Effect of Brown Sugars on the productivity of mulberry silkworm *Bombyx mori* L. (Lepidoptera; Bombycidae)

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ABSTRACT

The effect of supplementing mulberry leaves with two nutrient materials; namely, dark brown sugar and light brown sugar at different concentrations on the silkworm *Bombyx mori* L. were investigated for achieving an increase in its productivity. The obtained results indicated that mulberry leaves treated with dark brown sugar at concentration of 3% and the light one at 5% caused significant increase of the mean weights of mature larvae, silk glands and pupae. In addition, both the abovementioned treatments were the most efficient, improving silk and egg production. The estimated values of total haemolymph proteins (THP) of tested larvae confirmed the positive effects of these treatments, whereas the significant highest level of THP coincided almost exactly with the higher productivity of either silk or eggs.

INTRODUCTION

The focus of research in the field of sericulture lies in improving the quality and quantity of silk. One way of improving cocoon yield is to achieve an increase in the egg production by enriching the nutrition of silkworm by supplementing the mulberry leaves with extra nutritional elements. The silkworms require certain essential sugars, proteins, amino acids, fatty acids and vitamins for their normal growth and survival. These essential components are necessary for the growth of silk gland of *Bombyx mori* L. and higher production of egg and silk (Ito, 1978). El-Gayar *et al* (1982) found that sucrose 3% treatment increased cocoon weight of *Philosamia ricini* Boisd. El-Sayed Nagda (1989) reported that the treatment of castor-bean leaves with treacle 4% gave the heaviest larvae and pupae of *Philosamia ricini* Boisd, the highest weight value of silk gland, fresh cocoon, cocoon shell; and utmost increased rates of deposited eggs per female moth. Madhuri and Sandip (1997) found that the weights of silkworm *B. mori* L. larvae, cocoon shell and cocoon shell ratio were higher with four feedings per day and they were increased by supplementing feed with 1-3% glucose and as well the female fecundity was also increased.

Therefore one of simplest yet effective methods to enrich the leaves of either mulberry or castor bean is to supplement them with various known fortifying agents.

Based on the abovementioned findings, the present investigation aims to study the influence of dark and light brown sugars supplementation on silkworm *Bombyx mori* L. productivity.

MATERIALS AND METHODS

The experiments were performed on the Chinese F1 hybrid 9F7X mulberry silkworm *Bombyx mori* L. at El-Sabahia research station Alex. Larvae were reared according to the convential methods in trays and provided with suitable amount of fresh mulberry leaves variety Japanese under the prevailing laboratory hygrothermic conditions of 25.8◦c and 74.7% RH.

Substances used:

On the basis of nutritional requirements of carbohydrate for silkworms, two kinds of sugars had been chosen as food additive, dark brown sugar and light brown one produced by food, Inc. Yonkers. NY 10705, U.S.A.

Brown sugars are partly refined to retain some molasses syrup and other impurities of sugarcane which impart a pleasant flavour.

Dark brown sugar has more colour and stronger molasses flavor than light brown sugar. The components of the abovementioned tested sugars are given in Table, 1.

Table (1): Components of the tested sugars

Dark brown sugar		Light brown sugar
Sucrose	47.4%	31.4%
Moisture	25.2%	22.4%
Invert sugar	13.4%	34.7%
Mineral mater (ash)	5.5%	3.6%
Organic non-sugar	8.5%	7.9%

C.F. Oregon state University 2005
[http://food.oregonstate.edu/]

Treatments and experimental design:

The tested progressive concentrations were chosen on the basis of previously conducted studies on mulberry or castor-bean leaves that treated with nutrients by either spraying or dipping methods (El-Sayed, Nagda, 1989) and also performed research works on semi-artificial diets for rearing silkworms (Salem, 1974; Gomaa *et al*, 1976; El-Hattab, Samia,

1985; El-Karaksy *et al*, 1989; Abdel-Aziz, Magda, 2002 and El-Hattab, Samia, 2002).

Therefore, the tested concentrations of both kinds of sugars which had been used in the performed tests were 1, 3 and 5%.

The experiments included six treatments and control. Each treatment represented one concentration of the tested materials was replicated three times. Each replicate contained 150 fifth instar larvae. Fresh mulberry leaves were soaked in each of the selected concentration of tested materials. The leaves were air dried and then offered to the fifth instar larvae four times daily.

To estimate the effect of tested materials on the biometrics of mulberry silkworm *B. mori* L., daily inspection was done until larvae reached the pupal stage. The duration of either larvae or pupae was recorded, and the percentage of mortality was also estimated.

Fresh weights of mature 5th instar larvae, pupae, fresh cocoons and cocoon shells were measured. Moreover, prior to spinning cocoons, a sample of five mature experimented larvae was dissected and the silk glands were drawn and weighed. For estimating the female fecundity in each conducted treatment and control, ten couples of mated moths were randomize elected, each couple was kept in perforated paper bag till end of egg deposition. Number of eggs laid per female moth were counted and recorded.

The total haemolymph proteins of the mature larvae were estimated using the method of Lowery (1951).

Data were statistically analyzed to check the significance among treatments using F test and L.S.D.

RESULTS AND DISCUSSION

Effect of tested materials on the weights of larvae, pupae and silk glands:

Results in Table, 2 and illustrated Figure, 1 revealed that the mean weights of full grown larvae were significantly different in relation to the most adopted treatments of evaluated sugars. It is shown that the use of dark brown sugar at 3% and light brown sugar at 5% treatments gave the

heaviest weights of 1.972 and 1.998 g., respectively, whereas the rate of increase was about 27.637% and 29.320%, respectively, more than the mean weight of control larvae (1.545g.). The lightest weight of larvae was obtained after feeding on mulberry leaves treated with light brown sugar at 1% concentration; and was somewhat equal to that recorded for the control.

In comparison to different initiated treatments and control, statistical analysis of data proved that both treatments of light brown sugar at 5% and dark brown sugar at 3% gave the heaviest pupal weights of 1.491 and 1.460 g., respectively. But, the measured pupal weights were, somewhat decreased in the both treatments of dark brown sugar at 5% and light one at 3% that comprised 1.18 and 1.197 g., respectively. The lowest pupal weights of 1.030 and 1.045 g. which were statistically equal to that of control treatments of dark brown sugar at 1% and light one at 1%, respectively (Table, 2 and Fig. 2).

The fresh weights of silk glands of matured treated larvae exhibited a picture similar to that of larval weights (Table, 2 and fig. 3) in relation to the different run treatments. The larvae which fed on supplemented leaves with dark brown sugar at 3% or light one at 5% gave the heaviest silk gland weights of 0.364 and 0.365 g., respectively, in comparison to that of control larvae (0.244 g.). The lowest weight parameters of 0.313, 0.326 and 0.314 g. were obtained from the treatments of dark brown sugar at 5% and light one at 1% and 3%, but still significantly higher than that of the control treatment (0.244 g.)

However, these results are in accordance with those reported by El-Sayed Nagda (1989 and 1994), Govindan *et al* (1988), El-Karaksy and Idriss (1990), Muniandy (1995) and Manoharan (1997) who found that the detected parameters of fitness component of *Philosamia ricini* Boisd. or *Bombyx mori* L. larvae were significantly affected by the evaluated food additives.

Effect of tested materials on silk and egg production:

The effect of evaluated both kinds of sugars on silk and egg production are summarized in Table, 3 and illustrated in Figures 4 and 5. Similar to the corresponding results of the efficiency of the tested materials on larvae and pupae as well as the silk glands, since the treatments of dark

brown sugar at the rate of 3% and the light one at 5% always gave the most pronounced effect on the estimated parameters of the weights of either fresh cocoon or cocoon shell. Both the abovementioned treatments significantly increased the fresh cocoon weights by about 38.272% and 40.174%, respectively more than the control treatment (1.262 g.). The lightest weights of 1.283 and 1.297 g. were recorded for both treatments of dark and light brown sugars at the concentration of 1% (Table, 3).

The demonstrated results in Table, 3 and Fig. 5 indicate the significant effects of different treatments on the weight of cocoon shell whereas, the both treatments of dark brown sugar at 3% and the light one at 5% were greatly effective. The corresponding weights of cocoon shells increased by about 16.872% and 14.403% more than the control, respectively. The treatments of dark brown sugar and light one at 1% were less effective; indicating lower weights than other treatments, but still significantly heavier than those of control.

These results are in agreement with those obtained by Murugappan *et al* (1996) who observed that feeding silkworm *Bombyx mori* L. with mulberry leaves soaked in different concentrations of Jaggery (crude brown sugar) solution significantly increased larval growth and thereby improved weights of both fresh cocoons and cocoon shells.

Results of the effect of tested materials on the female moth reproductivity reveal that the female moths which resulted from the same treatments of dark brown sugar at 3% and light one at 5% laid an averages of 421.7 and 406.7 eggs/female moth, respectively, as against 317 eggs/female laid by control insects, since the rate of produced eggs had been increased by about 33.028% and 28.296% more than the control (Table, 3 and Fig. 6). These observations suggest that this enhanced egg production would be beneficial to Sericulturists, as more number of quality cocoons would be produced from a single laying to meet the growing demand of silk.

Many authors have reported that nutrients and food additives besides influencing the overall growth, enhanced fecundity in silkworms (Govindan *et al*, 1988; El-Karaksy and Idriss, 1990; Hosney *et al*, 1991; El-Sayed Nagda, 1994; Manoharan, 1997 and Yehia, Wagiha, 1998).

Effect of tested materials on the larval total haemolymph protein (THP):

The illustrated results in Table, 4 and Fig. 7 show the significant differences between the estimated values of total haemolymph proteins of tested larvae due to the run treatments of different concentrations of evaluated materials.

The use of both dark brown sugar at 3% and the light one at 5% indicated higher values of THP amounting to 781.753 and 773.767 µg/ml, respectively, which increased by about 50.948% and 49.406% more than the control. The higher value of THP after treatment of light brown sugar at 3% indicated also significant increase by about 36.706% more than the control.

These results confirmed the aforementioned effects of the evaluated both kinds of tested sugars on the studied biometrics (Tables 2, 3) as the highest level of haemolymph proteins coincided almost exactly with the higher productivity of either silk or eggs. Yehia Wagiha (1998) found that the detected values of total haemolymph proteins of *B. mori* L. 5^{th} instar larvae were significantly affected by the evaluated food additives.

Generally, it could be concluded that the results of the present study amply support the fact that identifying the optimum concentration of the chosen nutrient for a chosen insect is an important aspects in supplementation studies for better growth. In the present findings the optimum concentration for elevating the growth of *B. mori* larvae as well as their productivity was found to be the dark brown sugar at 3% and the light one at 5%.

Table (2): Effect of tested materials on the weight of larvae, pupa, and silk glands

Treatments	Wt. of Larva (g) A	Wt. of pupa (g) B	Wt. of Silk gland (g) C	Percent increase over control		
				Wt. of larva	Wt. of pupa	Wt. of silk gland
x 1%	c	d	c			
	1.723 ± 0.147	1.030 ± 0.036	0.244 ± 0.019	11.455	1.178	0
x 3%	a	b	a			
	1.972 ± 0.079	1.46 ± 0.044	0.364 ± 0.020	27.637	43.418	49.180
x 5%	b	c	b			
	1.852 ± 0.103	1.18 ± 0.041	0.313 ± 0.018	19.870	15.913	28.278
xx 1%	d	d	b			
	1.593 ± 0.115	1.045 ± 0.035	0.326 ± 0.038	3.106	2.652	33.606
xx 3%	b	c	b			
	1.898 ± 0.104	1.197 ± 0.050	0.314 ± 0.033	22.847	17.583	28.688
xx 5%	a	a	a			
	1.998 ± 0.087	1.491 ± 0.059	0.365 ± 0.020	29.320	46.463	49.590
Control	d	d	c			
	1.545 ± 0.085	1.018 ± 0.041	0.244 ± 0.030			
L.S.D	0.058	0.028	0.034			

x= Dark Brown Sugar.
xx= Light Brown Sugar.
- Each value represents the mean ± SD of A = 25 B = 20 C = 5 records.
- No significant differences among the means with the same letters.

Table (3): Effect of tested materials on Silk and egg production

Treatments	Wt. of Fresh cocoon (g) A	Wt. of Cocoon shell (g) B	No. of Deposited eggs C	Percent Increase over control		
				Wt. of Fresh cocoon	Wt. of Cocoon shell	No. of Deposited eggs
x 1%	cd	c	c			
	1.283	0.252	340.5	1.664	3.703	7.413
	± 0.041	± 0.008	± 19.477			
x 3%	a	a	a			
	1.745	0.284	421.7	38.272	16.872	33.028
	± 0.050	± 0.009	± 22.489			
x 5%	b	bc	bc			
	1.440	0.259	348.7	14.104	6.584	10
	± 0.044	± 0.004	± 33.658			
xx 1%	c	c	c			
	1.297	0.252	341.8	2.773	3.703	7.823
	± 0.043	± 0.012	± 22.763			
xx 3%	b	b	b			
	1.453	0.261	366.8	15.134	7.407	15.709
	± 0.066	± 0.006	± 26.682			
xx 5%	a	a	a			
	1.769	0.278	406.7	40.174	14.403	28.296
	± 0.062	± 0.007	± 17.895			
Control	d	d	d			
	1.262	0.243	317			
	± 0.044	± 0.005	± 28.483			
L.S.D	0.032	0.006	22.372			

x= Dark Brown Sugar.
xx= Light Brown Sugar.
- Each value represents the mean ± SD of A + B = 20 C = 10 records.
- No significant differences among the means with the same letters.

Table (4): Effect of tested materials on Haemolymph protein

Treatments	Total Heamolymph protein (µg/ml) A	Percent increase over control
x 1%	c	
	605.95 ± 54.679	17.002
x 3%	a	
	781.753 ± 38.709	50.948
x 5%	c	
	603.573 ± 14.310	16.543
xx 1%	cd	
	563.906 ± 15.326	8.884
xx 3%	b	
	707.993 ± 37.078	36.706
xx 5%	a	
	773.767 ± 35.225	49.406
Control	d	
	517.893 ± 15.720	
L.S.D	58.428	

x= Dark Brown Sugar.
xx= Light Brown Sugar.
- Each value represents the mean ± SD of 5 records.
- No significant differences among the means with the same letters.

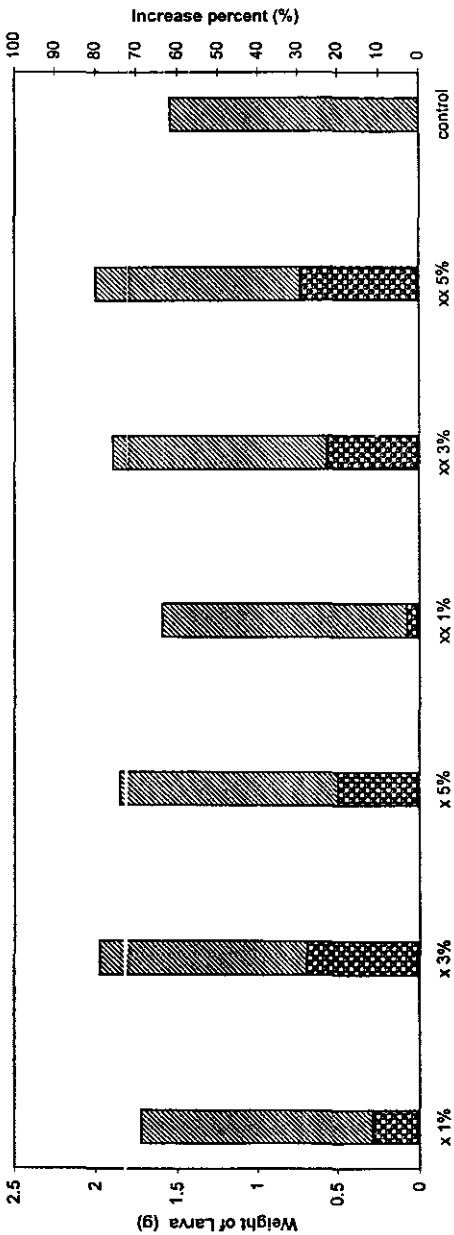

Fig.(1) Effect of the tested materials on the weight of Larva

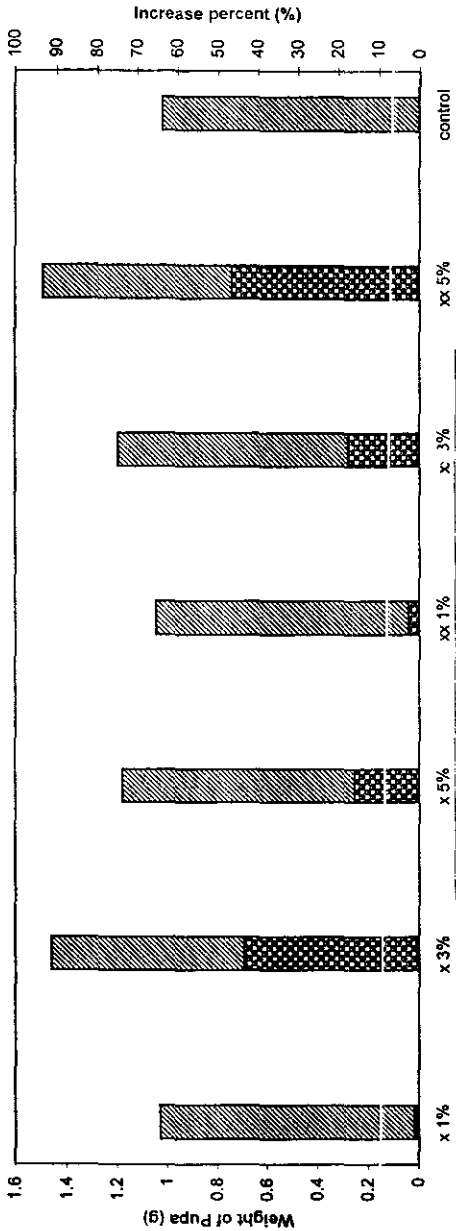

Fig.(2) Effect of the tested materials on the weight of Pupa

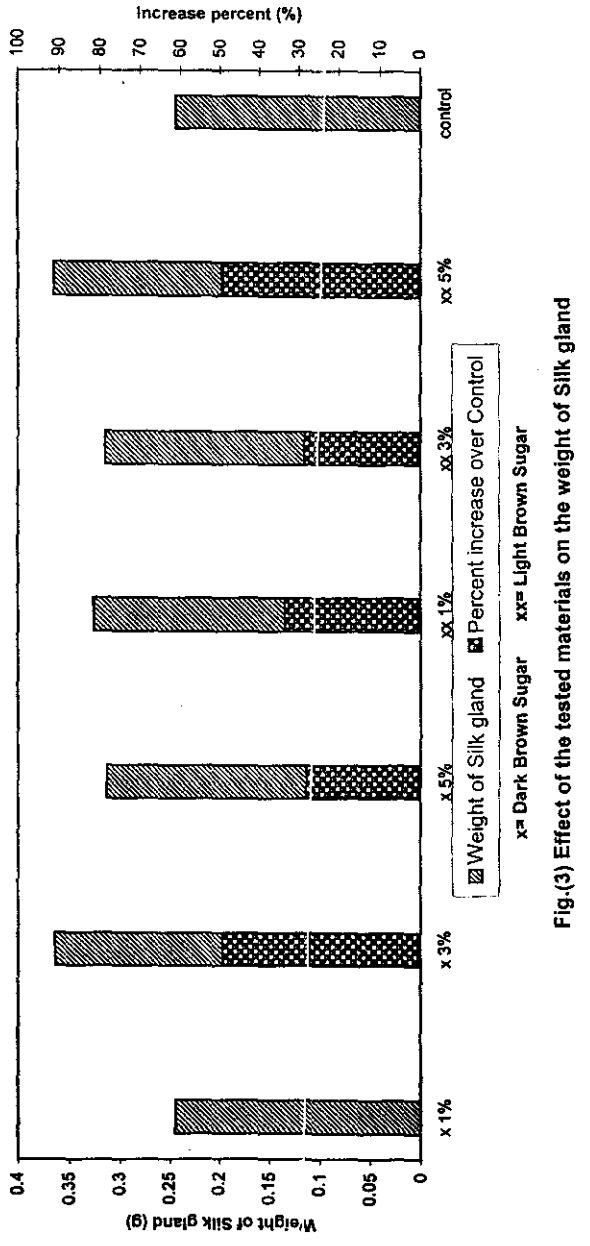

Fig.(3) Effect of the tested materials on the weight of Silk gland

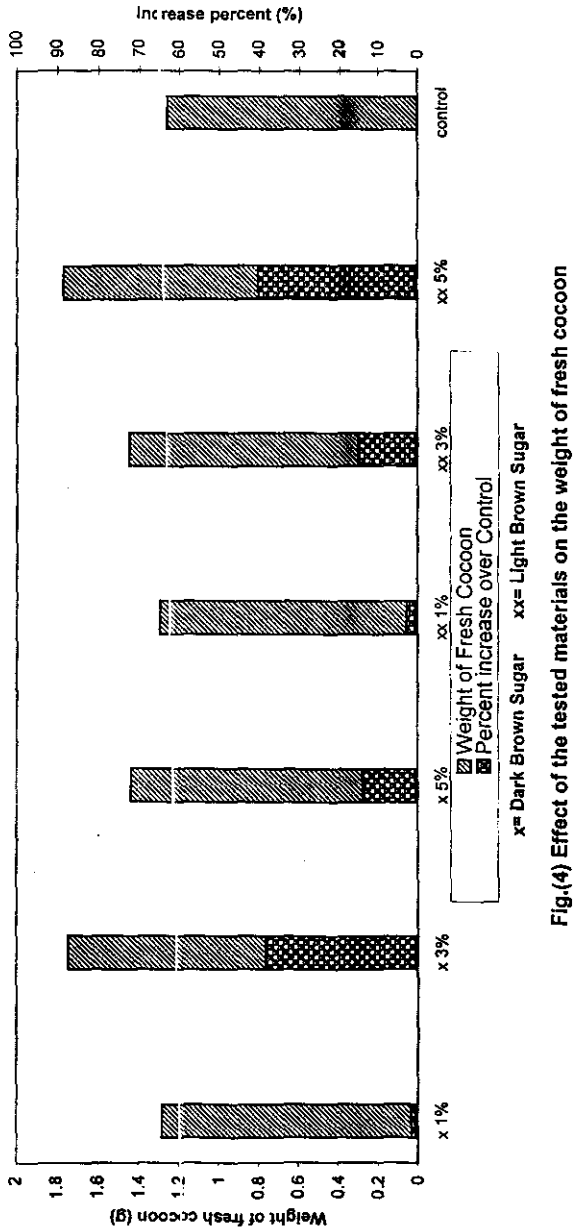

Fig.(4) Effect of the tested materials on the weight of fresh cocoon

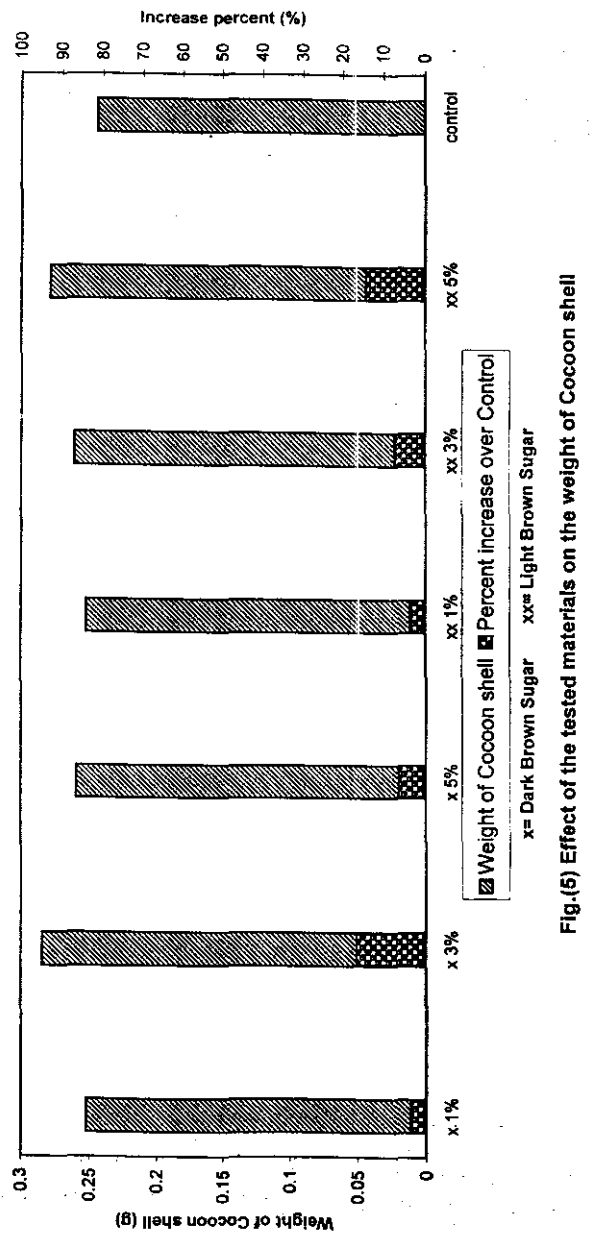

Fig.(5) Effect of the tested materials on the weight of Cocoon shell

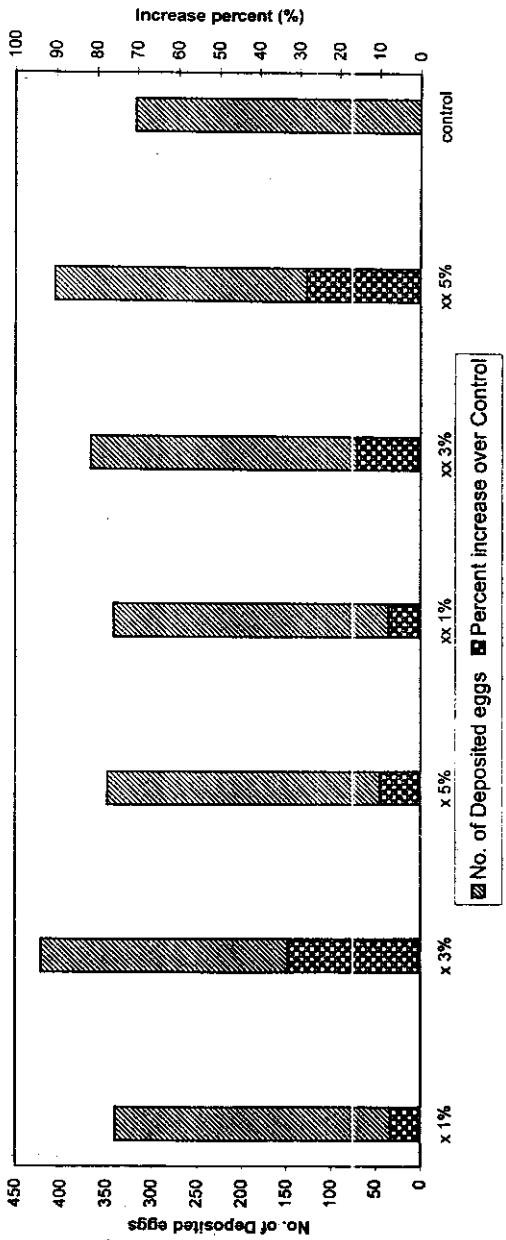

Fig.(6) Effect of the tested materials on the No. of Deposited eggs

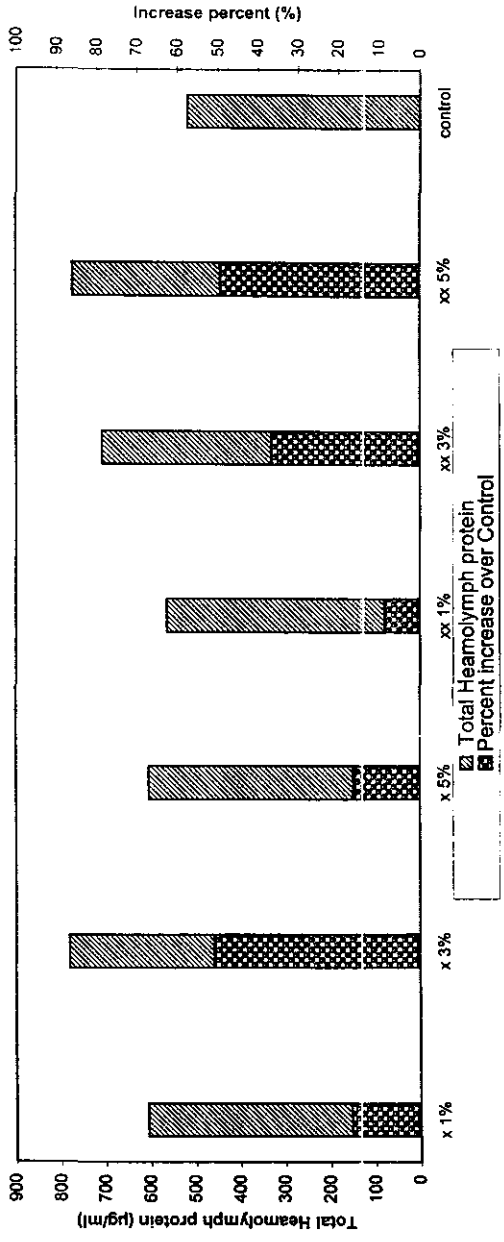

Fig.(7) Effect of the tested materials on the Total Heamolymph protein

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الملخص العربي

تأثير السكريات البنية على إنتاجية ديدان الحرير التوتية

منى ماهر محمود – وجيهة حسين يحيى

معهد بحوث وقاية النباتات – مركز البحوث الزراعية – الاسكندرية

يهدف هذا البحث إلى دراسة تأثير أضافة نوعين من السكريات على أوراق التوت و هما السكر البنى الغامق و السكر البنى الفاتح و ذلك بتركيزات مختلفة على دودة حرير القز بغرض زيادة الأنتاج.

أوضحت النتائج المتحصل عليها ان أوراق التوت المعاملة بالسكر البنى الغامق عند التركيز ٣% ، السكر البنى الفاتح عند ٥% أعطت اعلى المتوسطات فى اوزان كل من اليرقات الناضجة و غـدد الحريـر و العذارى. و ايضا فإن المعاملات السابقة كانت الأكثر تأثيرا على زيادة إنتاجية الحرير و البـيض. كمـا أظهرت تقديرات مستوى بروتينات الدم فى اليرقات المختبرة نتائج إيجابية لهذه المعاملات حيث توافقـت مع معنوية نتائج زيادة إنتاجية كل من الحرير و البيض.