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Syzygium Cumini L. Seed A Potent Source of Fiber, Protein and Natural Antioxidants

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ABSTRACT: *Syzygium cumini L. seeds have been documented in traditional medicine in Pakistan. The current research was aimed to assess the physicochemical characteristics, polyphenols and antioxidants of S. cumini seed. The physical characteristics such as the color of S. cumini seed were white to pink, the shapes resembled to oblong and coarse texture. The length, width and weight of fresh S. cumini seed were found to be (18.20±0.81mm, 11.05±0.41mm and 1.80±0.16g), respectively while the color of dried S. cumini seeds were light brown to brown, rhombus in shape with loutish texture. The average length, width and weight of dried S. cumini seeds were 16.47±0.45; 10.14±0.25 mm and 0.75±0.12 g respectively. S. cumini seeds powder were evaluated for their chemical composition e.g. carbohydrate, protein, fat, crude fiber, moisture content and ash (77.27±2.50, 3.62±0.30, 6.25±0.55, 10.30±1.20 and 1.55±0.11 g/100g), respectively. Quantitative analysis of total phenolic content was performed it was found that the methanolic and water extract had 52±1.65 and 40±1.25 mg GAE/g content. Free radical scavenging activity was also evaluated to estimate the antioxidant property of extract. Among tested extracts maximum % inhibition 96.61±1.90% was found in methanol extract and 69.30±1.56% in water extract, while BHT has % inhibition 50.70±1.32% at concentration 100 µg/ml. Similarly in reducing power activity assay the maximum absorbance 1.4704±0.05 was shown by methanol extract and 1.2075±0.03 in water extract of S. cumini seed powder respectively which was compared with BHT (0.9207±0.02). Therefore, it was concluded that these Syzygium Cumini L. seeds traditional medicinal plants provide a good source of nutrients, namely protein, fiber and natural antioxidants.*

Key words: *Syzygium cumini* L., Fiber, Polyphenols, DPPH, RPA, Antioxidants

INTRODUCTION

The significance of herbal medicines has increased the demand due to their least toxic side effects unlikely allopathic therapies. An appropriate analysis is crucial to investigate the safety and potency of herbal medicine. In this regard WHO focused to make sure the quality control measures by using modern technologies to apply particular standards and specifications (Chitnis et al., 2012). *Syzygium Cumini* L. is cherished for the colour, flavour and taste of its fruit. It is a very large tropical tree belonging to the *Myrtaceae* family, known by the synonym jambolan or black plum (Jagetia, 2017). It has chemo-preventive, radio-protective, anti-neoplastic properties and may confer medicinal value (Gajera et al., 2017; Pallavi and Sukumar, 2021). Domestically and industrially *S.* c*umini* fruit was used abundantly, particularly to produce its juice and as a constituent in wine. Seeds were obtained as a by-product after mass utilization and needs to dispose off (Patil et al., 2012). Seeds make up the 20% weight of fruit and contain high fiber content so utilized as cattle feed. A high amount of polyphenols were reported in seeds so can be a good source of antioxidant agent (Fig. 1).

Fig. 1. *Syzygium cumini* Lam seeds and its powder

The seeds of *S.* c*umini* are sour, acrid, nourishing, and contain chemical components such as jambolan, isoquercetin, kaempferol corilagin, 3,6-hexahydroxy dibenzoylglucose, glucoside, quercetin, myricetin, 1 -Gallo-glucose, β-glutaryl, 4,6-hexahydroxydibenzoyl-glucose and 3-gallo-glucose (Swami et al., 2012). Seed alkaloids jambosine and glycoside antimellin have a delaying effect on the conversion of starch to sugars and ellagic acid control blood pressure (Bijauliya et al., 2017). These seeds are reported to be rich in flavonoids, a well-known antioxidant with free radical scavenging and protective effects (Loganayaki and Manian, 2010; Faria et al., 2011; Mercado et al., 2021). *S. cumini* seed has many pharmacological properties, such as antibacterial effect (Banerjee et al., 2011; Meshram et al., 2011), anti-inflammatory (Kumar et al., 2008; Modi et al., 2010), gastric ulcer (Chaturvedi et al., 2007), it also acts as a liver stimulant, digestive, cooling and blood purifying agent. The seeds are also recognized for their anti-hyperglycemic activity and have been shown to impart a reducing effect in type 2 diabetic patients by lowering fasting glucose levels (Ayya et al., 2015; Sidana et al., 2017), by a Jamboline glycoside, which helps in the maintenance of glucose levels as in the normal limits (Kalse et al., 2016). Several bio-molecules were also reported in seeds such as carbohydrates, vitamins, minerals, and fibers. The main sugar polymers are glucose and fructose was reported (Prakruthi et al., 2021). In pharmaceutical and cosmetic industries *S. cumini* seeds can be a natural and economical source of bioactive components and food-supplemented dietary antioxidants.

The significance of antioxidants is well known in the biosphere, recently becoming more evident with circular economy and recycling methodologies. Antioxidants are compounds that inhibit oxidation, a chemical reaction that can produce free radicals and chain reactions that may damage the cells of organisms. Free radicals are molecules produced when the body breaks down food or when exposed to tobacco smoke or radiation. Natural antioxidants are widely distributed in food and medicinal plants. These natural antioxidants, especially polyphenols and carotenoids, exhibit a wide range of biological effects, including anti-inflammatory, anti-aging, anti-atherosclerosis, and anticancer (Raza et al., 2020; Ismat et al., 2022). The effective extraction and proper assessment of antioxidants from food and medicinal plants are crucial to explore the potential antioxidant sources and promoting their application in functional foods, pharmaceuticals, and food additives (Natasa et al., 2021). Several synthetic antioxidants were used such as tert-butyl hydroquinone (TBHQ), butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA) and propyl gallate (PG), piroxicam and meloxicam **(**Samra et al., 2022). These synthetic antioxidants have many side effects reported such as liver damage and act as carcinogen (Grice, 1988; Jagesar, 2019), so there is need to isolate natural antioxidants from indigenous sources. Undeniably, in recent years, many studies emphasized the use of plant based by-products to produce natural and eco-friendly antioxidants which can be effective alternative to synthetic antioxidants (Cama et al., 2010; Krishnaiah et al., 2011; Vayupharap and Laksanalamal, 2012), keeping view this we use *S. Cumini* (jamun) seed which is abundantly available in Pakistan. Therefore the main objective of the present research was to extraction/isolation & determination of natural antioxidants from *S. cumini* seed along with estimation of its fiber, protein and polyphenols.

MATERIALS AND METHODS

Chemicals and instruments required

Methanol, Folin-ciocalteau reagent, Sodium carbonate (Na_2CO_3), 2,2-Diphenyl picryl hydrazyl (DPPH), and Gallic acid were obtained from Sigma-Aldrich (St. Louis, USA). Instruments used were Spectrophotometer UV-VIS 1700 (Shimadzu, Japan) to measure absorbance, and a centrifuge machine (3000 System) Centurarian Scientific (Germany).

Syzygium cumini* L. *seed powder preparation

Ripe, disease-free and healthy *S. cumini* fruit was collected from the PCSIR Labs complex (July 2021 season) Lahore, Pakistan and identified by botanists. It was cleaned, washed and passed through a pulper to separate the seeds from the pulp. The seeds were then washed in water and dried for 48 hours at 60°C in a hot air dryer. After completely drying it was ground in a grinder to a fine powder with an average particle size of 0.60 mm. The seed powder was stored in an airtight container at -20 ºC until further use.

Proximate Composition

In order to gauge the proximate composition of *S. cumini* seed methods described in AOAC (2016) were used. Analysis was done for crude fat, ash, moisture content, carbohydrates, proteins, and crude fiber.

Total phenols

Total phenolics were estimated by standard analysis of Singleton *et al*., (1965) [27]. 0.1 g of the sample was dissolved in 50 ml of methanol and water. 0.2 ml from the above solution was mixed with water to the make volume of 3 ml and wait for three minutes after adding 0.5 ml of Folin reagent then added 2.0 ml of sodium carbonate (20%) solution and incubate the mixture in the dark for 30 min and measure the absorbance by using a spectrophotometer (UV-vis: 1700, Shimazdu, Japan) at 760 nm. From the standard curve of Gallic acid, concentrations of polyphenols in the extracts were estimated and derived. Results are shown as milligrams of gallic acid equivalents per milligram (mg GAE/g).

Antioxidant study by DPPH assay

Water and methnolic extracts of *S.* c*umini* seeds were subjected to free radical scavenging activity measured by using the method of Brand-Williams (1995) with slight modifications (Saeed et al., 2021). Methanolic solution (0.1 mM) of 2,2-diphenyl-1-picryl-hydrazine (DPPH) was prepared. In different concentrations (10–100 µg/ ml) of extract 3 ml of DDPH solution was added while Butylated hydroxytoluene (BHT) was used as positive control to compare readings. After 30 minutes of incubation in dark absorbance was taken at 517 nm in triplicates. Scavenging capacity was measured by using following equation:

Antioxidant activity (% Inhibition) = $[(A_c-A_s)/A_c] \times 100$

Where A_c is the absorbance of the $DPPH^{\cdot}$ solution (control) and A_s is the absorbance of sample.

Reducing power determination

In order to evaluate the reducing power of *S.* c*umini* powder extracts a method described by Oyaizu (1986) was used after some modifications. In different concentrations of the sample, 2.5 ml of phosphate buffer (0.2 M) with pH 6.6 and 1% potassium ferricyanide (2.5 ml) was added. The mixture was heated for 20 min at 50 °C in the water bath. After cooling, the mixture at 22°C -25°C (2.5 ml) of trichloroacetic acid (10%) was added and centrifuged for 10 minutes at 3000 rpm. Supernatants were obtained and mix it with distilled water (2.5 ml) and 0.5 ml of ferric chloride (0.1%) solution. Incubate it for 10 minutes and wait for the reaction completion. Absorbance was taken at 700 nm to measure the reducing capacity of extracts and standard BHT. A higher absorbance value indicates the higher reducing potential of extracts.

Statistical Analysis

Except for fiber analysis, data analysis was obtained from triplicate samples. Statistical analysis was performed using the statistical analysis system 9.1.3 software package (Seeram, 2008). A two-sample t-test was used to compare means in mean ± standard deviation value were expressed.

RESULTS AND DISCUSSION

Physical characteristic of dried S. cumini seeds

Physical characteristics aid in the visual identification of seeds. Therefore, some physical properties were observed mentioned in Table 1. The results indicated that the color of fresh *S. cumini* seeds were white to pink, oblong in shape and coarse texture, while the color of dried *S. cumini* seeds were light brown to brown, rhombus in shape with loutish texture. The average length, width and weight of fresh *S. cumini* seeds were 18.20±0.81 (mm), 11.05±0.41 (mm) and 1.80±0.16 respectively and the texture was relatively coarse. While the average length, width and weight of dried *S. cumini* seeds were 16.47±0. 52 (mm), 10.14±0.25 (mm) and 0.75±0.12 g respectively and the texture was relatively coarse. The results of current study were relatable to another research by Ghosh et al. (2017).

Table. 1. Physical characteristics of fresh and dried *S. cumini* seed

Sr. No.	Parameters	Observations	
		Before Drying (Fresh)	**After Drying**
1	Color	White to pink	Light brown to brown
2	Shape	Oblong	Rhombus
3	Texture	Coarse	Loutish
4	Length (mm)	18.20 ± 0.81	16.47 ± 0.52
5	Width (mm)	11.05 ± 0.41	10.14 ± 0.25
6	Weight (g)	1.80 ± 0.16	0.75 ± 0.12

Data are represented ± standard deviation

Proximate composition of S. cumini seed powder

Proximate composition of *S. cumini* seed was done to evaluate quantitative analysis of protein, carbohydrate, crude fat, crude fiber, ash and moisture as 3.62±0.30, 77.27±2.50, 1.01±0.06, 6.25±0.55, 1.55±0.11 and 10.30±0.90, respectively (Table 2). These results demonstrate consistent with previous findings reported by Desai et al. (2018), who described that *S. cumini* seeds consist of 14.31% moisture, 3.01% protein, 1.02% crude fat, 4.21% crude fiber and 2.87% ash. Previous studies have reported that *S. cumini* seeds have moisture content of 5.3% to 16.34%, protein content of 1.97% to 3.84%, ash content of 1.51% to 2.87%, fat content of 0.65% to 1.02%, and crude fiber content of 4.21% % to 7.01% (Akhtar et al., 2016; Kshirsagar et al., 2019; Pallavi and Sukumar, 2021). Composition of seed in this study was closely related to earlier study except the protein, fiber and ash contents exhibiting varied values with respect to *S. cumini* seed content such as 1.98, 4.27 and 2.46, respectively (Rafique et al., 2018). These differences may stem from differences in varieties, agricultural practices and climatic conditions (Ahmad et al., 2015; Raman et al., 2020).

Table 2. Nutritional facts of dried *S. cumini* seed powder

Sr. No.	Parameters	Values (g/100g)
1	Moisture (%)	10.30 ± 0.90
2	Ash (%)	1.55 ± 0.11
3	Crude fat (%)	1.01 ± 0.06
4	Crude fiber (%)	6.25 ± 0.55
5	Crude protein (%)	3.62 ± 0.30
6	Carbohydrate (%)	77.27 ± 1.5
7	Energy (Kcal/100g)	332.65 ± 2.7

± standard deviation

Total polyphenols

Available total phenolic content (TPC) values in (mg GAE/g) for *S. cumini* seeds include: 52±1.65 for the methanolic seed extract and 40±1.25 for the water extract, which seem to be a better source of total phenols. TPC was higher in the results of Kapor et al. (2015), who described hot-air dried *S. cumini* seeds had 3.67±0.49 g GAE/100, while Balyan and Sarkar (2017) had a lower content. Indicates high total polyphenol content i.e. 415 mg gallic acid equivalents/g *S. cumini* seed dry extract. These results are in line with Sheikh et al. (2011), Rydlewski et al. (2017) and Arivalagan et al. (2021). Polyphenols were bioactive component of plants and reported for their antioxidant activity as they demonstrate reducing potency by acting as a reducing agent. Those bioactive biomolecules were act as hydrogen donors and exhibit antioxidant actvity (Phuyal et al., 2020). Due to the presence of polyphenols in *S. cumini* seed have shown higher antioxidant capacities (Singh et al., 2016; Swami and Kalse, 2020). Finding of current study supported the beneficial aspect of

S. cumini seeds due to the presence of polyphenols.

Antioxidant Activity

I. DPPH Assay

The antioxidant activities of methanol and water extracts of *S. cumini* seeds were evaluated by the scavenging antioxidant (DPPH) method. At different concentrations of extract average, scavenging activity was seen as shown Fig. 2. Percentage inhibition (% I) values ranged from 28.40 to 92.60 % for methanol seed extract, 20.50 to 72.80 % for water extract, and 16.32 to 50.70 % for BHT and followed the order of effectiveness: methanol extract > water extract > BHT at same concentration. Present data is consistent with that of Hammam et al. (2019), who investigated the free radical scavenging activity of water, methanolic and acetone extract of *S. cumini* seeds and leaves and suggested that methanolic extracts have higher antioxidant activity. Similar results were obtained by Elizabeth Margaret et al. (2015) and Sehwag and Madhusweta, (2016). Antioxidants interact with DPPH by transferring electrons or hydrogen atoms to DPPH, thereby neutralizing free radical species (Rohadi et al., 2017; Wasswa et al., 2019). The level of free radicals (DPPH) neutralized is reflected by the % inhibition. Due to this neutralization, the color of the reaction mixture changed from purple to yellow which confirmed by decrease in absorbance at 517 nm (Mercado et al., 2021). In a similar study it was found that antioxidant activity was maximum in *Centella asiatica* (in aqueous) and *Spheranthus indicus* (in methanol) extracts (Yasmin et al., 2020).

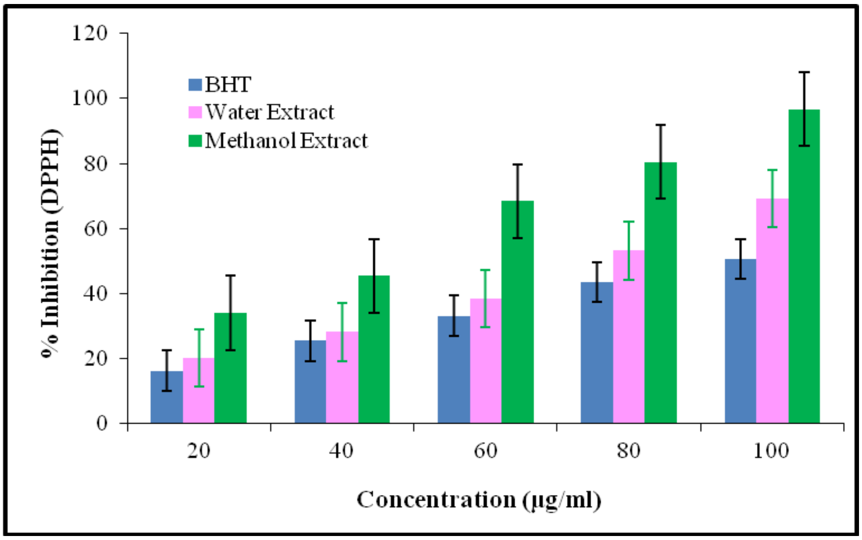

Fig. 2. % Inhibition of water, methanolic extract of *S. cumini* seed and BHT by DPPH assay

II. Reduce Power Assay

Higher reducing potency of the methanolic extract of *S. cumini* seed at a concentration of 100 µg/ml was observed than its water extract. The reducing activity of the methanol extract of *S. cumini* seed with an absorbance of 1.6704±0.05 was the highest and the reducing activity of water extract with an absorbance of 1.2075±0.02 was lower. The results showed that a greater degree of inhibition could be achieved with increasing concentrations of both extracts and thus demonstrate reducing activity in a concentration-dependent manner (Fig. 3). Reducing activity of standard BHT (1.3426±0.03 at 100µg/ml) was not as much effective as compared to our experimental sample. During the determination of the reducing ability of the extract, Fe^{3+} was converted to Fe^{2+}, which then reacted with $FeCl_2$ and formed complex ferrous iron (Wajiha and Qureshi 2021). As in the current study, Ahmad et al. (2020) reported that the reducing power of the methanol/water (80:20, v/v) extract of *S. cumini* seeds was enhanced with increasing extract concentration. Numerous reports have demonstrated a relative direct correlation between the reducing potency and antioxidant potential of various plant extracts (Munira et al., 2018; Pavai et al., 2019; Yadav et al., 2020). Our present results suggested that *S. cumini* seed extract can terminate the free radical chain reaction by donating electrons to free radical species and converting them to neutralized stable form.

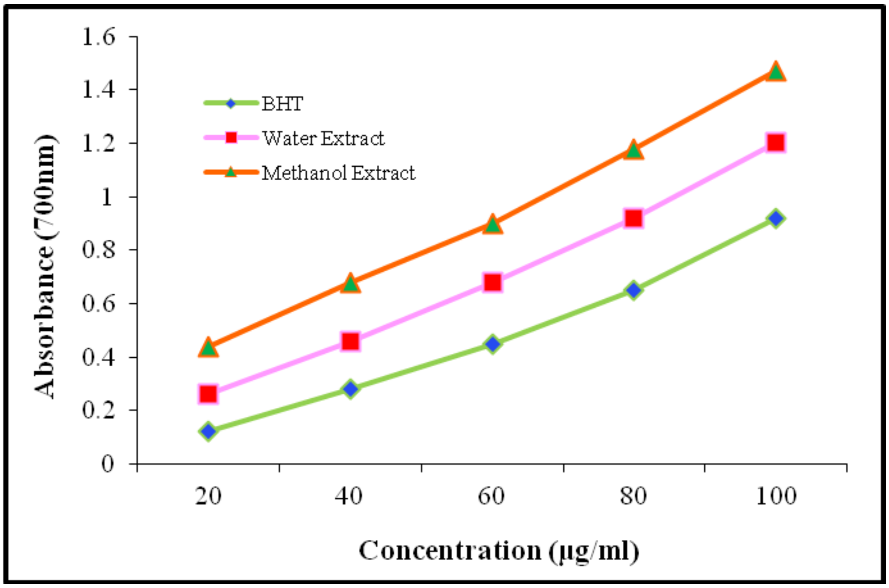

Fig. 3. Reducing potential of methanol and water extract of *S. cumini* seed and BHT

CONCLUSION

It is concluded that, *S. cumini* seeds contained a higher amount of fiber, protein and natural antioxidants. Methanolic extracts of *S. cumini* seeds had significantly ($p<0.05$) more polyphenols and antioxidant capacity in both assays, compared to water extracts. Therefore, this study showed that commonly discarded seeds can be used as natural antioxidants as an alternative to artificial ones.

REFERENCES

1. Ahmad R, Muhammad UA, Tanzeela N, Saeed AQ, Riaz H, Muhammad NS (2015). Proximate composition of *S. cumini* (*Syzygium cumini*) fruit and seed. J. Agri. and Env. Sci. 15(7): 1221-1223.
2. Ahmed S, Ahmed KS, Hossain MS, Azam MS, Rahman M, Hoque MM (2020). Proximate composition and antioxidant activity of *Syzygium cumini* fruit grown at different regions in Bangladesh. Food Res. 4(5): 1693 – 1699.
3. Akhtar M, Randhawa MA, Iqbal Z (2016). Nutritional, Therapeutic and Food Applications of Jamum (*Syzygium cumini*). Canad. J. Food Sci. Tech. 1(1): 1-8.
4. AOAC (2016). Official Methods of Analysis 21st ed. Gaithersburg, Maryland, U.S.A. Ass. Offic. Analy Chem.
5. Arivalaga, M, Priyanka DR, Rekha A (2021). Optimization of methodology for the extraction of polyphenolic compounds with

antioxidant potential and α-glucosidase inhibitory activity from *S. cumini* (Syzygium cumini L.) seeds. J. Horti. Sci. 16(1): 26-35.

6. Ayya N, Nalwade V, Khan TN (2015). Effect of *S. cumini* (Syzygium cumini L.) seed powder supplementation on blood glucose level of type-II diabetic subject. Food Sci. Res. J. 6(2): 353-6.
7. Balyan U, Sarkar B (2017). Aqueous extraction kinetics of phenolic compounds from *S. cumini* (*Syzygium cumini* L.) seeds. Int. J. Food Pro. 20(2): 372–389.
8. Banerjee J, Narendhirakannan RT (2011). Phytochemical analysis, antibacterial, *in vitro* antioxidant and cytotoxic activities of ethanolic extract of *Syzygium cumini* (L.) seed extract. Int. J. Pharm Sci. Res. 2: 1799-1806.
9. Bijauliya RK, Alok S, Singh M, Mishra SB (2017). Morphology, phytochemistry and pharmacology of *Syzygium cumini* (Linn.)-an overview. Int. J. Pharm. Sci. Res. 8(6): 2360-2371.
10. Brand-Williams W, Cuvelier ME, Berset C (1995). Use of free radical method to evaluate antioxidant activity. LWT Food Sci. Tech. 28: 25-30.
11. Cama, M, Hisil Y (2010). Pressurised Water Extraction of Polyphenols from Pomegranate Peels. Food Chem. 123: 878–885.
12. Chaturvedi A, Kumar MM, Bhawani G, Chaturvedi H, Kumar M, Goel RK (2007). Effect of ethanolic extract of *Eugenia jambolana* seeds on gastri ulceration and secretion in rats. Ind. J. Phy. Pharm. 51: 131-140.
13. Chitnis KS, Palekar SB, Koppar D.R, Mestry DY (2012). Evaluation of *syzygium cumini* linn. Seed formulations available in the market using spectrophotometric and chromatographic techniques. Int. J. Pharm. Sci. Res. 3(2): 556-560.
14. Desai GB, Sawate AR, Taur AT, Thorat PP, Deshmukh NM, Kshirsagar RB and Patil BM (2018). Effect of fortification of *S. cumini* Seed (*Syzygium cumini)* powder on nutritional and sensory quality of herbal multigrain cookies. Int. J. Chem. Stud. 6(2): 1083-1087.
15. Margaret E, Shailaja AM, Venugopal VR (2015). Evaluation of Antioxidant Activity in Different Parts of *Syzygium cumini* Linn. Int. J. Curr. Microbiol. App. Sci. 4(9): 372-379.
16. Faria AF, Marques MC, Mercadante AZ (2011). Identification of

bioactive compounds from jambolao (*Syzygium cumini*) and antioxidant capacity evaluation in different pH conditions. Food Chem.126: 1571-1578.

17. Gajera HP, Gevariya SN, Hirpara DG, Patel SV, Golakiya BA (2017). Antidiabetic and antioxidantfunctionality associated with phenolic constituents from fruit parts of indigenous black *S. cumini* (*Syzygiumcumini* L.) landraces. J. Food Sci. Technol. 54 (10): 3180-3191.
18. Ghosh P, Pradhan RC, Mishra S, Patel AS, Kar A (2017). Physicochemical and Nutritional Characterization of *S. cumini* (*Syzygium Cuminii*). Cur. Res. Nutri. Food Sci. 5(1): 25-35.
19. Grice HP (1988). Enhanced Tumour Development by Butylated Hydroxyanisole (BHA) from the Prospective of Effect on Forestomach and Oesophageal Squamous Epithelium. Food and Chem. Toxi. 26: 717–723.
20. Hammam MA, El-Kadousy SA, El-Sayed SM, Rashed RM (2019). Hypolipidmic effect of *S. cumini* (*syzygium cumini*). Menoufia J. Agric. Biotech. 4: 61 – 72.
21. Ismat K, Khalid M, Mughal AA (2022). Comparative study of antioxidative properties of Jhelum valley fruits. Pure and App. Biol. 11 (3): 861-870.
22. Jagessar RC (2019). Antioxidant properties of plant extracts. Edelweiss Phar. Analy. Acta. 1: 18-21.
23. Jagetia GC (2017). Phytochemical composition and pleotropic pharmacological properties of *S. cumini*, Syzygium cumini Skeels. J. Explor Res. Pharmacol. 2(2): 54–66.
24. Kalse SB, Swami SB, Sawant AA, Thakor NJ (2016). Development and quality evaluation of *S. cumini* seed powder fortified biscuit using finger millet. J. Food Pro. Tech. 7: 2-3.
25. Kapoor S, Ranote PS, Sharma S (2017). Bioactive Components and Quality Assessment of *S. cumini* (*Syzygium cumini L.*) Powder Supplemented Chapatti. Ind. J. Sci. Tech. 8(3): 287–295, 2015.
26. Krishnaiah D, Sarbatly R, Nithyanandam RA (2011). Review of the Antioxidant Potential of Medicinal Plant Species. Food and Bioprod. Proc. 89: 217–233.
27. Kshirsagar RB, Desai GB, Sawate AR, Deshmukh NM (2019). Physico-chemical and nutritional properties of *S. cumini* (*Syzygium cumini*) seed. J. Pharm. Phytochem. 8(2): 211-213.

28. Kumar A, Ilavarasan R, Jayachandran T, Deecaraman M, Kumar RM, Aravindhan P, Padmanabhan N, Krishan MRV (2008). Anti-inflammatory activity of *Syzygium cumini* seed. Afr J Biotechnol 7: 941-943.
29. Loganayaki N, Manian S (2010). *In vitro* antioxidant properties of indigenous underutilized fruits. Food Sci. Biotech. 19: 725-734.
30. Mercado CJG, Atienza LM, Sunico DJA, Maniwang JRC, Gapasin RP, Gaban PJV, Castillo-Israel K, Ann T, Cena-Navarro R, Estacio MAC (2021). Antioxidant, Anti-obesity, and Lipid-lowering Properties of Philippine "Duhat"(*Syzgium cumini* L. Skeel) Freeze-dried. Philip. J. Sci. 150 (4): 793-808.
31. Mercado CJG, Atienza LM, Sunico DJA, Maniwang JRC, Gapasin RP, Gaban PJV, Castillo-Israel KAT, Cena-Navarro R, Estacio MAC (2021). Antioxidant, Anti-obesity and Lipid-lowering Properties of Philippine "Duhat"(*Syzgium cumini* L. Skeel) Freeze-dried Fruit Flesh. Philip. J. Sci. 150 (4): 793-808.
32. Meshram GA, Yadav SS, Shinde D, Patil B, Singh D (2011). Antibacterial study and effect of ethanolic extracts of *Syzygium cumini* seeds powder on glucoamylase *in vitro*. J. Pharma. Sci. Res. 3: 1060-1063.
33. Modi DC, Patel JK, Shah BN, Nayak BS (2010). Antiinflammatory activity of seeds of *Syzygium cumini* linn. J. Pharm. Educ. Res. 1: 68-70.
34. Munira M, Uddin M, Islam M, Aktar K, Muhit A (2018). Evaluation of antioxidant, Cytotoxic, antibacterial and thrombolytic activity of the methanolic extracts of *Ficus racemosa* Fruits. J. Comple. Alter. Medi. Res. 5: 1-13.
35. Natasa I, Janja K, Tadeja KS, Anton I (2021). Antioxidant Activity of Elderberry Fruits during Maturation. Agric. 11(6): 555.
36. Oyaizu M (1986). Studies on products of browning reactions: antioxidative activities of products of browning reaction prepared from glucosamine. Jap. J. Nutri. 44: 307–315.
37. Pallavi JK, Sukumar M (2021). Isolation of low molecular weight carbohydrates from seeds of *Syzygium cumini* and an investigation in to their prebiotic properties. Int. J. Life Sci. Pharma. Res. 11(2): 84-90.
38. Patil SS, Thorat RM, Rajasekaran P (2012). Utilization of *S. cumini* Fruit

for production of red wine. J. Adv. Lab Res. Bio. 2(2): 200–203.

39. Pavai IS, Selvi BT, Anisha R (2019). Antimicrobial and antioxidant activity of the golden shower, *Cassia fistula*. Bio. Biotech. Res. Comm. 12: 1-14.
40. Phuyal N, Jha PK, Raturi PP, Rajbhandary S (2020). Total Phenolic, Flavonoid Contents, and Antioxidant Activities of Fruit, Seed, and Bark Extracts of *Zanthoxylum armatum* DC. The Sci. World J. 1-7.
41. Prakruthi DJ, Manu N, Roopashree TS, Anitha S (2021). Evaluation of Antioxidant and Antiproliferatory Activity of Syzygium Cumini Root Extracts for Possible Anticarcinogenic Potentials. Res. Rev. J. Pharm. and Phytochem. 9(4): 58-65.
42. Rafique A, Inam-ur-Raheem M, Asghar A, Shafqat Rasool M (2018). Assessing the Therapeutic Potential of *Cinnamon zeylanicum* (Cinnamon) and *Syzygium cumini* (jamun) seeds on hyperglycemia in diabetic rats. J. Nutr. Sci. Res. 3: 133.
43. Raman RK, Santhalakshmy S, Bosco SJD, Ganguly S (2020). Phytochemical properties of spray dried *S. cumini* juice powder as affected by encapsulating agents. J. Pharmaco. Phytochem. 9(3): 599-602.
44. Raza MA, Malik MS, Azam M (2020). Impact of natural antioxidants on biological systems. Lahore Garri. Uni. J. Life Sci., 4(02): 139-162.
45. Rohadi, Raharjo S, Falah, II, Santoso U (2017). Methanolic extract of Java Plum (*Syzygium cumini* Linn.) seeds as a natural antioxidant on lipid oxidation of oil-in-water emulsions. Int. Food Res. J. 24(4): 1636-1643.
46. Rydlewski AA, de Morais DR, Rotta EM, Claus T, Vagula JM, da Silva MC, Junior OOS, Visentainer JV (2017). Bioactive Compounds, Antioxidant Capacity, and Fatty Acids in Different Parts of Four Unexplored Fruits. J. Food Qty. 1-9.
47. Saeed MK, Nisa A, Ahmad I, Hina S, Zahra N, Kalim I, Masood S Quratulain S (2021). Physico-chemical Analysis, total polyphenolic content and antioxidant capacity of yellow dye extracted from *Curcuma longa*. Pak. J. Sci. Ind. Res. B: Biol. Sci. 64B (1): 25-29.
48. Samra MM, Hafeez H, Azam M, Imran M, Basra MAR (2022). Bi (III) complexes of piroxicam and

meloxicam: Synthesis, characterization, antioxidant, anti-inflammatory and DNA cleavage studies. J. Mol. Structr, 29:134234.

49. Seeram N. P (2008). Berry Fruits for cancer prevention: Current status and future prospects. J. Agri. and Food Chem. 56: 630-635.
50. Sehwag S, Madhusweta Das (2016). Composition and antioxidant potential of *S. cumini* (*Syzygium cumini* L.) from eastern India. Asian J. Biochem. Pharm. Res. 6*:* 2231-2560.
51. Sheikh SA, Shahnawaz M, Nizamani SM, Bhanger MI, Ejaz Ahmed (2011). Phenolic contents and antioxidants activities in Jamman fruit (*Eugenia jambolana*) products. J. Pharma. Nutri. Sci. 1: 41-47.
52. Sidana S, Singh VB, Meena BL, Beniwal S, Singh K, Kumar D, Singla R (2017). Effect of *Syzygiumcumini* (Jamun) seed powder on glycemic control: A double-blind randomized controlled trial. J. Med. Soc. 31(3): 185-9.
53. Singh JP, Kaur A, Singh N, Nim L, Shevkani K, Kaur H, Arora D (2016). *In vitro* antioxidant and antimicrobial properties of jambolan (*Syzygium cumini*) fruit polyphenols. LWT - Food Sci. Tech. 65: 1025-1030.
54. Singleton VL, Rossi JA (1965). Use of free radical method to evaluate antioxidant activity. Amer. J. Enol. Viticul. 16: 144-158.
55. Swami SB, Kalse SB (2020). Bioactive compounds in *S. cumini* (*Syzygium cumini* L.) Skeels. Pharma. Inn. J. 9(11): 161-167.
56. Swami SB, Thakor NSJ, Patil MM, Haldankar PM (2012). Jamun (Syzygium Cumini (L.): A review of its food and medicinal uses. Food Nutri. Sci. 3: 1100–1117.
57. Vayupharap B, Laksanalamal V (2012). Recovery of antioxidant from grape seeds and its application in fried food. J. Food Pro. Tec. 3(4): 1-6.
58. Wajiha, Qureshi NA (2021). In vitro anticoccidial, antioxidant activities and biochemical screening of methanolic and aqueous leaves extracts of selected plants. Pak. Vet. J. 41(1): 57-63.
59. Wasswa M, Tumuhimbise1 GA and Acham H (2019). Chemical characterisation of pulp, seed powder and a readyto-drink juice produced from *Syzygium cumini* fruit Makerere. Uni. J. Agri. Env. Sci 8: 44 – 57.

60. Yadav N, Pal A, Sihag S, Nagesh CR (2020). Antioxidant Activity Profiling of Acetonic Extract of jamun (*Syzygium cumini*L.) seeds in different *in-vitro* models. Ope. Food Sci. J. 12: 3-8.

61. Yasmin T, Azam M, Ummaimah MARB (2020). Bioactive compounds, antioxidant, and antineoplastic activities of Asian herbs. Chula Med. J. 64(2):191-202