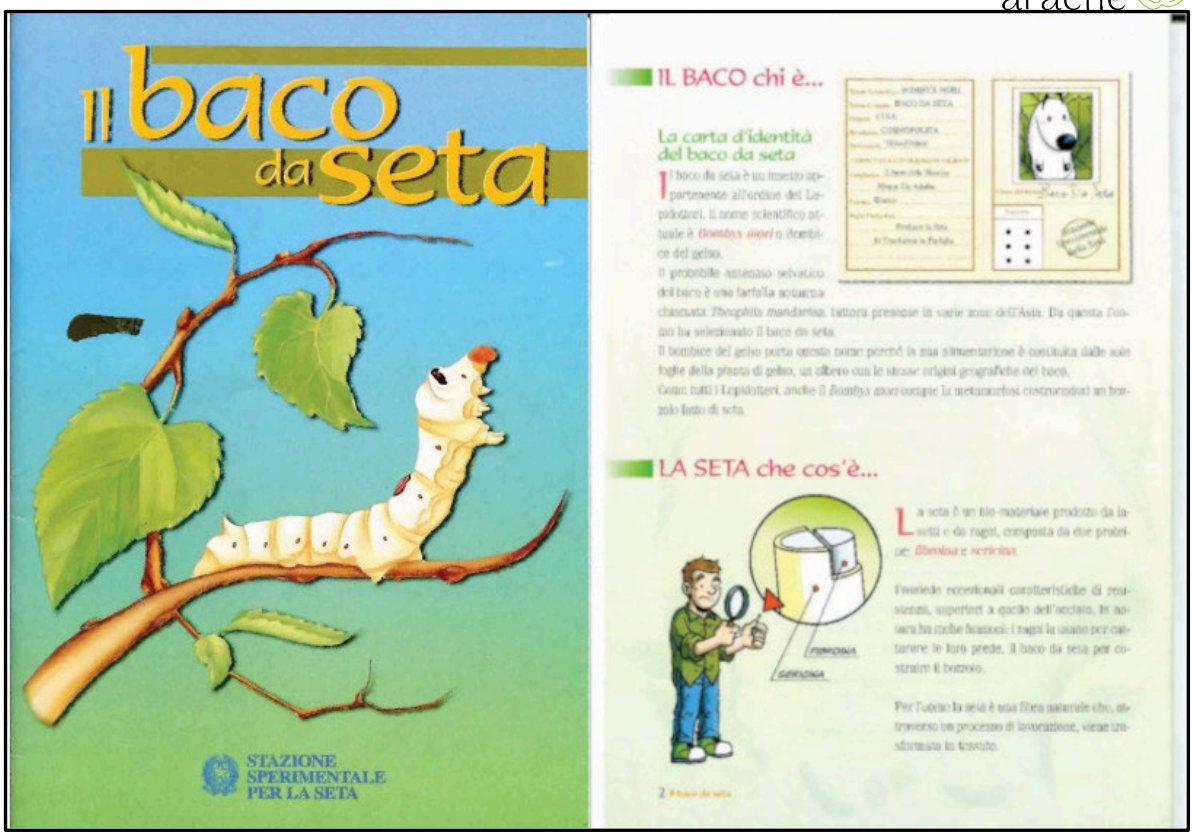

Figure 9 – The cover (left panel) and a page (right panel) of the manual of the early rearing kit. In the right panel there are some details about the main proteins that compose the silk threads, namely fibroin and sericin. The contents of the early manual will be updated and expanded according to the ARACNE mission

The educational-educational package that accompanied the previous educational kit consisted of an actual instruction manual that gave information on how to assemble the kit, how to fill the water cavity, how to calibrate the heater, and how to store the small boxes with the powdered or ready-to-use artificial diet. Another booklet was, on the other hand, specific and recounted the history of silk for primary and lower secondary school children. For this reason, it had cartoon illustrations and many figures. The preparation of this volume in English (possibly translated into the national languages by the partners) will also be the subject of experimentation, to test the most suitable format. In fact, it could be a printed basic text, with downloadable content online, depending on the interest and degree of depth that teachers and pupils want to give to the experience.

Some examples are reported in the references (Brion, 2016; Faragò & Filz, 2001; Molina Cimadevila, 2024; Simeoni, 2015; VV.AA., 2010; Wilcox J.K, 2006; Xin-Lin, 2020).

7. Conclusions

The work that has been carried out on the preparation of the educational kit and packages has focused primarily on the design aspects and the resolution of certain bureaucratic-administrative issues that slowed the manufacturing of the device. At the beginning of the discussion with the collaborating company, the device was simply hand-drafted, while, after defining all the critical aspects of the project, we relied on a technical designer for professional drawings. The device is currently in the process of being manufactured and is scheduled for delivery by the end of June for first testing in the lab.

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