Comparative study of solar cocoon dryer and multi-fuel cocoon dryer for quality raw silk production

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Abstract

A study was conducted in the experimental laboratory of Bangladesh Sericulture Research & Training Institute (BSRTI), Rajshahi from 2014-2015. The aim of this study was to to minimize the cocoon drying cost in Bangladesh for the newly fabricated solar cocoon dryer. In this fabricated cocoon drying device solar energy has been used for cocoon drying. The fabricated solar cocoon dryer has reduced the fuel cost and at the same time ensured the qualitative and quantitative raw silk production. Generally, most of the sericulture farmers dry their cocoon through direct sunlight, which reduces the silk quality and also increase the wastage percentage. The experimental results revealed that the fabricated solar cocoon drying chamber removed the moisture of fresh cocoon from 51.08%- 53.00% in 15-17.5 hours of drying period at temperature of 57^0-68^0 C. The fabricated solar cocoon dryer also reduced the cocoon drying period as well as reduced the fuel cost.

Keywords: Solar cocoon dryer, Minimize drying cost, silk production

Introduction

In Bangladesh Generally silkworm rearing is practiced in four different seasons due to steep fluctuation in agro-climatic conditions. In every seasons a large quantity of cocoons are produced, which need to be dried within a short period of time. Cocoons in their green condition with the live pupae cannot be stored for a long time. The rearers /sericulture farmers who produce cocoon have to wait for purchaser to sell their cocoons before the emergence of moth inside the cocoons. The live pupae are transformed into moth within 8-10 days and emerge from the cocoon by piercing the shell. Cut or pierced cocoons are unsuitable for reeling of raw silk, because the continuity of the bave in them is broken, thus the farmer loses their earnings. As a result farmers remain worried until they check the emergence of moth by drying cocoons. So they prefer to dry their cocoons under direct sunlight considering its abundance and minimum of cost *(Chowdhury et al.1995)*. The scorching heat of the sun kills and desiccates the pupa inside of the cocoon. But exposing cocoons directly to the harshness of the sun detracts cocoon quality and badly affects the reelability. *Chakraborty et al.(1995)* reported that ultraviolet rays of the sunlight adversely affects the quality of silk and increases the proportion of silk waste during reeling. Besides the shell of sun drying cocoon become harden which also negatively affects the reelability of the cocoons. *Shirol et al.(1994)* reported that 1kg of cocoon take about 7 days to achieve around 55% driage directly exposed to sunlight.

In winter season temperature of sunlight is not sufficient to kill the pupae of inside cocoon in time. In rainy season the problem drying becomes more aggravated, because the sunlight is not available. In Bangladesh the sericulture farmers are usually dried their cocoons under direct sunlight due to the abundance of suitable cocoon drying method as well as minimize the cocoon drying cost locally. There is a scope to use the electrical hot air dryer for drying cocoons at farmer's level but it is very costly and at the same time supply of electricity is not available in rural areas. As a result, the quantity of cut or pierced or fungus affected are more cocoons, which reduces the yield of raw silk production from in every season. Beside it was also observed that the existing electric cocoon drying machine is generally used only in the laboratory level and not affordable for poor farmers in the village level due to higher fuel cost. The few number of multi-fuel cocoons dryer are in use in the public sector only.

Keeping this idea in Bangladesh sericulture research and Training institute (BSRTI) fabricated a low cost solar cocoon drying chamber for drying cocoons in a short period of time at economic cost in hot seasons as well as to persuade the sericulture farmers for replacing the

traditional sun drying method which is reported to be harmful for cocoon color, reelability, strength and raw silk quality *(Shirol et al.1994).*

Materials and Methods

The solar cocoon drying chamber was developed which is incorporated with the following features.

Main body frame

The frame of the cocoon drying chamber was made of iron angle and the size was 3′-0″× 2′-0″×4′-0″ × (LWH), base 0′-6″, body 3′-6″ and angle frame 2″×2″ and under base 2″ flat bar were used. The body base door made by 20 gauze GI sheet 2″ and gape filled by glass wall. Door made by 1″ sheet and back side body made by steel sheet.

Cocoon tray

The cocoon tray was made of S.S sheet with S.S net at the bottom of tray, which helps in good aeration. The height of the tray was 3 cm high and the number of tray was 3, which was made as a drying chamber.

Ventilator

There were two ventilators placed at each of drying chamber for proper aeration and also to control the inside temperature with the opening and closing facilities.

Dial thermometer

A dial Thermometer has been placed at the top of the drying chamber to observe the inside temperature of the dryer during drying period from outside.

Power glass

A set of power glass was placed at the top level of the stand. Photographs of Solar cocoon dryer is shown in Fig. 1.

Fig. 1. Photographs of Solar cocoon dryer.

Experimental works

A series of experimental trial was conducted in different four silkworm rearing seasons viz. S_1-Jaistha(May-June),S_2-Vadury(Agast-september) S_3- (Augrahani October-November) and S_4-Chaita(February-March). The objective of this study was to find out the comparative cocoon drying performance, drying cost as well as raw silk quality and quantity of solar cocoon dryer and multi-fuel cocoon dryer. In the both cases bivoltine and multivoltine hybrid cocoons were used. There were 3 trays of drying cocoons and each tray 4 kg of fresh cocoons ware taken in each try for drying at a time. After loading of trays the door and ventilator of the drying chamber ware closed. After ignition of sun within 30-40 minutes the inside temperature of drying chamber rise up to 57-68 and observed in dial thermometer.

For uniform drying cocoon trays position inside the chamber were replaced from top to bottom after 1.5 hours interval. During drying period propeller was rotated by hand within 5-10 minutes interval to regulate the inside temperature equilibrium which helps to dry all cocoons properly. The cocoon samples were dried in the drying chamber following the methods of Subhas et al (1994).After drying was completed cocoon samples were taken out from the drying chamber and stored in racks in two days before reeling (Sonwalkar et al.1990). At the same time same type of cocoon samples were dried in an electric cocoon dryer and direct sunlight flowing the methods of Subhas et al(1994) and Shirol et al(1994) respectively. Before mass reeling fifty cocoons from each sample were reeled for single cocoon filament length, dropping and denier test in every seasons.

Reeling performances like raw silk recovery % reeleability %, silk waste %, denier and renditta were determined according to sonwalkar (1998) and Shamachary (1986) method. The raw silk quality was tested for different parameter as per standard methods.

Data of the comparative study of drying trials of cocoon in solar cocoon dryer (SCD) and multi-fuel cocoon drying (MCD) method in four different seasons has been exhibited in Table 1. Results revealed that the moisture content of fresh cocoons was removed from 52.13- 53.25% in SCD within 17.5 hours of drying period at temperature 57 -68^0 C but in MCD method moisture contents of fresh cocoon was removed from 55.05-56.20% in $5^1/_2$ hours of drying period at temperature around 110 - 55^0 C. The drying cost of fresh cocoon was obtained in MCD chamber

Tk. 0.91-098 per kg using wood as fuel. On the other hand there was no fuel cost for cocoon drying in solar dryer. *Chakraborty et.al (1995)* reported that 30.00-40.00% removal of moisture in 6 hours of drying at 90-110^{0}c(from higher to lower) temperature involve cost of drying at kg of fresh cocoon raging from 0.65-0.80 in fabricate portable cocoon drying chamber, where kerosene was used as fuel. *Chowdhury et al (1995)* observed that drying cost Rs 0.40 per kg of fresh cocoon using coal as fuel in low cost fire burnt cocoon drying chamber. Shirol et al. (1994) also reported that 1kg of fresh cocoon achieved around 55% of driage after thinly spread out under direct sun light for 7 days. The present findings are in agreement with that of Chakraborty et al. (1995) and Shirol et al. (1994) reports.

From the table 2 it was found that the average renditta, raw silk recovery%, reliability% and silk waste% were 10.29, 71.60, 69.47 and 24.96 in SCD on the other hand 10.37, 71.56, 69.45 and 25.11 in MCD respectively. These results revaluated that the overall reeling performance of reeled silk of cocoon dried in SCD chamber was better than the MCD chamber. There was also found the significant differences for reeling performances from season to season both for the SCD and MCD (table 2).

Table 1. Comparative study of drying trials of fresh cocoon between fabricated solar cocoon dryer (SCD) and multi-fuel cocoon drying (MCD) method

Drying parameters	Drying methods							
	Solar cocoon dryer (SCD)				Multi-fuel cocoon dryer (MCD)			
	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
Green wt. of cocoons used (kg)	10	10	10	10	10	10	10	10
Dry wt. of cocoons obtained (kg)	4.47	4.40	4.10	4.10	4.45	4.30	4.45	4.44
Percentage of moisture removed from green cocoons	52.13	53.10	52.25	53.25	55.05	56.15	56.20	56.19
Period of drying hours/days	15 hours	17.5 hours	17.5 hours	15 hours	5^1/$_2$ hours	5^1/$_2$ hours	5^1/$_2$ hours	5^1/$_2$ hours
Temperature reached (^{0}C)	60-68	57-65	57-65	60-68	110-55	110-55	110-55	110-55
Drying cost per kg (Tk)	-	-	-	-	0.91	0.93	0.98	0.98
Fuel consumed in 5 hours (Wood, kg)	-	-	-	-	4	4	4	4

Note: S_1, S_2, S_3 and S_4 = Silkworm rearing season, (S_1= 1st, S_2= 2nd, S_3=3rd and S_4=4th Season

Table 2. Comparative reeling performance of cocoon dried in solar cocoon dryer (SCD) and multi-fuel cocoons dryer (MCD)

Season	Drying parameters under two drying methods							
	Solar cocoon dryer (SCD)				Multi-fuel cocoon dryer (MCD)			
	Renditta	Raw silk recovery%	Reliability%	Silk waste%	Renditta	Raw silk recovery%	Reliability%	Silk waste%
S_1	10.60 b	70.10 d	68.12 d	28.01 a	10.98 a	70.02 d	68.02 d	28.50 a
S_2	10.92 a	71.18 c	69.05 c	25.23 b	10.86 b	71.20 c	69.26 c	25.22 b
S_3	9.90 c	72.40 b	69.50 b	23.56 c	09.85 c	72.35 b	69.40 b	23.05 c
S_4	9.75 d	72.70 a	71.22 a	23.02 d	09.79 d	72.70 a	71.10 a	23.02 c
Mean ± SD	10.29 ± 0.48	71.60 ± 1.03	69.47 ± 1.13	24.96 ± 1.94	10.37 ±	71.57 ± 1.05	69.45 ± 1.09	25.05 ± 2.19

Note: Renditta= The amount of green cocoon to get 1kg of raw silk.

Table 3. Comparative Quality characteristics of silk cocoons dried in solar cocoon dryer (SCD) and multi-fuel cocoon dryer (MCD) reeled on improved cottage reeling machine

Seasons	Drying parameters under two drying methods							
	Solar cocoon dryer (SCD)				Multi-fuel cocoon dryer (MCD)			
	Avg. size denier)	Tenacity (g/d)	Elongation %	Winding breaks/40 skeins/hr.	Avg. size (denier)	Tenacity (g/d)	Elongation %	Winding breaks/40 skeins/hr.
S_1	23.72 a	3.10 b	18.05 d	15 b	23.56 a	3.05 ab	17.90 d	16 ab
S_2	23.40 b	3.02 c	18.50 b	11 d	23.50 a	3.01 b	18.40 b	12 c
S_3	23.15 d	3.15 a	18.25 c	17 a	23.20 a	3.10 a	18.05 c	18 a
S_4	23.30 c	3.05 c	19.02 a	13 c	23.50 a	3.03 ab	18.97 a	14b
Mean ± SD	23.39 ± 0.20	3.08 ± 0.05	18.46 ± 0.36	14 ± 2.23	23.44 ± 0.14	3.05 ± 0.33	18.33 ± 0.41	15 ± 2.24

Renditta, raw silk recovery%, reliability% and silk waste% were found in seasons S_4 which were 9.75 d, 72.70 a%, 71.22a% and 23.02 d respectively for SCD drying chamber. On the other hand, renditta, raw silk recovery%, reliability% and silk waste% were obtained season 4, which were 9.79 d, 72.70%a, 71.10 and 23.25 c % respectively for MCD. The results of the cocoons dried in SCD chamber and MCD chamber methods are closely correlates with the previous findings of Chakraborty et al. (1995), Shiroal et al. (1994) and Quder et al,(2000-2004). There were significant variations of renditta, raw silk reelability% and silk waste% were observed between SCD and MCD methods in case of cocoon drying which are in agreement with that of sonwalkar et al. (1983) who opined that it may be due to cocoon drying, cooking and reeling method used.

From the table 3 it was found that the average size of denier, tenacity, elongation% and winding breaks were 23.39, 3.08 (g/d), 18.46% and 14 for SCD on the other hand 23.44, 3.05(g/d), 18.33% and 15% for MCD respectively. These results showed that the overall performance quality characteristics of reeled silk of cocoon dried in SCD chamber was better than the MCD chamber. There was also found the significant differences from season to season for quality characteristics of raw silk both the SCD and MCD (table 3).The highest average size of denier were 23.15d (S_3), tenacity 3.15a (S_3), elongation% 19.02 a (S_4) and winding breaks 11d (S_2) respectively for SCD drying chamber. On the other hand, the highest average size of denier 23.56a (S_1), tenacity 3.10a (S_3), elongation%18.97a (S_4) and winding breaks 12c (S_2) were respectively for MCD drying chamber. Sonwalkar et al. (1990), Hariraj et al. (1992) and Qader et al. (2000-2004) reported 3.9 (g/d) and 19.20 % 3.98 (g/d) and 18.10% and 3.12 (g/d) and 18.02% tenacity and elongation % respectively of raw silk, which corroborates with the present findings.

Conclusion

Solar energy for cocoon drying is a new idea in Bangladesh. Our fabricated solar cocoon dryer is capable to dry the green cocoon properly as well as to produce quality and quantity raw silk without any fuel cost. Though the SCD minimize the fuel cost for cocoon drying but it takes more time than the MCD. If the cocoon drying period will be reduced then the SCD will be more economic for sericulture farmers for drying their raw cocoon and also produced quality raw silk than the MCD. That is why, it is needed to continue this research work for further improvement and reduced the cocoon drying period in SCD.

References

Chakraborty A, Manna S S, Kar N B, Sen S K, Chowdhry S K and Pawankumar T. 1995.Cocoon drying: A solution.Ind.Textile j. 6:130-133.

Chowdhury S K , Roy S and Sangappa Shillin. 1995. Low cost fire burnt Cocoon drying Chamber. Indian slk,33:33-35.

Hariraj G , subhas V N, Lahshmipathaiah B N and Sonwalkar T N. 1992.Performance of multiend reeling machine and domestic reeling basin. Ind textile j 12 (2):98-100.

Qader M A, Hamid Miah M A, Rab M A and Samad Talukder M A. 2000-2004. Reeling performance and quality raw silk production: 1. Fabrication of improved cottage reeling machine.Bull. sericult.res.11:27-31.

Shamachary. 1986.Cooking technology suitable for different types of silkworm cocoons.Indian silk.25(5):13-14.

Shirol M M, Nadiger G S and Somashekar T H. 1994. Impoved method of sun drying of cocoons using black cloth. Indian silk ,April,23-27 p.

Sonwalkar T N . 1998. Silk reeling and processing. Lead paper presented in international Congress on Tropical Sericulture Practies. Central Silk Board ,Bagalore,India.

Sonwalkar T N, lahshmipathaiah B N, prabhu j and Mohan Rao R J. 1990. better Silk through CSTRI reeling machine. Ind .Textile j. 7C: 84-88.

Sonwalkar T N, Nagabhushanaiah Y V and krishanswamy S. 1943. Comparative reeling performance of bivoltine cocoons on an automatice reeling machine compared to filature type multiend reeling machine with pressurized, open and three pan cooking system.Ind.j.seric.27;40-50.

Subhas V N, Hariraj G , Lakshmipathaiah b N and Somashkar T H. 1994. Reeling performance and raw silk quality traits. ind. Textile j. 104(7):20-27.

Qader M A, Rab M A, Hamid Miah M A And Roy S. 2009. Fabrication of improved low cost multifuel cocoon cocoon drying chamber. Bangladesh journal of sericulture ,volume 2&3.