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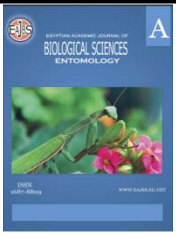

Using Red Beet (*Beta vulgaris* L.) Extract to Improve Silk Production of Mulberry Silkworm (*Bombyx mori* l.)

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ABSTRACT

The effect of addition the red beet extract to the food of mulberry silkworm, *Bombyx mori* as a supplements at three concentrations i.e. 25, 50 and 100% was investigated during the last larval instar. The mean weights of mature larvae, silk gland, fresh cocoon, pupae, and cocoon shell were recorded as indicator for growth and silk production of mulberry silkworm. All concentrations of red beet extract showed a significant increase in all traits of silkworm treated larvae. The concentration of 50% of red beet gave the best records which significantly enhanced the all traits (mature larvae, silk gland, fresh cocoon, pupae and cocoon shell) by 7.8, 27.94, 35.54, 35.19 and 31.6% higher than control, respectively. This study indicated that the red beet supplement can be used to increase the silk yield in commercial silkworm.

INTRODUCTION

Beetroot (*Beta vulgaris* L.) is botanically classified as an herbaceous biennial from Chenopodiaceae family and has several varieties with bulb colors ranging from yellow to red (Singh and Hathan 2014**)**. The red beetroot (*B vulgaris* L.) is a traditional and popular vegetable in many parts of the world. The beet plant usually known in North America as the beet, in Egypt as table beet also, garden beet, or red beet. It is several of the cultivated varieties of *B. vulgaris* grown for their edible taproots and their greens. It is especially rich in fiber as well as in sugars, but has a moderate caloric value. Many beet products are made from other *B. vulgaris* varieties, particularly sugar beet. Beetroot can be boiled or steamed, peeled and then eaten warm with or without butter as a delicacy; cooked, pickled, and then eaten cold as a condiment; or peeled, shredded raw, and then eaten as a salad. When beet juice is used, it is most stable in foods with a low water content, such as frozen novelties and fruit fillings. In recent years, there has been a growing interest in the biological activity of red beetroot (*Beta vulgaris rubra*) and its potential utility as a health promoting and disease preventing functional food. Beetroot is also being considered as a promising therapeutic treatment in a range of clinical pathologies associated with oxidative stress and inflammation. Its constituents, most notably the betalain pigments, display potent antioxidant, anti-inflammatory and chemo-preventive activity in vitro and in vivo (Clifford, *et al.* 2015).

It used against coronary disease and cancer (Kannan, 2011). Beetroots are rich in valuable, active compounds (Singh and Hathan 2014), such as carotenoids (Dias *et al*., 2009), glycine betaine, (de Zwart *et al*., 2003), betanin, polyphenols and flavonoids (Vali *et al*., 2007). The effects offered by beetroot can be realized with amounts easily achievable in the diet or with a supplement such as beetroot juice. A variety of beetroot based supplements including juices and capsules are now widely available and relatively inexpensive, particularly in comparison to synthetically manufactured drugs (Clifford, *et al.* 2015). Many studies show that organic food as vegetables, fruits and preserves contained more dry matter, C and B group vitamins, total sugar, indispensable amino acids, and minerals (kazimierczak *et al.* 2014). In the current study the Red Beetroot was supplemented as juice extract with the mulberry food of silkworm at different concentration to enhance the biological aspects of mulberry silkworm *Bombyx mori* L.

MATERIALS AND METHODS

Insects:

The mulberry silkworm *Bombyx mori* L., used in the current study, was the imported hybrid from Bulgaria. The larvae were reared under the laboratory hygrothermic conditions of 25±2^{0}c and 65-70% R.H., according to the conventional method, in trays and provided with suitable amounts of fresh mulberry leaves. The experimental study was performed on the last larval instar. All the larvae which moulted to the last instar at the same time were grouped and used for the experiment.

Red beetroot and Method of extraction:

The beetroot was used as extraction material, 250 gm of beetroot was cut into slices, 1000 ml of water was added then the mixture was heated at 100°C for 5 minutes (Slavov, *et al.* 2013). After cooling the juice was extracted through a cheese cloth and collected in a bottles and then used as a standard juice to make a different concentrations. From the extracted juice, 25%, 50% and 100% concentrations were prepared using distilled water as diluents. A distilled water control was also maintained.

Method of Treatments:

Mulberry leaves were dipped in the beetroot juice solution, shaded dried and offered to the larvae for feeding for each treatment, three times at first day of the last larval instar. Other feeds being untreated. The observations recorded were: weights of mature larvae, silk glands, fresh cocoon, pupae and cocoon shells. Each treatment and control contains twenty larvae and three replicates.

Statistical analysis

Statistics program version 9.0 was used for a statistical analysis of the semi-consumer evaluation results; a one-way analysis of variance (ANOVA) was performed using the Duncan non-parametric test (α = 0.05).

RESULTS

Effect of red beetroot juice on the weight of mature larvae:

Weights of mulberry silkworm larvae fed on mulberry leaves supplemented with red beetroot extract during the last larval instar at three concentrations 25, 50 and 100% are presented in Table (1). The data showed a significant increase in the mean weight of mature larvae by 7.2, 7.8 and 3.6%, respectively. The concentrations of 50 and 25% gave the highest significant increase compared to control. The highest significant increase in larval weights was gained when the larvae were fed on mulberry leaves supplemented with 50% of red beetroot juice.

Table 1: Mean weight (gm) of mature larvae fed on mulberry leaves supplemented with beetroot juice.

Treatment	Mean Weight (g)±SD	Changes %
Control	3.305 ± 0.160 c	-
25%	3.543 ± 0.141 a	7.2
50%	3.564 ± 0.169 a	7.8
100%	3.425 ± 0.115 b	3.6

In a column, means followed by the same letter are not significantly different, at the 5% level.

Effect of red beetroot juice on the weight of silk gland:

The silk glands mean weights of the larvae fed on mulberry leaves supplemented with red beetroot juice during the last larval instar at three concentrations 25, 50 and 100% are presented in Table (2). The data showed a significant increase in the mean weight of silk gland by 12.08, 27.94 and 24.61%, respectively. The concentrations of 50 and 100 % gave the highest significant increase compared to control. The highest significant increase in silk gland mean weights was gained when the larvae were fed on mulberry leaves supplemented with 50% of red beetroot juice.

Table 2: Mean weight (gm) of silk gland from larvae fed on mulberry leaves supplemented with red beetroot juice.

Treatment	Mean Weight (g)±SD	Changes %
Control	0.902 ± 0.053 c	-
25%	1.011 ± 0.102 b	12.08
50%	1.154 ± 0.102 a	27.94
100%	1.124 ± 0.140 a	24.61

In a column, means followed by the same letter are not significantly different, at the 5% level.

Effect of red beetroot juice on the weight of fresh cocoons:

Data represented in Table (3) showed that mulberry silkworm larvae fed on red beetroot supplement showed a significant increase in fresh cocoon weights at all concentrations. The highest significant increase (37.18 %) was gained when larvae were fed on red beetroot supplement of 25%, followed by 35.54 % at the concentration of 50% and 22.15% at the concentration of 100%.

Table 3: Mean weight of fresh cocoon after feeding the larvae on mulberry leaves supplemented with red beetroot juice.

Treatment	Mean Weight (g)±SD	Changes %
Control	1.463 ± 0.179 c	-
25%	2.007 ± 0.159 a	37.18
50%	1.983 ± 0.272 a	35.54
100%	1.787 ± 0.229 b	22.15

In a column, means followed by the same letter are not significantly different, at the 5% level.

Effect of red beetroot juice on the weight of pupae:

Red beetroot juice enhanced the mean weight of pupae at different concentrations as showed in (Table 4). The mean weights of pupae increased significantly than the control by about 37.85, 35.19 and 21.79% when larvae were fed on red beetroot supplements at the concentrations of 25, 50 and 100%, respectively. The highest significant increase was gained at the concentration of 25%.

Table 4: Mean weight of pupae after feeding larvae on mulberry leaves supplemented with red beetroot juice.

Treatment	Mean Weight (g)±SD	Changes %
Control	1.239 ± 0.177 c	-
25%	1.708 ± 0.182 a	37.85
50%	1.675 ± 0.278 a	35.19
100%	1.509 ± 0.246 b	21.79

In a column, means followed by the same letter are not significantly different, at the 5% level.

Effect of red beetroot juice on the cocoon shell weight and cocoon shell ratio:

The obtained data in Table (5) presented a significant increase in cocoon shell over than control by about 27.8, 31.6 and 19.2% when larvae fed on mulberry leaves supplemented with red beetroot at the concentrations of 25, 50 and 100%, respectively. On the other hand, the cocoon shell ratio was higher in untreated larvae than in treated ones. On the other hand cocoon shell ratio showed no significant differences between the untreated and treated larvae with red beetroot extract at all concentrations.

Table 5: Mean weight of Cocoon Shell after feeding larvae on mulberry leaves supplemented with red beetroot juice.

Treatment	Mean Weight (g)±SD	Changes %	Cocoon Shell Ratio %
Control	0.234 ± 0.052 c	-	15.99
25%	0.299 ± 0.057 ab	27.8	14.90
50%	0.308 ± 0.072 a	31.6	15.53
100%	0.279 ± 0.038 b	19.2	15.61

In a column, means followed by the same letter are not significantly different, at the 5% level.

It could be concluded that red beetroot juice improved the biology of silkworm and silk production at the all concentrations. The results indicated that the concentration of 50% of red beetroot juice significantly enhanced the all traits (mature larvae, silk gland, fresh cocoon, pupae and cocoon shell) by 7.8, 27.94, 35.54, 35.19 and 31.6% higher than control, respectively.

DISCUSSION

Our results showed that the intermediate concentration of 50% of red beetroot juice supplements significantly enhanced the all biological traits of mulberry silkworm (mature larvae, silk gland, fresh cocoon, pupae and cocoon shell) in comparison to control, these results were similar to those obtained by Saad (2013) who found that the concentration of 50% of mulberry fruit extract improved the mean weight of mature larvae, fresh cocoon, pupae and cocoon shell than control. It was also in similar trend of administration of thiamine (Rai *et al*., 2002), ascorbic acid (El-Karaksy and Idriss, 1990; Babu *et al*.,1992; Etebari *et al*., 2002; Thulasi and Sivaprasad, 2013), glycine (Chakrabarty and Kaliwal, 2012).

Nutritional value per 100 g Beet: Carbohydrates 9.56 g; Sugars 6.76 g; Dietary fiber 2.8 g; Fat 0.17 g; Protein 1.61 g; Vitamin A equiv. 2 μg ;beta-carotene 20 μg; Thiamine (B1) 0.031 mg; Riboflavin (B2) 0.04 mg; Niacin (B3) 0.334 mg; Pantothenic acid (B5) 0.155 mg; Vitamin B60.067 mg; Folate (B9) 109 μg; Vitamin C 4.9 mg; Calcium 16 mg; Iron 0.8 mg; Magnesium 23 mg; Manganese 0.329 mg; Phosphorus 40 mg; Potassium 325 mg; Sodium 78 mg; Zinc 0.35 mg; Water 87.58g (USDA Database, 2015)

Green leafy vegetables are the major dietary sources of nitrate. Particularly, plants grown in low exposure to sunlight, such as roots, have higher nitrate content compared to nitrate present in leaves and stems (Alexander, *et al.* 2008 and Lidder and Webb 2012). Nitric oxide is a potent vasodilator that increases blood flow and induces various intracellular actions such as increased mitochondrial and contractile efficiency. Ferguson *et al*. (2014) administered beetroot juice to rats and examined the muscle hemodynamic responses during exercise. The authors reported that dietary nitrate supplementation improved skeletal muscle blood flow and O_2 delivery/utilization matching during exercise, and increased the microvascular O_2 pressure in a dose dependent manner. Zafeiridis (2014) also, found that Nitric oxide is a potent vasodilator that increases blood flow and induces various intracellular actions such as increased mitochondrial and contractile efficiency. Dietary nitrate consumption reduces blood pressure, protects from ischemia-reperfusion injury, and improves endothelial dysfunction. Canadanovic-Brunet, *et al.* (2011) indicated that the extracts obtained from beet root pomace possess considerable amounts of phenolic compounds and betalains, they also showed that beetroot pomace, an inedible waste product in juice manufacture, might be a potent source of antioxidants, and has a potential as a value-added ingredient for functional foods. Vali *et al*., (2007) also, demonstrated that Table beet (*Beta vulgaris var. rubra*) contains important bioactive agents (betalaine and polyphenols), which have a wide range of physiologic effects. Pinna, *et al.* (2014) proved that beetroot juice supplementation may positively affect performance of trained master swimmers. It was cleared that silkworm larvae affected by the beetroot juice due to the effect of it's important bioactive agents which also have a physiological effects in the insects.

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ARABIC SUMMERY

إستخدام مستخلص جذور البنجر الأحمر لتحسين إنتاج الحرير بدوده الحرير التوتية

إبراهيم عبدالعظيم إبراهيم سعد ، رحاب حسني طه ، أشرف شريف فتحى
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تمت دراسة تأثير إضافة عصير بنجر المائدة الأحمر بتركيز 25 ، 50 ، 100% الى غذاء دوده الحرير التوتية خلال العمر اليرقى الخامس. وتم تقدير متوسط أوزان كل من اليرقة الكاملة النمو، غده الحرير، الشرنقة الطازجة، العذراء، قشره الحرير وذلك كمؤشر للنمو وإنتاج الحرير. وقد أعطت جميع تركيزات عصير البنجر الأحمر المعاملة زيادة معنويه بالنسبة لهذه القياسات في اليرقات المعاملة. كان للتركيز 50% لعصير البنجر افضل النتائج حيث كانت الزيادة معنويه مقارنه بالكنترول حيث أدى الى زياده متوسط اوزان كل من اليرقة الكاملة بنسبه 7.8% ، غده الحرير بنسبه 27.94% ، الشرنقة الطازجة بنسبه 35.54% ، العذراء بنسبه 35.19% وقشره الشرنقة بنسبه 31.6% مقارنه بالكنترول. وتوضح هذه الدراسة امكانيه زياده انتاج الحرير تجاريا عن طريق استخدام عصير البنجر كإضافة غذائية لغذاء الحشرة.