BIOCHEMICAL CONSTITUENTS OF DIFFERENT PARTS OF MULBERRY GENOTYPES

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Abstract- Mulberry leaf exclusively assures the growth and development of the silkworm larvae, being considered a complete value nutrient, so that the knowledge of its nutritional status is of great interest. The nutritional status of different mulberry varieties is ascertained by its biochemical constituents. Mulberry is rich sources of protein, carbohydrate, carotenoids, lipids, ascorbic acid, anthocyanins etc. Hence the current investigation was undertaken to study the biochemical constituents in different parts viz, roots, leaves and fruits of seven mulberry genotypes. The results indicated that AR-12 mulberry variety have recorded highest biochemical constituents.

Keywords: Mulberry, roots, leaves, fruits and Biochemical constituents

Introduction

Mulberry (*Morus* spp.) leaves have been the traditional feed for the silk worm (*Bombyx mori*). The growth and development of the silkworm larvae and subsequently cocoon production are greatly influenced by nutritional quality of mulberry leaves [3, 27]. Mulberry leaves are rich source of proteins, carbohydrates, chlorophyll a, chlorophyll b, total chlorophyll and total carotenoids, ascorbic acid and various mineral elements. Deficiency of certain nutrients or an imbalance of nutrients in leaves cause changes in the composition or metabolic activity of silkworm larval body [21].

Mulberry has been selected and improved for leaf quality and yield for a long time. The main use of mulberry globally is as feed for the silkworm, but depending on the location, it is also appreciated for its fruit (consumed fresh, in juice or as preserves), as a delicious vegetable (young leaves and stems), for its medicinal properties in infusions (mulberry leaf tea), for landscaping and as animal feed. In Peru, the multiple uses of mulberry have been recognized [46]. There are several places where mulberry is utilized traditionally as a feed in mixed forage diets for ruminants, like in certain areas of India, China and Afghanistan. In Italy there have been several studies on the use of mulberry for dairy cows and other domestic animals [6, 33, 42, 44] and in France there was a research project to introduce mulberry in livestock production [4].

The mulberry fruits are also known for its delicious taste and medicinal properties like vaso-tonic, anti-oxidant activity, anti-cancer, anti-viral, anti-inflammatory *etc.* [27]. Besides this, they are using for both medical and cosmetic purposes like to nourish skin and blood, benefit to liver, kidney and treat weakness. Botanically, the mulberry fruits are not a true berry, it is an aggregate fruit composed of smaller fruits called drupes, appearing like a swollen loganberry and highly sweet, succulent. Mulberry fruits are rich in glucose, sucrose, carotenes, vitamin B1, vitamin B2, vitamin C, tartaric acid and anthocyanins *etc.* The fruits contain high quantity of carbohydrate, anthocyanins and exploited for rich source of natural red food colorant proteins. The safety of synthetic pigments has been questioned, leading to reduction of number of permitted colorants [17]. Due to this limitation worldwide consumption tendency towards use of natural products as natural colorants has been increased significantly [37]. Besides their color attributes, anthocyanins have been reported to be beneficial to health as potent anti-oxidants and to improve visual acuity [34]. The major anthocyanins identified in fruit extract are cyanidin 3-glucoside and cyaniding 3-rutinoside [32, 41]. Many medicinal properties have been proved by clinical studies on various compounds present in mulberry (flavanoids, alkaloids, steroids) are responsible for therapeutic benefits [5].The root bark of mulberry tree in the first Chinese dispensatory "Shen Nong Ben Cao Jing" whose original anonymous volume probably appeared by the end of the third century. In the book, the root bark of the plant is called as 'Sang Bai Pi' [35, 36]. The herb has been used as anti-phlogistic, diuretic, expectorant and anti-diabetic in traditional Chinese medicine [8, 36]. A piperidine alkaloid (moranoline = 1-deoxynojirimycin) and glycoproteins (morans A and 20 K) were isolated as anti-diabetic agents from *Morus* root bark and leaves [18, 24, 45]. On the other hand, the antioxidant potency of some phenolic compounds (flavonoids, stilbenes and 2-arylbenzofurans) from *Morus alba* has been reported [14, 15, 22, 39].

The consumption of such biochemical constituents of this mulberry plant serves as dietary disease preventive food components. However, fewer efforts have been made to evaluate the biochemical constituents available in different parts of mulberry. Therefore, the present investigation was conducted to evaluate biochemical composition on different parts i.e. leaves, fruits and roots of mulberry genotypes found in India.

Materials and methods
Plant Materials
Mulberry leaves were collected from the experimental garden of Babasaheb Bhimrao Ambedkar Central University, Lucknow, Uttar Pradesh, India. Seven different mulberry varieties namely S-13, S-146, S-1, AR-12, S-36, S-54, and BR-2 were selected for the present investigation. 10 grams of different parts of mulberry samples were selected for estimation for their biochemical compositions such as protein, carbohydrate, total carotenoids, and total lipids contents in roots, leaves and fruits. Three replications were maintained for each variety throughout the experiment.

Determination of protein
Protein content was quantitatively measured by Lowry's method [30]. About 5 gm of different parts of mulberry samples viz, roots, leaves and fruits of different gentotypes was crushed and grinded in 50 ml of Trichloroacetic acid solution. The grinded material was collected and centrifuged at 4000 r.p.m. for 15 minutes. The clear supernatants were collected in different test tubes for assay for protein content by addition of Folin's reagent. The elucidation turns blue in colour. The absorbance of blue colour was measured with the help of U.V. Spectrophotometer at 650 nm wavelength. The protein content was calculated by standard Boven Serum Albumin. The results were expressed in mg/gm.

Determination of carbohydrate
Carbohydrates content in different mulberry samples was quantitatively measured by Dubois et al [9]. For estimation of carbohydrates content, 2 g leaves of different parts of mulberry samples viz, roots, leaves and fruits were grinded in distilled water with the help of mortar and pestle. Then leaf samples were centrifuged at 5000 rpm for 10 minutes. 0.5ml clear supernatants with 0.5 ml distilled water were collected in different test tubes and 4 ml of Anthrone reagent was added to obtain green colour. The absorbance of green colour was taken to estimate the carbohydrate content at 625nm wavelength by using U-V Spectrophotometer. The carbohydrates content was calculated by standard sugar solutions (Dextrose L) method and is measured in mg/gm.

Determination of Total Carotenoids
Total carotenoid was quantitatively measured by Ranganna method [38]. About 0.20 gm of different parts of mulberry samples viz, roots, leaves and fruits was grinded and extracted in 80% acetone solution till the colour of sample became colourless. The clear supernatants were taken to determine the absorbance at two wavelengths 480 and 510 nm, respectively against 80% acetone as blank. The absorbance of fruit samples was taken at different wavelengths and calculated the amount of total carotenoids in mg/ gm tissue.

Determination of Total anthocyanin content
About 2 gms of mulberry fruits of different genotypes were weighed and blended with same amount of ethanolic - HCl. The samples were left for 24 hrs. for maximum extraction of anthocyanins at 4°C. After 24 hours, the extracted material was filtered through Whatman filter paper and made to a known volume with ethanolic- HCl. Absorbance was determined at 535 nm against ethanolic - HCl as blank with the help of U.V. Spectrophotometer and calculated the total anthocyanin content with the help of following formula [38].

$$\text{Total O.D. per2g} = \frac{\substack{\text{Absorbance at} \\ \text{535nm}} \times \substack{\text{volume made} \\ \text{up of extract} \\ \text{used for colour} \\ \text{Measurement}} \times \text{Total volume} \times 100}{\text{ml of extract used} \times \text{weight of sample taken}}$$

$$\text{Total anthocyanin content in mg per 2g berry} = \frac{\text{Total O.D. per2g}}{98.2}$$

Determination of Lipids content
The total lipid content of different parts of mulberry samples viz. roots, leaves and fruits were estimated by Folch et al. method [13]. About 0.2 gm of each different mulberry samples was homogenized with 2 ml of chloroform and methanol mixture (2:1 v/v). The samples were taken for centrifugation for 15 minutes at 10,000 rpm. An equal amount or volume of 0.6 % saline solution was added to supernatant. Weight was taken at this stage. After mixing thoroughly, the samples were transferred to separating funnel and left in dark for overnight. Later, the lower organic phase was separated and evaporated at 60° C in an oven. The residues of different samples was weighed for total lipids content and expressed in mg/gm sample.

Statistical Analysis
The data were subjected to standard method of analysis of variance (ANOVA) single factor, and the significance of difference between the varieties was tested using 'f' criteria at 5 % and 1% probability levels .Values expressed are means of three replicates. Coefficients of variation (%) of each variety and each character were also computed.

Results and Discussion
The mean values quantitative determinations of various biochemical constituents of different varieties in leaves, fruits and roots of mulberry plant are shown in **Table 1-6**.

Biochemical constituents of leaves
From results of Table 1, high protein content was present in S-36 (0.317mg/gm) and a least value was observed in AR-12 variety (0.131mg/gm). BR-2 variety (0.308

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mg/gm) holds next position in terms protein content followed by S-54 (0.215 mg/gm), S-146 (0.189 mg/gm), S-13 (0.183 mg/gm), S-1 (0.168 mg/gm) and AR-12 (0.131 mg/gm) respectively. It was also found that S-13 and S-146 are on par with each other. The differences between the mulberry varieties in terms of protein content in leaves are highly significant (P>0.01). In a reporting of Food and Agricultural Organization, the total protein content when compared with other vegetables leaves, mulberry leaves showed higher protein content [12]. Adeduntan and Oyerinde [1] reported highest protein content in S-36 followed by S-54 and Kanva-2 which is accordance to present study. The high protein values observed is in agreement with Kasiviswanathan et al. [23] and it is an indication that both Mulberry can be of food value in man, silkworm and animal. Thirumalaisamy et al. [43] screened total protein content of six varieties of mulberry leaves viz S-13, S-30, S-36, Mysore Local, V-1 and RFS-135, of which V-1 recorded maximum total protein content (26.72%) whereas in the current study S-36 variety recorded highest protein content (0.315 mg/gm). The current results are not in accordance with the findings of Thirumalaisamy et al. [43].

High carbohydrate content was observed in AR-12 variety (0.624 mg/gm) followed by S-13 variety (0.505 mg/gm) , S-1 (0.466 mg/gm), S-54 (0.295 mg/gm), S-36 (0.247 mg/gm), BR-2 (0.239 mg/gm) and S-146 (0.180 mg/gm) respectively (Table 1). S-36, S-54 and BR-2 are on par with each other. AR-12 mulberry variety has recorded the highest amount of carbohydrate content and least in S-146 mulberry variety. The differences between the mulberry varieties in terms of total carbohydrates content in leaves are highly significant (P>0.01). Adeduntan and Oyerinde [1] reported highest carbohydrate content in K-2 which is not in the close agreement with current study. The sensory assessment indicated that black mulberry has fruity, sweet, sour, musky and woody flavour. Koyuncu et al. [25] surveyed native black mulberry genotypes for fruit and characters.

Table 2 indicated that, the total carotenoids content in different mulberry varieties and found highest in S-54 variety (0.195mg/gm) followed by S-36 (0.051mg/gm), BR-2 (0.037 mg/gm),S-1 (0.022 mg/gm), S-13 (0.022 mg/gm),AR-12 (0.020 mg/gm) and S-146 (0.019 mg/gm). S-13, S-146, S-1, and AR-12 are all on par with each other. A similar trend was found between protein and total carotenoids content. The differences between the mulberry varieties in terms of total carotenoids content in leaves are highly significant (P>0.01).

The total lipids content was found maximum in S-13 variety i.e.0.923 mg/gm sample while least value was recorded in AR-12 variety i.e. 0.180 mg/gm (Table 2). After S-13, S-54 variety has attained next position in lipid content i.e. 0.497mg/gm followed by BR-2 (0.383 mg/gm), S-1 (0.293mg/gm), S-146 (0.247mg/gm), S-36 (0.223 mg/gm). The differences between the mulberry varieties in terms of total lipids content in leaves are highly significant (P>0.01). Adeduntan and Oyerinde [1]

reported highest lipid content in S-36 variety which is not supporting to present analysis.

Krishnaswami et al . [26] observed that mulberry leaves containing water, protein total sugars, soluble carbohydrates, less minerals and crude fiber is best relished by different animals. According to Bose et al [7], S-34 cultivar was having maximum value of moisture, total minerals, non-reducing sugars, total sugars, total carbohydrate, and total free amino acids and concluded that S-34 being the most nutritive variety in rainfed conditions while the current analysis showed that AR-12 mulberry genotype being most nutritive ones under irrigated conditions in the reference region.

Biochemical constituents of fruits
Protein content, carbohydrate, total carotenoids, total anthocyanins and total lipids of fruits of different mulberry are given in Table 3 and 4. Among the different mulberry fruits varieties, S-36 varieties (0.281 mg/gm) contain highest concentration of protein followed by S-13 (0.246 mg/gm), AR-12 (0.237 mg/gm), BR-2 (0.227 mg/gm), S-54 (0.185 mg/gm), S-146 (0.166 mg/gm) and S-1 (0.128 mg/gm) (Table 3) . However, this value was found to be lower in S-1 variety (0.1029mg/gm). A different trend was found between the protein content of leaves and fruits. S-36 variety is the only common one found in both leaves and fruits. AR-12 and BR-2 are on par with each other. The differences between the mulberry varieties in terms of total lipids content in leaves are highly significant (P>0.01).

On the other hand, the carbohydrate contents in different mulberry fruits showed an incredible variation among different mulberry genotypes (Table 3). The carbohydrate levels in different mulberry fruits were found to be highest in S-36 (0.6548 mg/gm) and least found in BR-2 (0.3733 mg/gm). S-54 variety (0.582 mg/gm) recorded second highest carbohydrate content variety followed by AR-12 (0.521 mg/gm), S-1 (0.478 mg/gm), S-146 (0.443 mg/gm), S-13 (0.415 mg/gm) and BR-2 (0.373 mg/gm). The differences between the mulberry varieties in terms of total lipids content in leaves are highly significant (P>0.01).

In a preceding reporting, the carbohydrate content in mulberry fruit of Turkey region is 20.4% [11]. Difference in sugars content amongst cultivars has also been reported by other scientists [2, 10, 16, 19]. However, values noted in present study were higher than those of Hussain [19] and Elmac and Altuq [10] and lower than those of Gosh et al. [16]. Iqbal Khan and Munir [20] reported total sugars content in mulberry fruits grown in Pakistan region ranged between 21.163 to 34.777 % while in current study it range about 0.373 mg/gm-0.655 mg/gm.

The total carotenoids content of the evaluated mulberry fruits varieties varied between 0.0067 mg/gm to 0.0098 mg/gm (Table 4) .It was found that variability of total carotenoids content among different mulberry fruit samples was very less. AR-12 variety contains highest values (0.0095mg/gm) and lowest in S-13 (0.006 mg/gm).

There was constricted range of total carotenoids content in different mulberry fruits cultivars. Although AR-12 stood first position in total carotenoids content, S-36 and BR-2 followed very closely (insignificant difference) i.e.0.009 mg/gm. Almost all the mulberry varieties are very close to each other in relation to total carotenoids content. The differences between the mulberry varieties in terms of total carotenoids content in fruits are highly significant (P>0.01).

The total anthocyanins content of mulberry fruits samples contain an appreciable amount in S-146 and AR-12 varieties (102.76mg/2gm sample and 102.41 mg/2gm sample).On the other hand, S-1 variety contains least amount of total anthocyanins content (19.94mg/2gm sample) (Table 4) . BR-2 (98.653 mg/2 gm sample) mulberry variety holds the next position in terms of anthocyanins content followed by S-36 (93.387 mg/2 gm sample), S-54 (90.550 mg/2 gm sample), S-13 (21.887 mg/2 gm sample). S-36 and S-54 are on par with each other.

Anthocyanin content depends on climate, area of cultivation, and is particularly higher in sunny climates [31]. The differences between the mulberry varieties in terms of total anthocyanins content in fruits are highly significant (P>0.01). Total anthocyanins levels was found highest in S-146 and AR-12 varieties and are widely found in all other varieties except S-1 and S-13 variety since its color was creamish–white. However, the estimated total anthocyanins content of different mulberry cultivars of Korea ranges from 1229 to 2057 μg /g [40] whereas in India, it ranges from 19.94mg/2g sample to 102.76mg/2gm sample. On the other hand, Xiuming Liu and his co-workers [29] found the total anthocyanins content of different mulberry fruits cultivars ranges from 147.68 mg/l to 2725 mg/l.

The total lipids content in different mulberry fruits samples was found maximum in S-13 (1.110 mg/gm) while least content recorded in S-36 mulberry variety (0.567 mg/gm).Next to S-13 variety, AR-12 variety (0.920 mg/gm) recorded, followed by S-1 (0.863 mg/gm), BR-2 (0.783 mg/gm), S-146 (0.670 mg/gm), S-54 (0.627 mg/gm) lipid content (Table no. 4). Moreover, cultivars, soil and climatic conditions do have influence on the composition of fruits [20].The differences between the mulberry varieties in terms of total lipids content in fruits are significant (P>0.05).

Biochemical constituents of roots

The biochemical constituents like protein, carbohydrate, total carotenoids and total lipids content of roots of different mulberry genotypes were shown in Table no.5 and 6. There were scanty reports available regarding biochemical composition of roots in different mulberry varieties. The protein content in different mulberry roots samples was peak recorded in AR-12 mulberry variety (0.374 mg/gm) while BR-2 variety (0.197 mg/gm) recorded dip value. Next to AR-12 mulberry variety, S-146 variety (0.266 mg/gm) stood next position in respect to protein content followed by S-13 (0.254 mg/gm), S-1 (0.245 mg/gm), S-36 (0.241 mg/gm) and S-54 (0.224

mg/gm) (Table 5). This trend was quite different from that of protein content in leaves. The differences between the mulberry varieties in terms of protein content in roots are highly significant (P>0.01).

The carbohydrate content in different mulberry roots samples, S-13 variety (0.560 mg/gm) recorded maximum value while it was on fewer pars in BR-2 mulberry variety (0.2146 mg/gm) (Table no-5). AR-12 mulberry variety (0.369 mg/gm)recorded carbohydrate content next to S-13 variety followed by S-146 (0.317 mg/gm),S-1 (0.278 mg/gm), S-36 (0.265mg/gm), S-54 (0.263 mg/gm) and BR-2 (0.214 mg/gm). The differences between the mulberry varieties in terms of carbohydrate content in roots are highly significant (P>0.01).

The total carotenoids content was not found variably in different mulberry roots samples and its values indicated (Table no-6) that S-1 (0.0077 mg/gm) and S-36 variety (0.0074 mg/gm) recorded maximum and near values while BR-2 mulberry variety (0.0045 mg/gm) recorded least total carotenoids when compared to other mulberry varieties. S-146 mulberry variety (0.0067 mg/gm) recorded next position followed byAR-12 (0.0062 mg/gm). S-54 and S-13 mulberry varieties recorded same total carotenoids content i.e. 0.0056 mg/gm. Again the differences between the mulberry varieties in terms of total carotenoids content in roots are highly significant (P>0.01).

The total lipids content among different roots samples, S-13 variety (0.883 mg/gm) recorded highest value while least found in S-146 variety (0.190 mg/gm).AR-12 variety (0.593 mg/gm) holds next position in lipid content followed by BR-2 (0.483 mg/gm), S-54 (0.404mg/gm), S-1 (0.360 mg/gm), S-36 (0.210 mg/gm) and S-146 (0.190 mg/gm) (Table no-6). The differences between the mulberry varieties in terms of total lipids content in roots are highly significant (P>0.01).

Conclusion

In India, AR-12 mulberry variety at present can be cultivated not only for rearing of silkworms but also it will open the way to corporate sericulture system through which these varieties can be explored by herbal druggists as health supplements in pharmaceutical industry thereby making moriculture as profitable enterprise.

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Table 1- Biochemical constituents (Protein and Carbohydrates) in leaves of different mulberry varieties

Sl. No.	Mulberry varieties	Protein Content (in mg/gm)			Carbohydrate Content (in mg/gm)		
		Mean	S.D.	CV%	Mean	S.D.	CV%
1.	AR-12	0.131	0.002	1.770	0.624	0.058	9.309
2.	S-54	0.215	0.003	1.480	0.295	0.051	17.138
3.	S-13	0.183	0.002	1.023	0.505	0.014	2.712
4.	S-36	0.317	0.004	1.113	0.247	0.006	2.267
5.	Br-2	0.308	0.008	2.528	0.239	0.008	3.160
6.	S-146	0.189	0.003	1.480	0.180	0.006	3.434
7.	S-1	0.168	0.002	1.196	0.466	0.056	12.069
Inference		HS			HS		
CD 5%		0.007			0.064		
CD 1%		0.009			0.089		

Note: *SD- Standard deviation of mean   **CV%** - Coefficient of Variation in %   **CD at 1%** -Critical difference at 1% level risk*
***CD at 5%** -Critical difference at5% level risk   **HS**- Highly Significant*

Table 2- Biochemical constituents (Total Carotenoids and Lipids content) in leaves of different mulberry varieties

Sl. No.	Mulberry varieties	Total Carotenoids (in mg/gm)			Lipids content (in mg/gm)		
		Mean	S.D.	CV%	Mean	S.D.	CV%
1.	AR-12	0.020	0.003	13.765	0.180	0.036	20.031
2.	S-54	0.195	0.004	2.037	0.497	0.116	23.336
3.	S-13	0.022	0.002	8.457	0.923	0.076	8.272
4.	S-36	0.051	0.002	3.901	0.223	0.061	27.359
5.	Br-2	0.037	0.003	8.578	0.383	0.100	26.130
6.	S-146	0.019	0.003	15.032	0.247	0.060	24.437
7.	S-1	0.022	0.002	11.202	0.293	0.091	30.933
Inference		HS			HS		
CD 5%		0.005			0.142		
CD 1%		0.007			0.197		

Note: *SD- Standard deviation of mean   **CV%** - Coefficient of Variation in %   **CD at 1%** -Critical difference at 1% level risk*
***CD at 5%** -Critical difference at5% level risk   **HS**- Highly Significant*

Table 3- Biochemical constituents (Protein and Carbohydrates) in fruits of different mulberry varieties

Sl. No.	Mulberry varieties	Protein Content (in mg/gm)			Carbohydrate Content (in mg/gm)		
		Mean	S.D.	CV%	Mean	S.D.	CV%
1.	AR-12	0.237	0.007	2.922	0.521	0.006	1.113
2.	S-54	0.185	0.004	2.079	0.582	0.008	1.295
3.	S-13	0.246	0.010	4.015	0.415	0.004	0.975
4.	S-36	0.281	0.007	2.598	0.655	0.006	0.847
5.	Br-2	0.227	0.006	2.651	0.373	0.002	0.661
6.	S-146	0.166	0.003	2.019	0.443	0.005	1.028
7.	S-1	0.128	0.002	1.817	0.478	0.004	0.864
Inference		HS			HS		
CD 5%		0.011			0.009		
CD 1%		0.015			0.012		

Note: *SD- Standard deviation of mean   **CV%** - Coefficient of Variation in %   **CD at 1%** -Critical difference at 1% level risk*
***CD at 5%** -Critical difference at5% level risk   **HS**- Highly Significant*

Table 4- Biochemical constituents (Total Carotenoids, Lipids content and Total Anthocyanins) in fruits of different mulberry varieties

Sl. No.	Mulberry varieties	Total Carotenoids (in mg/gm)			Total Anthocyanins (in mg/gm)			Lipids content (in mg/gm)		
		Mean	S.D.	CV%	Mean	S.D.	CV%	Mean	S.D.	CV%
1.	AR-12	0.010	0.001	12.935	102.413	0.825	0.806	0.920	0.192	20.823
2.	S-54	0.007	0.001	14.394	90.550	2.062	2.277	0.627	0.131	20.826
3.	S-13	0.006	0.001	8.436	21.887	0.814	3.719	1.110	0.151	13.633
4.	S-36	0.009	0.000	4.028	93.387	7.093	7.595	0.567	0.155	27.358
5.	Br-2	0.009	0.001	8.505	98.653	0.474	0.481	0.783	0.160	20.439
6.	S-146	0.008	0.001	15.272	102.763	1.578	1.536	0.670	0.184	27.399
7.	S-1	0.007	0.001	12.222	19.943	0.218	1.094	0.863	0.120	13.916
Inference		HS			HS			S		
CD 5%		0.002			5.070			0.276		
CD 1%		0.002			7.037			-		

Note: SD- *Standard deviation of mean* **CV% -** *Coefficient of Variation in %* **CD at 1% -***Critical difference at 1% level risk*
CD at 5% -*Critical difference at5% level risk* **HS**- *Highly Significant* **S**-*Significant*

Table 5- Biochemical constituents (Protein and Carbohydrates) in roots of different mulberry varieties

Sl. No.	Mulberry varieties	Protein Content (in mg/gm)			Carbohydrate Content (in mg/gm)		
		Mean	S.D.	CV%	Mean	S.D.	CV%
1.	AR-12	0.374	0.005	1.244	0.369	0.009	2.558
2.	S-54	0.225	0.005	2.037	0.263	0.007	2.745
3.	S-13	0.254	0.004	1.698	0.560	0.008	1.365
4.	S-36	0.241	0.003	1.254	0.265	0.003	1.148
5.	Br-2	0.198	0.004	1.828	0.215	0.004	1.819
6.	S-146	0.266	0.005	1.995	0.317	0.003	1.097
7.	S-1	0.245	0.006	2.294	0.278	0.007	2.373
Inference		HS			HS		
CD 5%		0.008			0.011		
CD 1%		0.011			0.015		

Note: SD- *Standard deviation of mean* **CV% -** *Coefficient of Variation in %* **CD at 1% -***Critical difference at 1% level risk*
CD at 5% -*Critical difference at5% level risk* **HS**- *Highly Significant*

Table 6- Biochemical constituents (Total Carotenoids and Lipids content) in roots of different mulberry varieties

Sl. No.	Mulberry varieties	Total Carotenoids (in mg/gm)			Lipids content (in mg/gm)		
		Mean	S.D.	CV%	Mean	S.D.	CV%
1.	AR-12	0.0062	0.0006	8.9803	0.593	0.061	10.298
2.	S-54	0.0056	0.0005	8.1004	0.404	0.020	5.046
3.	S-13	0.0056	0.0006	10.0939	0.883	0.183	20.762
4.	S-36	0.0074	0.0008	10.7260	0.210	0.020	9.524
5.	Br-2	0.0045	0.0003	5.5513	0.483	0.172	35.616
6.	S-146	0.0067	0.0005	7.4751	0.190	0.075	39.736
7.	S-1	0.0077	0.0006	7.9697	0.360	0.062	17.347
Inference		HS			HS		
CD 5%		0.0010			0.184		
CD 1%		0.0013			0.256		

Note: SD- *Standard deviation of mean* **CV% -** *Coefficient of Variation in %* **CD at 1% -***Critical difference at 1% level risk*
CD at 5% -*Critical difference at5% level risk* **HS**- *Highly Significant*