Establishment of Tapping Technique in Indian Ash Tree, Jhingam (Lannea coromandelica) (Houtt) (Merr) and Arjun (Terminalia arjuna) (Roxb) in Pakhanjure Uttar Bastar Kanker Region of Chhattisgarh

Abstract:

Gum and resin from non-wood forest products (NWFP) play a crucial role in the income and livelihoods of small-scale farmers. Recently, there has been a significant increase in industrial demand for these products. Therefore, a study titled "Establishment of tapping techniques in Indian Ash Tree (Jhingam) and Arjun in the Pakhanjure region of Chhattisgarh" was conducted in 2022–23 to assess various traditional, mechanical, and gum enhancer applications for enhancing gum and resin production during both the winter and summer seasons.This research revealed that the Jhingam tree demonstrated excellent potential for gum production throughout the year. Specifically, the application of a 2% ethylene-based gum enhancer injected via the drill method at 1-meter height from the ground in trees with over 90 cm diameter significantly increased gum production quantity, rate, and quality. Analysis of physiochemical properties showed that this treatment resulted in higher moisture content, pH, and bulk density (0.76-0.78) while reducing tapped density. Fat and protein content were also higher compared to other methods. The angle of repose indicated good capsule-filling properties at 31.87%.

On the other hand, the Arjun tree exhibited lower gum production potential compared to Jhingam, with most production occurring during the summer. Similar to Jhingam, the application of a 2% ethylene-based gum enhancer reduced moisture content, pH, and bulk density while increasing fat and protein content. Both gums showed high solubility in hot water, with viscosity at 6.1 cP(high) at 100 rpm and 1 cP (low) at 10 rpm in a 1% solution. The angle of repose for Arjun gum was 25.33%.

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Keywords:*Tapping techniques, Gum production, Indian ash tree (Jhingam), Arjun tree*

1.Introduction

Different kinds of gums, such as mucilage gums, seed gums, and exudate gums, are found in various forms. Exudate gums are typically found in specific plant families like Leguminosae, Rosaceae, Combretaceae, and Sterculiaceae. They are abundant in certain plants, animals,

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seaweeds, fungi, and other microbial sources, serving different structural and metabolic functions. Families like Anacardiaceous, Combretaceae, Meliaceae, and Rutaceae are also notable for producing gums. These gums are sourced from different parts of plants, with some extracted from seed epidermis and others from leaves and bark.

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According to the Forest Types classification by Champion and Seth (1968), forests in Chhattisgarh can be grouped into two categories: Tropical Moist Deciduous Forests and Tropical Dry Deciduous Forests, further divided into 12 specific forests. Dominant tree species in these forests include Sal (Shorea robusta) and Teak (Tectona grandis), along with other significant species like Bija (Pterocarpus marsupium), Saja (Terminalia tomentosa), Dhawdha (Anogeissus latifolia), Mahua (Madhuca indica), Tendu (Diospyros melanoxylon), and bamboo (Dendrocalamus solidus). About 50% of villages in the region are within a 5 km radius of forests, with the local population primarily comprising tribal communities, economically disadvantaged individuals, non-tribal residents, and landless people who heavily rely on forests for their livelihoods and various needs. From January 1, 2015, to February 5, 2019, a total of 3,793.05 hectares of forest land in Chhattisgarh was converted for non-forest purposes under the Forest Conservation Act of 1980 (MoEF & CC, 2019).Gum exudates consist of polysaccharides and metabolic by-products from plant tissue, occurring naturally or often as a response to adverse conditions such as disease, injury to bark or wood, drought, high temperatures, abrasion, or strong winds. They hold significant importance as Non-Wood Forest Produce (NWFP) and are directly used in the food and pharmaceutical industries due to their commercial value. The demand for natural gums/resins, known as biopolymers, is steadily rising due to their biocompatibility and acceptability.

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India has a dominant position in global trade for certain Natural Resins and Gums (NRGs) like lac (Kerria lacca Ker), Gum Karaya, and Guar gum. The country primarily produces Gum Karaya, Guar gum, Karaya gum (Sterculia urens), Dhawada gum (Anogeissum latifolia), Babool/Babul gum (Acacia nilotica), Prosopis gum or Mesquite gum (Prosopis juliflora), Khair gum (Acacia catechu), Jhingan gum (Lannea coromandelica), Palas gum (Butea monosperma), Char gum (Buchanania lanzan Spreng), and Guggul gum (Commiphora wightii). Maharashtra (29.05%), Madhya Pradesh (19.69%), Jharkhand (13.98%), Telangana (10.08%), and Chhattisgarh (7.82%) collectively contribute around 80% of the country's natural gum production. In Chhattisgarh, the production includes Gum kondagogu (Cochlospermum gossypium), saja (T. tomentosa), Jhingam (L. coromandelica), palas (B.

monosperma), khair (A. catechu), and char (B. lanzan Spreng), totaling 2 tons (Yogi et al., 2021)Gum-producing trees are vital to the economy, predominantly thriving in tropical and arid tropical forests. They yield a variety of gums extensively utilized in industries, food, and medicine in India, as highlighted by (Bhattacharya et al., 2012). Gathering gum from natural forests and selling it for livelihood is common among forest dwellers and communities reliant on gum collection, especially in regions abundant in forests like central Indian states such as Madhya Pradesh, Chhattisgarh, Andhra Pradesh, Orissa, Jharkhand, Bihar, Gujarat, and Rajasthan, which serve as significant sources of commercially valuable gums.

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Chhattisgarh State, with its abundant forests and favorable agro-climatic conditions, boasts a substantial forest cover of 43.6% of the total land area, as emphasized by (Bhattacharya et al., 2012). The Bastar region, characterized by dense forests, houses over 67% of the state's tribal population, heavily reliant on forest resources. Gum trees have been identified across various forests in Kanker, Jagdalpur, Bijapur, Sukuma, Korea, and Gariyaband. The collection of karaya gum in Chhattisgarh is regulated by the forest department. According to (Gupta et al., 2012) the total gum yield in Chhattisgarh from Sukuma, Bijapur, and Dantewada was recorded as 1049.88 Quintal per year in 2008-09. The gum obtained from these trees, known as Indian gum or ghatti gum, finds application in calico printing and various other uses.

Plant-derived natural gums, highly sought-after and widely traded non-timber forest products acquired from forests, are formed through gummosis, a process where internal plant tissues disintegrate, leading to the breakdown of cellulose, hemicelluloses, and complex carbohydrates present in plant cell walls. Composed of monosaccharide units linked by glycoside bonds, gums are hydrophilic carbohydrates, insoluble in oils or organic solvents but water-soluble. When exposed to water, they absorb it, causing them to swell or disperse, resulting in a viscous solution or jelly-like consistency.

Jhingam (Lannea coromandelica) is a deciduous tree of moderate to large size, characterized by its spreading crown and sturdy branches, reaching heights of up to 24m and widely distributed throughout most of India. Its bark, either grey or whitish, peels off in irregularly rounded plates, while its imparipinnate leaves, densely clustered at branch ends, consist of 7-9 oblong-ovate leaflets. The tree bears small, yellowish or purplish unisexual flowers, with male flowers arranged in slender compound racemes and female flowers forming simple pubescent racemes. Its red, compressed, reniform fruits contain seeds.

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Jhingam tree produces mucilaginous gum found on bark wounds and cracks, though often contaminated by boring insect excreta and mixed with bark tannin filters. In northern India, gum extraction occurs from March until early rains, enhancing sugarcane juice clarity and brightness as a dehydration agent. Comparable in precision performance to Lytron-X 886, an imported synthetic product, it effectively removes impurities from the juice. Maximizing gum yield requires considerations like chemical use, extraction timing, tree age, and width, with positive results shown by the use of ethephon as a gum production inducer (Prasad et al., 2012).Lannea coromandelica, commonly found across India including the Andaman Islands, thrives in altitudes of up to 1,500 meters in the Himalayas. It is prevalent in sub-Himalayan sal forests and mixed deciduous forests of outer hills and plains, particularly in dry regions. Often used for avenues, hedges, and boundaries, it sheds its leaves during hot seasons.

Arjun (Terminalia arjuna), belonging to the Combreteaceae family, is a large tree with fissured bark and drooping branches. The herbal industry in India consumed over 2,000 tons of "Arjuna bark" between April 2005 and March 2006, with an annual estimated demand ranging from 2,000 to 5,000 tons. Its bark contains chemical compounds like arjunolic acid, luteolin, kaempferol, flavones, and quercetin, making it valuable as a cardiac tonic.

The "Establishment of tapping technique in Indian Ash Tree, Jhingam (Lannea coromandelica) and Arjun (Terminalia arjuna) in the Pakhanjure region of Chhattisgarh" This research aims to establish safe tapping methods for biopolymer production with the following objectives:

- ❖ Assessing the impact of seasonal variation and tapping techniques on gum production in Jhingam and Arjun.
- ❖ Evaluating the physiochemical properties of gum under different seasonal conditions and tapping methods.

2. Materials and Methods

The experiment for gum extraction was conducted on Jhingam (Lannea coromandelica) and Arjun (Terminalia arjuna) trees in the P.V. 124 (Avinash Nagar) area of the Pakhanjure block, located in the Kanker district of Chhattisgarh, during the years 2022-2023. Kanker, situated at 81.48°N latitude and 20.24°E longitude, has an average elevation ranging from 300 to 600 meters above sea level. The experimental site, positioned at 74.58°N latitude and 15.58°E longitude, experiences a tropical wet and dry climate. The region receives an average annual rainfall of 1000-1200mm, with 80% occurring during the rainy season from June to the end of September,and occasional rainfall continues from October to February.

Chhattisgarh, with a total geographical area of 137.90 lakh hectares (4.15% of the country's geographical area), comprises 63.55 lakh hectares (46% of its total geographical area) of forest land. The state is renowned for its Sal forests, covering nearly 36% of the total forest area. Teak forests are also abundant, primarily in the western and southern parts of the state. The forests in Chhattisgarh are categorized as either tropical moist deciduous forests or tropical dry deciduous forests.

2.1 ExperimentalMaterials

The naturally growing Jhingam (Lannea coromandelica), Arjun (Terminalia arjuna), trees were selected and investigated during the year 2022-2023 at village
P.V. 124, Pakhanjure block area, district Kanker (Chhattisgarh). The brief description of study trees is as follow.

Jhingam (*Lannea coromandelica*) is a medium to large deciduous tree commonly found throughout India. It typically grows up to 24 meters tall and features a spreading crown with sturdy branches. The bark is smooth, either grey or white, and sheds in irregular, rounded plates. Its leaves are imparipinnate, ranging from 25 to 45 cm in length, densely clustered at branch ends. The fruit is red, compressed, reniform, and contains seeds. Each leaf comprises 7-9 oblong-ovate leaflets measuring 7.5 to 15 cm. Its flowers are small, yellowish or purplish, unisexual, arranged in male and female fascicles within slender compound racemes.
Jhingam tree produces a mucilaginous substance known as Jhingan gum, which oozes from wounds and fissures in the bark. However, this gum often contains waste from irritating insects and may also be contaminated with tannin filtered through the bark. In northern India, tapping for gum extraction typically occurs from March to early April.

Fig.1Jhingam(*Lannea coromandelica*)

Arjun (*Terminalia arjuna*) is a deciduous tree of considerable size, reaching up to 30 meters in height and with a tree girth of 2-2.5 meters at 1 DBH. Its trunk often displays buttresses and a fluted appearance. The tree's root system is superficial and shallow, spreading radially along stream banks. Its large crown spreads out with drooping branches.The bark of Terminalia arjuna is typically grey or pinkish-green, thick, smooth, and sheds in thin, irregular sheets. The genus name Terminalia is derived from the Latin word 'terminus' or 'terminalis,' indicating the habit of leaves being densely clustered or borne at the tips of shoots.

Gum extraction from Terminalia arjuna bark resin was conducted and utilized as a gelling agent in combination with sodium alginate.

Fig.2 Arjun(*Terminaliaarjuna)*

2.2.Tapping techniques

2.2 A. Traditional method of tapping

Two Traditional methods were used i.e. First one is Single cut with axe and second is double cut method. These all treatments are applied at 1-meter DBH (distance at breast height). The treatments were applied since November 2022 to April 2023. The Traditional treatments were given as below:

- Single cut was made with the help of axe around 5 cm long and 3 cm deep on the tree trunk.
- Double cut was made at distance of 20 cm with the help of axe around 5 cm long and 3 cm deep on the same tree trunk.

2.2 B. Mechanical method of tapping

Four mechanical methods were used i.e. First one is Stripping method, second is semi arc method, third is v- shape and fourth double V-shape method. These all treatments are applied at 1-meter DBH (distance at breast height). The treatments were applied since November 2022 to April 2023. The mechanical treatments were given as below:

- Stripping method was made with the help of axe around 10cm longand 2cm width on the tree trunk.

LanneacoromandelicaTerminalia arjuna

Fig 3: Single cut method of tapping in Jhingam (Lanneacoromandelica), Arjun (Terminalia arjuna)

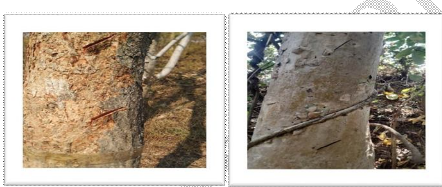
- A semi arch (10 cm length x 4-5 cm width x 2cm deep in) Jhingam and 10cm length x

4-5 cm width x 2 cm deep in) Arjun was made with the help of knife and bark remover till the second layer was exposed.

- V-shape of cut was made on the tree trunk with the help of butcher knife.
- Two V- shape cuts were made at the distance of 10 cm with the help of butcher knife on the same tree.

2.2 C. Chemical (use of gum enhancer) tapping technique

The chemical tapping of selected trees involved the use of different concentrations of gum enhancers such as ethephon (2-chloro-ethyl-phosphonic acid) (trade name KRIPON-39), sulfuric acid, and acetic acid in 1%, 2% & 4%. These enhancers were applied to the tree trunk using a hand-operated drill machine to induce gummosis. The treatments were administered using a volume of 10 ml syringe, with 4 ml of the gum enhancer injected three times throughout the tapping period. The first treatment was administered in the last week of December, followed by the second treatment in the last week of February, and the third treatment in the month of April. The drilling was performed in a clockwise direction, creating an upward-inclined hole with a diameter of 8 mm and a depth of 2.5 cm. The gum enhancer was injected into the hole and immediately covered.



Lannea coromandelica ***Terminalia arjuna***

Fig 4: Double cut method of tapping in Jhingam (Lanne coromandelica), Arjun (Terminalia arjuna),

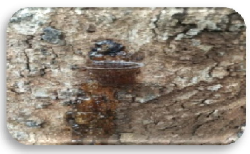
Lannea coromandelica ***Terminalia arjuna***

Fig 5 : Stripping method of tapping in Jhingam (Lannea coromandelica), Arjun (Terminalia arjuna)

Lannea coromandelica ***Terminalia arjuna***

Fig 6: Double V- shape method of tapping in Jhingam (Lannea coromandelica), Arjun (Terminalia arjuna)


Drilling ***Injecting Gum Enhancer***

Covering with clay ***Gum exudation***

Fig.7: Chemical (use of gum enhancer) method of tapping in Jhingam (Lannea coromandelica)


Drilling ***Injecting Gum Enhancer***

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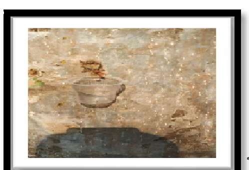
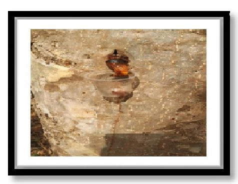

Covering with clay ***Gum Exudation***

Fig.8: Chemical (use of gum enhancer) method of tapping in Arjun (Terminalia arjuna)

3. Results and Discussion

The experimental findings of the present investigation have been described under the following heads:

3.1 The impact of seasonal variation and tapping technique in production.
3.2. Impact of different season and tapping methods on physiochemical properties of gum.
3.3. Correlation study of seasonal variation in production, tree girth classes and method of tapping with gum productions.

3.1 The impact of seasonal variation and tapping technique in production

Gum tapping was conducted during the winter to summer period (November to June) in the year 2022-23 using traditional, mechanical, and gum enhancer methods. Various treatments were applied Mechanical ie., including single cut (T1), double cut (T2), stripping (M1), semi arc (M2), V-shape (M3), and double V-shapes (M4) methods, along with different concentrations of gum enhancers, such as ethephon @ 1% (C1), ethephon @ 2% (C2), ethephon @ 4% (C3), H_2SO_4 @ 1% (C4), H_2SO_4 @ 2% (C5), H_2SO_4 @ 4% (C6), CH3COOH @ 1% (C7), CH3COOH @ 2% (C8), and CH3COOH @ 4% (C9). A hand-operated drill machine with an 8 mm drill bit, rotating clockwise, was used to induce tapping to produce biopolymers. The drilling depth was approximately 3-4 cm. The outcomes of this approach were compared with the traditional and mechanical methods of tapping. All treatments were administered on the tree trunk at 1 DBH (1.37 cm, distance at the breast height of the tree).

3.1.A The time requirement for gum exudation in traditional and mechanical tapping methods.

The duration of gum exudation in the experimental trees played a crucial role and was influenced by various factors such as the exudation season, temperature, relative humidity %, tree girth, tree elevation, tree inclination, sun direction, and the timing of treatments applied to the tree, including traditional, mechanical, and chemical methods (using different gum enhancers) etc.

The investigation focused on the traditional and mechanical tapping techniques employed in Jhingam (Lannea coromandelica) and Arjun (Terminalia arjuna) trees. The tree girth was in general more in tree of Arjun as compared to Jhingam.

However, the minimum time required for exudation of biopolymers was observed in Jhingam in all traditional and mechanical treatments exudated up to few days in mechanical method of tapping while, in use of gum enhancer it was extended up to 4-6 days in winter season and 3-5 days in summer season

In Arjun (Terminalia arjuna) tree gum exudation was started after 6-7 days after treatment in single cut and double cut methods and after 9-15 days in stripping method, semi arc method, V- shape and double V-shape method in winter season and gum exudation was started after 5-10 days in all traditional and mechanical treatments in summer season.

3.2.A The time requirement for gum exudation by use of gum enhancer tapping methods

Gum tapping experiments were conducted on three experimental trees, namely Jhingam (Lannea coromandelica) and Arjun (Terminalia arjuna), using gum enhancers. Despite the traditional tapping methods employed to extract biopolymers for medicinal and commercial purposes, standardized gum tapping techniques have not yet been established for these trees.

In the experimental treatments i.e., ethephon @ 1% (C1), ethephon @ 0 2% (C2), ethephon @ 4% (C3), H_2SO_4 @ 1% (C4), H_2SO_4 @ 2% (C5), H_2SO_4 @ 4%(C6), CH3COOH @1% (C7), CH3COOH @2%(C8), CH3COOH @4%(C9), were appliedas gum enhancer to induce the artificial signals of stress to the biopolymer exudation. However, the mechanism of exudation is natural and the any hostile environmentlike, drought, flood, wound, insect attack high temperature, fire enhanced the exudation of biopolymers (gum).Each treatment involved the use of 4 ml of gum enhancer and these treatments were applied three times during the entire experimental period, specifically in November, February, and March. For the Jhingam (Lannea coromandelica) trees selected for the experiment, their girth at 1 DBH (distance at breast height) ranged from 80-110 cm. on the tree trunk. The onset of exudation was observed within a week for all treatments, and the exudation process lasted for approximately 10-11 days and C2 treatment (ethephon @ 2%) and C3 treatment (ethephon @ 4%) required more time as compared to other experimental treatments for the exudation to occur. On the other hand, H_2SO_4 @ 1% (C4), H_2SO_4 @ 2% (C5), CH3COOH @ 1% (C7), and CH3COOH @ 2% (C8) did not result in any gum exudation in winter season (Table 1) and the gum exudation in all treatments are 8-12 days. However, treatment H_2SO_4 @ 1% (C4), H_2SO_4 @ 2% (C5), CH3COOH @ 1% (C7), and CH3COOH @ 2% (C8) are not gum exudation in summer season. The Arjun tree (Terminalia arjuna) chosen for the experiment had a tree girth ranging from 90-110 cm. Gummosis in this tree began in the 10-12 days after application of various treatments, including ethephon @ 1% (C1), ethephon @ 2% (C2), ethephon @ 4% (C3), The exudation process continued up to 3-4 weeks after the induction of gummosis. However, treatment H_2SO_4 @ 1% (C4), H_2SO_4 @ 2% (C5), H_2SO_4 @ 4%(C6), CH3COOH @1% (C7), CH3COOH @2%(C8), CH3COOH@4%(C9), were found to be ineffective in inducing gummosis in the Arjun tree, and no exudation was observed in winter season and the exudation process in 10-11 days after application of various treatments, including ethephon @ 1% (C1), ethephon @ 2% (C2), ethephon @ 4% (C3), However, treatment H_2SO_4 @ 1% (C4), H_2SO_4 @ 2% (C5), H_2SO_4 @ 4%(C6), CH3COOH @1% (C7), CH3COOH @2%(C8),CH3COOH @4%(C9), are not gum exudation in summer season.

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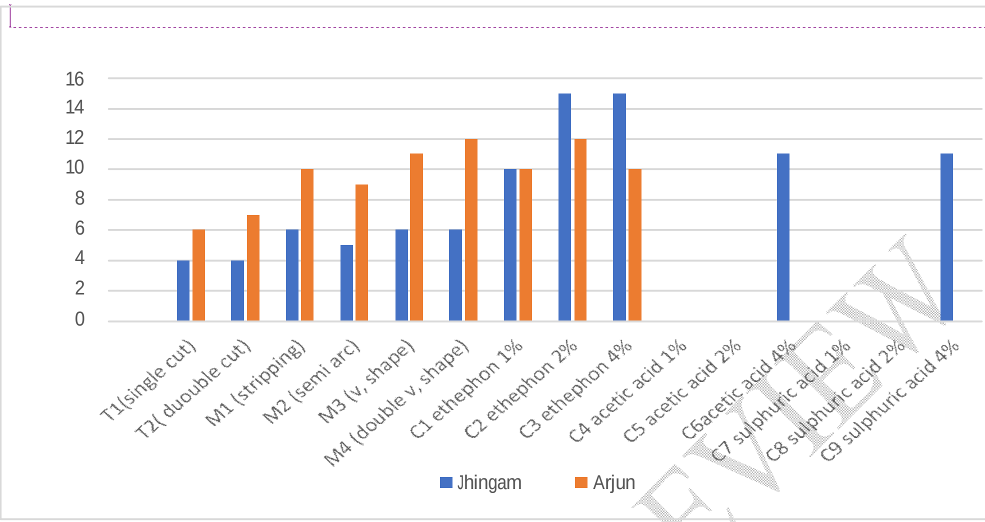

Fig 9: Time required for gum exudation by traditional, mechanical and gum enhancer methods in all experimental trees in (winter season).

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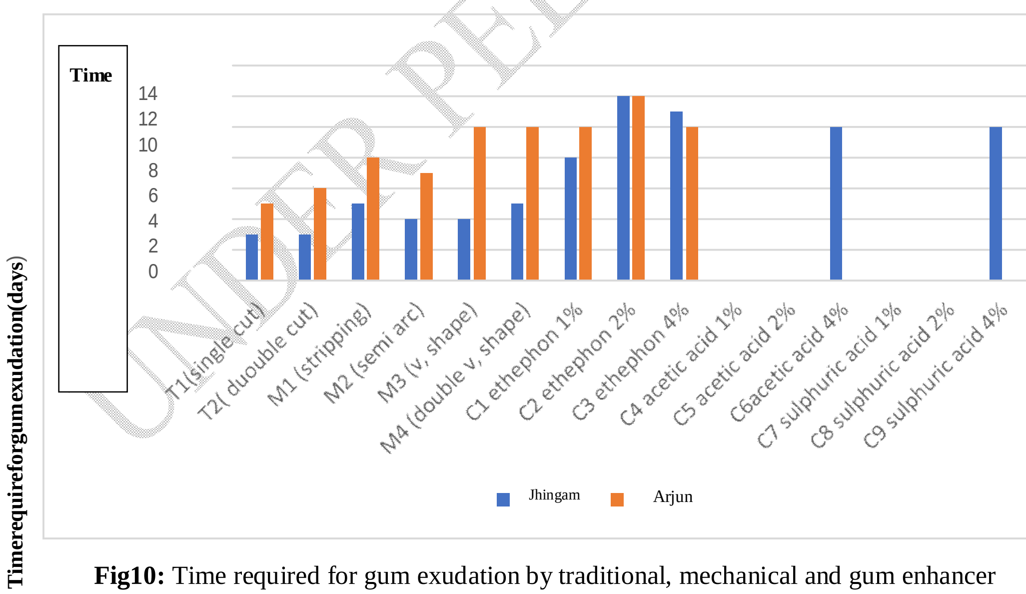

Fig10: Time required for gum exudation by traditional, mechanical and gum enhancer methods in all experimental trees in (summer season)

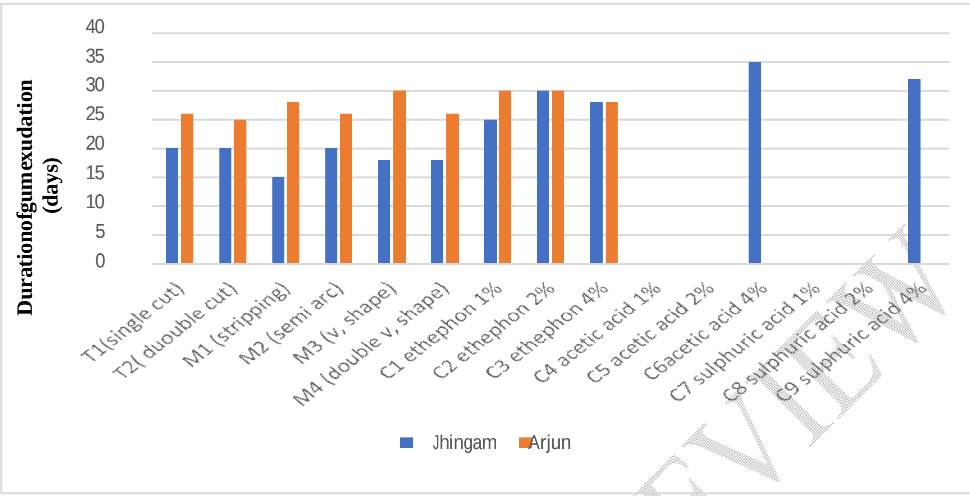

Fig11: Duration of gum exudation by traditional, mechanical and gum enhancer methods in all experimental trees in (winter season)

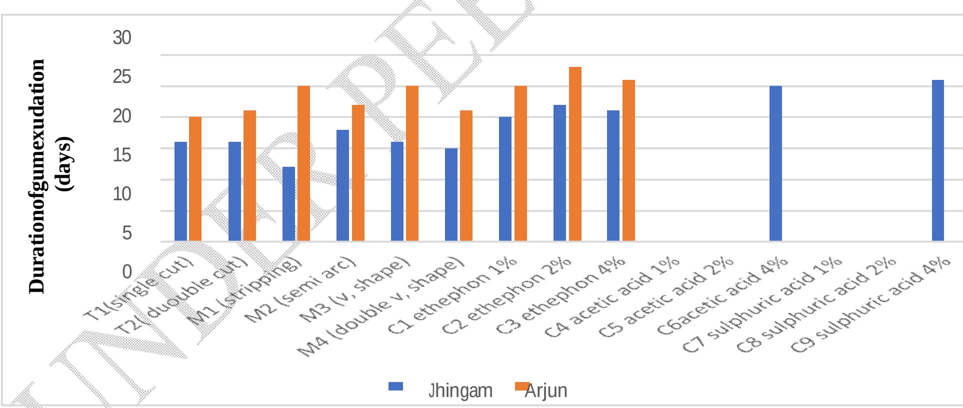

Fig 12: Duration of gum exudation by traditional, mechanical and gum enhancer methods in all experimental trees in (summer season).

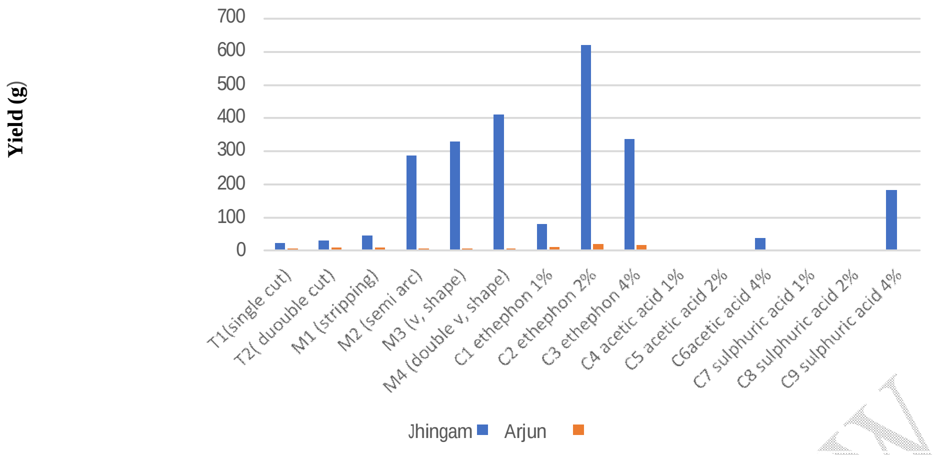

Fig13: Gum yield exudated by traditional, mechanical and gum enhancer methods in all experimental trees in (winter season).

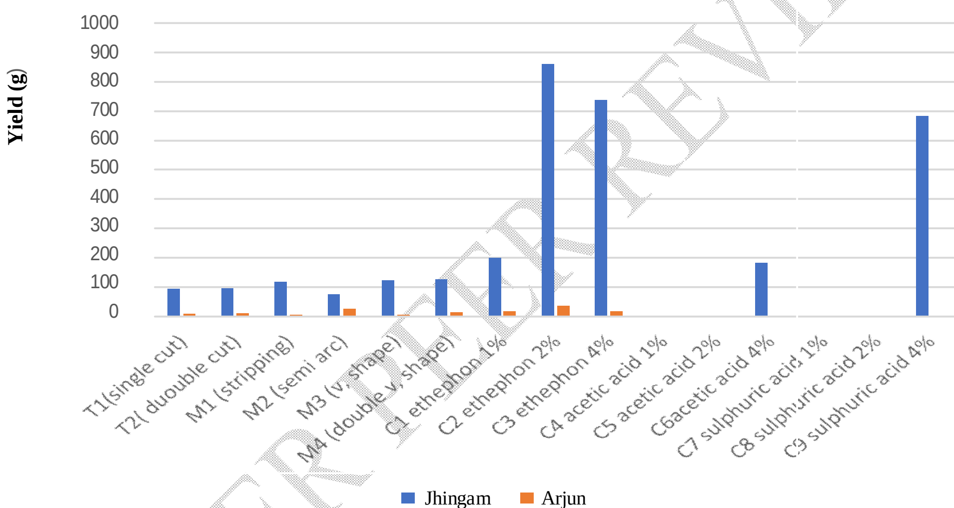

Fig 14: Gum yield exudated by traditional, mechanical and gum enhancer methods in all experimental trees in (summer season).

3.2 Quality Parameter Physiochemical analysis of Lannea coromandelica(Houtt) (Merr) andTerminalia arjuna (Roxb)

3.2.1 pH

The pH values of gum samples extracted from Jhingam and Arjun trees using various tapping methods were analysed. It was noted that all experimental gum samples were slightly acidic. The pH wasgenerally higher in Jhingam gum compared to Arjun gum. After 60 days of harvesting, the pH of Jhingam gum was higher when tapped using traditional and mechanical methods compared tousing a gum enhancer (chemical method). Among traditional and mechanical methods, the semi-arc method showed the highest pH, followed by the single-cut method, while the double-cut method had the lowest pH in the winter season.

In the summer season, the highest pH was observed in the ethephon@1% treatment, while the single-cut method had the lowest pH. For Arjun gum, the pH was higher when tapped using traditional and mechanical methods compared to using a gum enhancer. Among traditional and mechanical methods, the single-cut method showed the highest pH, followed by the semi-arc method, while the double V-shape method had the lowest pH in the winter season. In the summer season, the highest pH was observed in the ethephon@4% treatment, while the ethephon@2% treatment had the lowest pH.The acidic nature of gum samples derived from Anogeissus latifolia was attributed to the presence of acidic sugars such as Larabinose, D-galactose, D-mannose, D-xylose, and D-glucoronic acid. Similar findings were reported by (Ahmed etal.,2009) in Anogeissus leicarpous.

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Table 1. : The pH of gum sample of collected by traditional, mechanical and gumenhancer (chemical) methods in Jhingam (Lannea coromandelica)

Treatment	Mean (winter)	Mean (summer)

Traditional methods
Single cut
Double cut

Mechanical methods
Stripping
Semi arc V shape
Double V shape

Use of Gum Enhancer
Ethephon 1%
Ethephon 2%
Ethephon 4%
Acetic acid 4%

H2SO4 4%

4.69	4.33
4.43	4.53
4.48	4.73
4.73	4.30
4.60	4.40
4.60	4.93
4.25	5.00
4.79	4.07
4.87	3.87
4.25	3.97
4.25	3.93

SEd	0.15	0.16
SEm±	0.11	0.11
CD(p=0.05)	0.32	0.33
CV	3.35	3.51

Table .2: The pH content of gum sample of collected by traditional, mechanical and use of gum enhancer (chemical) methods in Arjun (Terminalia arjuna)

Treatment	Mean (winter)	Mean (summer)
Traditional methods		
Single cut	5.66	5.70
Double cut	5.34	5.90
Mechanical methods		
Stripping	5.27	5.40
Semi arc V shape	5.55	5.73
Double V shape	5.13	6.13
	5.19	5.07
Use of Gum Enhancer		
Ethephon 1%	5.57	5.13
Ethephon 2%	5.57	4.93
Ethephon 4%	5.67	5.60

SEd	0.18	0.14
SEm±	0.13	0.10
CD(p=0.05)	0.37	0.29
CV	4.78	3.92

3.2.2.Ash content

The ash content of gum samples was analysed 60 days after tapping. Overall, the ash content was higher in Jhingam gum tapped using traditional and mechanical methods compared to using a gum enhancer (chemical method).Among traditional and mechanical methods, the stripping method showed the highest ash content, followed by the V-shape method, while the double-cut method had the lowest ash content in both winter and summer seasons. Among chemical tapping methods, the highest ash content was observed in the acetic acid @4% treatment, while the H2SO4 @ 4% treatment had the lowest ash content in the winter season. In the summer season, the highest ash content was observed in the ethephon @ 2% treatment, while the ethephon @ 4% treatment had the lowest ash content.

For Arjun gum, the ash content was higher when tapped using traditional and mechanical methods compared to using a gum enhancer. Among traditional and mechanical methods, the double V-shape method showed the highest ash content, followed by the double-cut method, while the V-shape method had the lowest ash content in the winter season. In the summer season, the highest ash content was observed in the double-cut method, while the stripping method had the lowest ash content.Total ash content is often used for characterization and mainly consists of carbonates, phosphates, silicates, and silica.
This parameter provides insights into mineral interactions within the structure, affecting polysaccharide characteristics.

Table 3: The ash content of gum sample of collected by traditional, mechanical and gum enhancer (chemical) methods in Jhingam (Lannea coromandelica).

Treatment	Mean (winter)	Mean (summer)
Traditional methods		
Single cut	5.66	5.70
Double cut	5.34	5.90
Mechanical methods		
Stripping	5.27	5.40
Semi arc V shape	5.55	5.73
Double V shape	5.13	6.13
Use of Gum Enhancer		
Ethephon 1%	5.19	5.07
Ethephon 2%	5.57	5.13
Ethephon 4%	5.57	4.93
Acetic acid 4%	5.67	5.60
H2SO4 4%		
SEd	0.33	0.04
SEm±	0.24	0.03
CD(p=0.05)	0.71	0.09
CV	16.19	1.72

Table 4 : The ash content of gum sample of collected by mechanical and use of gum enhancer (chemical) methods in Arjun (Terminalia arjuna)

Treatment	Mean (winter)	Mean (summer)
Traditional methods		
Single cut	2.86	2.94
Double cut	2.44	2.43
Mechanical methods		
Stripping	3.48	3.55
Semi arc V shape	3.11	3.52
Double V shape	3.11	3.45
Use of Gum Enhancer		
Ethephon 1%	2.60	3.32
Ethephon 2%	4.28	4.15
Ethephon 4%	3.56	4.54
Acetic acid 4%	4.25	3.14
H2SO4 4%	4.66	3.67
	3.34	3.27
SEd	0.28	0.01
SEm±	0.20	0.01
CD(p=0.05)	0.59	0.02
CV	10.11	0.42

3.3.Moisture content

The moisture content of gum samples was analyzed 60 days after tapping, revealing higher levels in Jhingam gum tapped traditionally and mechanically compared to using a chemical gum enhancer. Among traditional and mechanical tapping methods, the stripping method showed the highest moisture content in both winter and summer seasons, while the double V-shape method had the lowest moisture content in winter, and the double-cut method had the lowest in summer. In chemical tapping methods, the acetic acid @ 4% treatment exhibited the highest moisture content in winter, and the ethephon @ 1% treatment had the highest in summer, with the ethephon @ 4% treatment showing the lowest in both seasons. Similarly, Arjun gum tapped traditionally and mechanically displayed higher moisture content, with the double V-shape method recording the highest levels in winter and the V-shape method in summer. Among chemical treatments, the ethephon @ 2% treatment had the highest moisture content in winter, while the ethephon @ 1% treatment had the highest in summer, with both seasons showing the lowest moisture content in the single-cut method. Research suggests an inverse relationship between moisture content and shelf life, with lower moisture content contributing to increased gum

stability by deactivating enzymes and reducing microbial activity, as indicated by studies by Bashir and Haripriya (2016) and Amid and Mirhosseini (2012).

Table 5: The moisture content of gum sample of collected by traditional, mechanical and gum enhancer (chemical) methods in Jhingam (Lannea coromandelica).

Treatment	Mean (winter)	Mean (summer)
Traditional methods		
Single cut	13.43	12.27
Double cut	11.77	11.57
Mechanical methods		
Stripping	14.33	12.87
Semi arc V shape	12.90	12.43
Double V shape	12.93	11.60
Use of Gum Enhancer		
Ethephon 1%	11.90	12.13
Ethephon 2%	11.57	12.00
Ethephon 4%	12.30	11.03
Acetic acid 4%	10.65	10.20
H2SO4 4%	12.90	11.70
	11.77	11.17

SEd	0.89	0.47
SEm±	0.63	0.34
CD(p=0.05)	1.85	0.99
CV	8.76	4.96

Table 6: The moisture content of gum sample of collected by traditional, mechanical and use of gum enhancer (chemical) methods in Arjun (Terminalia arjuna).

Treatment	Mean (winter)	Mean (summer)
Traditional methods		
	11.90	10.03

Single cut
Double cut

Mechanical methods
Stripping
Semi arc V shape
Double V shape

Use of Gum Enhancer
Ethephon 1%
Ethephon 2%
Ethephon 4%
Acetic acid 4%
H_2SO_4 4%

12.77	10.40
11.53	10.63
11.32	10.67
12.13	11.07
13.27	10.40
12.53	11.50
13.26	10.93
12.90	11.47

SEd	0.58	0.29
SEm±	0.41	0.20
CD(p=0.05)	1.23	0.61
CV	5.73	3.28

3.4. Viscosity

The dynamic viscosity of gum samples from Jhingam and Arjun trees was assessed by measuring their viscosity with distilled water at various spindle speeds (10, 20, 30, 50, 60, and 100 rpm) using a spindle size of 61, at room temperature. Results indicated that for Jhingam gum, viscosity was highest at 100 rpm (6.8 cP) and lowest at 10 rpm (0.8 cP) in a 1% solution, while in a 2% solution, viscosity peaked at 100 rpm (4.38 cP) and was lowest at 50 rpm (2 cP). Similarly, Arjun gum displayed higher viscosity at 100 rpm (6.1 cP) and lower at 10 rpm (1 cP) in a 1% solution, and at 100 rpm (4.04 cP) and lower at 30 rpm (1.2 cP) in a 2% solution. Factors such as storage duration, gum solution preparation technique, solution concentration, and ambient temperature during preparation can affect viscosity, with the quantity of insoluble gel present being a significant influencing factor.

Table7: viscosity (cP) of gum sample exudated from Jhingam and Arjun trees in 1% solution

Rpm	Jhingam	Arjun
100	6.1	6.1
60	2.1	4.5
50	1.6	4.2
30	1.4	3.4
20	1	2.4
10	0.8	1
5	0	0

Table 8: viscosity (cP) of gum sampleexudated from Jhingam and Arjun trees in 2 % solution.

Rpm	Jhingam	Arjun
100	4.38	4.04
60	3.2	3.12
50	2	2.1
30	0	1.2
20	0	0
10	0	0
5	0	0

Plate 1 : TappedbyTraditional,MechanicalandChemica

3.5. Colour of Gum

A) The collected gum of Jhingam (Lannea coromandelica) by Traditional, mechanical as well as by using of gum enhancer for exudation of gum were analyzed visually on the basis ofColour.

Plate 2 : TappedbyTraditionaland Mechanical

Plate 3 : TappedbyChemical

B)The collected gum of Arjun (Terminalia arjuna) by Traditional, mechanical as well as by using

of gum enhancer for exudation of gum were analyzed visually on the basis ofColour.

3.3 Correlation analysis

The correlation coefficient is a statistical instrument employed to evaluate the intensity and direction of the connection between two or more variables. It serves a pivotal role in appraising the efficiency of the selection process. Consequently, correlation offers valuable insights into the extent of the relationship among various contributing attributes.

Table 9 Correlation study of seasonal variation in production, tree girth classes and method of tapping with gum productions:

	Jhingamyield (winter)	Jhingamyield (summer)	Jhingam Treegrith	Arjunyield (winter)	Arjun yield (summer)
Jhingamyield	**0.574***				
JhingamTreegrith	0.134NS	0.157NS			
Arjunyield (winter)	0.492NS	**0.669***	0.057NS		
Arjunyield (summer)	**0.815****	0.470NS	0.043NS	0.540NS	
ArjunTreegrith	-0.064NS	**0.653***	0.413NS	0.196NS	-0.163NS

The Correlation studies of seasonal variation in production, tree girth classes and method of tapping with gum

productions of indicated that there was highly significant in between Arjun yield (summer) with Jhingam yield (winter) **(0.815**)**, and significant between Jhingam yield (summer) with Jhingam yield (winter) **(0.574*)** and significantly between Arjun yield (winter) with Jhingam yield (summer) **(0.669*)** and significantly between Arjun yield (summer) with Jhingam yield (summer) **(0.653*)** and others traits show non-significant result.

4. Conclusion

The biopolymers obtained from the experimental trees have demonstrated significant value across various industrial applications. However, their efficient extraction requires the implementation of scientifically sound tapping techniques. Traditional cutting methods for tapping Arjun trees were found to be less effective, but the application of a gum enhancer like ethephon @ 2% shows promise for year-round tapping, except during the rainy season. In contrast, traditional methods such as single and double cuts proved to be efficient for tapping Jhingam trees throughout both winter and summer seasons. Interestingly, the use of a gum enhancer, especially ethephon @ 2%, showed superior results in both seasons for higher biopolymer production in Jhingam trees. This highlights the significant potential of Jhingam trees for tapping and enhancing Non-Wood Forest Produce (NWFP) resources, thereby improving the income and livelihoods of marginal farmers in Chhattisgarh. The rate of gum exudation was observed to be high during the summer months (May-June) in Jhingam trees, while in Arjun trees, the peak exudation rate occurred in March to April.

The physicochemical properties were not significantly affected by the use of gum enhancers. It caused the pH and moisture content to slightly decrease, while the ash, protein, and fat contents significantly increased. The bulk density and tapped density of the biopolymers removed from the experimental trees, however, did not change.

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