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Phyto Essential Oils from *Cymbopogon flexuosus* and *Lavendula officinales* – Antibacterial Activity and Effect on Nutritional and Economic Traits of Mulberry Silkworm, *B. Mori*

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ABSTRACT

The experiment evaluates the effect of two essential oils isolated from aromatic plants *Lavendula officinales* and *Cymbopogon flexuosus* against larval instars of silkworms by using fortification method. The tested essential oils had no adverse effect on larval growth or commercial characters of the silkworm except at higher concentrations. This experiment is part of doctoral work carried out during 2011 to 2014 and is one of the first attempt to understand the effect of the phyto essential oils at different concentrations on larval characters, nutritional efficiency and commercial characters. These findings would contribute not only in controlling the bacterial diseases but also helps in increasing the commercial characters there by an increase in silk production without affecting the silkworm egg production.

Key words - Essential oils, nutritional efficiency, commercial characters, egg production.

INTRODUCTION

In India eco-friendly products from more than 6000 plants are used as herbal medicines which satisfy 75% of the medical needs of the population. In sericulture, attempts have been made to increase cocoon production through hormones, steroids, enhancement of leaves with nutrients, plant extracts and its constituents and spraying of an antibiotics. Essential oils from aromatic and medicinal plants have received attention due to their natural biological activity.

Essential oils are characterized by terpenoids, aliphatic acid esters and phenolic compounds present in high concentrations varies when extracted from different plant parts and their species which protect the insects against pathogens and food contaminants. In recent years great attention is being paid for development and screening of antimicrobial agents and its evaluation methods from different sources to combat microbial resistance.

Several workers have carried out research on antimicrobial properties of essential oils and their constituents in many pioneering works in the past, though more knowledge on the related compounds is lacking. In recent years development of resistance to the pathogens is a great challenge, hence there is an urgent need to look for an alternative and novel antimicrobial to overcome this problem, hence essential oils have been recommended for the same.

Natural plant extracts along with their related sources that have been possessing antimicrobial properties are sources and alternatives to the synthetic drugs that are being used for controlling many infectious diseases (1, 2).

Essential oils have been proved to be a good source of bioactive compounds with antimicrobial and anti-oxidative properties. The essential oils consist mostly of terpenes (mostly mono terpene and sisquiterpenes), terpenoids (oxygenated compounds such as aldehydes, ketones, phenols, alcohols etc) and aromatic plants (3-10).

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In the past years, there is an increased interest on the antibacterial activity of essential oils. In this paper, the effect of essential oils on certain bacterial pathogens isolated from the gut tissue of the mulberry silkworm was studied on par with other paramaters.

The performance of different stages of silkworm is influenced by nutritional physiology. The nutrient composition of the mulberry leaves and quantitative aspects of nutrition in the insect are correlated with chemical ecology of insect plant relationship and insect development. (11).

In present scenario, efforts have been made to study the effect of medicinal and aromatic plants on the performance of silkworms as these botanicals are not only showing phago stimulant effect are also ecofriendly and showed improvement in the commercial characters of the silkworm larvae. When the mulberry leaves is enriched by nutrient supplements to improve commercial characters and production. Thus an attempt has been made to study the effect of lemongrass oil and lavender oil on the nutritional efficiency growth and commercial characters of silkworm as such the amount of leaf consumed and the food quantity digested by the silkworm has an effect on silkworm physiological performance and production of silk (12).

MATERIAL AND METHODS

Botanical description of lavender oil and lemongrass oil

Lavendula angustifolia - (formerly) *L.angustifolia* is a herb belonging to the family Lamiaceae, an ornamental species that grows best in dry, well - drained, sandy soil commercially grown for the production of lavender oil used in cosmetics, perfumes and tropical applications. in lavender oil which are isolated from flower heads of lavender which is composed of major contents of linalyl acetate (30 - 55%), linalool (20 - 35%), tannins (5 - 10%) and caryophyllene (8%). 100 phytochemicals have been identified in the essential oils which possess antibacterial activity against several bacterial pathogens.

***Cymbopogon flexuosus*:-** It belongs to the family Poaceae is an essential oil yielding perennial plant useful for medicinal purpose due to its anti-oxidant, anti-microbial and healthy beneficial bio active effects. The main component of the oil is the source of citrus (75%) is used in flavoring of soft drinks and used in preparation of ionone. Lemongrass oil has been expected as safe essential oil for the human consumption as it having antimicrobial activity. (13)

The disease free laying of Kolar Gold silkworm strains were obtained from *F, grainage* and reared on mulberry leaves under laboratory conditions at 24^{0}C - 28^{0}C. The experimental larvae after IV moult were counted and grouped into 18 batches of 100 larvae each which include the test and control batches. Four different concentrations of oils (1%, 5%, 10%, 15%, 20%) were prepared as treatments on par with control (methanol) and normal (water) batches. Mulberry leaves were fortified with test solutions by an atomizers which were later dried under shade and fed to the test silkworm batches once in IV instar and daily in V instar. The effect of essential oils of different concentrations were used in the management of flacherie diseases and on the larval weight and economic traits of silkworms were calculated.

Antibacterial Activity

The silkworm cadavers were collected from the Kakatiya University lab for antibacterial studies which were later surface sterilized with 0.1% mercuric chloride solution later washed thrice with distilled water. The bacterial pathogens were isolated from the gut tissue of the silkworms (14). Then, with the help of the cotton swab, the primary culture suspension was streaked on nutrient agar media and incubated at room temperature using streak plate techniques. After attaining good growth of bacteria, the slants were stored in refrigerator at 4^{0}C (15 - 17). Then with the help of inoculation loop from 10^{-2} dilution, the inoculation was streaked on nutrient agar media to ensure confluent microorganism growth. 6mm diameter discs were prepared from sterile Whatsman no 1 paper for the study in triplicate. Sterilized discs impregnated with 15 µl of different concentrations (1:1, 1:5, 1:10 and 1:20) of lavender and lemongrass oils were placed on nutrient agar surface with a forceps (Table-1).

Table-1: Effect of Lemongrass oil and Lavendar oil on *Bacillus cereus* and *Proteus vulgaris* with four concentrations (1:1, 1:5, 1:10 and 1:20)

Essential oil Concentration	Inhibition zone in mm	
Lemon grass oil	***Bacillus cereus***	***Proteus vulgaris***
1:01	2	5
1:05	2	4
1:10	3	3
1:20	3	2
Lavender oil		
1:01	3	6
1:05	4	7
1:10	5	8
1:20	2	4

The paper disc moist with ethanol was used as a vehicle of control. After 24 hours, diameter of the inhibition zones were assessed for anti-microbial activity and characterization of the bacterial pathogen was done.

Attempt is to study the effect of lavender and lemongrass oils on nutritional efficiency and cocoon parameters of mulberry silkworm.

RESULTS AND DISCUSSION

Morphological Characters

Morphological characteristics were carried out (18, 19) showed the over shape of the colonies in case of *Bacillus cereus* as circular, convex colonies with irregular edges, while in case of *Proteus vulgaris* the colonies were circular with regular edges.

Biochemical Characterization

Biochemical tests such as catalase and nitrate reduction test were done to characterize the isolated bacterial pathogens from silkworms. It was found that cherry red colour appeared when the specimen was *Bacillus cereus* while for *Proteus vulgaris* which is gram negative bacteria it does not show any colour with nitrate reductase test. When catalase test was carried out bubbles of oxygen was released for *Bacillus cereus* which is gram positive while *Proteus vulgaris* showed negativity with catalyst test as no bubbles appeared.

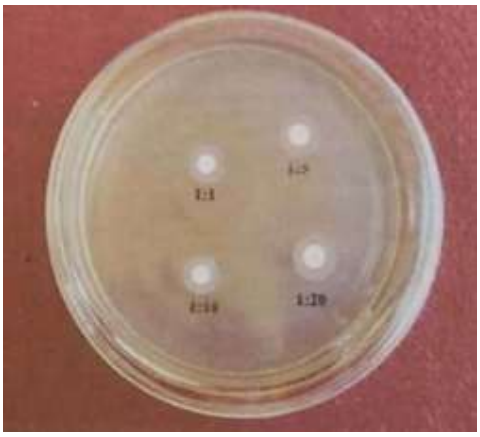
Effect of the Essential Oils on the Larval Weight of Silkworms

Lavender oil

Fortification of mulberry leaves with lavender oil at different concentrations showed the following data which is presented in (Table 2,3, Figure 2, 3, 4, 5).

Figure-1. Anti-microbial activity of Lavender oil and Lemongrass oil against B. cereus and P. vulgaris.

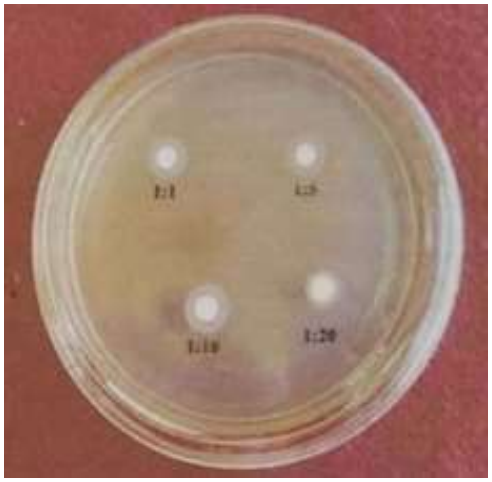
***Bacillus cereus* (gram +Ve)**



***Proteus vulgaris* (gram –ve)**

Lavender oil

***Bacillus cereus* (gram +Ve)**



***Proteus vulgaris* (gram –ve)**

Lemongrass oil

Table-2. Effect of Lavender oil on larval weight of mulberry silkworm Bombyx mori, L

Sl No.	Treatment	I Instar (gm)		II instar (gm)		III Instar (gm)		IV Instar (gm)		V Instar					
										At beginning Max wt (gm)		In the middle Max wt (gm)		At the time of Mounting Max wt (gm)	
		Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE
1	T1	0.06	0.00 ±0.00	0.73	0.02 ±0.01	5.30	0.10 ±0.05	7.70	0.26 ±0.13	15.33	1.17 ±0.58	21.13	0.31 ±0.15	34.77	0.35 ±0.18
2	T2	0.06	0.00 ±0.00	0.73	0.01 ±0.01	5.33	0.21 ±0.10	7.73	0.35 ±0.18	15.73	0.61 ±0.31	21.80	0.30 ±0.15	34.90	0.30 ±0.15
3	T3	0.06	0.00 ±0.00	0.74	0.03 ±0.01	5.47	0.15 ±0.08	8.27	0.42 ±0.21	16.17	0.31 ±0.15	22.33	0.90 ±0.45	36.77	0.31 ±0.15
4	T4	0.06	0.00 ±0.00	0.73	0.03 ±0.01	5.33	0.06 ±0.03	7.43	0.67 ±0.33	14.77	0.96 ±0.48	20.47	0.91 ±0.45	34.53	0.76 ±0.38
5	Control	0.06	0.00 ±0.00	0.74	0.02 ±0.01	5.30	0.36 ±0.18	7.40	0.20 ±0.10	14.80	0.46 ±0.23	20.83	0.75 ±0.38	33.53	0.78 ±0.39
6	Normal	0.06	0.00 ±0.00	0.72	0.01 ±0.01	4.97	0.21 ±0.10	7.10	0.20 ±0.10	13.43	0.64 ±0.32	19.53	1.36 ±0.68	33.97	0.21 ±0.10

Each value is the mean of 5 observations. SD and SE are standard deviation and standard error.

Maximum larval weight (16.17gr/10 worms) were found at the beginning of the Vth instar in T_3 treatment which gradually increased to 36.77 gm/ 10 worms at the time of mounting.

Lemongrass oil

During the IVth instar, maximum larval weight of 7.35 gm/10 larvae were observed in 1:10 concentration. At the beginning of Vth instar the larval weight was increased to 15.02 gm/10 worms at T_1 concentration. While at the time of mounting the maximum larval weight of 41.64 gm/10 larvae was observed at T_3 when compared to control (36.98gm/10 worms) and normal batches (35.16 gm/10 worms).

Effect of Essential Oils on Nutritional Efficiency of Silkworm *B.Mori*, L

Lavender oil

Nutritional efficiency for different concentrations of lavender oil are given in table, 5, Figure-6, 7.

The amount of food ingested (1746gms) and digested (1218gms) was significantly high in the batches fed on mulberry leaves treated with 1:10 concentration of lavender oil. The descending order of values in ingestion and digestion capacity was observed at T_3, T_4, T_2 and T_1 and control batches. Significantly low (1722gm and 1723gm) ingesta and digesta (1190gm and 1199gm) were recorded in control and normal treatments respectively. Except T_4 batch, the approximate digestibility (69.22 grams to 69.75 grams) gradually increased from T_1 to T_3 batches, High reference ratio of 3.30% was recorded in 1:10 concentration treatment batch than control (3.27%) and normal (3.25%).

The efficiency of conversion of ingesta and digesta to larval mass decreased in the silkworms treated with essential oil at 1:20 concentration. A significant difference was observed in the efficiency of conversion of ingested and digesta to biomass food in treated batches when compared to control and normal.

Lemongrass oil

The nutritional indices of silkworm treated with lemongrass oil have been presented. It is clear that the food ingested and digested by the silkworms in treated batches were superior over the control batch. Among the four concentrations of lemongrass oil tested batches, the highest food ingested (2213 gm) and digested (1645 gm)

Table-3. Effect of Lemongrass oil on larval weight of mulberry silkworm Bombyx mori, L

Sl No.	Treatment	I Instar (gm)		II instar (gm)		III Instar (gm)		IV Instar (gm)		V Instar					
										At beginning Max wt (gm)		In the middle Max wt (gm)		At the time of Mounting Max wt (gm)	
		Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE
1	T1	0.06	0.00 ±0.00	0.48	0.01 ±0.01	4.36	0.02 ±0.01	7.04	0.18 ±0.09	15.02	0.41 ±0.21	25.22	0.58 ±0.29	37.06	0.58 ±0.29
2	T2	0.06	0.00 ±0.00	0.52	0.00 ±0.00	4.28	0.13 ±0.06	7.20	0.04 ±0.02	15.44	0.17 ±0.09	26.98	0.13 ±0.07	39.05	0.60 ±0.30
3	T3	0.06	0.00 ±0.00	0.49	0.01 ±0.00	4.30	0.16 ±0.08	7.35	0.10 ±0.05	16.10	0.45 ±0.23	27.22	0.29 ±0.14	41.64	0.47 ±0.23
4	T4	0.06	0.00 ±0.00	0.52	0.01 ±0.01	4.22	0.08 ±0.04	7.12	0.08 ±0.04	13.97	0.17 ±0.09	26.32	0.30 ±0.15	39.36	0.39 ±0.20
5	Control	0.06	0.00 ±0.00	0.50	0.01 ±0.00	4.08	0.05 ±0.02	6.83	0.17 ±0.08	13.90	0.37 ±0.18	26.36	0.63 ±0.31	36.98	0.24 ±0.12
6	Normal	0.06	0.00 ±0.00	0.49	0.00 ±0.00	4.08	0.11 ±0.05	6.99	0.05 ±0.02	13.31	0.72 ±0.36	26.86	0.26 ±0.13	35.16	0.31 ±0.16

Each value is the mean of 5 observations. SD and SE are standard deviation and standard error.

were observed for 1:10 concentration. Approximate digestibility values observed for all the oil treatments was significantly superior to that of the control values.

Highest approximate digestibility (74.33%) was observed for lemongrass oil at 1:10 concentration. The highest value of AD indicates suitability of the feed for the silkworm. The high appropriate digestibility (74.32 gm and 74.99 gm) were observed in the larvae treated with 1:5 and 1:10 concentrations respectively.

The reference ratio did not show much difference among the treatments, there was not much difference when these values were compared to that of control (3.75%) and normal batches (3.62%). The efficiency of conversion of ingesta to larval mass increased remarkably with increase in concentrations. Decrease in ECI (18.2%) was observed at 1:20 concentration while the efficiency of conversion of digesta (25.3%) to larval mass among treated and untreated was maximum at 1:10 concentration.

Effect of Selected Essential Oils on Commercial Characters of Silkworm

The observations recorded on the effect of feeding of different concentrations of essential oils on the economic traits of mulberry silkworm *Bombyx mori* are present in Tables 6, 7, Figure-8, 9, 10, 11.

Lavender oil

ERR% and average cocoon weight was highest in T_3 batch (94% ± and 1.39 grams ± 0.16) followed by T_2 and T_4 batches. The difference in the average shell weights between treated and control was not found to be significant when compared to normal, while average shell ratio percentage was significant in T_3 batch (13.87% ± 0.75) when a comparison was drawn between treated and control batches. The average filament length (949.83 m) and denier was significant in T_3 batch (26.09D) when compared to control and other batches.

Lemongrass oil

When compared to control (81%) the ERR % at 1:10 concentration (97.67% ± 0.58) showed significant increase followed by T_2 treatment. Among the treatments, T_3 showed a significant increase in average cocoon weight (1.93 grams ± 0.10) when compared to other treatments and control batches, while the pupal weight recorded was higher inT_2 concentration (1.58 grams ± 0.10). Average shell weight showed significant increase in T_3 batch (0.33

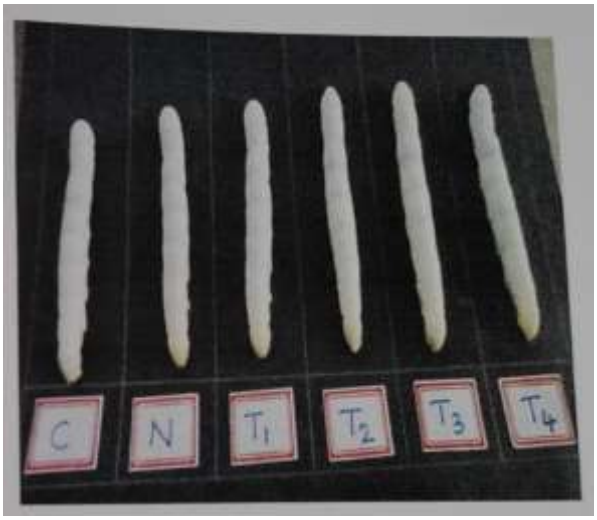


Figure-2. Lavender oil

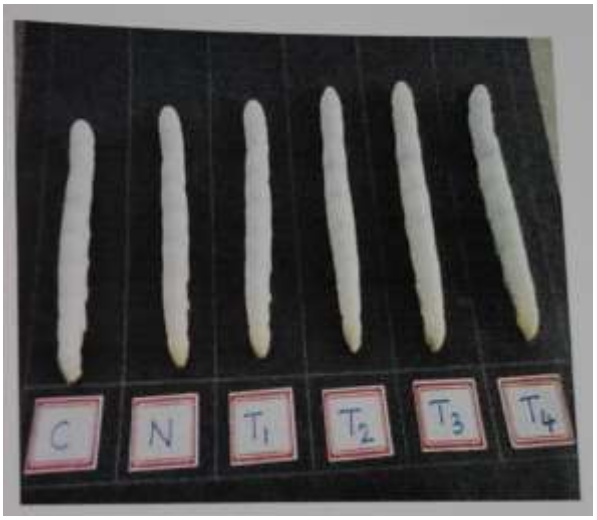


Figure-3. Lemongrass oil

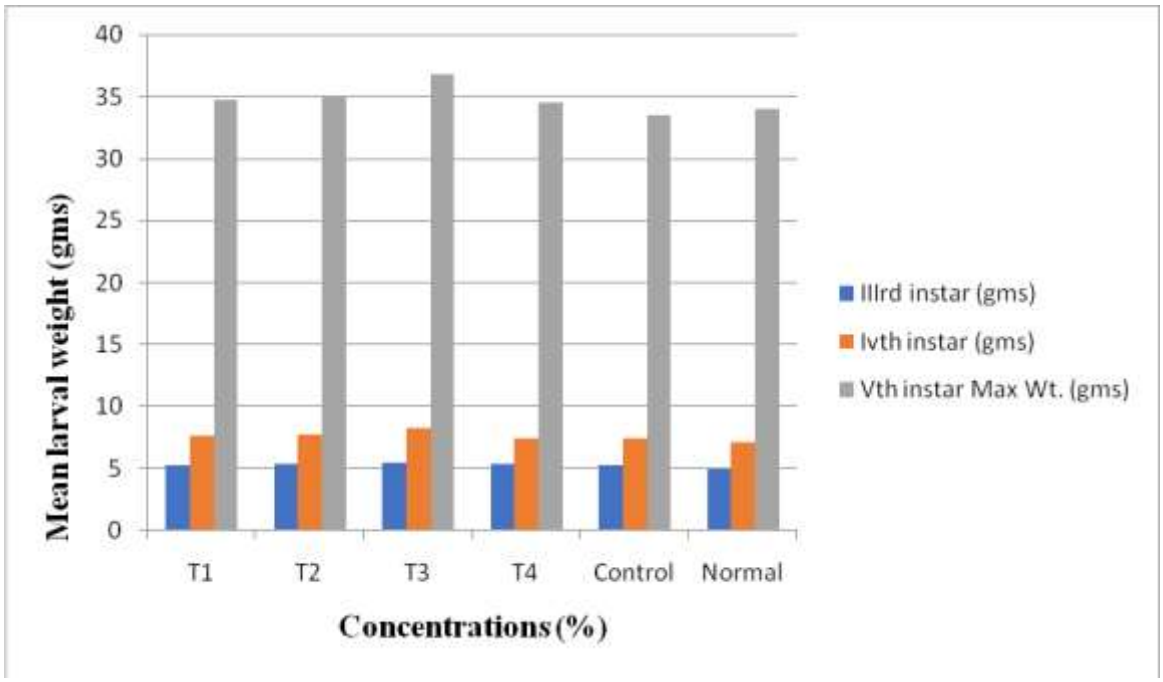


Figure-4. Effect of Lemongrass oil on mean larval weight

grams ± 0.01) followed by T_2 (0.31 gm) and T_4 (0.31 gm) treated batches. The average shell percentage in T_2 (17.39%) and T_3 (17.99%) showed a significant increase in values on comparison with control and other treated batches. The average filament length of 1045.46 m ± 24.06 was observed in T_3 batch. However, in T_1 to T_3 treatments, there was a marginal increase over the control batch. The denier showed significant value of 30.93D, 29.55D and 29.23D in T_4, T_3 and control batches respectively.

Discussion Related to Larval Weight

The data on larval weight were recorded for Ist to Vth instars with special reference to antibacterial activity. The main objective of the present study is to know the impact of lavender oil and lemongrass oil on larval nutritional efficiency and economical characters of silkworm.

The dosage levels were selected after several trials and the selected concentrations did not show any lethal effect on silkworms when treated with essential oils through mulberry leaves. When larvae were fed with lemongrass oil, it showed maximum larval weight which may be due to enhancement of bio availability of the nutrients for digestion in the selected oils resulting in the robust growth of the silkworms.

The present findings are in close conformity with those results (20 – 23). The increased larval weight as reported by the above scientists maybe due to stimulation of protein synthesis, nucleic acid and macro molecules by the

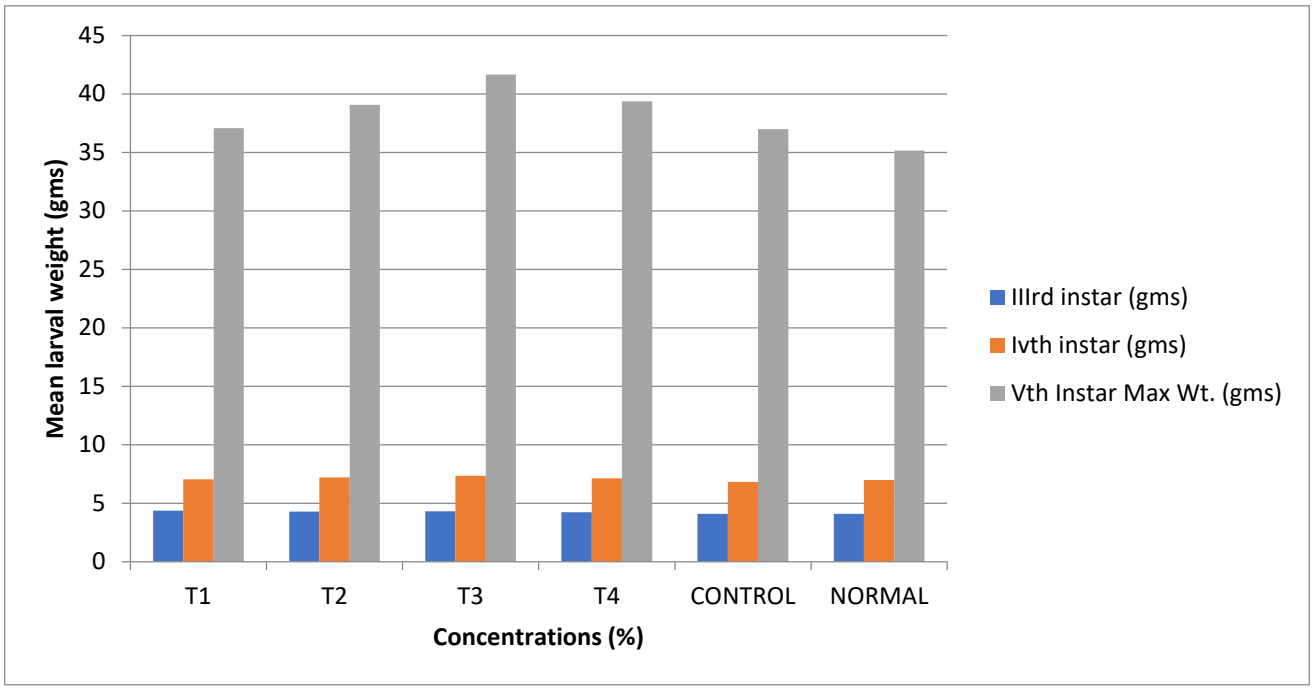


Figure-5. Effect of Lavender oil on mean larval weight

Table-4: Variations in the nutritional efficiency in the silkworm *B.mori*, L treated with different concentrations of Lavender oil

Sl No	Treatment	Ingesta (gm)	Excreta (gm)	Digesta (gm)	Appropriate digestibility (gm)	Reference ratio %	E.C.I %	E.C.D %
1	T1	1712	525	1181	69.22	3.24	20.4	29.4
2	T2	1714	526	1187	69.31	3.25	20.4	29.4
3	T3	1746	528	1218	69.75	3.30	21.1	29.5
4	T4	1733	527	1206	69.57	3.28	19.9	28.6
5	Control	1722	526	1190	69.44	3.27	19.4	28.0
6	Normal	1723	524	1199	69.42	3.25	19.3	27.9

Each value is the mean of 5 observations. ECI=Efficiency of conversion of ingested food
ECD=Efficiency of conversion of ingested digesta

Table 5: Variation in the nutritional efficiency in the silkworm *B.mori*,L treated with different concentrations of Lemongrass oil

Sl No	Treatment	Ingesta (gm)	Excreta (gm)	Digesta (gm)	Appropriate digestibility (gm)	Reference ratio %	E.C.I %	E.C.D %
1	**T1**	**2197**	**565**	**1632**	**74.28**	**3.88**	**16.8**	**22.7**
2	**T2**	**2208**	**567**	**1641**	**74.32**	**3.89**	**17.6**	**23.7**
3	**T3**	**2213**	**568**	**1645**	**74.99**	**3.89**	**18.8**	**25.3**
4	**T4**	**2156**	**560**	**1593**	**73.99**	**3.84**	**18.2**	**24.7**
5	**Control**	**2098**	**558**	**1540**	**73.4**	**3.75**	**17.1**	**23.3**
6	**Normal**	**1995**	**551**	**1444**	**72.38**	**3.62**	**17.6**	**24.3**

Each value is the mean of 5 observations. ECI=Efficiency of conversion of ingested food
ECD=Efficiency of conversion of ingested digesta

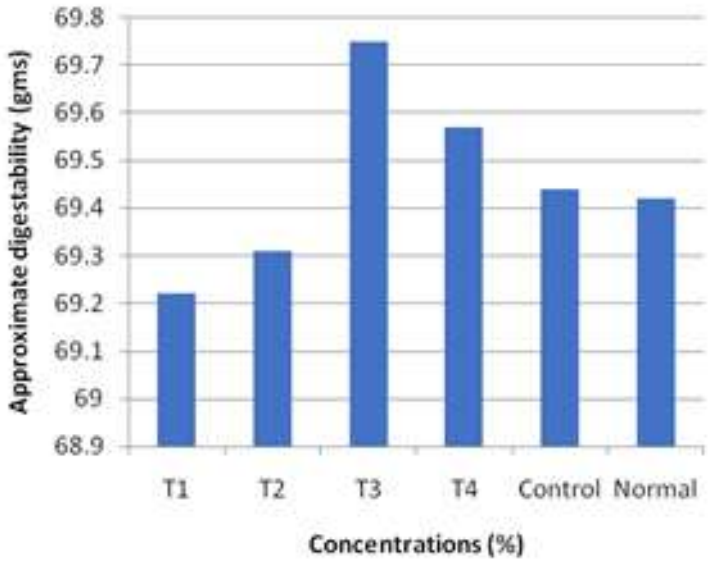


Figure-6. Effect of Lavender oil on approximate digestibility

Table-6. Effect of Lavender oil on economic characters of the mulberry silkworm *B.mori*, L

Sl No.	Treatment	Average cocoon wt. (gm)		Average pupal wt. (gm)		Average shell wt. (gm)		Average shell ratio (%)		Average filament length (m)		Denier		ERR (%)	
		Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE
1	T1	1.32	0.07 ±0.04	1.17	0.01 ±0.00	0.19	0.02 ±0.01	13.25	0.41 ±0.20	938.71	40.17 ±20.23	27.07	0.85 ±0.42	82.00	2.00 ±1.00
2	T2	1.25	0.03 ±0.01	1.11	0.07 ±0.03	0.19	0.02 ±0.01	13.79	0.51 ±0.26	924.21	16.06 ±8.03	27.23	0.43 ±0.21	89.33	1.53 ±0.76
3	T3	1.39	0.16 ±0.08	1.14	0.03 ±0.01	0.21	0.05 ±0.02	13.87	0.75 ±0.38	949.83	14.06 ±7.03	26.09	0.67 ±0.33	94.00	1.00 ±0.50
4	T4	1.34	0.04 ±0.02	1.14	0.01 ±0.00	0.19	0.03 ±0.02	13.64	0.20 ±0.10	918.95	7.33 ±3.67	26.90	0.12 ±0.16	89.33	1.53 ±0.76
5	Control	1.33	0.07 ±0.03	1.14	0.04 ±0.02	0.18	0.01 ±0.00	13.50	0.28 ±0.14	919.16	4.02 ±2.01	26.37	0.19 ±0.09	85.33	2.52 ±1.26
6	Normal	1.24	0.12 ±0.06	1.12	0.06 ±0.03	0.18	0.01 ±0.00	13.33	0.90 ±0.45	915.47	9.50 ±4.75	25.50	0.13 ±0.07	82.00	2.00 ±1.00

Each value is the mean of 5 observations. SD and SE are standard deviation and standard error

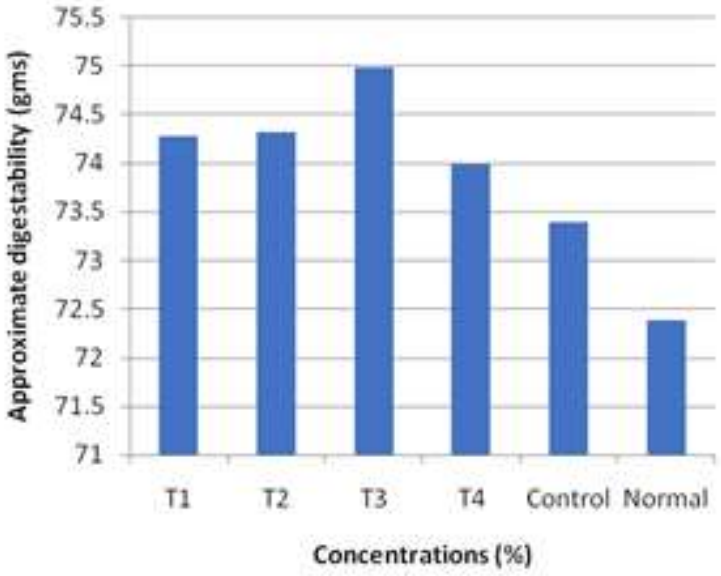


Figure-7. Effect of Lemongrass oil on an approximate digestibility

Table-6. Effect of Lemongrass oil on economic characters of the mulberry silkworm *B.mori*, L

Sl No.	Treatment	Average cocoon wt. (gm)		Average pupal wt. (gm)		Average shell wt. (gm)		Average shell ratio (%)		Average filament length (m)		Denier		ERR (%)	
		Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE	Mean	SD SE
1	T1	1.83	0.08 ±0.04	1.54	0.08 ±0.04	0.29	0.01 ±0.01	16.47	0.88 ±0.44	901.67	33.53 ±16.76	31.07	1.21 ±0.61	93.33	0.58 ±0.29
2	T2	1.85	0.05 ±0.03	1.58	0.10 ±0.05	0.31	0.01 ±0.01	17.39	0.25 ±0.12	942.85	19.84 ±9.92	28.67	0.42 ±0.21	94.67	1.53 ±0.76
3	T3	1.93	0.10 ±0.05	1.56	0.08 ±0.04	0.33	0.01 ±0.01	17.91	0.34 ±0.17	1045.46	24.06 ±12.03	29.53	1.49 ±0.75	97.67	0.58 ±0.29
4	T4	1.88	0.06 ±0.03	1.61	0.04 ±0.02	0.31	0.02 ±0.01	16.86	0.04 ±0.02	946.04	37.16 ±18.58	30.93	0.39 ±0.20	91.67	0.58 ±0.29
5	Control	1.77	0.11 ±0.05	1.48	0.09 ±0.04	0.29	0.02 ±0.01	16.69	0.59 ±0.29	945.36	36.38 ±18.19	29.23	1.06 ±0.53	81.00	1.00 ±0.50
6	Normal	1.66	0.21 ±0.10	1.45	0.06 ±0.03	0.29	0.02 ±0.01	16.77	1.10 ±0.55	916.12	24.18 ±12.09	27.14	0.52 ±0.26	77.67	2.52 ±1.26

Each value is the mean of 5 observations. SD and SE are standard deviation and standard error

active compound (alcohols, esters and terpens) in the lavender and lemongrass oil.

Figure-8. Lemongrass oil

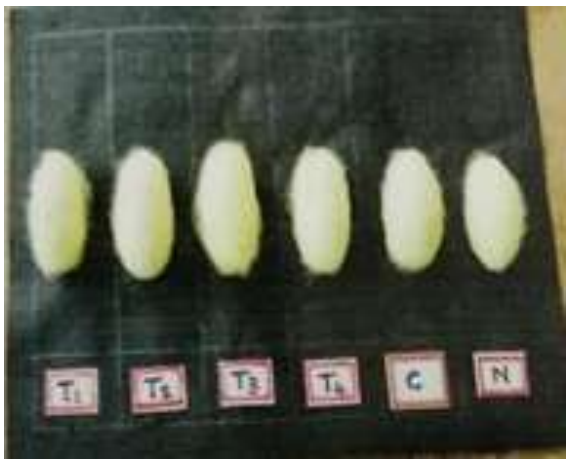
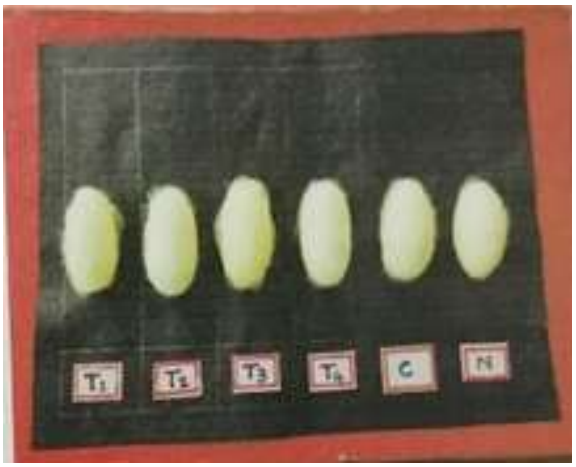


Figure-9. Lavender oil



Effect of Essential Oil on Nutrient Efficiency

The nutritional parameters increased when compared with normal and control batches fed with mulberry leaves fortified with the selected oils. This might be due to increase in efficiency to convert the mulberry leaf into growth perhaps by the conversion of energy from the production of biomass considered the dependency of FCI and ECD on the digestive enzyme activity (24 - 26). It was also reported by that the high feed conversion efficiency parameters are closely related to silk production (27, 28). It is also reported that food consumption and silk production are the ultimate indices to evaluate the efficiency conversion of ingesta and digesta into biomass in terms of shell ratio percentage in relation to the food intake.

Effect of Essential Oils on Commercial Characters of Silkworm

The host plants selection behavior or feeding preferences of the silkworm are mediated by the feeding stimulants, silkworms can utilize only few compounds from mulberry plants. The phagostimulants present in the mulberry leaves are aliphatic amino acids, while the inorganic salts which act as feeding co-factors combined with mixtures provide optional phagostimulative diet effect (29, 30).

The secondary metabolites such as the sterol, terpenes linalool, linalyl acetate act as biting and attractants factors are the constituents of the lavender oil and lemon grass oil. Lemongrass oil also contains Z-asarone a component which stimulates appetite and thereby promotes digestion. The phenolic compounds not only act as biting factors but also enhances the development rate in different stages of silkworm. The improvement in commercial characters might be due to physiological stimulations by these constituents present in the essential oils which affect

Figure-10. Effect of Lavender oil on average cocoon weight in silkworm Bombyx mori, L

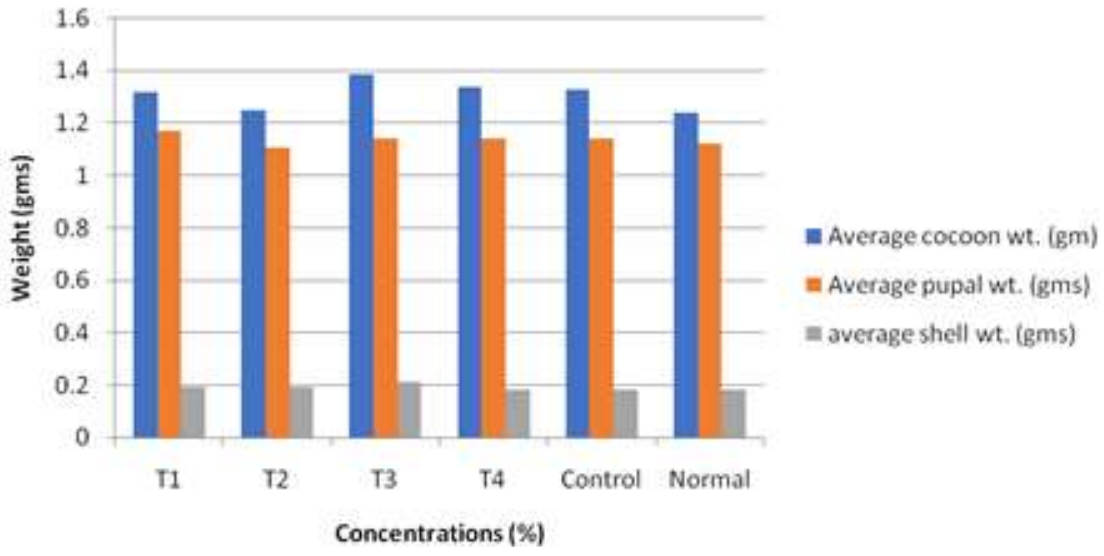
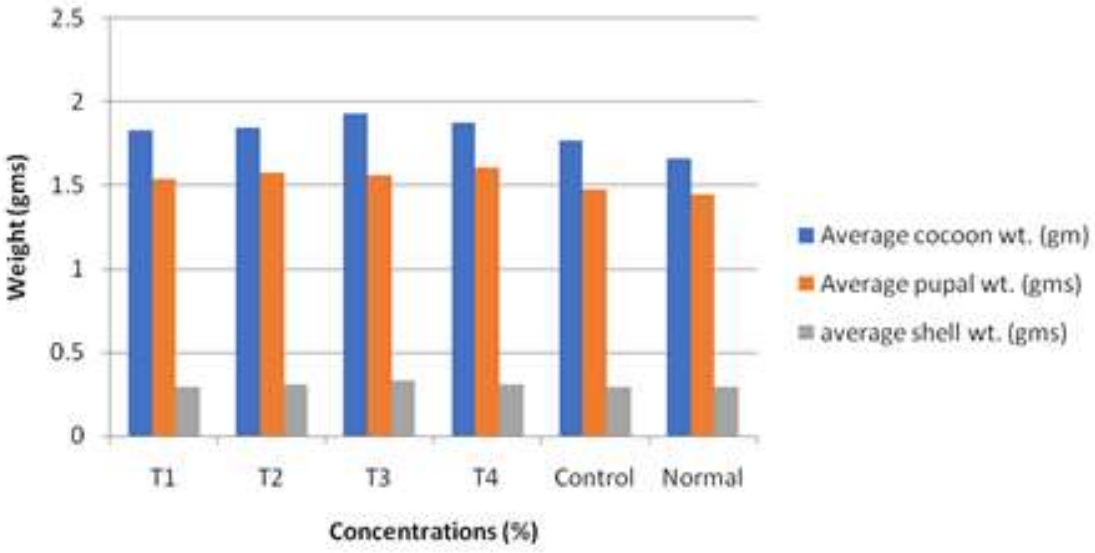


Figure-11. Effect of Lemongrass oil on average cocoon weight in silkworm Bombyx mori, L



the silkworm larvae by increasing the food consumption, lead into maximum larval growth and thereby the commercial characters.

CONCLUSION

Studies indicated that the essential oils extracted from *Lavendula angustifolia* and *Cymbopogon flexuosus* have certain growth stimulant activity and these can be used to increase silk yield in commercial rearing without any toxic effect on the silkworms. Fortification of these oils can be recommended to the rearers to enhance the economic traits which may open a new avenue in sericulture.

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Conflicts of Interest

Authors declare that there is no conflict of interests regarding the publication of this paper.

References

[1] Murugan. K, D. Jayabalan, K.N.Senthil and N. Sivaprakashan, 1998. Growth promoting effects of plant products on silkworm. J. sci. Ind. Res, 57: 740 – 745.

[2] Eid, M.A.A., A.N.E.I. Nakkdy and M.Sahch, 1989. Effect of supplementary amino acids on silk secretion by the larvae of philosamia ricini. Indian journal of Sericulture., 28: 224 – 232.

[3] Dubey, N.K. 2004. Global Promotion of herbal medicine: India's opportunity current science. 86(1): 37 – 41.

[4] Srivastava, K and V.B. Upadhyay, 2013. Effect of phytoecdysteroid on silk producing potential of multivoltine mulberry silkworm (Bombyx mori Linn). The Bioscan, 8 (1): 43 – 47.

[5] Hiware, C.J., 2006. Effect of fortification of mulberry with homeopathic drug Nux vomica on Bombyx mori L. Homeopathy, 95(3): 148 – 150.

[6] Rajsekhargouda R. Gopalan, M. Jeyaraj and N. Natarajan, 1997. Field performance of plant extracts on mulberry silkworm Bombyx mori L. Entomen 22(3&4) : 235 – 238.

[7] Balamurugan, R and L. Isairasu, 2007. Effect of the herbal tonic "Iogen" on the growth and cocoon parameters of mulberry silkworm, Bombyx mori L. Proceedings of the National seminar on Applied Zoology, ANJA College, Sivakasi.

[8] Deshmukh, R.B and V.B. Khyade, 2013. Utilization of Aloe veera (L) herbal tonic for treating mulberry leaves before feeding the Vth instar larvae of silkworm, Bombyx mori L. (Race: PMX CSR$_2$). IJB, 02(01): 281 – 285.

[9] De Sosa Barros A., de Morais S.M., Ferreira P.A.T., Vieira I.G.P., Craveiro A.A, de santos Fontenelle R.O., de Menezes J.E.S.A., da silva F.W.F., de Sousa H.A Chemical composition and functional properties of essential oils from Mentha species. Tnd. Crops prod 2015; 76: 557 – 564. doi : 10.1016/j. indcrop. 2015.07.004. [Cross ref] [Google scholar]

[10] Jongnuanchan, P., Benjakul, S. Essential oils: Extraction, bioactivities and their uses for food preservation. J.food Sci. 2014, 79, R 1231 – R1249. [Cross ref] [Pub Med].

[11] Waldbauer G.P (1968). The consumption and utilization of food by insects. Adv. Insect physio

5229-288. 10. 1016/s 0065 – 2806 (08) 60230-1 [Cross Ref] [Google Scholar].
[12] Waldbauer G.P (1964). The consumption, digestion and uitilization of solanaceous and non – solanaceous plant by larvae of the tobacco horn worm ptoto parce sexta (Johan) (Lepidoptera : Sphingidae). Entomol.
[13] S.S. Shankar, A.Rai, A.Ahmed, M.Sastry (2005). Controlling the optical properties of lemongrass extract synthesized gold nanotriangles and potential application in infrared – absorbing optical coatings. Chemistry of materials. 17(3) : 566 – 572.
[14] Poinar. G.O and Thomas, G.M 1984. Laboratory guide to Insect pathozen and parasites plenium press, New York, London.
[15] Govindan R., Narayanaswamy T.K., Devaiah M.C. 1998. Principles of silkworm pathology. Seri. Scientific Publishers, Bangalore. 420.
[16] Safaei – Ghomi J., and A.A. Antimicrobial and antifungal properties of the essential oil and methanol extracts of Eucalyptus largiflorens and Eucalyptus intertexta. Pharmacogn. Mag 2010; 6: 172 – 175. doi : 10.4103/0973 – 1296.66930. [PMC free article] [Pub Med] [Cross Ref] [Google Scholar].
[17] Astani A., Reichling J., Schnitzler P. Comparative study on the antiviral activity of selected monoterpenes derived from essential oils. Phytother. Res. 2010; 24: 673 – 679. doi: 10: 1002/pter. 2955 [PMS free article] [Pub Med] [Cross Ref] [Google Scholar].
[18] Aneja K.R. 1996 .a. Methods of obtaining pure culture of microorganisms. In : Experiments in microbiology, plant pathology. Tissue culture and mushroom cultivation, 2nd Ed, New Age International (p) Ltd., New Delhi: 139 – 153.
[19] Aneja, K.R. 1996 .b. Staining methods, In: Experiments in microbiology, plant pathology, Tissue culture and Mushroom cultivation. Visvaprakashan, 2nd Ed. New Age International (P) limited, New Delhi : 60 – 86.
[20] Sachidananda., Tiwari., Surendra Prasad and V.B. Upadhyay. 2014. Bioactivity of Aloe Vera oil on the weight and length of larval of silkworm, Advance in Biological Research, Vol . 8(1): 37 – 43.
[21] Zah, C., L. A., Marghitas, A Matei and M.N., Madas, 2014. The effect of dietary supplements on the development of B.mori, L silkworm. Animal science and Biotechnologies. Vol 44(1): 153 – 157.
[22] Shahin R., Gadelhak G., Mahmaud S.M., EI-Agan and Idriss M. 2013. The effects of lettuce seed oil on some economical parameters of the mulberry silkworm Bombyx mori, L. Journal of Applied Sciences Research, vol. 9(4) 2702 – 2707.
[23] Singh, P.S., Prasad and V.B., Upadhyay. 2014. Effect of Aloe Vera oil influences the fecundity and hatchability of multivoltine mulberry silkworm Bombyx mori, Linn Pinnacle Biological Sciences, Article ID pbs, Vol 116 – 117.
[24] Silveira Rama. V, Gracas Machodo Freir. M., Roberto Postali parsa, J and Ligia Rodrigues Macedo, M. 2009. Regulatory effects of an inhibitor from plathymenia foliolosa seeds on the larval development of Anagasta Kuehniella (Lepidoptera). Comparative Biochemistry and Physiology, Vol 152: 255 – 261.
[25] Broadway, R.M and Duffey S.S 1998. The effect of plant protein quality on insect digestive physiology and the toxicity of plant proteinase inhibitors. Journal Insect physiology, Vol. 34: 1111 – 1117.
[26] Huang Z., Sh:P., Dai J and Du, J. 2004. Protein metabolism in spadopteral itura (F) is influenced by the botanical insecticide azadirach in. Pesticide Biochemistry and Physiology, Vol. 80: 25 – 93.
[27] Mathur V.B, Rahmathulla V.K, Vijayabhal. 2002. Consumption and efficiency of food in new elite bivoltine hybrid silkworm. Inter J of Indus Entomol. Vol. 5(2): 213 – 216.
[28] Gokulamma, K and Reddy, Y.S 2005. Role of nutrition and environment on the consumption growth and utilization indices of selected silkworm races of Bombyx mori, L. Indian j Seric. Vol. 44(2): 165 – 170.
[29] Patil RR., G.D. Hipparagi, S.N Karuga, B.R. Banakar, M.M Khazi, R. Srinivasan and V. Umesh. 2001. Exploitation of plant products with phagostimulant properties on mulberry silkworm, Bombyx mori, L. Proceedings of the national seminar on Mulberry Sericulture Research in India, November 26 – 28, Bangalore, India, 38.
[30] Pratheesh Kumar., C.J. Prabhakar and C.K Kambli. 2010. Impact of botanicals on growth, development and reproduction of silkworm, Bull. Ind. Acad. Seri. Vol. 14(11).