ISSN No:-2456-2165

Nutrient Composition, Phytochemical Profile and Antioxidant Properties of *Morus nigra*: A Review

Mitali Mehta*
University Department of Botany
Ranchi University
Ranchi, India

Anil Kumar
University Department of Botany
Ranchi University
Ranchi, India

Abstract:-*Morus nigra* commonly known as black mulberry belongs to the family Moraceae. Mulberry plants have been grown for the production of silk worms and for the preparation of vinegars, juices, jams, marmalades, wines and cosmetics. *M. nigra* plant is native to South-western Asia and it is used as traditional herbal medicines for humans and animals since time immemorial. In this article, recent research progress on various phytochemical constituents, nutrient composition and antioxidant properties from different parts of *M. nigra* are reviewed. *M. nigra* are in worldwide trend as the plants exhibited various biologically active substances and pharmacological effects such as antioxidant, anti-diabetic, anticancer, anti-inflammatory, antimicrobial, anti-obesity and weight-loss activities. It is rich in source of bioactive compounds that can improve and promote human health, mainly based on its antioxidant properties.

Keywords:-*Morus nigra; phytochemical profile; nutrient composition; antioxidant property*
***Author for Correspondence** E-mail:- mitalimehta2526@gmail.com, Tel:- 9142966156

I. INTRODUCTION

Over the last few years, berry fruits have moved under the spotlight on nutritional research of research bodies since it has highlighted the ability to impact on human health and animals [1].

Morus nigra L., commonly called as black mulberry or blackberry, is a species of flowering plant and perennial shrub belonging to family Moraceae [2]. The plant is native to south western Asia and has been grown throughout Europe and around the Mediterranean for centuries. It is known for its large no. of chromosomes, 308(44 X ploidy) [3]. Mulberry belongs to the genus *Morus.* The tree can reach to a height of 10-13 meters [4]. The leaves are 10-20 cm long and tree can yield dark purple-black fruit of about 2-3 cm after maturation. The fruit has unique, delicious and refreshing taste. [5]. It has the ability to grow under a wide variety of soil types and climatic conditions. *Morus* is distributed worldwide with much greater amount in India and China [6, 7]. It is widely distributed in temperate to sub-tropical areas of northern hemisphere especially in Europe, Asia, North America and Africa [8,9]. Plants possess great importance in food, medicinal, economical and industrial areas. The juice of the fruits has been used as remedies for cough and cold, asthma, tumors, diarrhea, fever, headache, wounds and hypertension. *Morus* species are used as rearing silk worm, *Bombyx mori* [10, 11]. Its leaves are also used as cattle fodder and known for enhancing milk yield [12].

The dark black colour is due to the high concentration of anthocyanins in the fruits that are phytochemicals which have strong antioxidant action. It is fast growing deciduous, woody and perennial tree. It is an economically important plant; its fruits are used in the preparation of marmalades, juices, jams, vinegars, liquors, natural dyes and in cosmetic industries[13-15].

II. PROXIMATE COMPOSITION

Ercisli and Orhan (2007) recorded moisture contents from 71.5% to 74.6% in mulberry species [8].

In 2010, Imran et al examined the fruits of four *Morus* species and the proximate compositions of mulberry fruits were recorded and mentioned in the table 1. Moisture content of *M. nigra* was in between (78.03±3.22) FW and found that it has highest moisture content than other *Morus* species. Total ash content found in between (0.50±0.08) g/100g DW in *M. nigra* fruits. Total lipid content in the range of (0.55±0.06) g/100g DW. Total protein content was found to be (0.96±0.16) g/100g DW i.e., lowest amount of protein content was found in *M. nigra* fruits than other *Morus* species. The crude fibre content was recorded exceptionally high in *M. nigra* fruits i.e., (11.75±1.21) g/100g DW, rest are recorded comparatively small amount of fibres. Hence, it shows that *M. nigra* could be a good source of fibre. Total carbohydrate contents showed lowest value i.e., (13.83±1.20) g/100g DW. There was a slight variation from other species. The calorific value i.e., energy value was also recorded low in *M. nigra* fruits i.e., (64.11±2.45) kcal/100g on dry weight basis. [16]

Plant name	Moisture (g/100 g FW)	Ash (g/100 g DW)	Lipid (g/100 g DW)	Proteins (g/100 g DW)	Fibre (g/100 g DW)	TC (g/100 g DW)	Energy (kcal/100 g DW)
M. nigra	82.40±3.85	0.50±0.08	0.55±0.06	0.96±0.16	11.75±1.21	13.83±1.20	64.11±2.45

Table 1:- Proximate composition of fruits of *M. nigra* [16]

A study conducted by Iqbal et al 2012 in the leaves of three varieties of mulberry and the mean values of proximate composition of leaves was recorded. The ash content was 9.12± 0.41 in the leaves of *M. nigra* variety. Other composition like moisture content was recorded as 6.7±0.3 which was higher than other varieties of mulberry leaf. Lipid content, fibre content and protein content in leaves of *M. nigra* was ranged from 5.13±0.19, 12.32±1.18 and 19.76±2.12 respectively. Fibre content was found to be higher from other varieties [17].

Nutrients	*Morus nigra* L.
Ash	9.12±0.41
Moisture	6.7±0.3
Lipid	5.13±0.19
Fibre	12.32±1.18
Protein	19.76±2.12

Table 2:- Proximate composition of leaves from three varieties of mulberry [17]

In 2015, Khattak et al collected fruits of *M. nigra* from different geographical locations and found the moisture content of fruits was in the range of 8.9 to 12.3%. The crude protein was recorded in between 8.6 to 13.15% lowest from Swabi and highest from D.I. Khan location for *M. nigra* fruit. The crude fat of *M. nigra* fruit ranged between 2.7 to 4.7% highest from Swabi. The ash value ranged between 7.0 to 9.8% lowest in Swat and highest in Peshawar. The crude fibre of *M. nigra* fruits are recorded in between 11.6 to 14.45%. Highest from Swabi and has significant variations with respect to geographical locations. Total carbohydrate content also showed variations and found highest from Swat i.e., 57.0% and lowest from Peshawar i.e., 51.4%. The calorific values were found in between 278.8 to 297.1 kcal/100g on a dry weight basis. Highest calorific value was recorded from Swabi. Therefore, the results of *M. nigra* fruit samples were found to be a good source of lipids, proteins, fibres, carbohydrates and energy. However, some significant variations or concentrations were found according to the studied parameters and having sources of different food composition, the fruits are in good demand in the market. [18]

	Locations				
Nutrients	**D. I. Khan**	**Karak**	**Peshawar**	**Swabi**	**Swat**
Moisture (%)	9.6±0.4	10.1±0.7	11.6±0.6	8.9±0.9	12.3±0.9
Crude protein (%)	13.1±0.8	9.3±0.2	11.1±0.5	8.6±0.9	9.4±0.3
Crude fat (%)	2.7±0.1	4.1±0.5	3.2±0.2	4.7±0.5	2.7±0.2
Ash (%)	9.1±0.4	7.9±0.3	9.8±0.4	8.3±0.1	7.0±0.3
Crude fibre (%)	11.6±0.1	14.2±0.4	13.0±0.6	14.4±0.4	13.0±0.6
Carbohydrate (%)	53.8±1.6	54.3±0.7	51.4±0.4	54.8±1.3	57.0±0.3
Energy (kcal/100 g)	292.5±8	291.7±14	278.8±17	297.1±10	289.9±12

Table 3:- Proximate composition of *M. nigra* fruit collected from different geographical locations of Khyber Pakhtunkhwa [18]

In 2014 Koyuncu et al worked on wild-grown black mulberry. Proximate composition of eight *M. nigra* genotypes of fruits and leaves were studied. The minimum moisture content was found in the fruits of M-17 genotype and the maximum was found in M-28 genotype and ranged from 77.30 to 84.27%. The mean value of moisture content was found to be 82.31%. Total sugar ranged from 5.09 (M-18) to 7.26% (M-11) and the mean value was found to be 6.25%. The crude fat was found to be in between 3.15 (M-28) to 6.79% (M-17) and mean value was 5.75%. The ash value ranged from 0.12 (M-28) to 0.36% (M-14) and mean value was 0.21%. The crude protein ranged from 7.66 (M-28) to 12.93% (M-22) and the mean value was 10.25%. The leaf crude protein ranged from 20.94 (M-14) to 29.15% (M-17) and the mean value was 25.72%. [19]

ISSN No:-2456-2165

	Fruit					Leaf
Genotype	**Moisture**	**Total sugar**	**Ash**	**Crude fat**	**Crude protein**	**Crude protein**
M-5	81.97	7.05	0.17	5.65	10.04	29.07
M-8	81.49	7.08	0.24	5.92	9.76	25.34
M-11	82.86	7.26	0.21	5.52	9.56	24.06
M-14	82.35	6.44	0.36	6.71	10.36	20.94
M-17	77.30	5.45	0.23	6.79	10.31	29.15
M-18	84.20	5.09	0.28	6.06	11.39	25.00
M-22	84.03	6.11	0.13	6.22	12.93	28.59
M-28	84.27	5.53	0.12	3.15	7.66	23.61
Mean	82.31	6.25	0.21	5.75	10.25	25.72
Max	84.27	7.26	0.36	6.79	12.93	29.15
Min	77.30	5.09	0.12	3.15	7.66	20.94

Table 4:- Proximate composition of black mulberry fruits and leaves [19]

III. MINERAL COMPOSITION

A study carried out in 2010 by Ercisli et al, where black and purple mulberry genotypes were determined. Genotypes MN1, MN2, MN3 AND MN4 were taken in *M. nigra* and found the various minerals and recorded. The minerals like N, P and K values are 800,289 and 1005 mg/100g respectively were found in *M. nigra* genotypes which were higher from the *M. rubra* genotypes. [20]

		w/(mg/100 g)								
Species	**Genotypes**	**N**	**P**	**Ca**	**K**	**Mg**	**Na**	**Zn**	**Mn**	**Fe**
M. nigra	MN1	680	314	145	1314	114	55	3	6	5
	MN2	910	334	138	922	107	64	2	7	6
	MN3	880	291	135	912	111	60	4	6	5
	MN4	740	218	129	873	98	51	4	8	5
Mean value		800	289	137	1005	108	58	3	7	5

Table 5:- Mineral content of black and purple mulberry genotypes [20]

In 2010, Imran et al conducted a work on which four species of mulberry were taken and estimated the mineral composition of the fruits. The mineral composition of four mulberry species was varied. As from the observation, K was found to be a predominant element in all the *Morus* species i.e., (1270+_9.36) mg/100g in *M. nigra*. Other minerals like Ca, Na, Mg, Fe, Zn, and Ni were recorded as (470±6.95), (272±5.32), (240±3.51), (77.6±1.98), (59.20±2.25) and (1.60±0.11)mg/100g respectively. The Fe content was found in highest amount with respect in highest amount with respect to other species. [16]

Plant name	**K**	**Ca**	**Na**	**Mg**	**Fe**	**Zn**	**Ni**
Morus nigra	1270±11.50	470±6.95	272±5.32	240±3.51	77.6±1.98	59.20±2.25	1.60±0.11

Table 6:- Mineral composition of *M. nigra* fruit [16]

In 2011, Khalid et al, tested trace minerals in the fresh juice of black mulberry (*M. nigra*) after wet digestion using an HNO3-HClO4 acid mixture with a Perkin Elmer 360 Atomic Absorption Spectrophotometer (PerkinElmer, Waltham, MA, USA).In the work, it was found that potassium was present greater in amount i.e., 1300 mg/100g and manganese was found to be lowest in amount i.e., 7 mg/100g of fresh juice of *M. nigra*. Other minerals like sodium, calcium, magnesium, zinc and iron were reported as 160, 150, 130, 45 and 40 respectively. [21]

Trace minerals	**Amount in black mulberry (*Morus nigra*) fresh juice (mg/100g)**
Potassium	1300
Sodium	160
Calcium	150
Magnesium	130
Zinc	45
Iron	40
Manganese	7

Table 7:- Trace mineral composition of fresh juice of black mulberry (*Morus nigra*) [21]

ISSN No:-2456-2165

The mineral composition of *M. nigra* fruits is shown in Table mentioned below given by Khattak et al, 2015. The result showed Phosphorus and Potassium were the predominant elements. The concentration of Calcium elements varied from 337±10 to 502±12 mg/100 g. Other elements like Na, Mg, Fe, Mn and Zn, were varied from 266±6 to 302±4, 255±3 to 386±17, 22±0.1 to 43±0.2, 9±0.0 to 19±0.2 and 35±0.1 to 62±0.3 mg/100 g respectively. All the elements showed significant variations with respect to geographical location. [18]

	Locations				
Minerals	**D. I. Khan**	**Karak**	**Peshawar**	**Swabi**	**Swat**
Ca	502±12	501±26	337±10	461±6	455±25
Na	283±9	300±7	287±12	266±6	302±4
Mg	352±19	267±2	386±17	367±12	255±3
Fe	41±0.3	43±0.2	22±0.1	34±0.0	29±0.2
Mn	16±0.1	14±0.0	9±0.0	19±0.2	11±0.1
Zn	62±0.3	35±0.1	35±0.2	53±0.2	45±0.2
K	1452±56	1736±19	1819±35	2123±100	2234±67
P	1765±75	2185±86	1639±45	1932±66	2520±88

Table 8:- Mineral composition (mg/100 g) of *Morus nigra* fruit collected from different geographical locations of Khyber Pakhtunkhwa [18]

IV. PHYTOCHEMICAL PROFILE

A. Total phenolic content

Phenols are found abundantly in plants and have been found incredible interest in nutrition from researchers and food manufacturers because of the physiological functions of phenols. In recent decades, researchers indicate that it helps in the prevention of certain diseases. It constitute among the largest group of secondary metabolites.

By Ozgen M et al in 2009, 14 superior mulberry species of *M. nigra* were investigated across Turkey. Phenolic content in the fruits were measured according to the Singleton and Rossi's procedure (1965). TP content was found as 2485 microgram GAE/g FW and some species contains higher than 3000 µg GAE/g FW (N24, N35, N49, N60 and N68). [5]

In 2009 Kutlu et al prepared Acidified methanol (AME), Acidified water (AWE) and Methanol+water (MWE) extracts of mulberry and found the mean values as 555, 462, 332 µg gallic acid equivalent/ml extract respectively. It was reported that methanol and water can increase the yield of total phenol. [22]

In 2010, Ercisli et al, a study carried out in Turkey on *M. nigra* and *M. rubra* genotypes and clearly showed that the total phenolic content of *M. nigra* genotypes i.e., 1826-2483 GAE microgram/g was higher than the *M. rubra* genotypes i.e., 1584-1789 GAE µg/g. [20]. In the same year Imran et al worked on fruits *Morus* species and found low phenolic content in *M. nigra* i.e., 880±7.20 mg/100g FW in comparison to other species. [16]

Another work in 2010, Memon A.A. et al studied in which three species of *M. nigra* were grown in Pakistan. Total phenolic content of fruit and leaf extracts were determined using FC method (mmol/100g GAEq). The TP content were in the range of 3.89 and 11.79 mmol/100g in the dry weight of fruit and leaf extracts respectively. From the observed result it is clear that the leaf extracts contain higher total phenolic content than fruit extracts. [23]

Khalid et al (2011), reported 2050 µ/g of total phenolics in fresh black mulberry juice. One year later, Mahmood et al (2012), reported phenolics in unripe, semiripened and fully ripened samples of *M. nigra* fruit i.e., 575,722 and 2287 mg/100g respectively [21]. Another work done by Thabti et al in 2011 where leaves of mulberry species were examined grown in the Southern region of Tunisia. The total phenolic content was reported to be 598.66 mg GAE/100g DM in leaves of *M. nigra*. [24]

In 2012, Arfan et al studied total polyphenolic compounds (TPC) of sugar-free extracts (SFEs) were extracted from *M. nigra* fruits using methanolic and acetonic extract. The highest TPC was received from *M. nigra* acetonic SFE i.e., 173 mg/g than the methanolic SFE i.e., 164 mg/g. [25]

A comparative study of 3 varieties of mulberry leaves was carried out by Iqbal et al 2012. The total phenolic content was ranged from 24.37±2.14 mg GAE/ g of dried leaves in *M. nigra* leaves and found to be highest in amount. [17]. In August 2013, Murthy et al estimated the phenols in Tender, medium and coarse stage of leaf maturity and found 7, 40, 8, 54 and 7.84 mg/g respectively in the leaf quality evaluation of mulberry germplasm varieties [26].

A study done by Sofia et al in 2014 in which they found that the black-coloured mulberries has higher total phenolic content than white-coloured mulberries. The highest and lowest phenolic content was found in DN3 (1.02 m Mg GAE/100 g frozen weight) and DA2 (0.143 m Mg GAE/100 g frozen weight) respectively [27].

In 2015 Natic et al found that the Chologenic acid and rutin were the main phenolic compounds [28]. In 2015, Khattak, K. F. et al, the study was carried out to see the effect of geographical location on the phytochemical profile of *M. nigra* fruits collected from five different locations of

Khyber Pakhtunkhwa, Pakistan. According to the observed result, phenolic content of *M. nigra* fruits were in between 558.0 to 109.7 mg of GAE per 100g.The higher phenolic content was found in the fruits collected from D. I. Khan and smallest phenolic content was found in Peshawar region [18].

	Locations				
Phytochemicals	**D. I. Khan**	**Karak**	**Peshawar**	**Swabi**	**Swat**
Phenols	1090.7±50.6	995.0±15.7	558.0±3.2	93.0±5.6	880.3±17.0
Anthocyanins	159.7±7.0	263.7±12.2	67.0±4.6	205.7±.5	346.3±5.1
Flavonoid	93.3±7.5	135.0±6.1	63.7±6.8	147.7±6.4	244.0±10.1
Alkaloids	520.0±17.3	571.7±12.9	404.0±16.4	648.3±11.0	446.3±10.1
Ascorbic acid	26.3±0.6	24.3±2.1	19.3±1.5	32.7±1.5	19.3±0.6

Table 9:- Phytochemical profile (mg/100g) of *M. nigra* fruit collected from different geographical locations of Khyber Pakhtunkhwa [18]

Total phenolic content was reported from 1920 (13-BIT-2) and 2575 (13-BIT-7) GAE mg/gin the work done by Okatan et al 2016 in *M. nigra* fruits grown in Turkey [29].

In 2016 Gondoglu et al examined phenolic compounds in mulberry varieties and found that black mulberry had highest phenolic level than the other varieties [30].

In 2018 Volkan Okatan found ellagic acid, rutin, quercetin, gallic acid, catechin, chlorogenic acid and caffeic acid as the main phenolic compounds in his work with different values in the genotypes of *M. nigra*. The highest and lowest phenolic content was found in 64USA03 (2977.30 mg $GAEg^{-1}$) and 64USA10 (1874.35 mg $GAEg^{-1}$) genotypes respectively [31].

B. Alkaloid

Alkaloids are naturally occurring organic compounds that contain nitrogen atom or atoms. In plants, they are mainly synthesized as secondary metabolites.

Work by Khattak et al (2015), 5 Geographical locations were taken and observed that the alkaloids ranged between 404.0 to 648.3 mg/100g on dry weight basis in *M. nigra* fruit. The highest alkaloid content was seen in Swabi and lowest in Peshawar [18]. Previously, the alkaloid contents were determined gravimetrically (Okwu, 2005) by Imran et al 2010. He worked on frits of four *Morus* species and observed that the *M. nigra* contained 630 mg/100g FW of alkaloid contents [16].

C. Flavonoid

Flavonoids are the plant secondary metabolites which play a very important role against the oxidative stresses. *Morus* family contain large amount of flavonoid and this type of phytochemical is taken in the form of nutrition. Flavonoid can control lipid peroxidation [32].

In 2011, Thabti et al reported the total flavonoid content i.e., 440.54 mg RE/100 g dry matter. This study reported lowest polyphenol and flavonoid contents in the leaves of *M. nigra* with respect to other species of Mulberry [24]. The high content of flavonoid was found in ethanol extract of fresh mulberry fruit from Southeast Serbia in 2009 by Kostic et al [33].

In 2018, Yu et al worked on different varieties of mulberry leaves and total flavonoid content were measured using a calorimetric assay and were ranged from 21.36 ±1.53 to 56.41±2.02 mg/g on dry weight basis. Highest flavonoid content was found in GS8 variety and lowest was seen in XG variety [34]. Previously, in 2015 Khattak et al estimated the flavonoids using the method of Aiyegoro and Okoh (2010). The flavonoid contents were ranged from 63.7±6.8 to 244.0±10.1 mg/100g of *M. nigra* fruit collected from 5 different geographical locations. Highest was found in Swat and lowest was in Peshawar [18].

In 2017 Budiman et al found Flavonoid, Polifenol, Tanin, Monoterpenoid in the phytochemical screening of *M. nigra* ethanol extract [35].

A work done by Moura C A at el 2019 in which one steroid (β-steroid) and two glycosylated flavonoids (Kaempferol 3-O-glycoside and quercetin 3-O-glycoside) were found for the first time in the species collected in Casa Nova [36].

D. Anthocyanins

Anthocyanins may appear red, purple, blue and black. They are water-soluble pigments and odorless. In 2009, work done by Ozgen et al, total monomeric anthocyanins was estimated by pH differential method (Giusti and Wrolstad, 2005) using UV vis spectrophotometer in *M. nigra* and *M. rubra*. He observed that *M. nigra* contains high amount of anthocyanins i.e., 571 µg/g [5]. While a study carried out in Turkey (Ercisli et al 2010) on *M. nigra* and *M. rubra* genotypes. It was observed that the total anthocyanin content of black mulberry ranged from 674 to 787 Cy 3-glu µg/g on per fresh mass basis. Mean value of total anthocyanin content was 719µg/g [20].In 2011, Nauman Khalid et al, total anthocyanin of fresh *M. nigra* juice was recorded 769 µg/g in Cy 3-glu equivalent [21].

In an experiment conducted by Khattak et al (2015) in Pakistan from different geographical origins of plant, analysis of anthocyanins has been shown significant

variations. The analyzed anthocyanin contents ranged from 67.0 to 346.3 mg of Cyanidin-3-glucoside equivalent per 100g on dry weight basis. The highest content of anthocyanin was present from the sample collected from Swat and the lowest content was observed in Peshawar[18].

Okatan et al, 2016 reported total anthocyanin content per fresh weight of *M. nigra* cultivars ranged from 643 (13-BIT-4) and 826 (13-BIT-8) Cy 3-glu mg/g [29].

E. Vitamins

Lale and Ozcagiran (1996) found 16.6 mg/100 ml extract of Vitamin C in *M. nigra* [37].

A work carried out in Turkey by Ercisli et al in 2010 in Black and purple mulberry genotypes where it was found that the average Vitamin C content i.e., 20.79 mg/100ml of *M. nigra* is higher than the *M. rubra*genotypes i.e., 18.87 mg/100 ml [20]. In 2010 Iqbal et al recorded 32 mg/100g Vitamin C content in fresh *M. nigra* fruit. [26] In 2012 Iqbal et al found that Ascorbic acid was found to be maximum followed by *M. nigra* and then the minimum was found in *M. rubra* leaves [17].

In 2010 Imran et al, certain *Morus* species were examined Riboflavin (Vitamin B2), niacin or nicotinic acid (Vitamin B3) and ascorbic acid (Vitamin C) were detected from the selected water-soluble vitamin and found that the *M. nigra* showed low levels of Riboflavin in the samples ranged between (0.040±0.000) mg/100g FW. Niacin was recorded between 1.60±0.10 mg/100g FW. Ascorbic acid was found to be in between 15.37±0.89 mg/100g FW. That means ascorbic acid was recorded higher in *M. nigra* [16].

	(mg/100 g FW)		
Plant name	**Riboflavin**	**Niacin**	**Ascorbic acid**
Morus nigra	0.040±0.000	1.60±0.10	15.37±0.89

Table 10:- Vitamin contents of *Morus nigra* fruit. [16]

In 2011, Nauman Khalid et al, the ascorbic acid content in fresh black mulberry juice was found to be 23.45 mg per 100 ml. [21]

According to Khanzadi Fatima Khattak et al 2015, fruits samples from 5 different places of Pakistan contains Vitamin C ranged from 19.3 to 32.7 mg/100g and the maximum value was recorded from Swabi and the lowest value from the Swat and Peshawar and found that effect of geographical location was not known for *M. nigra* fruits on its Vitamin C content [18].

In 2015 S. P. Eydursan, S. Ercisli et al, they found that the Vitamin C content was in between 10.123 and 16.293 mg/100 g for *M. nigra* genotypes [38].In 2016, Okatan et al found that local black mulberry cultivars have high Vitamin C i.e., between 18.40 (13-BIT-3) and 23.67 (13-BIT-6) mg/ 100 g for *M. nigra* cultivars [29].

In 2018 Volkan Okatan found the total Vitamin C content in the genotypes of *M. nigra* and the highest value was found in 64USA06 (31.34 mg 100 g^{-1}) and the lowest value in 64USA10 (19.73 mg 100 g^{-1})[31].

V. ANTIOXIDANT ACTIVITY

In Ozgen et al 2009 worked on *M. nigra* and *M. rubra* fruits in Turkey. The result showed that the *M. nigra* contain high amount of anthocyanins and phenolic contents, which automatically increase the value and popularity in the market from other mulberries. The phytochemical profile and antioxidant capacity of the fruits shows high attraction of consumers. Three *Morus* species were taken and in the fruits and leaves of the plant antioxidant activity was determined. DPPH scavenging activity of *M. nigra* fruits and leaves showed 3.89±0.04 and 11.79±0.51mmol/100 g GA Eq. respectively [5].

In 2009 Kutlu et al found that the AWE (Acidified water) showed the best DPPH scavenging activity ($P<0.05$) than MWE (Methanol+water) when considered at low concentration (10 and 25µL of extract in the reaction mixture) [22].

In 2012 Arfan et al worked on antioxidant activity of mulberry fruit extracts in which Sugar-free methanolic and acetonic extract of *M. nigra* and *M. alba* were prepared. The observed total antioxidant activity was in methanolic extract was 1.25 mmolTrolox/g and in acetonic extract was 1.19 mmolTrolox/g. It was reported that total antioxidant capacity of SFE of *M. nigra* fruits was greater than the SFE of *M. alba* fruits [25].

Cultivar	**Extraction solvent**	**Total antioxidant activity (mmolTrolox/g)**	**EC_{50} (µg/ml)**
M. nigra	Methanol	1.25±0.06	48±1
	Acetone	1.19±0.04	58±1

Table 11:- Antioxidant capacity of Sugar-free extracts (SFEs) of *M. nigra* fruits [25]

ISSN No:-2456-2165

Khalid et al 2011 has reported antioxidant capacity of black mulberry juice. The antioxidant activity was 14 µmol/g Trolox Equivalent (TE) in the FRAP assay and 20 µmol/g TE in the DPPH assay [21].

Ercisli et al 2010 reported 13.35 TE µmol/g in the black mulberry genotypes in FRAP assay and 18.98 TE µmol/g in DPPH assay. The result showed that black mulberries had high antioxidant capacity than purple mulberries and yield is increased due to the demand [20]

Species	Genotypes	FRAP as TE µmol/g	DPPH as TE µmol/g
M. nigra	MN1	14.11	21.17
	MN2	12.26	16.22
	MN3	13.94	19.87
	MN4	13.10	18.98
Mean value		13.35	18.98

Table 12:- Antioxidant capacity of *M. nigra* genotypes [20]

Kamiloglu et al 2013 performed four methods (ABTS, DPPH, FRAP, CUPRAC) for antioxidant capacity and the result showed extreme variations in the samples of mulberry products. The result showed that Fresh mulberry has highest antioxidant capacity than other mulberry products like mulberry wine, dried mulberry, mulberry ice-cream, mulberry juice, mulberry jam, mulberry syrup, etc [39].

	TAC (mg TEAC/100 g DW)			
Sample	**ABTS**	**DPPH**	**FRAP**	**CUPRAC**
Fresh mulberry	7475.6±740.0	2114.7±104.3	3536.7±106.0	6092.3±637.0
Mulberry wine	4338.8±784.0	1039.5±82.9	1683.1±35.4	4020.6±93.2
Dried mulberry	2686.3±238.3	580.0±23.8	1016.2±26.7	2749.4±304.1
Mulberry ice-cream	1729.3±134.1	402.0±12.1	886.1±20.3	1161.6±84.3
Mulberry molasses	1311.2±144.8	368.5±21.2	458.2±28.1	1218.4±110.3
Mulberry juice	670.5±231.8	313.4±21.3	456.5±35.5	1347.5±32.0
Mulberry jam	333.3±87.51	94.0±4.8	146.6±3.4	491.3±32.0
Mulberry syrup	44.3±7.9	10.9±0.8	19.4±2.7	77.7±5.0

Table 13:- Total antioxidant capacity (TAC) of selected *M. nigra* L. products

In 2014 Sofia et al found that the black-coloured mulberries shows higher antioxidant activity and DN3 genotype of black-coloured mulberry was the more good in terms of health benefits [27].

Sanchez-Salcedo et al 2015 done a work on white and black mulberry genotypes. The result showed the highest antioxidant activity in the black mulberry genotypes than the white mulberry genotypes. The antioxidant was performed by two assay i.e., ABTS assay and DPPH assay. The mean value obtained from the ABTS assay was 3.84 to 20.73 mg trolox DW and in the DPPH assay was 3.62 to 12.91 mg trolox DW [40].

In Khattak et al 2015, methanolic extracts of the *M. nigra* fruits were prepared. The free radical scavenging activity of the methanolic extracts was analyzed by using DPPH radical and results are reported as EC_{50} values (µg/ml). Low value of EC_{50} value shows the sign of high DPPH scavenging activity. DPPH scavenging activity ranged from 46.7 to 458.4µg/ml. Highest DPPH scavenging activity was reported from D. I. Khan and lowest from the Peshawar. Sample collected from Swabi, Swat, and Karak shows activity as 53.7µg/ml, 96.3µg/ml and 162.1µg/ml respectively. The antioxidant activity shows significant variations in EC_{50} value with the effect of geographical distribution of plants originated [18].

In 2018, Yu et al determined antioxidant activity in the leaves of mulberry by FRAP, ABTS and DPPH method and showed ranged from 91.62 to 149.15 µmol AAE/ g DW in FRAP. DPPH activity of leaves ranged from 33.22 to 56.37 µmol TE/g DW and ABTS activity ranged from 51.28 to 70.84 µmol TE/g DW [34].

VI. CONCLUSION

Morus nigra contain high amount of nutritive value in the fruits and leaves. The leaves and fruits contain proximate composition such as moisture, ash, lipid, protein, fibre, total carbohydrate and energy having different proportion. The mineral composition contains potassium, sodium, calcium, magnesium, zinc, iron, manganese, etc. The fruit contains high amount of phenol, alkaloid, flavonoid, anthocyanin and vitamins. The different varieties of *M. nigra* contain different concentration of phytochemicals and antioxidant activities. Effect of different geographical area affects the concentration of the contents present in the fruits and leaves of *M. nigra*. It is concluded that the *M. nigra* have different phytochemicals which shows strong antioxidant action which are helpful in the nutritional research and provides health benefits to Humans

and animals. It also provides great medicinal research and health supplements.

REFERENCES

[1]. Nile, S. H., and Park, S. W. (2014). Edible berries: Bioactive components and their effect on human health. *Nutrition*, *30*(2), 134-144.

[2]. KATSUMATA, F. (1971). Shape of idioblasts in mulberry leaves with special reference to the classification of mulberry trees. *The Journal of Sericultural Science of Japan*, *40*(4), 313-322.

[3]. Zeng, Q., Chen, H., Zhang, C., Han, M., Li, T., Qi, X., and He, N. (2015). Definition of eight mulberry species in the genus *Morus* by internal transcribed spacer-based phylogeny. *PloS one*, *10*(8), e0135411.

[4]. Rahman, A. H. M. M., and Khanom, A. (2013). Taxonomic and ethno-medicinal study of species from Moraceae (Mulberry) Family in Bangladesh Flora. *Research in Plant Sciences*, *1*(3), 53-57.

[5]. Özgen, M., Serçe, S., and Kaya, C. (2009). Phytochemical and antioxidant properties of anthocyanin-rich *Morus nigra* and *Morus rubra* fruits. *Scientia Horticulturae*, *119*(3), 275-279.

[6]. Datta, R. K. (2000). Mulberry cultivation and utilization in India. *FAO animal production and health paper*, 45-62.

[7]. Benavides JE, Hernández I and Esquivel J. FAO-Animal Production and Health Paper, no. 147. Supplementation of grazing dairy cattle with mulberry in Costa Rica. Suplementación de ganadolecherobajopastoreo con moreraen Costa Rica. ISBN. 2000; 92-5-104568-2.).

[8]. Ercisli, S., and Orhan, E. (2007). Chemical composition of white (*Morus alba*), red (*Morus rubra*) and black (*Morus nigra*) mulberry fruits. *Food chemistry*, *103*(4), 1380-1384.

[9]. Majinda, R. R. T., Mazimba, O., andMotlhanka, D. (2011). Antioxidant and antibacterial constituents from *Morus nigra*.

[10]. Absar, N., Yeasmin, T., Raza, M. S., Sarkar, S. K., and Arisaka, F. (2005). Single step purification, characterization and N-terminal sequences of a mannose specific lectin from mulberry seeds. *The protein journal*, *24*(6), 369-377.

[11]. Venkatesh Kumar, R., and Chauhan, S. (2008). Mulberry: life enhancer. *Journal of Medicinal Plants Research*, *2*(10), 271-278.

[12]. Dillard, C. J., and German, J. B. (2000). Phytochemicals: nutraceuticals and human health. *Journal of the Science of Food and Agriculture*, *80*(12), 1744-1756.

[13]. Elmacı, Y., and Altuğ, T. (2002). Flavour evaluation of three black mulberry (*Morus nigra*) cultivars using GC/MS, chemical and sensory data. *Journal of the Science of Food and Agriculture*, *82*(6), 632-635.

[14]. Darias-Martín, J., Lobo-Rodrigo, G., Hernández-Cordero, J., Díaz-Díaz, E., and Díaz-Romero, C. (2003). Alcoholic beverages obtained from black mulberry. *Food Technology and Biotechnology*, *41*(2), 173-176.

[15]. Imran, M., Talpur, F. N., Jan, M. I., Khan, A., and Khan, I. (2007). Analysis of nutritional components of some wild edible plants. *Journal-Chemical Society of Pakistan*, *29*(5), 500.

[16]. Imran, M., Khan, H., Shah, M., Khan, R., and Khan, F. (2010). Chemical composition and antioxidant activity of certain *Morus* species. *Journal of Zhejiang University Science B*, *11*(12), 973-980.

[17]. Iqbal, S., Younas, U., Chan, K. W., Sarfraz, R. A., and Uddin, M. (2012). Proximate composition and antioxidant potential of leaves from three varieties of Mulberry (*Morus* sp.): a comparative study. *International journal of molecular sciences*, *13*(6), 6651-6664.

[18]. Khattak, K. F. (2015). Effect of geographical distributions on the nutrient composition, phytochemical profile and antioxidant activity of *Morus nigra*. *Pakistan journal of pharmaceutical sciences*, *28*(5).

[19]. Koyuncu, F. A. T. M. A., Vural, E., Koyuncu, M. A., and Yildirim, F. (2004). Evaluation of black mulberry (*Morus nigra* L.) genotypes from lakes region, Turkey. *European journal of horticultural science*. *69*(3), 125-131.

[20]. Ercisli, S., Tosun, M., Duralija, B., Voća, S., Sengul, M., andTuran, M. (2010). Phytochemical content of some black (*Morus nigra* L.) and purple (*Morus rubra* L.) mulberry genotypes. *Food Technology and Biotechnology*, *48*(1), 102-106.

[21]. Khalid, N., Fawad, S. A., and Ahmed, I. (2011). Antimicrobial activity, phytochemical profile and trace minerals of black mulberry (*Morus nigra* L.) fresh juice. *Pak. J. Bot*, *43*(6), 91-96.

[22]. KUTLU, T., DURMAZ, G., ATEŞ, B., Yilmaz, I., and ÇETİN, M. Ş. (2011). Antioxidant properties of different extracts of black mulberry (*Morus nigra* L.). *Turkish Journal of Biology*, *35*(1), 103-110.

[23]. Memon, A. A., Memon, N., Luthria, D. L., Bhanger, M. I., andPitafi, A. A. (2010). Phenolic acids profiling and antioxidant potential of mulberry (*Morus laevigata* W., *Morus nigra* L., *Morus alba* L.) leaves and fruits grown in Pakistan. *Polish Journal of Food and Nutrition Sciences*, *60*(1).

[24]. Thabti, I., Marzougui, N., Elfalleh, W., and Ferchichi, A. (2011). Antioxidant composition and antioxidant activity of white (*Morus alba* L.), black (*Morus nigra* L.) and red (*Morus rubra* L.) mulberry leaves. *Actabotanicagallica*, *158*(2), 205-214.

[25]. Arfan, M., Khan, R., Rybarczyk, A., and Amarowicz, R. (2012). Antioxidant activity of mulberry fruit extracts. *International journal of molecular sciences*, *13*(2), 2472-2480.

[26]. Murthy VNY, Ramesh HL, and Lokesh G. Leaf quality evaluation of ten mulberry (*Morus*) Germplasm varieties through phytochemical Analysis. Int. J. Pharm. Sci. Rev. Res. 2013; 21(1), 182-189.

[27]. Sofia, P. G., Ariana-Bianca, V., Corina, C., Gogoasa, I., Corina, G., and Cerasela, P. (2014). Chemical characterisation of white (*Morus alba*), and black (*Morus nigra*) mulberry fruits. *J Horticultural Fore Biotech*, *18*, 133-5.

[28]. Natić, M. M., Dabić, D. Č., Papetti, A., Akšić, M. M. F.,Ognjanov, V., Ljubojević, M., and Tešić, Ž. L. (2015). Analysis and characterisation of phytochemicals in mulberry (*Morus alba* L.) fruits grown in Vojvodina, North Serbia. *Food chemistry*, *171*, 128-136.

[29]. Okatan, V., Polat, M., andAşkin, M. A. (2016). Some physico-chemical characteristics of black mulberry (*Morusnigra* L.) in bitlis. *Scientific Papers-Series B, Horticulture*, *60*, 27-30.

[30]. Gundogdu, M.,Muradoglu, F., Sensoy, R. G., andYilmaz, H. (2011). Determination of fruit chemical properties of *Morus nigra* L., *Morus alba* L. and *Morus rubra* L. by HPLC. *Scientia Horticulturae*, *132*, 37-41.

[31]. Okatan, V. (2018). Phenolic compounds and phytochemicals in fruits of black mulberry (*Morus nigra* L.) genotypes from the Aegean region in Turkey. *Folia Horticulturae*, *30*(1), 93-101.

[32]. Hussain, F., Rana, Z., Shafique, H., Malik, A., and Hussain, Z. (2017). Phytopharmacological potential of different species of *Morus alba* and their bioactive phytochemicals: A review. *Asian Pacific journal of tropical biomedicine*, *7*(10), 950-956.

[33]. Kostiæ, D. A., Dimitrijeviæ, D. S., Mitiæ, S. S., Mitiæ, M. N., Stojanoviæ, G. S., and Živanoviæ, A. V. (2013). Phenolic content and antioxidant activities of fruit extracts of *Morus nigra* L (Moraceae) from Southeast Serbia. *Tropical Journal of Pharmaceutical Research*, *12*(1), 105-110.

[34]. Yu, Y., Li, H., Zhang, B., Wang, J., Shi, X., Huang, J., and Deng, Z. (2018). Nutritional and functional components of mulberry leaves from different varieties: Evaluation of their potential as food materials. *International Journal of Food Properties*, *21*(1), 1495-1507.

[35]. Budiman, A., Aulifa, D. L., Kusuma, A. S. W., and Sulastri, A. (2017). Antibacterial and antioxidant activity of black mulberry (*Morus nigra* L.) extract for acne treatment. *Pharmacognosy Journal*, *9*(5).

[36]. Moura, C. A., Oliveira-Júnior, R. G. D., Oliveira, A. P. D., Silva, A. L., Silva, J., Santos, R. F. D., ... and Costa, E. V. (2019). Chemical constituents from the leaves of *Morus nigra* L. (Moraceae) collected in Casa Nova, Bahia, Brazil. *Revista Virtual de Quimica*, *11*(2), 394-400.

[37]. Lale, H., andOzcagiran, R. (1996). A study on pomological, phenologic and fruit quality characteristics of Mulberry (*Morus* sp.) species. *Derim*, *13*(4), 177-182.

[38]. Eyduran, S. P., Ercisli, S., Akin, M., Beyhan, O., Geçer, M. K., Eyduran, E., and Erturk, Y. E. (2015). Organic acids, sugars, vitamin C, antioxidant capacity, and phenolic compounds in fruits of white (*Morus alba* L.) and black (*Morus nigra* L.) mulberry genotypes. *Journal of Applied Botany and Food Quality*, *88*.

[39]. Kamiloglu, S., Serali, O., Unal, N., and Capanoglu, E. (2013). Antioxidant activity and polyphenol composition of black mulberry (*Morus nigra* L.) products. *Journal of Berry Research*, *3*(1), 41-51.

[40]. Sánchez-Salcedo, E. M., Mena, P., García-Viguera, C., Martínez, J. J., and Hernández, F. (2015). Phytochemical evaluation of white (*Morus alba* L.) and black (*Morus nigra* L.) mulberry fruits, a starting point for the assessment of their beneficial properties. *Journal of functional foods*, *12*, 399-408.