HEAT TREATMENT OF COCOONS SILKWORMS AND ITS EFFECT ON STIFLING PUPAE'S AND QUALITY OF THE PRODUCED SILK FIBERS.

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ABSTRACT

To export or store cocoons mulberry silkworm yield for a long time, cocoons must be dried to stifling the pupae inside the cocoons and to reduce the high moisture levels of cocoon shell and pupae body to a safe moisture level. This safe level should be low enough to reduce fungi and microbial growth, which cause decomposition and affecting the quality and appearance of the silk fiber.

The aim of this research work was to study the effect of heated air treatment of cocoons silkworms on the stifling pupae's inside cocoons and quality of the produced silk filaments. A small portable batch dryer suitable for small Egyptian rearer's silkworm was used. This system was compared with the conventional method for drying and stifling pupae's in Egypt. The experimental treatments included four different levels of heating air temperature (55, 65, 75 and 85 °C), and three different levels of air flow rate forced through the cocoons (1.0, 1.5, and 2 m^3/min). The obtained data showed that, during the conventional sun drying, the cocoons moisture content decreased gradually from initial moisture of 64.5 ± 0.5% (w.b) to a final level of 10 ± 1.0 % (w.b) after 4.5 days (60 h). While heating cocoon artificially at air temperature of 85 °C and air flow rates of 1.0, 1.5 and 2.0 m^3/min reduced the drying time by about 91.6, 92.5 and 94 %, respectively, as compared with the traditional drying of cocoons (control treatment).

On the same time, the maximum value of the killed pupae's, length of silk filament, silk filament strength and cocoons reel-ability was always obtained at treatment of 85 °C air temperature and 2 m^3/min air flow rate. At this treatment, the highest values of the killed pupae (99.35 %), silk filament force (18.8 cN/tex), and elongation of silk filament (11.83 %) were achieved. This resulted in highest value of cocoons reel-ability (67 %) and highest length of silk filament (930 m). The drier may be offers a substantial increase in the price of silk

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filament (higher categories price) by decreasing the total reeling losses, and consequently increase the yearly economic return.

INTRODUCTION

Silk production, including sericulture, is well known as a highly employment-oriented, low capital-investment activity ideally suited to the conditions of a labor-abundant and agro-based economy. Recognizing the importance of sericulture, government should takes series of development measures to popularize it. Usually, the silkworms are reared in agricultural farms to obtain cocoon for silkyarn. All the cocoons produced in the farm are dried and used as source material for producing silk fiber. However, the cocoons used for the production of silkworm eggs are known as seed cocoons.

Egypt produces about three tons of raw natural silk while the local market needs more than 300 ton that must be imported from abroad (Agric. Statis., 2004). Cocoons silkworms are usually harvested manually at a relatively high moisture level of about 65 + 0.5 % (w.b.). After harvesting, cocoons were inspected to eliminate the unfit products (cull and defective cocoons). Then it must be treated, to kill the inside pupa through drying them, to maintain the quality characteristics and to obtain the same measure of filament.

Metcalf and Flint (1983) stated that each cocoon is composed of a single, continuous thread commonly averaging about 1,000 m in length. If the moth were allowed to emerge, this single unbroken thread would be dissolved and broken into hundreds of tiny, useless pieces. The silk grower needs comparatively few moths to provide a new stock of eggs. He does need millions of cocoons. The other cocoons must be saved from injury by the moth. Accordingly, about 10 days after they have made their cocoons, their pupae are killed by dropping the whole lot into hot water, by steaming them, by dry heat, or by fumigation.

Soo-Ho et al. (1990) and Wu et al. (1992) showed that the main purpose of drying cocoons silkworms is to kill the pupae and reduce the potentially harmful moisture content, enabling them to be stored up to a year in proper conditions. Therefore, silkworm cocoons must be dried as soon as harvested because of the possibility of moths emerging from the pupae they contain and spoiling there important feature, reel-ability. A proper drying enables cocoons to stand a long storage (6-12 months) without growing molds. A whole dried cocoon has moisture content about (8 - 12 %) and (6 - 8 %) in cocoon shell while the dried pupae body contains about (7-13%).

S.E.S., (1986) and (1992a) indicated that fresh cocoons contain alive pupae which, in the natural cycle, will moth, breaking the cocoon and making it useless for silk production. To control the cycle the pupae must be killed and the cocoons treated so that they can be stored and used in the reeling process as required. The percentage of moisture content varies with silkworm variety, rearing season, male or female, etc. The majority of water is contained in the pupae body (75-79%), while the fresh cocoon shell contains (11 – 12 %). For this reason, the fans should be sized to provide air velocity of 1.0 m/s, air heated to 102 $\pm$ 2 °C is sufficient for rapid drying. Air temperatures above 115 $\pm$ 5 °C will damage the sericin content, so that in the reeling process, the groping ends efficiency and reel-ability decline, with resultant decrease in raw silk percentage of cocoon.

S.E.S. (1992b), Narasaiah (1992) mentioned that the purpose of cocoon drying is to prevent the emergence of maggots and moths, remove the moisture contained in the cocoon shell and pupae and thereby make cocoons capable of being preserved for a long time under normal temperature and humidity. Several methods of artificial drying have been tried to kill the pupae, by spread cocoons on perforated mats or in a wire box where they are exposed to steam of water for three hours. After that, cocoons are subjected to drying. but the method most commonly used for pupae killing and drying cocoons involves blowing heated air at 50 to 102 $\pm$ 2 °C vertically through a grill on which the cocoons placed in mesh bags.

Kottbey (1993) showed that in Egypt, sun dying is still the most common method to preserve cocoons. Due to lack of sufficient preservation methods, rearer's have to spread the yield of cocoons to be dried in thin layers on paved grounds or mats where they are exposed to sun rays and wind from 3-5 successive days. Considerable losses may be occurred during natural sun drying due to various effects such as rodents, insects, rain and microorganisms.

This method has a negative effect on the sericin layers of these cocoons and decreases the quality characteristics due to expose cocoons to ultraviolet and infrared rays, which in turn, increase the total reeling losses of cocoons. She also indicated that the silk filament lose about 50% from its strength if exposed to ultraviolet rays for 6 hours.

Aruga (1994) stated that in killing the pupae care should be taken so as not to spoil the properties of cocoons. For the cocoons obtained from spring rearing, many times the pupae are infected with uzifly larvae which ultimately kill the pupae escape by cutting a hole in the cocoon. Hence, the cocoons should be dried at proper time whereby both the pupae and the uzifly larvae in the cocoons are killed.

Natural sun drying is one of the most common ways to conserve cocoons after harvest. Cocoons are spread on the ground to be dried by sun and wind. During drying these are neither protected against dust and rain nor against rodents, birds and insects. Poor quality due to contamination with partially pathogenic microorganisms and high losses caused by uneven or incomplete dehydration are the characteristics of sun drying (Yong-woo, 1999). He added that in the case of artificial drying, the initial drying temperature has the largest effect on the cocoon shell. When the temperature exceeds the highest limits, sericin is sharply degenerated leading to a decrease in raw silk percentage. If the initial temperature for cocoon drying is lowered too much, it is apt to deteriorate the neatness and cleanness result of the raw silk quality.

Morohoshi (2001) indicated that cocoons should be dried after harvesting and before storage or marketing. Drying helps reduces water level, and prevents entry of decay causing organisms during storage and helps in killing the pupae inside cocoons.

ARC (2000 and 2002) showed that when the harvested cocoons are kept as such, the pupae inside them metamorphose into moths. These moths tear the cocoon to emerge. Therefore, cocoons meant for reeling silkyarn need to be treated in such a way that the pupae inside the cocoons are killed at a particular time. In Egypt, the fresh cocoons are spread in a thin layers in a mat or planks of wood and exposed to direct sunlight for 3-5 days depending on the intensity of the solar radiation. The main disadvantage is silk fibers sensitivity to ultraviolet rays, which harm fiber strength and color. Incomplete drying may cause uneven cooking results and consequently, lower the raw silk quality in relation to cleanness and neatness. (Ganga, 2003).

To provide high quality silk product for export it is necessary to develop suitable methods of drying and stifling the pupae inside cocoons. Artificial drying of cocoons is not only to replace the manual work but also to adapt systems, which may help for Egyptian rearer's to determine their prices in an accurate basing on the quality and quantity of silk in the cocoons.

The general objective of this research work was to study the effect of heated air treatment of cocoons silkworms on the stifling pupae's inside cocoons and the change in quality of the produced silk fibers. A flatbed batch dryer suitable for small Egyptian rearer's silkworm was used and compared with the conventional method for drying and stifling pupae's in Egypt. The specific objectives were to:

1- Determine the change in the moisture content of cocoons silkworms.
2- Determine the time required for complete drying.
3- Evaluation of product quality in terms of the killed pupae's, silk filaments length, cocoons reel-ability; and tensile strength in term of force and elongation of silk filaments after heat treatment process.

MATERIALS AND METHODS

- Materials:

During the spring seasons of 2005 - 2006, about 60 kg of Chinese cocoons, strain was collected and used for this investigation. This strain was obtained from Sericultural Research Department. Plant Protection Res. Institute., Branch of Sharkhia. Agric. Res. Center. (ARC), Egypt.

- Structure of the dryer:

A small flatbed batch dryer was designed, and constructed in the workshop of Ag. Eng. Res. inst. (AEnRI), ARC. The gross dimensions of the dryer are 125 cm long, 75 cm wide and 80 cm high, as shown in Fig (1). The silkworm cocoons were placed on a netting wire floor above the plenum. Netting wire was installed 30 cm above the bottom of the batch forming an air chamber under the wire netted floor. The storage volume above the floor was 470 Litter (0.47 m^3). A blower and duct for forcing heated air are located at one side of the dryer house, to force the heated air from the plenum through the cocoons. Electric heaters (4 kW) were fixed in open steel cylinder of 10 cm diameter and connected to a dial thermostat to control the drying air temperature The blower was powered by a single phase electric motor of 0.375 kW and 2850 rpm.

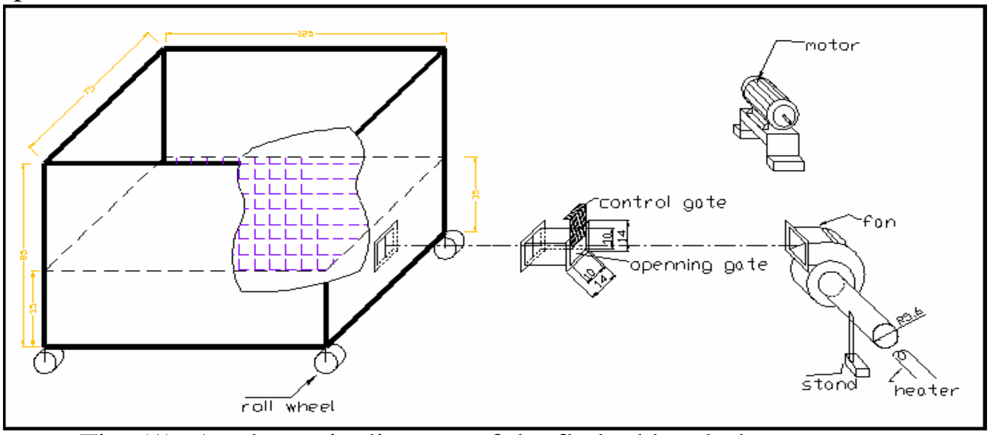

Fig. (1): A schematic diagram of the flatbed batch dryer.

The variables considered in this evaluation were selected according the relevant studies as recommended by S.E.S. (1992a and 1992b) and Kottbey (1993), as follows:

- Levels of heating air temperature (55, 65, 75 and 85 °C).
- Levels of Air flow rates forced through the cocoons (1.0, 1.5 and 2.0 m^3/min).

- Experimental Procedure:

A mulberry cocoons silkworm were harvested (collected) manually at moisture content of 64.5 ± 0.5% w.b. The collecting cocoons were inspected to eliminate the unfit products (cull and defective cocoons) by manual picking. The fit cocoons were divided into two parts (conventional field drying, and artificial drying).

- The first part of cocoons was naturally dried in the open field. They were spread in one layer under the ambient conditions, and turned each one hour during the day time, then, it covered during the night time as it usually practiced by Egyptian rearer's according to Kottbey (1993).

- Before starting the experimental work, the dryer was operated with a dummy sample of cocoons for at least one hour. This period of time was essential for heating air and stabilizing the air flow rate. After that, the second part of fresh cocoons was taken, and manually placed on the netting wire floor of the dryer. Then the heated air passes from the bottom of dryer to diffuse up through the product with the required temperature and air flow rate.

The heating process was continued till the moisture content of whole cocoons reached the desired level, of (10 $\pm$ 1.0% w.b). In this case, cocoons have a complete drying of the cover and the pupae body, according to Soo-Ho et al. (1990) and Wu et al. (1992).

After that, the dried samples were taken and placed in clean common burlap bags and kept under normal storage condition in order to determine the quality characteristics of silk filaments.

- Measurements:

- Cocoons moisture contents.

Moisture content of the cocoons was measured according to AOAC (1996). Cocoons samples were dried using drying oven at 105 °C until a constant weight. Samples were taken at intervals of half hour for artificial drying and at intervals of 4 hours for field drying to determine the moisture loss. Cocoons samples were weighed before and after drying.

- Air temperature:

Copper-constantan thermocouples were used to measure the ambient air temperature at different points inside the dryer. They were calibrated at both boiling and freezing points. Thirty thermocouples (copper–constantan) were used and evenly distributed in three parallel planes (top, middle and bottom) in order to measure the ambient air temperature inside the dryer and one thermocouple was used to measure the ambient air temperature outside the dryer at intervals of half an hour. The measurements were conducted by using digital thermometer (model Omega-type J, USA).

- Air relative humidity:

A digital hygrometer (Trisense - hygro, anemometer and thermometer) model-37000, USA, was used to measure the air relative humidity at adjacent points of temperature measurements.

- Air flow rate:

A hot wire anemometer model (Testo 425, Germany) with accuracy at (± 0.01) was used to measure the inlet air speed at the dryer window in m/s. which multiplied by the area of the intake window to give the required air flow rate in m^3/s entering the dryer.

- Solar radiation measurement:

The solar radiation flux incident on a horizontal plane in W/m^2 using the monthly average meteorological report of Ismailia - Elquassasin Station (May 2006) was employed during drying of cocoons in the open field.

- Stifling pupae's determination, %:

Stifling pupae's inside cocoons were determined in the laboratories of Sericultural Department, Plant Protection Res., Institute, branch of Sharkhia. Agric. Res. Center (ARC), Egypt, according to Wu et al. (1992) as follows:

Four replicates of 10 cocoons were taken randomly from each treatment and opened carefully using a sharp scissor. The died pupae were noted and expressed as percentage of the original number of cocoons.

- Quality evaluation tests of silk filament:

The quality characteristics of the silk filaments included total length of silk filaments, and cocoons reel-ability. The tests were accomplished in the laboratories of Sericultural Department., Plant Protection Res., Institute, branch of Sharkhia. Agric. Res. Center (ARC), Egypt.

While, the tensile strength as well as force and elongation of silk filaments were performed in the laboratories of the Egyptian Cotton Quality Control Center, Spinning Research Department. Cotton Res., Institute; (ARC), Egypt, using Zwick 1511 tensile tester.

- Length of silk filament.

For measuring the total length of silk filament, 10 cocoons were taken randomly from each treatment and softened by soaking in boiling water. The rated silk filament of every cocoon was measured.

- Reel-ability of cocoons, %:

The reel-ability of cocoons *(Rc)* was determined according to Aruga (1994) using the following formula:

$$Rc\ (\%) = \frac{Cutting.No.of\ .filament.during.reeling.operation}{Number.of\ .reeled.cocoons} \times 100\ ,\ \%$$

- Force and elongation of silk filaments.

Zwick 1511 tensile tester was used for testing the tensile strength of silk fibers. It is a constant rate of extension (CRE) tester and it is claimed to be suitable for testing single yarns, woven strips and lea strength. This tester consists of four units; which are the tester (yarn length is 500 mm), the creel, the processor and the printer. The input parameters are: number of test per reel, number of reels, yarn count (1.96 tex = 17.14 denier) and test speed (60 mm/min).

The output parameters are:

-Single yarn strength (F-Max)………. cN/tex

-Breaking load (F-Max)………………. N

-Work to break ………………………. cN/tex

-Test time …………………………….. Seconds

-Extension at break (elongation)……. %.

RESULTS AND DISCUSSIONS

- Artificial Drying.

Figure (2) show the change in cocoons moisture content with drying time under different heated air temperatures and different air flow rates. The heat treatment process continued until the cocoons moisture content decreased about of (55 ± 1.0% w.b) from the initial moisture content (64 ± 0.5 % w.b). It can be seen from Fig. (2) that the drying period of cocoons decreased as the air temperatures increased from 55 to 85 °C, and as air flow rates increased from 1.0 to 2.0 m^3/min.

Figure (2) shows that at minimum air temperature of 55 °C, increasing air flow rates from 1.0 to 2.0 m^3/min caused a gradual decrease in the cocoons moisture content from initial moisture of (64 ± 0.5 % w.b) to a final level of (10 ± 1.0% w.b) in 7, 6 and 5.5 h for 1.0, 1.5 and 2.0 m^3/min air flow rate, respectively. Meanwhile, increasing the drying air temperature to the maximum level of 85 °C at air flow rates of 1, 1.5 and 2 m^3/s caused an extreme decrease in the drying period to 5.0, 4.5 and 3.5 h respectively.

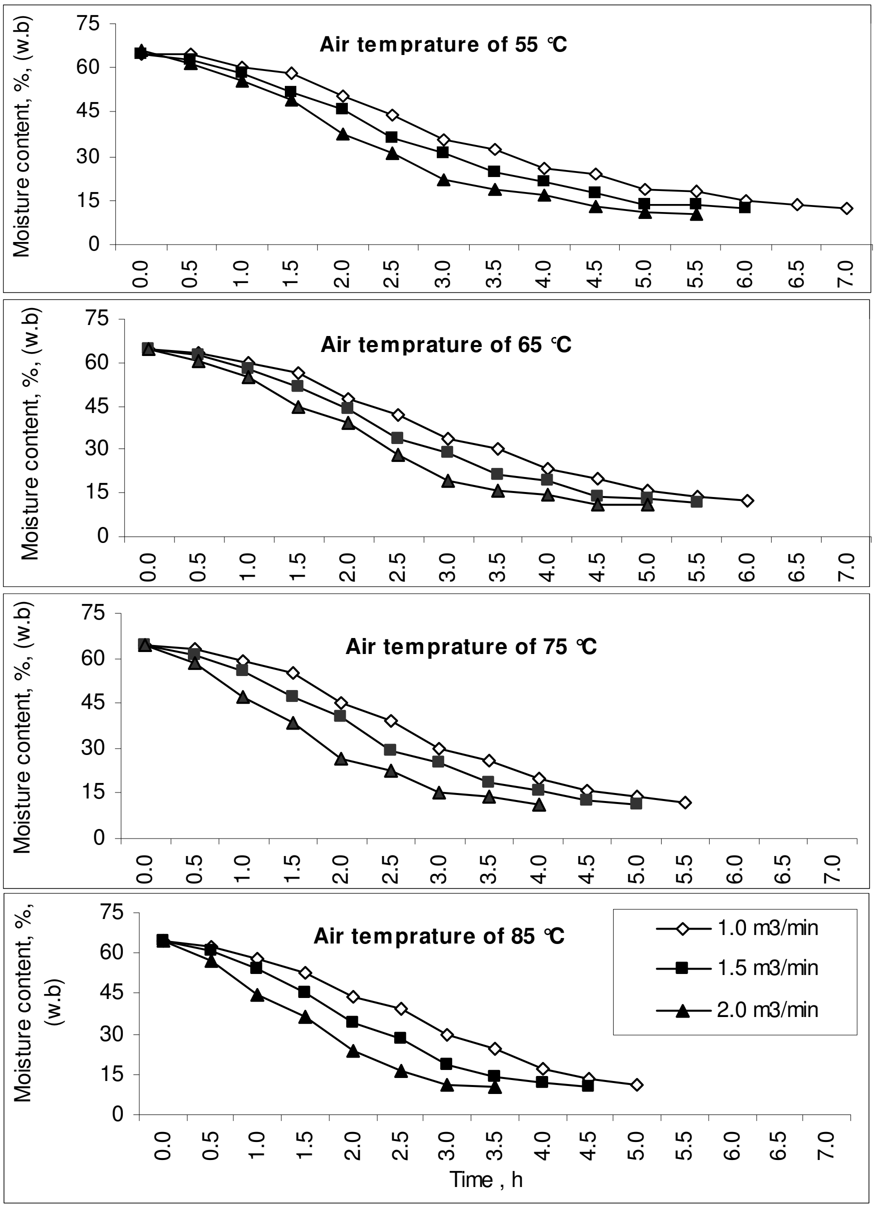

Fig. (2): The relationship between the cocoons moisture content and time under different air temperatures and different air flow rates.

This means that, the artificial heating of cocoons using 55 °C can reduce the required time of drying cocoons by about 88.3, 90.1 and 90.9 % at air flow rates of 1.0, 1.5 and 2 m^3/min respectively, as compared with traditional drying method (control treatment). Similarly, heating of cocoons using 85°C at the same level of air flow rates can reduce the time of drying cocoons by about 91.6, 92.5 and 94 % respectively, as compared with the traditional drying method. This may be attributed to the higher temperature and lower relative humidity of the heating air inside the dryer as compared with the ambient air outside the dryer.

- Conventional Field Drying.

The weather conditions, such as, ambient air temperature, air relative humidity and solar radiation, cocoon temperature and cocoon moisture content during the period of field drying were presented in Figs. (3, 4 and 5). The hourly average daily solar radiation flux incident on a horizontal plane was plotted against solar time (Fig. 3). The obtained data showed that the hourly average solar radiation was 549.32 W/m^2 during the experimental work. The figure also shows that the solar radiation was gradually increased from sunrise until reached a maximum value of 876 W/m^2 at noon. It then decreased gradually until it reached the minimum value of 255.48 W/m at sunset. The variations in solar energy available during the drying time were affected on the ambient air temperature and air relative humidity in the field which in turn influenced on the average moisture loss and quality properties of cocoons.

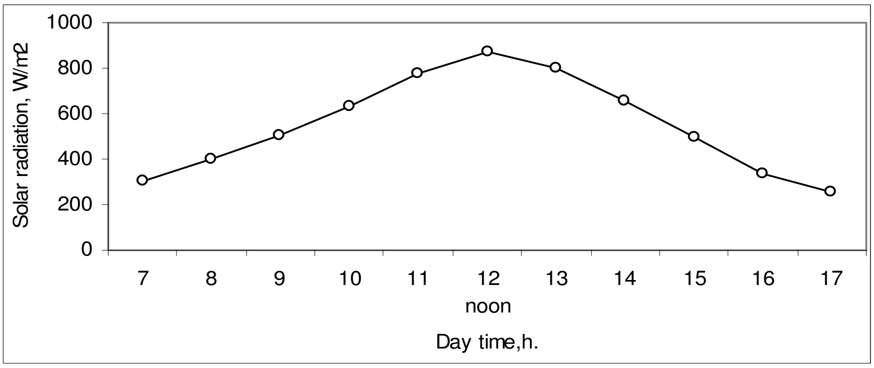

Fig. (3): Hourly average daily solar radiation versus solar time during field drying.

The daily average ambient air temperature and relative humidity during daylight were 28.2 °C and 36 %, while, they were at night 14.9 °C and 80.8 %, respectively (Fig. 4). During the drying period of cocoons, the average cocoon temperatures were 27.17 and 13.93 °C during the day and night time, respectively. The results also show that the average ambient air temperature during the day time was higher than the overall average cocoons temperature by about 1.03 and 0.97 °C, (Fig. 4).This may be due to the evaporation of moisture from cocoons, which depends upon the water vapor pressure to difference between the air surrounding the cocoons and ambient air.

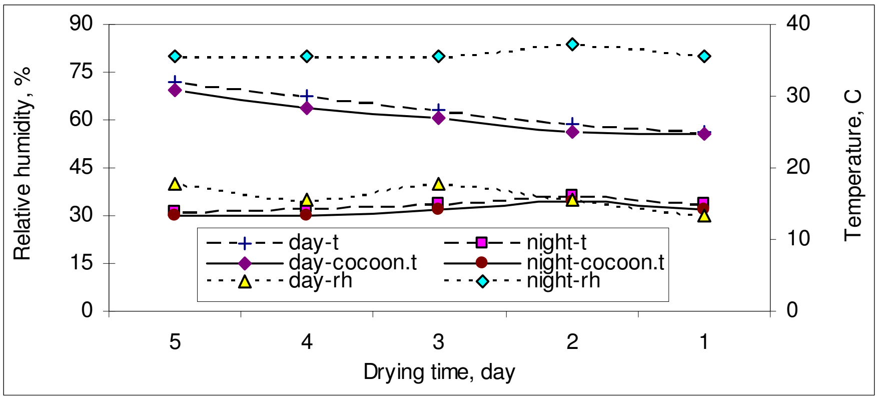

Figure (4): Daily average ambient air temperature (t), relative humidity (rh) and cocoons temperature against day time during field drying.

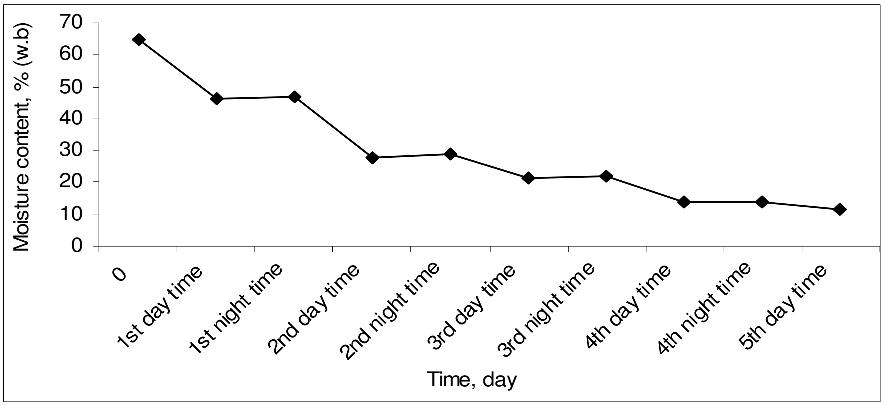

Figure (5): Daily average cocoons moisture content against drying time in the field (conventional drying method).

Figure (5) illustrates the changes in average cocoons moisture content with drying time for the traditional drying method. It also shows a gradual decrease in the cocoons moisture content from initial moisture of 64.5 % (w.b) to a final level of about 10 $\pm$ 1.0% after 4.5 day (60 h).

It also reveals that the cocoon moisture content decreases with a higher rate during the first two days and then starts to decline during the next two days, while it was remained nearly constant during the last day of the drying period.

- Stifling Pupae's, %:

It can be seen from Fig. (6) that the killed pupae's percentage was highly affected by different air flow rates, different heating air temperature and the interaction between them.

Figure (6) shows that at 55 °C of air temperature, increasing air flow rates from 1.0 to 2.0 m^3/min caused a gradual increase in the died pupae's which was 92.53, 93.56 and 93.88 % at 1.0, 1.5 and 2.0 m^3/min air flow rate, respectively. Meanwhile, increasing the ambient air temperature from 55 to 85 °C at any air flow rates caused an excessive increase in the percentages of the killed pupae's.

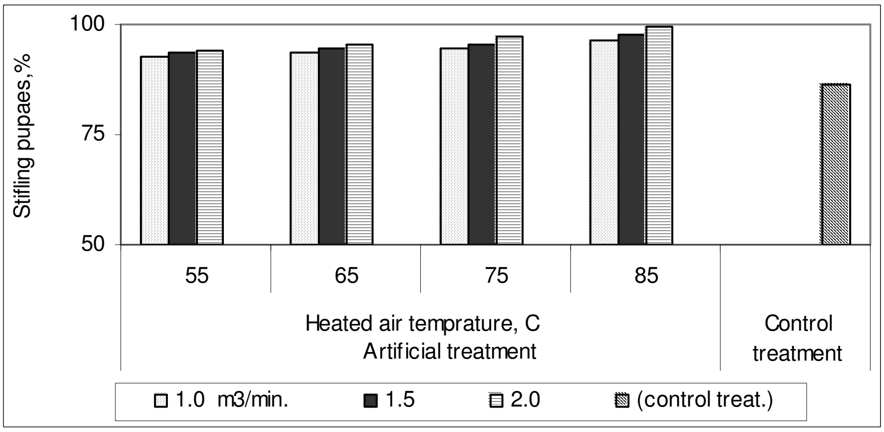

Figure (6): Stifling pupae percentage as affected by different heat treatments.

In general, it can be said that, the artificial heating of cocoons using 85 °C increase the killed pupae's by about 10.3, 11.6 and 13 % at air flow rates of 1.0, 1.5 and 2 m^3/min respectively, as compared with the dying pupae's in the traditional drying method (control treatment). This may be attributed to the higher temperature and lower relative humidity of the drying air inside the dryer that may be excessive the moisture losses from the cocoon shell and pupae body.

The highest average value of killed pupae (99.35 %) was always associated with artificial heating at 85 °C of heating air temperature and 2 m^3/min of air flow rate as compared to the value of (86.45 %) for the traditional drying method as shown in Fig. (6).

- Quality Evaluation Tests.

The aforementioned results, indicated that at any heating air temperature in the range of 55 - 85 °C increasing the air flow rates from 1.0 to 2.0 m^3/min during drying process of cocoons cause a corresponding decrease in the drying time. Moreover, the highest killed pupae was obtained at treatment of 85 °C heating air temperature and 2 m^3/min air flow rate. Hence, the data of quality evaluation tests at air flow rates of 1.0 and 1.5 m^3/min must be excluded from the calculation because the pupae's killed tends to decrease extremely.

- The total length of silk filaments and cocoons reel-ability.

The quality of cocoons and silk filament is strongly depends on the drying method and its effect on the cocoons reel-ability. Reel-ability is a very important property of cocoons; this denotes the degree of ease in unwinding the cocoon filament. And represents the percentage ratio of unbroken filament to the whole filament length.

Table (2) shows that increasing the heating air temperature from 55 to 85 °C at 2 m^3/min air flow rates during artificial drying caused a slightly increase in the total length of silk filaments and cocoons reel-ability percentage comparing with drying method in the open field. The total lengths of silk filaments were 908, 915, 922 and 930 m and the corresponding cocoons reel-ability were 64.5, 65.3, 66.4, 67.2 % respectively. Meanwhile, control treatment produced a lower length of silk filaments and cocoons reel-ability percentage, which was 622 m and 52.1 %, respectively. The obtained data also showed that, heating cocoon artificially at 2.0 m^3/min air flow rate and air temperature of 55, 65, 75 and 85 °C increased the total length of silk filaments by about 45.9, 47.1, 48.2 and 49.5 %, and increased the cocoons reel-ability by about 23.8, 25.3, 27.4 and 28.5 %, respectively, as compared with the traditional (control) treatment. This increase in the total length of silk filament and cocoons reel-ability percentage in artificial heating may be due to the increase in the tensile strength of silk fibers, which in turn increase the cocoons reel-ability and decrease the cutting number of silk filament during reeling operation, as compared with traditional drying method. This decrease in the length of silk filament and cocoons reel-ability in sun drying method may be due to a negative effect on the sericin layers of these cocoons which decreases the quality characteristics due to expose cocoons to ultraviolet and infrared rays. Which in turn lower the raw silk quality in relation to cleanness and neatness which increase the total reeling losses of cocoons as reported by Kottbey (1993), ARC (2002) and Gang (2003).

Table (2): Length of silk filament and cocoons reel-ability as affected by different drying methods

VARIABLES		CHARACTERISTICS	
Heating air temp., °C	Air flow rates, m^3/min	Silk filaments length, m	Reel-ability of cocoons, %
55	2.0	908	64.5
65		915	65.3
75		922	66.2
85		930	67.0
Control treatment (Sun drying)		622	52.1

- The tensile strength (force and elongation) of silk filaments.

Data collected on the tensile strength of silk filaments as affected by different heating methods are presented in Table (3). After heating process, the quality that assessed as force and elongation was markedly higher with increasing heated air temperature from 55 to 85 °C at air flow rate of 2 m^3/min comparing with traditional sun drying method of cocoons (control treatment).

The highest values of silk filament force (18.8 cN/tex) and elongation (11.83 %) were recorded at 85 °C of air temperature and air flow rates of 2.0 m^3/ min. Whereas, the lowest values of silk filament force (12.8 cN/tex) and elongation (7.27 %) were observed under the traditional sun drying.

Table (3): The results of silk filament strength (force and elongation) as affected by different drying methods.

VARIABLES		Test results				
Heating air temp., °C	Air flow rates, m^3/min	F - Max (Force), cN/tex	F - Max, N	Work up to break, cN/tex	Test time, s	E break (Elongation) %
55	2.0	16.3	0.3	15.9	44.3	8.82
65		17.1	0.3	15.9	47.8	9.51
75		17.4	0.3	16.5	50.3	10.05
85		18.8	0.4	17.6	58.8	11.83
Control treatment (Sun drying)		12.8	0.3	10.9	39.6	7.27

This decrease in the force (cN/tex) and elongation (%) of silk filament in sun drying may be due to the exposed of cocoons to sun rays for a few days (3-5), which in turn has a negative effect on the sericin layers of these cocoons and decreases the quality characteristics due to expose cocoons to ultraviolet and infrared rays as reported by Kottbey (1993), and ARC (2002).

CONCLUSION

The obtained results could be summarized in the following points:

1- The developed flatbed batch dryer was able to dry cocoons from the initial moisture content (64.5 %, w.b) to a final level of (10 ± 1.0%, w.b) after 3.5 h using 85 °C air temperature and air flow rate of 2.0 m^3/min. However, during field drying, the cocoons moisture content decreased to the same level after 4.5 day (60 h).

2- Artificial heating of cocoons using 85 °C at air flow rates of 1.0, 1.5 and 2.0 m^3/min can reduce the required time of drying cocoons by about 91.6, 92.5 and 94 %, respectively, as compared with control treatment.

3- At heating air temperature of 85 °C and air flow rate of 2 m^3/min, the highest values of killed pupae (99.35 %), silk filament force (18.8 cN/tex), and elongation of silk filament (11.83 %) which reflect highest value of cocoons reel-ability (67 %) and highest length of silk filament (930 m) were obtained.

4- The drier may be offers a substantial increase in the price of silk filament (higher categories price) by decreasing the total reeling losses, and consequently increase the economic return yearly.

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الملخص العربى

المعاملة الحرارية لشرانق ديدان الحرير وأثرها على خنق العذارى وجودة الخيوط المنتجة

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- يعتبر مشروع تربية ديدان الحرير من المشروعات الزراعية الصناعية الصغيرة لإنتاج خيوط الحرير الطبيعي الخام من الشرانق التي تفرزها ديدان الحرير وقد تتم بهدف الحصول علي فراشات للتزاوج ووضع البيض وحفظه لمواسم تربية تالية، ويبدأ النشاط الصناعي بعد عملية حصاد الشرانق حيث تمر الشرانق بعملية فرز لاستبعاد الشرانق التالفة والمخالفة للشكل ثم تجفف لقتل العذارى داخلها قبل تحولها إلى فراشات تقوم بإفراز نواتج الهضم القلوية من مؤخرتها وهذه تعمل على إذابة خيوط الشرنقة وتقطيعها وعمل فتحة تخرج منها فتتلف الشرنقة وتصبح غير صالحة للحل. يجرى العلاج ألتجفيفي للشرانق في مصر بالطريقة التقليدية وذلك بتفريدها في طبقات رقيقة لمدة تتراوح بين ٣-٥ أيام بحيث تكون الشرانق معرضة لأشعة الشمس وتتوقف كفاءة جفاف الشرانق وخنق العذارى على مدى توفر الظروف الجوية الملائمة لاجرائها٠ وتعتبر عملية قتل العذارى وتجفيف الشرانق من أهم المعاملات الأساسية لنجاح تخزين وتصدير الشرانق، كما أن تنفيذها بالطريقة الصحيحة يعتبر من العوامل الهامة المؤثرة في احتفاظ الشرانق بجودتها أثناء عمليات الشحن والتخزين حيث تقلل من فرص إصابتها بالعفن والأمراض الفطرية مما يقلل من نسب الشرانق التالفة قبل وصولها إلي منافذ ألتسويق٠ بالإضافة إلي إنتاج خيط حريري ذو مواصفات جودة علية مما يزيد من قيمة الناتج النهائي.

***باحث أول بمعهد بحوث الهندسة الزراعية – الدقي - جيزة.**

- **تهدف هذه الدراسة** إلي إمكانية معاملة الشرانق حراريا لخنق العذارى وتجفيف الشرانق، باستخدام مجفف صناعي يعمل بطريقة السريان الجبري للهواء المسخن، وذلك بهدف نشره بين المربين لتقليل الوقت اللازم لعملية خنق العذارى وتجفيف الشرانق، وتنفيذها بالطريقة الصحيحة التي تضمن احتفاظ الشرانق بجودتها أثناء التخزين.

- تم دراسة بعض العوامل المؤثرة على خنق العذارى وجفاف الشرانق مثل درجة حرارة هواء التسخين (٥٥ ، ٦٥ ، ٧٥ ، ٨٥ درجة مئوية)، ومعدلات سريان الهواء (١,٠ – ١,٥ – ٢,٠ م٣/ دقيقة)، كما اشتملت الدراسة على مقارنة التجفيف الصناعي للشرانق بالطريقة التقليدية الشائعة لدى المربين في مصر.

- تم قياس التغير في المحتوى الرطوبى للشرانق، والزمن الكلى اللازم لإجراء عملية التجفيف؛ كما تم تقدير نسبة الشرانق المخنوقة (الميتة)، وخصائص الجودة للخيوط الناتجة من حل الشرانق من خلال تقدير [الطول الكلى للخيط - قابلية الشرانق للحل – قوة الشد والاستطالة للخيط المحلول]. **وتتلخص أهم النتائج في النقاط التالية:**

- أوضحت النتائج انخفاض الزمن الكلى اللازم لتجفيف الشرانق صناعيا، حيث انخفض المحتوى الرطوبى للشرانق تدريجيا من المحتوى الرطوبى الإبتدائى (٦٤,٥ ± ٠,٥%، أساس رطب) إلى المحتوى الرطوبى النهائي (١٠± ١,٠%، أساس رطب) في زمن قدره ٤ ساعة بينما استغرقت هذه العملية زمن قدره ٦٠ ساعة (٤,٥ يوم) عند إجرائها بطريقة التجفيف الطبيعي في الحقل.

- إنخفض الزمن الكلى اللازم لتجفيف الشرانق صناعيا عند مقارنته بطريقة التجفيف الطبيعي الحقلي (معاملة الكنترول) بنسبة ٩١,٦؛ ٩٢,٥؛ ٩٤%، حيث انخفض المحتوى الرطوبى للشرانق من المحتوى الرطوبى الإبتدائى إلى المحتوى الرطوبى النهائي عند تسخين الشرانق باستخدام هواء درجة حرارته ٨٥ درجة مئوية ومعدلات سريانه ١,٠؛ ١,٥؛ ٢,٠ م٣/ دقيقة على التوالي.

- تحسنت خصائص الجودة لخيوط الحرير الناتجة من حل الشرانق المعالجة حراريا باستخدام هواء حرارته ٨٥ درجة مئوية ومعدل سريانه ٢ م٣/دقيقة، حيث أعطت هذه المعاملة أعلى نسبة خنق للعذارى (٩٩,٣٥ %)، وأعلى قوة شد لخيوط الحرير (١٨,٨ سنتنيوتن/تكس) و أعلى استطالة (١١,٨ %)، كما زادت قابلية الشرانق للحل لتصل (٦٧ %)، وزاد طول الخيط الحريري إلي ٩٣٠ متر، بينما انخفضت خواص الجودة لمعاملة الكنترول (التجفيف الحقلي الطبيعي) حيث كانت قوة شد الخيط (١٢,٨ سنتنيوتن/تكس) والاستطالة (٧,٢٧ %)، كما انخفضت قابلية الشرانق للحل لتصل (٥٢,١ %)، وانخفض طول الخيط الحريري إلي ٦٢٢ متر، وانخفضت نسبة العذارى المخنوقة (الميتة) داخل الشرانق لتصل إلى (٨٦,٣٥ %) عند تجفيفها طبيعيا.

- تحسن خصائص الجودة لخيوط الحرير الناتجة من حل الشرانق المعالجة حراريا يمكن أن يحقق للمربين زيادة في العائد الاقتصادي وذلك نظرا لتماثل الخيط الناتج من حل هذه الشرانق، وانخفاض نسبة العادم (فواقد الحل) نظرا لارتفاع قابلية هذه الشرانق للحلً عند مقارنتها بخواص الجودة للشرانق المجففة شمسيا في الحقل.