Application of Microwaves for Silkworm, *Bombyx mori* L. Cocoon Drying

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Abstract: The present work is looking for applying microwave technique in silkworm cocoons desiccation. The traditional methods are using sun rays and hot-air, both methods take a long time. To shorten the drying time, microwave was used to dry silkworm cocoons. Fresh cocoons were irradiated with microwave at (2450 MHz / 800 W) for 20 to 30 sec. The best result was obtained by using the microwave in intervals for ten, five and then another five seconds (Mic 10+5+5). A significant increase in filament weight, length and silk ratio was recorded. However, insignificant decrease in number of cuts in silk filament was detected.

Key words: *Bombyx mori* L., microwave, cocoon drying.

INTRODUCTION

The key goal of cocoon drying is to protect cocoon quality, preserve condition of cocoons for reeling and prevent damage caused by long periods of storage. The first hazard is the continued metamorphosis of the pupa. A newly emergent moth will pierce the shell rendering the cocoon useless for conversion to raw silk (Lee 1999).

Recently several researchers outlined the cocoon drying equipment types to meet the demand of high cocoon quality, large scale of production and discharge pollutants approved by national standard for the environmental protection (Shancai and Guifang, 2000).

In order to reduce the maggot and perforation in the fresh cocoon, as well as extend the shelf life of cocoon drying, using the bactericidal function of microwave to study the best process condition of killing pupa through microwave (Shuai *et al.* , 2009). Microwaves are electromagnetic waves with frequencies ranging from about 300 MHz to 300 GHz (Decarceau, 1985).

Therefore, the present study was carried out to evaluate the efficacy of microwave energy treatment on *Bombyx mori* L. cocoons and its impact on quality of cocoon parameters.

MATERIAL AND METHODS

1- Microwave:
A microwave oven, EM-P562, Sanyo, Japan, capacity 28 L. and cavity dimension 325 X 555 X 450, output: 800 W, 17 % was used. The operating frequency of the oven was 2450 MHz.

2- Silkworm:
Silkworm egg batches were obtained from the Sericulture Research Department (SRD) of Plant Protection Research Institute (PPRI), Agricultural Research Center, Giza, Egypt. The rearing technique was done in the lab. under the hygro-thermic conditions 28 ± 2 °C and 75 ± 5% RH, following the standard methodology of rearing in SRD according to Krishnaswamy (1978). Larvae were fed on leaves of Kokuzo-27 mulberry variety.

The fresh cocoons were collected and separated into 5 groups, each group contain 30 cocoons for applying different drying techniques and then reeled by the reeling machine at the SRD.

*First group* (the Control) was fresh reeled.

*Second group* was dried by hot air in ovens (70°C for 24 hours).

*Third group* was dried by sun rays, cocoons were placed in one layer on metal surface 2 hours for 3 days.

*Fourth group* was dried by microwave {2450 MH / 800 W, 17 %} for 30 sec.

*Fifth group* was dried by microwave {2450 MH / 800 W, 17 %} at intervals 10 sec then 5 sec , then another 5 sec (Mic 10+5+5).

Cocoon weight, filament length, number of filament cuts, filament weight and silk ratio for each group were recorded.

Silk ratio was calculated by the following formula:

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\text{Silk ratio} = \frac{\text{Filament weight}}{\text{Cocoon weight}} \times 100
\]

Results were subjected to analysis of variance according to Snedecor and Cochran (1981).
Results:

In the present study several methods for cocoon desiccation were applied (hot air, sun rays, microwave 10+5+5 seconds and microwave 30 seconds) then reeled and reeling parameters were compared with control (fresh cocoons). The drying effect was studied on cocoon weights, filament length, filament cuts, filament weight and silk ratio.

Cocoon weight is the most significant commercial feature of cocoons, as this parameter indicate the approximate quantity of raw silk that can be reeled.

The heighest single cocoon weight was significantly recorded for the control group (0.82 g.), while the other groups showed nearly the same weight.

The single filament weight was significantly high for microwave (Mic 10+5+5 seconds) group (0.183 g.), followed by hot air and sun rays methods (0.156 and 0.153 g., respectively) then microwave 30 seconds and control (0.113 and 0.103 g., respectively).

The filament length determines the workload, rate of production, fitness of silk thread.

In the present study, the filament length showed the same trend as filament weight, significantly the heighest filament length was recorded for microwave (Mic 10+5+5 seconds) group method followed by hot air and sun rays methods (790.60, 765.47 and 698.27 cm, respectively).

Raw silk index is the most important for the value of the cocoon as it has a direct impact on both the market price of cocoons and the production costs of raw silk.
Silk ratio for microwave (Mic10+5+5 seconds) drying method was significantly the highest ratio (35.987 %) followed by hot air, sun rays, microwave 30 seconds and control (31.633, 30.567, 24.903 and 15.360 %, respectively).

The number of filament cuts for each method was not significantly affected by drying methods.

**Discussion:**

The present work is a trial on the applied research of microwave technique in silkworm cocoons desiccation. As drying kills the pupa and evaporates moisture that would, otherwise, ruin cocoons (Sheng-hai, 2006).

In the traditional sun rays drying method, no investment is required to kill pupae and dry cocoons in bright sunshine. Fresh cocoons are spread in thin layers on planks of wood and exposed to direct sunlight. Depending on the strength of the sun, the process takes two to three days. Though cheap and simple to employ, however, the main disadvantage is silk fibre's sensitivity to ultra-violet rays, which harm fiber strength and colour (Lee 1999). In the present study it was noticed that, cocoon placed on metal surface reduced the time required to kill pupae.

The hot air cocoon dryer (Oven) is very common in sericulturally advanced countries. Fresh cocoons are placed in thin layers in the drying chamber at 90 °C for 7 hours (Lee 1999).

In microwave treatment, the maggot and perforation can be prevented effectively by using the low power of microwave (2450 MHz, 119 W), with suitable time of about 240 to 300 seconds (Shuai et al., 2009). With this treatment, there is no obvious influence to the structure and properties of cocoon shell. However, in the present study, after several trials, 30 seconds of drying was enough as the treated sample was very small (30 cocoons).

Shanghai and Yaying (2003) found that mass power ratio has an important influence on drying rate, while when the mass power ratio is more than 8 W/g, the pupae in the cocoons burst, which would affect the quality of cocoons desiccation. microwave desiccation of cocoons improves the efficiency of desiccation and the neatness degree of silk. The obtained results agree with the above as the power ratio used in the present study was operated at the low energy level, i.e. 17 % of power output, no burst pupae was noticed as the drying time of cocoons was very short 30 or 10+5+5 seconds.

Dong-liang et al. (2011) used microwave to dry silkworm cocoons that are partly dried by hot air instead of using hot air only. The best results obtained by using microwave (280 W) for 18 minutes to dry 60 % of cocoons. The silk reeled with this method differ very little compared with that dried with conventional method. They found that this method can dry silkworm cocoons more efficiently.

Drying with microwave was found to shorten the cocoon cooking time with increased reelability (Kagawa et al., 1994). Similar results were obtained in the present study as treatment method of 10+5+5 seconds gave the highest silk ratio.

Reed and Viney (2010) noticed that, exposure to microwave did not significantly affect mechanical properties of silk filament if the samples were kept in a desiccators after reeling.
Conclusion:
Finally, microwave can be used practically on large scale, at low power, to dry the largest amount of *Bombyx mori* cocoons in less time while maintaining the technological properties of silk filament.

REFERENCES