A Study on Physico-chemical and Nutritional Properties of *Paras*VarietyJamun (*Syzygium cumini* L.) Leaves

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ABSTRACT

This study concentrated on the complete physico-chemical characterisation of *paras* variety fresh Jamun (*Syzygium cumini* L.) leaves, which are a rich resource in traditional medicinal and culinary uses. Physical parameters such as dimensions (length, width, thickness), mass, bulk density and colour (L*, a*, b*) were measured, yielding dimensions ranging from 151.61 to 174.10 mm in length, 67.20 to 97.57 mm in width, and 0.28 to 0.33 mm in thickness. These leaves had a greenish to dark green colour with mean L*, a* and b* values of 30.26 ± 5.94, -5.45 ± 3.02, and 9.21 ± 5.02, respectively. The chemical examination showed moisture content (59.56 ± 1.61%, d.b.), ash content (1.96 ± 0.03%), crude fibre (7.96 ± 0.28%), crude fat (0.58 ± 0.08%), protein (5.48 ± 0.08%), and carbohydrates (28.52 ± 1.59%). The leaves have high total phenolic content (37.48 ± 2.57 mg/100 g) and antioxidant activity (5.87 ± 0.17%). These results highlight the nutritional and therapeutic potential of jamun leaves, hence endorsing their use in a range of health-promoting applications.

Keywords:*Physico-chemical Properties, Paras Variety, Jamun Leaves, Medicinal*

INTRODUCTION

Jamun (*Syzygium cumini* L.), also known as the Indian blackberry, is an underutilized tropical fruit renowned for its medicinal and therapeutic properties. Globally, the estimated production of Jamun is 13.5 million tons per annum, with India contributing approximately 15.4%, making it the second-largest producer in the world. The significance of Jamun extends beyond its fruit, as its leaves hold substantial value in Ayurvedic medicine, particularly in treating digestive disorders, liver diseases such as necrosis and fibrosis, and conditions like diarrhea and ulcers. The leaves biochemical and phytochemical constituents, including polyphenols, impart anti-cancer properties, while their antibacterial properties are beneficial for oral health, treating throat problems, and promoting dental hygiene when used as a powder (Patil *et al.*, 2012).

For diabetic patients, Jamun leaves and fruit are especially valuable due to their anti-diabetic properties. The black plum helps convert starch into energy, thereby maintaining blood sugar levels. During summer, consuming Jamun regularly is advised for diabetics because of its low glycemic index, which helps reduce symptoms like frequent urination and thirst. Extracts from Jamun's bark, seeds, and leaves are also effective in lowering urine sugar levels, demonstrating its extensive use in Indian folklore medicine for various ailments, including diabetes, cancer, cardiovascular diseases, and stroke. These health benefits are largely attributed to the high content of phenolic compounds and phytochemicals in Jamun (Rizvi *et al.*, 2022).

Jamun leaves possess numerous therapeutic properties, including astringent, sweet, refrigerant, carminative, diuretic, digestive, antihelmintic, febrifuge, constipating, stomachic, and antibacterial effects. Various parts of the plant are employed to treat diabetes, pharyngitis, spleenopathy, urethrorrhea, and ringworm infection. Specifically, the leaves are used to address diabetes, constipation, leucorrhoea, stomachache, fever, gastropathy, strangury, and dermopathy, as well as to inhibit blood discharges. The plant's bioactive compounds, such as acetyloleanolic acid, triterpenoids, ellagic acid, isoquercitrin, quercetin, kaempferol, and myricetin, exhibit significant antioxidant and free radical scavenging activities (Gajera *et al.*, 2017).

A thorough analysis of the physicochemical properties of Jamun leaves demonstrates their potential for a variety of industrial uses. Kumar *et al*. (2009) discovered several key neutral components in the leaves, including octadecane (16.91%), nonacosane (9.98%), triacontane (9.38%), octacosane (7.38%), heptacosane (4.86%), hexadecanoic acid (4.25%),and eicosane (4.02%), indicating their suitability for pharmaceutical and industrial applications. Jamun leaves contain a variety of vital nutrients and bioactive substances, including calcium, magnesium, potassium, iron, zinc, and phosphorus. GC-MS analysis of Jamun leaf essential oil shows significant amounts of τ-cadinol and τ-muurolol, suggesting promise for healing skin wounds and infections (Qamar *et al.*, 2022).

The goal of this research is to fully utilise the nutritional and physico-chemical characteristics of the leaves of the Paras variety Jamun in order to enhance knowledge of this important but underappreciated resource and enable its use in a variety of medicinal and therapeutic contexts.

MATERIAL AND METHODS

Fresh Jamun leaves of *paras* variety were procured from the Horticulture Farm at Anand Agricultural University, Anand, Gujarat, Indiain the month of August. These leaves were sorted, washed, and surface-dried. The fresh jamun leaves were then stored at 4℃ (Nobosse*et al.*, 2017).

Determination of physical properties

Size

The size parameters (length, width, thickness) of the jamun leaves were measured using a digital caliper (Type: ED30, Make: BAKER) with a range of 0-300 mm and a least count of 0.01 ± 0.013 mm (maximum error of 0.02 mm up to 100 mm and 0.03 mm above 100 mm). Three readings of each parameter were recorded, and the average value was noted (Shoba, 2009).

Mass

The mass of the jamun leaves was determined using an electronic weighing balance (Maximum capacity: 1 kg, Model: RW11-3220-044, Make: Mettler-Toledo India Private Ltd., Mumbai). Three readings of the mass of each leaf were measured, and the average value was recorded.

Bulk density

The bulk density of the sample was determined by using a dried, empty measuring cylinder of known volume. A known weight of the sample was placed in the measuring cylinder and gently tapped to settle the sample. The filled cylinder was then weighed. This experiment was repeated three times (Mohsein, 1986).

$$Bulkdensity\ (\rho b) = \frac{\mathrm{Mx}}{\mathrm{Vc}} \qquad ...(3.1)$$

Where,

ρb = Bulk density (g/cm^3),

Mx = Weight of the sample (g) and

Vc = Volume of the cylinder (cm^3)

Colour value determination

The color of the jamun leaves and fine jamun leaf powder was determined using a Lovibond tintometer (Type: Lovibond® RT850i) on the CIELAB scale (L*, a*, b*). The tintometer was initially calibrated, and the samples were analyzed for their L* (lightness), a* (red/green), and b* (yellow/blue) values. Three replications were taken for each sample.

Determination of chemical properties

Moisture content

The moisture content was determined using the method described in AOAC (1990) with a hot air oven (Make: NOVA Instruments Pvt. Ltd., Ahmedabad). A metallic dish was dried at 110°C for one hour, cooled in a desiccator, and weighed (W_1). A 5 g sample was placed on the dish and weighed (W_2). The sample was dried in the oven at 100 ± 5°C until a constant weight was obtained (W_3). Biomass with very high moisture needs more heat fordrying, which adversely affect pyrolysis process (Makavana et al., 2022).Moisture content was calculated using:

$$\text{Moisture content } (\%, \text{ d.b.}) = \frac{[(W_2 - W1) - (W3 - W1)]}{W3 - W1} \times 100 \qquad \dots (3.2)$$

Where,

W_1= Weight of empty metallic dish, g

W_2 = Weight of metallic dish with sample, g

W_3 = Weight of metallic dish with dried sample, g

Ash content

Ash content was determined using a muffle furnace (Make: Creative Lab World, Delhi) as described by AOAC (2012). The furnace was preheated to 550℃. An empty silica crucible was weighed, and 5 g of the sample was placed in it. The sample was ashed in the furnace at 550℃ until completely charred. The crucible was cooled in a desiccator and weighed. Ash content (%) was calculated using:

$$\text{Ash } (\%) = \frac{W_2 - W_1}{W_3} \times 100 \qquad \dots (3.3)$$

Where,

W_1 = Weight of empty crucible, g

W_2 = Weight of crucible + Ash, g

W_3 = Weight of sample, g

Crude fiber content

Crude fiber content was estimated using the Fibra-plus instrument (Make: Pelican Equipments, Chennai) as described by AOAC (2012). About 2 g of the sample was treated with 1.25% H_2SO_4 for 1 hour, then washed with 1.25% NaOH solution and distilled water.

The neutral residue was dried, weighed, and ignited in a muffle furnace. Crude fiber (%) was calculated using:

$$\text{Crude fiber (\%)} = \frac{W_2 - W_3}{W_1} \times 100 \quad \ldots (3.4)$$

Where,

W_1 = Weight of sample, g

W_2 = Weight of crucible + sample after washing and drying, g

W_3 = Weight of crucible + ash, g

Crude fat content

Crude fat was analyzed using a Soxhlet apparatus (Make: Pelican Equipments, Chennai) as described by AOAC (2012). A 5 g sample was placed in a thimble, extracted with 250 ml of hexane for about 5 hrs, evaporated, dried at 100℃, cooled in a desiccator, and weighed. Crude fat (%) was calculated using:

$$\text{Crude fat (\%)} = \frac{\textit{Weight of flask with oil} - \textit{Weight of empty flask}}{\text{Total weight of the sample}} \times 100 \quad \ldots (3.5)$$

Protein content

The protein content of the sample was determined by Micro-kjeldahl method (AOAC, 2012). Weighed sample of 1 g transferred to a digestion flask followed by the addition of 3 g of catalyst mixture ($NaSO_4$:$CuSO_4$ in 5:1) and 10 ml of concentrated HCL. The contents were then digested till transparent liquid was obtained. The volume of digested material was made up to 100 ml with distilled water. Measured aliquot of digested material was distilled with excess of 40% NaOH solution and the liberated ammonia was collected in 20 ml of 2% boric acid solution containing 2-3 drops of mixed indicator. The entrapped ammonia was titrated against 0.01 N HCL. A reagent blank was similarly digested and distilled. Nitrogen content in the sample was calculated as follows and a factor of 6.25 was used to convert nitrogen to protein.

$$\text{Nitrogen (\%)} = 14 \times (T - N) \times \text{Normality of HCL} \times \frac{100}{W \times 1000} \quad \ldots (3.6)$$

$$\text{Protein content (\%)} = \%\ \text{Nitrogen} \times 6.25 \ldots (3.7)$$

Where,

T = Titre value

N = Titre value of blank sample

W = Weight of the sample, g

Carbohydrate content

Carbohydrate content of the sample was calculated by difference. It was calculated by using the following formula:

Carbohydrate (%) = 100 % (moisture + ash + crude fiber + crude fat + protein) ...(3.8)

Totalphenolcontent

Total phenol content was determined using the method described by Balaji *et al.* (2014). A 100 g sample was extracted with 500 ml methanol using a Soxhlet extractor for 8-10 hours. The extract was filtered, and the total phenolic content was determined using the Folin-Ciocalteu assay. For every 1 ml of extract, 1 ml of Folin-Ciocalteu reagent and 2 ml of 2.5% sodium carbonate were added, mixed, and allowed to stand for two hours in the dark. Absorbance was measured at 750 nm. Quantification was done using a standard curve of gallic acid, expressed as mg gallic acid per gram of sample.

Antioxidant activity

Antioxidant activity was measured using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method (Joshi *et al.*, 2019). A 2 g sample was extracted with 0.5 ml methanol, centrifuged, and 0.1 ml of extract was added to 3 ml of absolute ethanol. The mixture was incubated for 60 minutes in the dark, and absorbance was measured at 517 nm. Inhibition (%) was calculated using:

$$\text{Inhibition (\%)} = \frac{(AB - AA) \times 100}{AB} \qquad \ldots (3.9)$$

Where,

AB = Absorbance of control

AA = Absorbance of sample

RESULTS AND DISCUSSION

Physico-chemical analysis of fresh jamun leaves

The physicochemical investigation of fresh Jamun leaves included physical, chemical, and proximate characteristics. These studies offer vital information about the nutritional and functional qualities of jamun leaves, information that is necessary for their possible use in a variety of culinary and health-related products. The findings of these evaluations are explained in full below.The energy consumption of installation and retrieval operation in case of mechanical method were 225.24 and 238.19 MJ/ha respectively, and in case of manual method were 23.22 and 28.40 MJ/ha respectively, which is 870.03 and 738.70 per cent higher as compared to manual method (Balas et al., 2022).

Evaluation of physical attributes of fresh jamun leaves

Freshly harvested Jamun leaves were used to measure their physical parameters, such as length, width, thickness, mass, bulk density, and colour value. These attributes are critical for understanding the structural and functional aspects of the leaves, which can affect their processing, storage, and use in a variety of applications.Table 1. shows the means and standard deviations for various measurements. The observed difference in these physical qualities can be related to the leaves' inherent heterogeneity, which is influenced by factors such as leaf age, ambient conditions, and genetic variants within the Jamun population.

Table 1. Physical properties of fresh jamun leaves

Physical Attributes	**Mean ± S.D.**
Length, mm	162.86 ± 10.38
Width, mm	82.55 ± 10.61
Thickness, mm	0.30 ± 0.02
Mass, g	4.62 ± 0.86
Bulk density, g/cm^3	0.62 ± 0.05

The length of Jamun leaves varied from 151.61 to 174.10 mm, with a mean of 162.86 ± 10.38 mm. This suggests that the leaves are relatively lengthy, which may be advantageous for some applications, such as bioactive chemical extraction, where a bigger surface area can lead to improved extraction effectiveness. With a mean value of 82.55 ± 10.61 mm, the breadth of the leaves varied from 67.20 to 97.57 mm, indicating that they are broad and capable of yielding a significant biomass for processing. Bulk density was found rise husk, rice straw, sugarcan bagasses, cotton stlks and coconut leaves were 331.59, 380.54,723.20,206.14 and 35.57 kg / m^3 (Makavana et al., 2021).

The Jamun leaf thickness varied from 0.28 to 0.33 mm, with an average of 0.30 ± 0.02 mm. The leaves' thin nature may contribute to their ease of processing, particularly during drying and grinding procedures. The leaves ranged in mass from 2.90 to 5.50 g, with an average of 4.62 ± 0.86 g. This mass range implies that the leaves are lightweight, which is useful for transportation and handling.

The bulk density of leaves varied from 0.616 to 0.625 g/cm^3, with a mean value of 0.62 ± 0.05 g/cm^3. The bulk density of Jamun leaves indicates a moderate packing density, which might affect storage requirements and transportation efficiency.

The leaves were observed to be greenish to dark green in color. Color analysis, an important parameter for sensory attributes of food products, was also performed. The CIELAB color space parameters (L*, a*, b*) were measured, indicating the degree of lightness, red/green, and yellow/blue components, respectively. The values obtained for these parameters are shown in Table 2.

Table 2. Colour values of fresh jamun leaves

Colour parameters	Range	Mean Value ± S.D.
L*	26.25-36.20	30.26 ± 5.94
a*	-8.26--2.45	-5.45 ± -3.02
b*	4.35-14.25	9.21 ± 5.02

The standard values for green colour on D65/10° were 33.00, -6.71, and 11.15 for the L*, a*, and b* colour parameters, respectively. This suggests that fresh Jamun leaves were greenish to dark green, as evidenced by the L* value of 33.00 recorded with the Lovibond tintometer. The L* value, which measures lightness, varied from 26.25 to 36.20, with a mean of 30.26 ± 5.94. The negative a* values (-8.26 to -2.45 with a mean of -5.45 ± 3.02) indicate the green colour of the leaves. The b* readings, which measure the yellow/blue component, ranged from 4.35 to 14.25, with a mean value of 9.21 ± 5.02 indicating a little yellowish hue.

The colour characteristics of the leaves are critical to their acceptance and marketability, particularly in food and nutraceutical applications. The greenness of the leaves indicates their freshness and quality. The more closely the product's colour matches that of the fresh commodity, the more likely it will be accepted by consumers. The colour values obtained in this investigation show that Jamun leaves retain a good green colour, which is likely to appeal to consumers.

Evaluation of chemical attributes of fresh jamun leaves

The chemical characteristics of fresh Jamun leaves were determined according to the methods described. The evaluated chemical composition includes moisture content, ash content, crude fiber content, crude fat content, protein content, carbohydrate content, total phenolic content, and antioxidant activity. The results are presented in Table 3.

Table 3. Chemical parameters of fresh jamun leaves

Parameters	Mean Value ± S.D.
Moisture content, % (d.b.)	59.56 ± 1.61

Ash content, %	1.96 ± 0.03
Crude fiber content, %	7.96 ± 0.28
Crude fat content, %	0.58 ± 0.08
Protein content, %	5.48 ± 0.08
Carbohydrate content, %	28.52 ± 1.59
Phenolic content, mg /100 g	37.48 ± 2.57
Antioxidant activity, %	5.87 ± 0.17

The moisture percentage of fresh Jamun leaves was 59.56 ± 1.61%. Moisture content is an important factor in regulating the shelf life and storage conditions of the leaves. High moisture level can promote microbial growth and spoiling, so it is critical to consider proper drying and storage methods to extend the shelf life of the leaves.Thedeveloped implement was operated by the mini-tractor using three-point hitch, it performsboth the operations of installation and retrieval of drip line (Balas et al., 2018).

The total mineral concentration (ash content) was 1.96 ± 0.03%. This number estimates the inorganic content of the leaves, which can be useful for nutritional purposes. The presence of minerals enhances the total nutritional content of the leaves and can provide a variety of health benefits.A study was conducted to assess the microbial load on lemon fruits at different postharvest handling stages (Makavana et al., 2018a).

The crude fiber content of jamun leaves was 7.96 ± 0.28%. Crude fibre is an important component of dietary fibre, which is required for good digestive health. The presence of fibre in the leaves can help with digestion and avoid constipation. Additionally, dietary fibre has been linked to a variety of health benefits, including a lower risk of cardiovascular disease and better glycemic management.

Crude fat content was 0.58 ± 0.08 %. Fat content is an important metric for determining the energy value and lipid composition of leaves. Despite their low fat content, Jamun leaves can contribute to total nutritional value. The leaves' low fat content makes them ideal for low-calorie diets and health-conscious consumers.

The protein level was 5.48 ± 0.08%, which is vital for body growth and repair. Protein content in plant leaves varies greatly, and the presence of protein in Jamun leaves enhances their nutritional value. Proteins have key roles in a variety of physiological processes, including enzyme functioning, immunological function, and muscle repair.The percentage of blown pods, un threshed pods, broken pods and spilled pods were observed as 14.51, 18.92, 0.126, 1.04% and 6.07, 14.59, 0.361, 0.99% for GG-22 and GG-20 varieties (Amarutiya et al., 2020).

The carbohydrate content of jamun leaves was 28.52 ± 1.59%. Carbohydrates are the body's major source of energy, and their presence in the leaves boosts the nutritional profile. The carbohydrate composition consists of both simple sugars and complex carbs, which give quick and sustained energy release. Study on the development of a small capacity (5kg) fixed bed reactor pyrolyser for shredded cotton stalk as feed stalk (Makavana, J.M. and Sarsavadia, P. N.,2018c).Potato slices ware subjected tovarious pre-drying treatment viz., blanching in hot water at temperature, i.e., 60, 70, 80, 90and 100˚C and blanching time, i.e., 2.0, 3.0, 4.0 and 5.0 min (Kapadiya et al., 2018). To reduce cropdamage, machinery like the finger weeder andtorsion weeder need precise steering (Balas et al., 2022).

The phenolic content of jamun leaves was found to be 37.48 ± 2.57 mg/100 g. Phenolic chemicals are renowned for their antioxidant qualities, which can help avoid oxidative stress and associated illnesses. The high phenolic content of Jamun leaves suggests that they could be used as a source of natural antioxidants to promote health and prevent disease. Antioxidant activity was found at 5.87 ± 0.17%. Antioxidants have an important role. Bulk density of rice husk and rice straw was 331.59 kg/m^3 and 380.54 kg/m^3 respectively (Makavana et al. 2018b).

CONCLUSION

In conclusion, the physico-chemical examination of fresh Jamun leaves demonstrated promising properties. The leaves measured 162.86 ± 10.38 mm in length, 82.55 ± 10.61 mm in breadth, and 0.30 ± 0.02 mm in thickness. They weighed 4.62 ± 0.86 g and had a bulk density of 0.62 ± 0.05 g/cm^3. They had a greenish to dark green colour with L*, a*, and b* values of 30.26 ± 5.94, -5.45 ± 3.02, and 9.21 ± 5.02, respectively. Chemically, the leaves included 59.56 ± 1.61% moisture, 1.96 ± 0.03% ash, 7.96 ± 0.28% crude fiber, 0.58 ± 0.08% crude fat, 5.48 ± 0.08% protein, and 28.52 ± 1.59% carbohydrates. They have 37.48 ± 2.57 mg/100 g of total phenolic content and 5.87 ± 0.17% antioxidant activity, making them suitable for usage in industries like food, medicines, and nutraceuticals.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

REFERENCES

Patil, S., Thorat, R., & Rajasekaran, P. (2012). Utilization of jamun fruit (*Syzygium cumini*) for production of red wine. *Journal of Advanced Laboratory Research in Biology*, 3 (3), 200-203.

Amrutiya, M. D., Makavana, J. M., Kachhot, A. R., Chauhan, P. M., & Tiwari, V. K. (2020). Performance evaluation of tractor operated groundnut thresher. Current Journal of Applied Science and Technology, 38(6), 1-15.

Balas, P. R., Makavana, J. M., Mohnot, P., Jhala, K. B., & Yadav, R. (2022). Inter and intra row Weeders: A review. Current Journal of Applied Science and Technology, 41(28), 1-9.

Rizvi, M.K., Rabail, R., Munir, S., Inam-Ur-Raheem, M., Qayyum, M.N., Kieliszek, M., Hassoun, A. & Rana, M.A. (2022). Astounding health benefits of jamun (*Syzygium cumini*) toward metabolic syndrome. *Molecules*, 27, 7184. https://doi.org/10.3390/molecules27217184

Makavana, J. M., Makwana, P. J., Kukadiya, V. D., & Joshi, A. M. (2018a). Post-harvest losses of lemon fruits: An assessment of microbial floral strength during post-harvest handling. International Journal of Current Microbiology and Applied Sciences, 7(5), 1184-1188.

Gajera, H.P., Gevariya, S.N., Hirpara, D.G., Patel, S.V., & Golakiya, B.A. (2017). Antidiabetic and antioxidant functionality associated with phenolic constituents from fruit parts of indigenous black jamun (*Syzygium cumini* L.) landraces. *Journal of Food Science and Technology*, 54 (10), 3180-3191. DOI : 10.1007/s13197-017-2756-8

Kapadiya, D. C., Makavana, J. M., & Kathiria, M. K. (2018). Effect of hot water blanching treatment on quality of dried potato slices. Int. J. Curr. Microbiol. Appl. Sci, 7(7), 2754-2764.

Kumar, A., Jayachandran, T., Aravindhan, P., Deecaraman, D., Ilavarasan, R., & Padmanabhan, N. (2009). Neutral components in the leaves and seeds of *Syzygium cumini*. *African Journal of Pharmacy and Pharmacology*, 3 (11), 560-561.

Qamar, M., Akhtar, S., Ismail, T., Wahid, M., Abbas, M., Mubarak, Y., Barnard, R., Ziora, Z., & Esatbeyoglu, T. (2022). Phytochemical profile, biological properties, and food applications of the medicinal plant *Syzygium cumini*. *Foods*, 11 (3), 378.

Nobosse, P., Fombang, E., & Mbofung, C. (2017). The effect of steam blanching and drying method on nutrients, phytochemicals and antioxidant activity of Moringa (*Moringa oleifera* L.) leaves. *American Journal of Food Science and Technology*, 5 (2), 53-60.

Shoba, H. (2009). Studies on drying of methi leaves. (Trigonella foenum graecum). M.Tech. Thesis submitted to University of Agricultural Scicences, Bangalore, Karnataka.

Makavana, J.M. and Sarsavadia, P. N. (2018c) Development of batch type biomass pyrolyser for agricultural residue.pp.1-118.

Mohsein, N.N. (1986). Physical properties of plant and animal materials. *Gordon and Breach Science Publishers*, New York.

Makavana, J. M., Agravat, V. V., Balas, P. R., Makwana, P. J., & Vyas, V. G. (2018b). Engineering properties of various agricultural residue. Int J Curr Microbiol App. Sci, 7(6), 2362-2367.

AOAC (1990). Official Methods of Analysis, 15th edn. Association of Official Analytical Chemists, Washington, DC.

Makavana, J. M., Sarsavadia, P. N., Chauhan, P. M., Dulawat, M. S., Dobariya, U. D., & Yadav, R. (2021). A review pyrolysis: Different agricultural residues and their bio-char characteristics. International Journal of Environment and Climate Change, 11(7), 80-88.

AOAC (2012). Official Methods of Analysis, 19th Edition, Association of Official Analytical Chemists, Washington DC.

Balaji, K., Hean, K., Ravinchandran, K., & Sikarwar, M. (2014). In-Vitro evaluation of antioxidant activity and total phenolic content of methanolic extract of *Convolvulus pluricaulis*. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 5, 959-964.

Balas, P. R., Makavana, J. M., Jhala, K. B., Chauhan, P. M., & Yadav, R. A. (2022). Economically comparison of mini tractor operated installer and retriever of drip line. Indian Journal of Agriculture and Allied Sciences, 8(1), 2395-1109.

Joshi, N., Bains, K., & Kaur, H. (2019). Optimization of drying time and temperature for preparation of antioxidant rich vegetable powders from unconventional leafy greens. *Chemical Science Review and Letters*, 8(29), 70-78.

Makavana, J. M., Balas, P. R., Dharsenda, T. L., Dobariya, U. D., & Chauhan, P. M. (2022). Develop small capacity fixed bed pyrolyser for bio-char production. Recent Advances in Agricultural Science and Technology for Sustainable India-Part-I, Pg, 356-366.

Balas, P. R., Jhala, K. B., Makavana, J. M., & Agravat, V. V. (2018). Design and development of mini tractor operated installer and retriever of drip line. International Journal of Current Microbiology and Applied Sciences, 7(8), 1566-1577.