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**Silk cocoon production — Code of practice
— Part 3: Silk cocoons handling**

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Foreword

Rwanda Standards are prepared by Technical Committees and approved by Rwanda Standards Board (RSB) Board of Directors in accordance with the procedures of RSB, in compliance with Annex 3 of the WTO/TBT agreement on the preparation, adoption and application of standards.

The main task of technical committees is to prepare national standards. Final Draft Rwanda Standards adopted by Technical committees are ratified by members of RSB Board of Directors for publication and gazettment as Rwanda Standards.

DRS 357-3 was prepared by Technical Committee RSB/TC 029, *Textile and Leather Technology*.

In the preparation of this standard, reference was made to the following standard (s):

- 1) TAS 8201-2012 Good practices for silk cocoon production
- 2) Sericulture training manual for farmers in Rwanda

The assistance derived from the above source is hereby acknowledged with thanks.

DRS 357-3 consists of the following parts, under the general title *Introductory element — Main element*:

- *Part 1: Mulberry leaves production*
- *Part 2: Mulberry silkworm rearing*
- *Part 3: Silk cocoons handling*

Committee membership

The following organizations were represented on the Technical Committee on *Textile and Leather Technology* (RSB/TC 029) in the preparation of this standard.

Ministry of Trade and Industry (MINICOM)

University of Rwanda-College of Science and Technology (UR-CST)

National Agricultural Export Development Board (NAEB)

Rwanda Inspectorate, Competition and Consumer Protection Authority (RICA)

HeWorks Silk Rwanda Ltd

Rene Pharmacy

UTEXRWA Ltd

OXALIS Ltd

LIXIL/SATO

Rwanda Standards Board (RSB) – Secretariat

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Introduction

Sericulture is an agro-based sector, involving rearing silkworms to produce silkworm cocoons and raw silk by reeling cocoons. The major sericulture activities comprise of mulberry cultivation to feed the silkworm larvae, silkworm rearing to produce cocoons, reeling of cocoons to unwind the silk filament and silk processing and weaving to gain value added silk products.

The growth and development of silkworm is greatly influenced by environmental conditions. The biological as well as cocoon-related characters are influenced by ambient temperature, rearing seasons, quality mulberry leaf, and genetic constitution of silkworm strains. Different seasons affect the performance of *Bombyx mori* L.

Silkworm rearing depends on the availability of mulberry leaves. It is occasionally limited by the dry season, which is the time to avoid silkworm rearing because mulberry growing is retarded due to drought and exceeding high temperature gives rise to the retardation of silkworm growing.

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Silk cocoon production — Code of practice — Part 3: Silk cocoons handling

1 Scope

This Draft Rwanda Standard provides guidance on good practices for post-harvest cocoon handling activities namely de-flossing, packaging of fresh cocoons, means of transportation of fresh cocoons to the collection centres, sorting, drying and storage.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this standard, the following terms and definitions apply.

3.1

cocoon

outer protective shell spun by silkworm larva covering itself before transforming into pupa stage

3.2

fresh cocoon

cocoon that consists of a live pupa and shell with or without de-flossing

3.3

dried cocoon

cocoon that consists of a dead pupa after getting dried

3.4

defect cocoon or poor cocoon

cocoon whose shape is with abnormal characteristics i.e. double cocoon, pierced cocoon, inside soiled cocoon, outside soiled, thin-shelled cocoon, loose-shelled cocoon, thin-ended cocoon, malformed cocoon, printed cocoon, crushed cocoon, and mouldy cocoon

3.5

floss

short or waste silk fibers, especially from the outer surface of the cocoon of a silkworm

3.6

stifling

process in which, the pupa inside the cocoons are killed by subjecting them to high temperature treatment via sun drying, steam or hot air in order to maintain the continuity of silk filament making up the cocoon

4 Silk cocoon handling

The proper handling of silk cocoons results in good quality silk products. The following are activities to be controlled for better results:

4.1 De-flossing of fresh cocoons

After harvesting, all loose fibres on cocoons surface are removed, giving it a clean look. If flosses remain on the cocoon, they stick to one another and it becomes difficult to sort the cocoons. Failure to de-floss cocoons also lowers the marketability of the cocoon. The floss should be removed by hand or using a de-flossing machine if available.



Figure 1 Harvested cocoons with floss De-flossed cocoons

4.2 Packaging of fresh cocoon

After harvesting, de-flossing and sorting, cocoons are packed in clean baskets or a woven polypropylene bags. The recommended quantity of cocoons to be packed is as per Table 1.

Table 1—Quantity of cocoons to be packed

S/No	Type of packaging material	Nominal capacity /size	Acceptable quantity of cocoon (kg)
i.	Baskets	-	15

ii.	Woven polypropylene (Kg)	50	15-18
iii.		100	33

4.3 Transport of fresh cocoons

After proper harvesting and removal of diseased or damaged cocoons, the fresh cocoons are taken to the Cocoon collection center (CCC). For short distances, the farmer may carry the cocoons in baskets or bags. If the distance is longer, cocoons should be transported using any suitable means with precautions to avoid damage, vibration and shock. The following precautions should be considered:

- It is advisable to avoid carrying cocoons over long distances, however, in case of transportation, use of P.V.C. containers with 15 kgs capacity is recommended.
- Shock absorbers to prevent damage over long distances should be used (i.e. Sponge, saw dust, husk,.).
- For the purpose of good hygienic practices, cocoon should be pack
- Fresh cocoons should arrive at the CCC within two to three days after harvest.

4.4 Sorting

4.4.1 Sorting frequency

3.4.1.1 When reeling is carried out with irregular and non-uniform cocoons it results in thread breakage, poor reelability, decreased raw silk recovery, variation in raw silk denier, and poor neatness.

3.4.1.2 The types of defects encountered in the sorting process are: inside soiled cocoons, outside soiled cocoons, cocoons with prints of cocooning frames, flimsy or loose-shelled cocoons, perforated cocoons, thin-end cocoons, thin-shelled cocoons, fluffy cocoons and mouldy cocoons.

3.4.1.3 The recommended number of times the sorting should be carried out is as follows:

- Silkworm farmers remove defective cocoons as well as double cocoons before taking the produce to the Cocoon collection center.
- At the reception of cocoon collection center, cocoons sorting shall be done for the second time, to ensure good quality cocoons for reeling, for accurate verification.
- Before processing, dried cocoon shall be sorted

4.4.2 Sorting procedure

Cocoons are spread out on a table and the sorter pick out the defective cocoons by visual inspection and place them in separate containers. The sorting room is generally located close to the cocoon stores and should be provided with good ventilation and lighting.

4.5 Cocoons grading

After sorting, cocoons fall into the following grades:

3.5.1 Grade I: Good quality cocoons, which do not have defects

Note: under Grade I, the quality of cocoon may vary in accordance with the cocoon unit weight and shell ratio.

3.5.2 Grade II: Defective cocoons, including inside soiled cocoons, outside soiled cocoons, cocoons with imprints of cocooning frames, malformed cocoons,

3.5.3 Grade III: Double cocoons, made by two silkworms cooperatively.

3.5.4 Grade IV: Waste cocoons, including: perforated cocoons, thin-end cocoons, thin-shelled cocoons, loose-shelled cocoons, fluffy cocoons and mouldy cocoons.

4.6 Cocoons drying and storage

4.6.1 Drying conditions

3.4.1.1 The drying temperature impacts the quality of the cocoon and the resulting raw silk. If the temperature exceeds certain limits, sericin degenerates and concurrently efficiency, reelability and raw silk percentage declines. It is advisable to observe the following limits: for hot air drying $115\pm 5^{\circ}\text{C}$ is recommended on contact with the cocoon, for steam-heat drying $102\pm 2^{\circ}\text{C}$ is the preferred guideline.

3.4.1.2 While setting higher finishing temperature increases drying efficiency, the melting point of sericin declines when the drying rates exceeds 50 percent. The finishing temperature should be reduced gradually from 60°C in hot air drying and 55°C in steam-heat drying.

3.4.1.3 Cocoons that are to be stored for long periods prior to reeling need to be dried to the optimum levels. The complete drying process covers band one up to eight within provided temperature and duration as per table 2

Table 2—Perfect drying for long term storage (Hot Air Circulating Type)

Band No.	1	2	3	4	5	6	7	8
Temperature($^{\circ}\text{C}$)	110	105	100	90	85	83	62	60
Humidity (RH%)	3-4			8-10				20-23
Degree Drying(%)	100-85	85- 69	69-59	59-51	51-46	46-43	43-42	42-40
Period(min.)	45	45	45	45	45	45	45	45

For short term storage, cocoon drying is performed under conditions of temperature and relative humidity as per Table 3.

Table3— Half Drying Cocoon (Hot Air Circulating Type) for short term storage

Band No.	1	2	3	4	5	6	7	8
Temperature(□)	110	110	100	100	93	93	80	72
Humidity(RH%)	3-4			5-7			15-18	
Degree Drying(%)	100-90	90-79	79-70	70-68	68-62	62-57	57-53	53-50
Period(min.)	27	27	27	27	27	27	27	27

8.1.5 Cocoons for reeling without storage require hot air drying of cocoons is in place of steam stifling as per Table 4

Table 4 –Drying temperature (cocoons for reeling without storage)

Steps	Temperature	Duration
1.	110-100°C	45-60 minutes
2.	100-90°C	45-60 minutes

4.6.2 Dried cocoon storage

4.6.2.1 Storage room

In building cocoon storage room, the following should be considered:

- a) Air space for ventilation should be provided at the bottom of the storage room, at least 1m above the floor, to prevent moisture coming up from underground.
- b) the bag stack shall be built at least one (1) meter away from the walls of a store. This allows easy inspection and prevents moisture ingress from contact with the wall
- c) the bag stack shall not be built too high and not closer than 1.5 m to the store roof beams so that staff can work on top of stacks;
- d) The cocoon stores should preferably be built with double walls or make single walls as thicker as possible.
- e) Windows should be small and fixed at high level and provided with an exhaust fan to enable moisture accumulating in the room to be drawn out.

- f) The storage room should be lined with an iron sheet, the windows should be covered with a wire net of about 1.5mm mesh
- g) Cloth or woven polypropylene bags are recommended as containers for dried cocoon storage.
- h) Shelves should be provided in three to four tiers to accommodate cocoon bags to avoid piling of bags/baskets, in order to reduce the fungus development in dry cocoons during storage.
- i) If humidity exceeds 70 percent, action should be taken to reduce humidity such heating. Precautions should be taken to prevent fire outbreak.
- j) The cocoon storage room shall be built in durable materials.
- k) The room shall be disinfected and protected to prevent pests
- l) The room shall be disinfected and protected to prevent pests.

4.6.2.2 Cocoons storage

3.7.2.1 When long periods of storage are not necessary half dried cocoons as per table 3 may be stored in thin layers in trays kept on wire mesh racks. These racks may be placed in a well-ventilated room so that the cocoons are not affected by fungus due to presence of moisture.



Figure 2 Cocoon storage racks

3.7.2.2 For long periods of storage, cocoons should be hot air dried to the optimum level in order to remove the water content from the pupa.

3.7.2.3 The cocoon storage room should be maintained at a temperature and relative humidity not exceeding 25-30°C and 40-55% respectively so that fungus attack on the cocoon is prevented.

3.7.2.4 Cocoons waiting for transportation should be kept in a manner that they are not too densely overlaid causing accumulated heat and moisture that affect their quality.

5 Record keeping

The following information should be recorded and kept:

- a) month-year of silk worm eggs production
- b) day-month-year of the first hatching
- c) day-month-year of silkworm mounting;
- d) daily temperature and relative humidity of silkworm rearing house;
- e) day-month-year of harvesting fresh cocoon;
- f) day-month-year of cocoon drying;
- g) quantity of cocoons for each grade
- h) application of substances used to prevent and control silkworm diseases; and

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Annex A (informative) Characteristics of defective cocoons

A.1 A double cocoon is a cocoon with more than one silkworm nest together. The silk yarn from this type of cocoon tends to break easily during a reeling process because there are more than one silk threads twisted. Thus, the silk yarn reeling ability and efficiency is low. The derived silk yarn is uneven. Double cocoon is caused by different reasons too many silkworms per frame, high temperature and high humidity. Double cocoons are used for manufacture of a coarse, non-uniform yarn called "dupion".

A.2 Pierced or perforated cocoon are cocoon pierced out by a maggot of Uzi fly leaving a hole on the cocoon causing silk yarn filament breaks. Thus, the silk yarn reeling ability and efficiency is low. It can be used only for hand spinning or as raw material of machine spun silk yarn.

A.3 Inside soiled cocoon or dead cocoon or melted cocoon are cocoon which contains dead pupa inside or made by an infected silkworm but still on cocoon development stages. The pupa is dead and sticks to the inside shell of the cocoon causing a stain which yields low quality silk yarn which is dull in colour. They do not make sound when shaken.

A.4 Outside soiled cocoons are cocoon derived from silkworm urine before cocooning or contamination by infected silkworms in the same frame. These are recognized by a rusty colour spot on the cocoon shell caused by absorption of intestinal fluid/urine of the mature worm formed during mounting. The cocoons become soggy before reeling and reelability is very poor.

A.5 Thin shell cocoons are cocoon not fully developed which is caused by infected silkworm. The silkworms have only short time to spin the cocoon before they die. In other case, the mature silkworms are transferred too late and thus they spin cocoon on the side of rearing trays or tables, leaving little fibre when they are placed on a cocoon frame. It is not possible to reel this type of cocoons as they become too soggy.

A.6 Loose shell cocoon or Flimsy cocoons means a cocoon produced under an improper environmental condition whose shell is loosely spun in layers and has a low silk content. These cocoons are easily overcooked and fibre from this type of cocoon tends to break easily when reeled.

A.7 Thin-end cocoon: The cocoon is unusually thin at one or both ends, and when cooked thinner part becomes soggy leading to several filament breaks during reeling process. Thus, the silk yarn reeling ability and efficiency is low. The cause of this defect may be attributed to species characteristics or improper temperature and humidity during rearing and mounting.

A.8 Malformed cocoon means a cocoon made from silkworms in an improper cocoon frame, or from weak silkworms. This prevents the silkworms from completing the cocooning process and the cocoons are distorted and irregular. When cooked with normal cocoons, they are either soggy easier or hard depending on the condition of each malformed cocoon.

A.9 Cocoon with prints of cocoon frame or scaffold pressed cocoons means a cocoon made by a silkworm on the edge of a cocoon frame or on the lining paper. The cocoon is too flat with some thicker parts. This is due to too many silkworms per a cocoon frame, leaving little space for cocooning. Sometimes it occurs because the cocoon frame is improper.

A.10 **Crushed cocoon** means a cocoon caused by poor handling during transportation. The cocoons are crushed to one another. The filament from these cocoons break easily especially at the crushed spots.

A.11 **Musty or mildwed cocoon** means a cocoon caused by an incomplete cocoon drying process and improper moisture control in a cocoon storage room. This condition allows fungus to grow in the cocoon shell. It is not advised to reel this type of cocoons as the filament gets deteriorated.

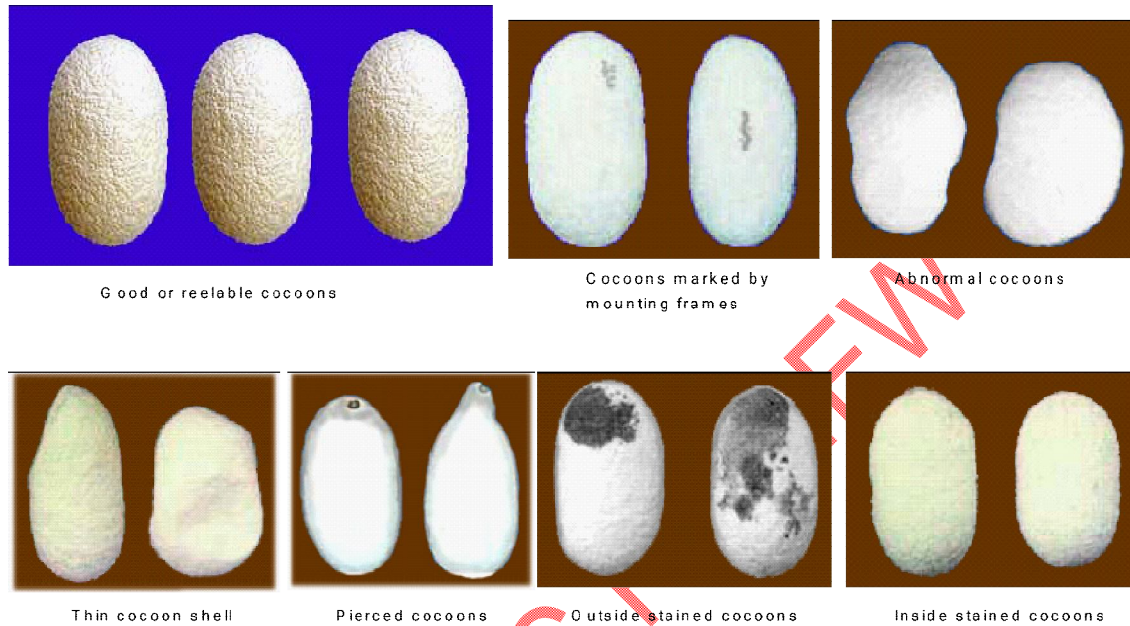


Figure A.1: good quality cocoons and defected cocoons

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