Mechanization Status in *Karaya* Gum Tapping and Scope for Improvement: A Review

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Abstract

Natural gums are among the important non timber forest products and are produced from a wide range of plants. *Karaya* gum is the dried exudate produced from *Sterculia urens* tree, which is an important raw material for textile, cosmetic, food, pharmaceutical and other industries. Gums are produced by exposing the gum ducts on the stem of the trees by making suitable incision. The existing tapping technique and devices are traditional, location specific, less efficient and time consuming. Tools and equipments developed for *karaya* gum tapping may be used to enhance productivity of the gum tappers, reduction in time of operation, drudgery and manpower requirement with increase in *karaya* gum production. Similarly, improved tapping technique and tools will minimize injury to the trees and help in sustainable production of gums with conservation of natural population of *karaya* trees. Increase in sustainable livelihood of rural and tribal people might be possible with adoption of scientific methods of *karaya* gum tapping to get remunerative prices of the products. The gum production systems need to be improved for efficient utilization of natural resource with higher yield and reduced manpower requirement. There is need to follow scientific methods of tapping and collection of the *karaya* gums in order to get remunerative prices of the products. Battery operated tools/equipments may be given preference in *karaya* gum tapping work especially in remote areas where electricity is a problem so that productivity of the person involved in karaya gum tapping work may be enhanced.

Keywords: Gum tapping, *Karaya* gum, Tools, Mechanization

Introduction

Natural Resins and Gums (NRGs) are produced by plants in the form of sticky exudates and nodules spontaneously. It is also collected by making incisions in the bark of the tree trunk by weaker sections of the society dependent on forests for their livelihood particularly tribal farmers in rural areas. NRGs sector is one of the most important sources of livelihood support of more than 50 million population inhabiting forest and sub forest areas and is a major source of employment. In India over 5 million tribal depend on Non-Wood Forest Products (NWFPs) for their employment and household income from the forests (Rawat and Jishtu, 2006). NRGs are non-toxic, biodegradable and eco-friendly for use in various industries. Gums are viscous secretion of some trees and shrubs that hardens on drying, are solids consisting of mixtures of polysaccharides (carbohydrates) which are either water-soluble or absorb water and swell up to form a gel or jelly when placed in water. Most of the NRGs are collected in small quantities by forest dwellers by adopting traditional tapping methods. Benefit mainly depends on

the quality of the produce. NRGs industry can provide employment and a steady additional income to rural people and thereby stop their migration into the towns and cities. The existing NRGs tapping technique and devices are traditional and location specific. The techniques and devices which are in vogue are less efficient and time consuming and having problem in handling and its operation. Therefore, there is tremendous potential to develop the sector further.

Karaya gum is the dried exudates obtained from the stem and root of *Sterculia* tree, family *Sterculiaceae*. The gum is produced by genus *Sterculia* and is collected after tapping or blazing the tree or as natural exudates (Elkhalifa et al., 2010). It is also known as Indian tragacanth and obtained from *Sterculia urens* Roxburgh. Local name of *karaya* gum is *Gulu*, *Kadaya*, *Karaya*, *Katera*, *Kullo* and *Tapsi*. Globally, *karaya* gum trees are found in South Africa, Australia, Pakistan, Panama, Philippines, Indonesia, Senegal, Sudan and Vietnam. In India, major *karaya* gum producing states are Andhra Pradesh, Madhya Pradesh, Maharashtra, Gujarat, Odisha, Rajasthan, Tamil Nadu, Karnataka, Jharkhand and Chhattisgarh.

Karaya gum is used in several industries due to its low solubility in water and low cost but swells to many times its original volume (Mali et al., 2012). Gum *karaya* is used for many industries i.e., petroleum and gas, printing and textile, paper and pulp, leather and allied products, ammunition and explosives, electrical appliances, adhesives, confectionery, medicine, pharmaceuticals and cosmetics (Gautami and Bhat, 1992; Dikshith et al., 1984 and Kuruwanshi et al., 2017). India is the leader in gum *karaya* production and export in the world (Srivastava and Ray, 2015).

Annual production of *karaya* gum in India was approximately 100.35 tons during the year 2015-16. Export of gum during 2015-16 was 263,130.94 tons valued at Rs. 311,995.60 lakhs. Out of the total gum export during the year, 230.77 tons gum *karaya* was exported for Rs. 771.59 lakhs (Yogi et al., 2018). The paper discusses different techniques developed and adopted by previous researchers for *karaya* gum tapping from *Sterculia urens* trees and scope of improvement in it.

Fig. 1 Blaze made for *karaya* gum tapping

Traditional Method of *Karaya* Gum Tapping

There is some natural exudation of *karaya* gum but most gum is collected by tapping. Descriptions of the tapping slightly vary according to the source of the information, but all entail removal of sections of bark from the trunk of the tree. Guidance rules have been laid down by the Forest Research Institute, Dehradun, in India, but in practice the rules are not adhered to and the dimensions of the "blaze" are often exceeded. Tapping which involves deep and wide wounds to the tree to maximize gum yields is damaging to the tree, and this led to a ban on tapping by Indian Forestry Department in the 1980s.

Fig. 2 Karaya gum exudate

Karaya gum is commercially tapped through blazing, peeling or by making deep cut in the base of the tree trunk with an axe. The normal practice in Chhattisgarh and Madhya Pradesh for *karaya* gum tapping is by making a blaze with the help of an axe on the tree trunk (**Fig. 1**). During the survey, three types of blazings have been observed by Shaw et al. (2010) under *karaya* gum tapping. First type of blazing for tapping *karaya* gum involves making 2-3 blazes of around 10 cm × 20 cm size on the tree trunk at different places at a time and collection of the gum begins after 7-8 days. To continue the process of tapping further, another 2-3 or more blazes are made on the trunk of the tree. In the second type of gum tapping method, around 10-20 cuts are made on the tree trunk at a time and collection of gum start after 7-8 days. Similarly, to continue tapping, another 10-20 cuts are again made on the tree trunk immediate after gum collection. In third type of gum tapping technique, a big blaze is made on the tree trunk and collection of gum starts after 7-8 days (**Fig. 2**). In similar fashion another blaze is made after tapping gum from first blaze. Such method of tapping leads to girdling of tree (Sharma et al., 2016a).

Indian experience exhibits that tapping is confined to trees with a minimum of 28.7 cm diameter at breast height (DBH) and the initial size of the blaze is limited to 15 cm tall, 10 cm wide and 0.5 cm deep. The tapping technique is accomplished by removal/incision of bark from the trunk with special tapping tool. Sixteen successive visits can be made to the tree at two-week intervals, removing a further

2 cm high section of the bark above the previous one at each visit, and leading to a maximum depth of the blaze of 2.5-3.0 cm. An additional blaze can be worked for every 16 cm DBH increment above 28.7 cm DBH, providing sufficient space is left between adjacent blazes. Tapping is best done during the hot season to maximize yields (Coppen, 1995). The gum begins to exude immediately and the exudation continues for several days. The maximum amount of exudation occurs within the first 24 hours (Sao, 2012). The gum is in the form of huge irregular tears. The best quality gum is collected during April, May and June. During this time, as the weather gets warmer the yield increases (Anonymous, 2007a).

Due to the enormous socioeconomic importance *karaya* gum products, in India, researches are conducted by different researchers to improve the tapping techniques (Shiva et al., 2006) and they have designed special tools for tapping. According to Shiva et al. (2006) the newly designed tools have controlled the optimum depth of the blazes/incisions on the trees that may help to obtain optimum quantity of gum without causing damage to the trees. Average yield per tree ranges from 1-5 kg and 4.3-7.2 kg during one year/season according to Coppen, 1995; Anonymous, 2007b and USAID, 2005, respectively. It is hoped that the newly designed tools will prove useful in obtaining the sustained production of gums without causing mortality of trees. In India, as *karaya* gum is vital for tribal economy with respect to its trade value, there is a pressing need to develop a scientific and sustainable tapping method to increase the yield and quality and ensure the survival of the tapped trees (Shiva et al., 2006).

Tapping of *karaya* gum from gum yielding trees (*Sterculia* urens) is done by blazing and stripping off the tree bark. Maximum amount of gum is produced within first 24 hours of blazing and continued for few days. It solidifies in the form of gum tears when exposed in the environment. *Karaya* gum can be tapped throughout the year except during rainy season as is either washed off and does not get dried easily and also poor in quality i.e., darker in color with high moisture content and impurities. Though the gum exudes from the blazes all the year around; the flow is more copious in the hot weather and best quality gum is produced during January to June. Blazing of the trees has an important bearing on the tree health and heavy tapping is believed to impair the seed fertility and thus regeneration. Therefore, tapping should be done with the least possible harm to the trees. Precaution should be taken while tapping gum, the *karaya* gum tree should be of at least 3 ft. in girth and blazing should be confined to main stem above 3 ft. from the ground level. The blazes of the rows should be alternate and depth of the blaze should not exceed ½" till second layer is exposed and each blaze should be a semi circle with 6" wide base. In the 2nd and 3rd year, tapping can be continued by extending the 1st year blaze 5 cm above the previous year's treated area and old wounds should not be reopened. In order to keep the longevity of the tree and for better quality of gum, tapping should not be done continuously and trees should be given long periods of rest before re-tapping so that the blazed portion gets enough time to heal which takes about 60 days after tapping and resume normal activity. Excessive tapping of the tree may also deteriorate the

Table 1 Comparative description of recommended methods of gum tapping from *Sterculia urens* trees

Karaya tapping methods aspect	Method adopted by Damoh & Jabalpur Forest Departments	Method proposed by FRI, Dehradun
Appropriate tree girth	90-135 cm	> 90 cm
Number of blazes/tree at a time	2 blazes in case of 90-135 cm girth trees	1 blaze for a tree of 90 cm girth
	3 or 4 blazes in trees with girth > 135 cm	An additional blaze for every increment of 50 cm of girth
Position of the blaze	Not specified	Not lower than 30 cm from the ground level
Initial size of the blaze	15 cm long and 7.5 cm wide	15 cm long and 10 cm wide
Maximum size of the blaze	45 cm long and 25 cm wide	47.5 cm long and 12.5 cm wide
Blazing instrument characteristics and its handling	Should be sharp but do not hammer the bark lest the pores should get compressed and closed	Sharp instrument
Depth of initial blaze	Should just penetrate the wood	Maximum 0.5 cm deep in wood cambium
Freshening	Only 1.5-3 mm bark thickness should be cut and removed each time	Each time, 2 cm bark above the initial blaze should be removed; the blaze depth should not exceed 3 cm; freshening to be done fortnightly
Tapping cycle	4-5 years	For continuous tapping, the tree can be divided in to 3 zones; 1 zone is tapped/season; hence a 3-5 year cycle is followed
Proposed yield	75-150 kg/annum per 100 blazes; in case of a tree of 90-135 cm girth – 1.5 to 3 kg/annum	75-100 kg/annum per 100 blazes; in case of a tree with 2 blazes and of 90-135 cm girth, gum yield would be 2.5 to 5 kg/annum

gum quality. The yield has increased about 20 to 30 times over the control and about 10 times more than the traditional tapping methods used by the local people (Kumar, 2016). There was a marked difference in the yield among individual trees, presumably due to heterozygosity.

The best quality gum is collected during April-June i.e., before commencement of monsoon. As the weather becomes warmer, the gum yield and quality improve. Collection may be repeated after the monsoons in September, although this gum may be darker in color and lower in viscosity. When trees are incised or blazed, gum begins to flow immediately, and exudation continues for several days. The maximum amount of exudation occurs within the first 24 hr. The yield of the gum from matured trees is estimated at 1 to 4.5 kg per tree per season. The average tree can be tapped five times during the lifetime (Sao, 2012).

Scientific Tapping Method

Several agencies have explored methods of tapping the gum tree to maximize gum yields (both qualitatively and quantitatively) without killing the precious tree resource. Two of the improved methods of *karaya* gum tapping, one adopted by the Damoh and Jabalpur Forest Departments and another evolved by the Forest Research Institute (FRI) Dehradun are summarized in **Table 1** (Anonymous, 1973; Fri, 1972 and Bhattacharya et al., 2003).

Table 2 Methodology of *karaya* gum tapping developed by Kovel Foundation, Visakhapatnam in collaboration with Girijan Co-operative Corporation, Visakhapatnam

Steps	Procedure
1	Select a suitable karaya tree for gum tapping having 90 cm or more girth at waist height whose trunk matches the entire arms-reach of a normal individual.
2	Clean the debris and loose bark from tree trunk using leaves or a piece of cloth followed by clearing the ground area within 100 cm radius near the selected tree for hindrance free working of gum tapper.
3	Develop a 12-15 cm horizontal incision on the tree trunk at waist height using sharp knife (**Fig. 4**) and join the ends of incision by another, higher, crescent shaped incision on the tree trunk (**Fig. 3**).
4	Deepen the two incisions with sharp knife up to about 3.0 cm deep and do not remove the bark.
5	Beat the bark bounded by the incisions using mallet or blunt end of sharp knife/axe till the bark becomes soft and pulpy and leave it attached with tree trunk for a fortnight.
6	Remove the dried and died beaten portion of bark from incisions by hands or using knife after a fortnight and peel off a thin layer of live bark from the top crescent portion to initiate gum exudation.
7	Clean the area in and around the blaze using a piece of cloth and attach a small polythene sheet to the face of the blaze using thorns so that oozed gum from the crescent incision should drip on the polythene in the form of large, irregular tears and leave the polythene on the tree trunk for at least two days.
8	Return on the 3rd day with the sharp knife and a bamboo basket hanging from the elbow by a coir rope and remove thorns from lower end of polythene attached to the blaze by holding polythene alongwith collected gum carefully in one hand followed by removing thorns from upper end of the polythene. Cut the gum stream to disconnect the gum collected on the polythene from the flows oozing from the trunk using knife by other hand and place the polythene with its gum in the bamboo basket carefully. After removal of gum from blaze, a new and clean polythene sheet should be attached for further collection of gum from same blaze. Freshen the crescent shaped blaze by slicing a very thin layer from it, using knife, if the gum flow has ceased.
9	Repeat the step no. 8 every 3rd day, till the blaze is too high on the trunk for tapper to reach easily which takes 3 years usually. Start preparing a new blaze, if blaze is too high from the reach of the tapper followed by developing only one blaze per tree, at a time.
10	New blaze should be made diametrically opposite the first blaze followed by Steps 2 to 9 for another 3 years. Third blaze may be made on one side between the first and second blaze developed and similarly, fourth blaze would be developed on the side opposite to the 3rd blaze on the trunk. After a karaya tree has been tapped for 12 years continuously in this way, the wound from the first blaze should have healed completely and the trunk on that side is ready for tapping again.
11	Gum bearing polythene sheets are inverted and emptied on to a larger polythene sheet that has been spread over a bamboo-mat on a raised platform. This platform should be at least of waist height and constructed in an open, dust-free and sunny space to allow the gum to dry quickly. Pieces of bark, leaves or other extraneous material should be removed from the semi-solid gum using forceps. The gum pellets are than sun dried until they become brittle.
12	Dried gum is then sorted into grades on the basis of color and amount of visible impurities.
13	Dried gum should be stored in clean and airtight polythene bags ready for the market.

Fig. 3 Blaze formed for *karaya* gum tapping using sharp knife

Semi Circular Blazing Technique of *Karaya* Gum Tapping

A semi-circular blazing technique for *karaya* gum tapping was developed by Kovel Foundation, Visakhapatnam (Andhra Pradesh) in collaboration with Girijan Co-operative Corporation, Visakhapatnam (Andhra Pradesh) for scientific tapping of *karaya* gum from *Sterculia urens* tree using specially devised sharp knife (**Fig. 4**) to make incisions on the tree trunk. Kovel's technique not only incorporates the basic principles followed in the earlier improved methods developed for *karaya* gum tapping from *Sterculia urens* trees but also permits continuous, sustainable tapping of high-quality gum. Methodology of *karaya* gum tapping developed by above organizations as described by Bhattacharya et al., 2003 are detailed in **Table 2**.

Tools and Material Requirement for *Karaya* Gum Tapping from *Sterculia urens* Trees Through Semi Circular Blazing Technique

Under mentioned tools and materials (**Table 3** and **Fig. 4**-**9**) required for *karaya* gum tapping from *Sterculia urens* trees through semi circular blazing technique developed by Koval Foundation in collaboration with Girijan Co-operative Corporation, Visakhapatnam (Andhra Pradesh).

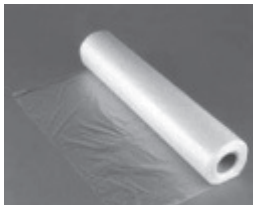
Steps for *karaya* gum tapping technique developed and standardized by Kovel Foundation, Visakhapatnam in collaboration with Girijan Co-operative Corporation, Visakhapatnam (Andhra Pradesh) depicted as pictorial representation in **Fig. 10**.

Mechanization in Blazing Technique of *Karaya* Gum Tapping

A blazer to control the size and depth of blaze for sustainable *karaya* gum production and conservation of karaya gum producing trees (**Fig. 11**) was developed by researchers from Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) under All India Network Project on Harvesting, Processing and Value Addition of Natural Resins and Gums. The developed blazer was found suitable for making blaze on *karaya* tree (**Fig. 12**) for gum tapping (Patil et al., 2018).

Shiva et al., 1994 developed a newly designed improved gum tapping tool (**Fig. 13**) and utilized in the gum tapping experiments from *Acacia nilotica* and *Prosopis juliflora* respectively and observed that tool developed have controlled the optimum depth of the blazes/incisions on the trees that may help to obtain optimum quantity of gum without causing damage to trees. Developed tool was found successful in the case of Babool and Prosopis gum tapping experiments conducted at Meerut and Mathura Forest Division in Uttar Pradesh. They reported that developed tool likely to prove beneficial in the tapping of commercially important gums i.e., *karaya* gum from *Sterculia urens*/ *Sterculia villosa*, jhingan gum from *Lannea coromandelica*, ghatti gum from *Anogeissus latifolia*, semla gum from *Bauhinia retusa* trees etc. The developed tool has sharp edged

Table 3 Tools and Materials required for karaya gum tapping and their purpose

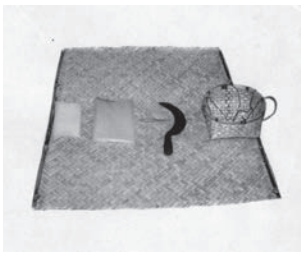
Purpose	Tools and Material	Purpose	Tools and Material
Making blaze/incision on tree trunk for gum tapping	 **Fig. 4** Sharp knife	Fixing polythene on the developed blazes for collection of exudated karaya gum and for easy collection	 **Fig. 5** Small polythene
Transportation of collected karaya gum from field to storage area safely	 **Fig. 6** Bamboo basket	Removal of impurities from collected karaya gum	 **Fig. 7** Forceps
Covering karaya gum kept over bamboo mat for drying at elevated height from ground	 **Fig. 8** Large polythene	Drying of collected karaya gum	 **Fig. 9** Bamboo mat

rectangular chisel at one end of size 10 cm length, 4 cm height and 4 cm depth particularly for gum tapping from *Sterculia urens* trees made of mild steel sheet and a rectangular piece of mild steel is fixed at another end having length 15 cm, width 4 cm and height 4 cm respectively. For making blazes on the tree trunk for gum tapping, the developed tool was required to be placed at desired position on the tree trunk and hammered. The edge of the tool was so designed that the chisel does not go more than 5.0 cm in wood just below the Cambium.

Sharma and Prasad, 2013 conducted experiment for *karaya* gum tapping from *Sterculia urens* trees growing in Taimara Valley about 25 km from ICAR – Indian Institute of Natural Resins and Gums, Ranchi on Ranchi – Jamshedpur National Highway 33 utilizing semi-circular blazing technique of *karaya* gum tapping developed and standardized by Koval Foundation, Visakhapatnam in collaboration with Girijan Co-operative Corporation, Visakhapatnam (Andhra Pradesh).

Fig. 10 Steps of karaya gum tapping through semi circular blazing

(i) Selection of suitable tree for gum tapping

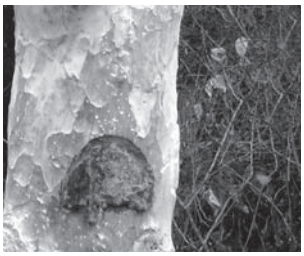


(ii) Tools and material required for karaya gum tapping

(iii) Method of making blaze

(iv) Semi circular blazing

(v) Hammering the cut bark for removal



(vi) Bark after hammering

(vii) Separation of hammered bark

(viii) Installation of polythene sheet

(iv) Extraction of karaya gum

(x) Karaya gum transportation

(xi) Removal of impurities from collected gum

(xii) Drying of exudated karaya gum

Fig. 11 Blazer for making blaze on *karaya* tree for gum tapping

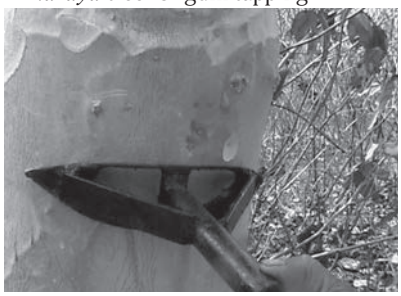
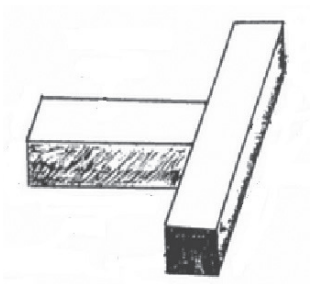


Fig. 12 Blaze developed on the tree trunk using blazer

Fig. 13 Improved gum tapping tool



After one month of treatment, exudated gum was collected and the blaze of each tree were refreshed by removing thin bark of the blaze for opening the gum ducts for further gum exudation and the freshening process continued throughout the experiment duration with monthly interval. It was observed that gum exudated from the trees round the year but exudation was more during hot weather condition. Minimum and maximum gum yield was 304.88 g and 1,310.48 g for trees having diameter 0.56 and 0.70 m respectively. Physical damage in the trees was worked out to be 91.16 cm^2 on area and 231.55 cm^3 on volume basis, respectively.

Gum Inducer Technique of *Karaya* Gum Tapping

A simple and safer technique of tapping with substantial increase in the yield is being developed using ethephon (2 – chloro ethyl phosphonic acid) to enhance gum yield and faster wound healing. After 45 days a thick wound tissue will develop at the injured region and almost replaces the damaged tissue when using this method. The wound is completely healed in 60 days after tapping. While using this method the yield increases by approximately 20 to 30 times more than the control. There is also a marked difference in the yield among individual trees, presumably owing to heterozygosity. The systematic and scientific tapping technique using ethephon as a stimulating agent for gummosis or gumresinosis could ensure substantial improvement and sustainable production of these materials (Balakrisnan, 2003).

Scientific technique of gum arabic tapping known as "gum inducer technology" developed by researchers from ICAR – Central Arid Zone Research Institute, Jodhpur (Rajasthan) under ICAR – All India Network Project on Harvesting, Processing and Value Addition of Natural Resins and Gums as detailed below was adopted by researchers from Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) and ICAR – Indian Institute of Natural Resins and Gums, Ranchi (Jharkhand), respectively for *karaya* gum tapping from *Sterculia urens* trees.

To produce and enhance gum arabic production from Acacia senegal tree, a small size hole of 12 mm diameter and 25 mm deep with 45° inclination towards inner side is made on the tree trunk about 450-500 mm above the ground using manually operated drill (**Fig. 14**) and mixture of sulphuric acid (H_2SO_4) and ethephon is injected in the hole (780 mg/4 ml) through disposable syringe (**Fig. 15**) followed by patching the hole with wet clay soil or bee wax (**Fig. 16**) after treatment to make the hole air tight for enhancing gummosis process utilizing ethylene gas produced inside the hole.

Sharma and Prasad, 2013 conducted experiment for *karaya* gum tapping from *Sterculia urens* trees naturally growing in Taimara Valley about 25 km from ICAR – Indian Institute of Natural Resins and Gums, Ranchi on Ranchi – Jamshedpur National Highway 33 utilizing gum inducer technique developed for gum arabic tapping from *Acacia senegal* trees by researchers from ICAR – Central Arid Zone Research Institute, Jodhpur (Rajasthan) under ICAR – All India Network Project on Harvesting, Processing and Value Addition of Natural Resins and Gums. After one month of treatment, exudated gum was collected and hole of each tree were rebored up to the same depth as made earlier for opening the clogged gum ducts for further gum exudation and the process was continued throughout the experimentation at monthly interval. It was observed that gum exudated from the trees throughout the year but exudation was higher during hot weather condition. Minimum and maximum gum yield was 1,189.10 g and 4,285.65 g, respectively for trees having diameter 0.56 and 1.15 m. Physical damage in the trees through gum inducer technology was worked out to be 1.27 cm^2 on area and 12.86 cm^3 on volume basis.

Fig. 14 Making hole with hand drill

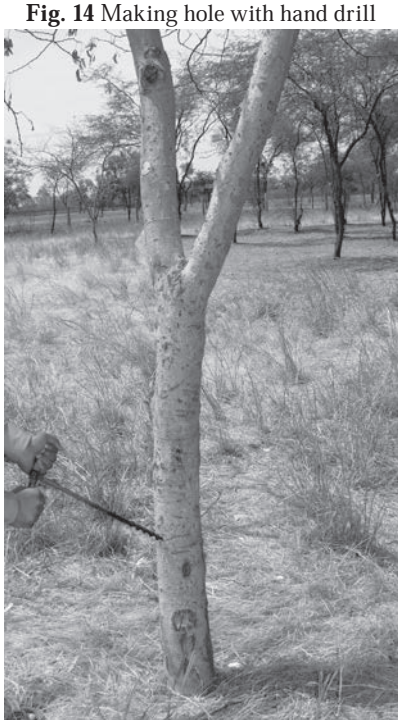


Fig. 15 Injecting gum inducer

Fig. 16 Covering the hole by moistened clay

The gum inducer technology was found better for *karaya* gum tapping from *Sterculia urens* trees in Jharkhand region with 17 times less damage to trees on volume basis and about 200% higher gum yield compared to semi circular blazing technique of *karaya* gum tapping.

Nair, 2003 conducted experiment on 15 trees of *Sterculia urens* in the Ghati village near Gwalier Highway No. 3 to find out optimum concentration of ethephon to induce maximum production of gum with minimum injury to the tapped trees. Using a specially devised knife, holes each of 5 mm diameter and 2-3.5 cm depth based on the thickness of the bark were made on the tree trunk 20 to 30 cm distance at 100 cm above the ground level. The holes were angled towards the base of the tree to prevent the backflow of the introduced solutions. One hole in each tree was maintained as control injecting distilled water and the rest were treated with ethephon. One milliliter of ethephon containing 190/285/390 milligrams of active substance (one ml of distilled water for control) was dispansed in to each hole. Five trees were used for each concentration. The first collection of gum produced in the control and treated holes were made after 15 days. The succeeding 3 collections were done after every 10 days. It was noticed that the trees treated with 285 milligram of active substance of ethephon have yielded highest amount of gum and therefore this concentration was used for further experiments.

The tapping experiments were repeated at Ghati village in Madhya Pradesh and Cheedipalem in Andhra Pradesh. Fifteen trees of various sizes and ages were selected for the study at both the sites. The trees were tapped in March, May and November 1995 in Ghati village using 285 mg of active substance to understand the seasonal variation in the gum yield. The tapping of trees at Cheedipalem were done in February and May in 1996. The *karaya* trees are tapped by the tribal people with the help of Girijan Co-operative Corporation in Andhra Pradesh. The yields from the traditional tapping method and the method using ethephon were compared. The tribal people remove 50 to 55 cm length of bark across the trunk with a sickle and collect the gum as tears or as irrigular fragments. The tapped trees often fail to regenerate after some years. The trees were tapped throughout the year except in the rainy season. Study revealed that ethephon treatment resulted in the increase in gum production of about 40 to 85 times more than the control. The harvest from the ethephon treated trees was of high quality gum. The gum started oozing out of the holes within 3 to 5 hours and gets hardened when comes in contact with environment. The control holes produced negligible amount of gum. It was found that the damaged tissues of the ethephon treated holes were nearly replaced with wound tissue after 45 days. The injury was completely healed after 2 months. Results of the tapping done at Ghati village of Madhya Pradesh in the year 1995 shows highest amount of gum produced in May and least amounts in November. The tapping experiments conducted in Cheedipalem, Andhra Pradesh also shows copious gum production in the summer month. The yield of gum when tapped using ethephon was about 10 times more than the yield when tapped using traditional method which ensures minimum injury to the trees so that the tree is regenerated easily, thus guaranteering sustainable production of gum. The injury made by the traditional tapping is very large (50 to 55 cm long). The gum exudation in *karaya* tree is highest in April - May, the exudation is about 10 times more than the production in November. Therefore, it is suggested that *karaya* gum tapping for commercial purpose be done only during March to May and the trees may be given rest in the remaining part of the year. This will ensure regeneration of the tapped trees, sustainable supply of *karaya* gum with good economic return.

Fig. 17 Battery operated drill

Fig. 18 Drill attachment/bit

Mechanization in Gum Inducer Technique of *Karaya* Gum Tapping

The gum inducer technique developed for gum arabic tapping by researchers from ICAR – Central Arid Zone Research Institute, Jodhpur (Rajasthan) under ICAR – All India Network Project on Harvesting, Processing and Value Addition of Natural Resins and Gums was mechanized using battery operated drill instead of manually operated drill (**Fig. 17**) to enhance the productivity of gum tappers. It can drill holes up to a diameter of 18 mm in wood. The drill can be operated with battery and drill attachment/bit (**Fig. 18**) supplied by the company. This drill can be operated for long duration in remote area with the backup of a charged battery which may be replaced as per requirement (Sharma et al., 2016b).

Prasad et al., 2012 reviewed the

work carried out for mechanization of *karaya* gum tapping and reported use of axe (**Fig. 19**) and blazing knife (**Fig. 20**) for making blaze in blazing method of *karaya* gum tapping. They further reported use of hand and battery-operated drill (**Fig. 21** and **Fig. 22**) for making hole in gum inducer method of gum tapping using different gum inducers.

An investigation was carried out by Kuruwanshi et al., 2017 at former Central Government Forest Division, Biladi at Tilda block of Raipur (Chhattisgarh) during year 2015 and 2016. The experiment was laid out with three replication and six treatments i.e., distilled water as control (T_1), different ethephon concentration (T_2 - 2.34%, T_3 - 3.12%, T_4 - 3.9%) and Indole Acetic Acid (T_5 - 400 ppm, T_6 - 800 ppm) for potential gum production from *Sterculia urens* Roxb. Gum inducer technology developed by researchers from ICAR – Central Arid Zone Research Institute, Jodhpur (Rajasthan) under ICAR – All India Network Project on Harvesting, Processing and Value Addition of Natural Resins and Gums for gum arabic tapping was utilized for *karaya* gum tapping from *Sterculia urens* trees with distilled water and different concentrations of ethephon and IAA. During the period of experiment only two times 4 ml gum enhancer was introduced in treated trees in the month of March and May, respectively. It is observed that gum exudation in form of tears begin after 7-10 days of treatment (**Fig. 22**). Maximum rate of gum exudation observed in month of May during the year 2015 (440.33 g) and 2016 (530.1 g) followed by April and March and minimum rate of gum exudation was observed in June for the year 2015 and 2016. Similar enhanced gum arabic production of 0.8-0.90 kg per tree using 4 ml containing 960 mg active substance in the month of April/May also reported by (Bhatt and Mohan Ram, 1990 and Harsh et al., 2013). It was concluded that application of 3.9% concentrated ethephon was significantly superior for *karaya* gum production during 2015 (717.05 g) and 2016 (777.45 g) followed by 3.12% and 2.34%. Rate of gum exudation using IAA @ 800 ppm was minimum during both the years. Similar enhancement in *karaya* gum production without any apparent ill effect on the health of the tree through injecting ethephon (4 ml) in the tree trunk of *Sterculia urens* trees during March and May also reported by Gupta et al., 2012 and Babu and Menon, 1989. Average quantity of gum exudation was highest for 3.9% concentration of ethephon followed by 3.12% and 2.34% compared with control. Similar increase in gum production with application of ethephon also reported by Sharma and Prasad, 2013.

Prasad et al., 2012 reported that researchers from Indira Gandhi Krishi Vishwavidyalaya, Raipur centre of ICAR – All India Network Project on Harvesting Processing and Value Addition of Natural Resins and Gums conducted experiment on *karaya* gum tapping from *Sterculia urens* trees located at Kurrabhata village of Gariaband (Chhattisgarh) by injecting ethephon during May - June, 2010 (**Fig. 23**). On each tree 4 holes of 6 mm diameter and 5 cm deep were made with the help of manually operated drill followed by injecting 1 ml ethephon in each hole with the help of disposable syringe and 1 ml distilled water as control. Researchers from the centre on *karaya* gum at IGKV, Raipur under Network Project on HPVA of NRG concluded that mean gum yield was 320 g per tree with ethephon, whereas in control gum production was negligible. Maximum and mini-

Fig. 19 *Karaya* gum tapping using axe

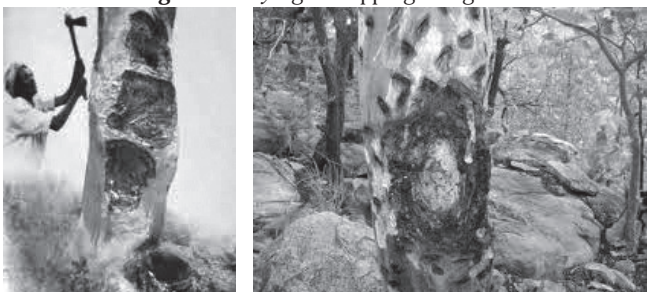


Fig. 20 Use of blazing knife for making blaze in karaya tree for gum exudation

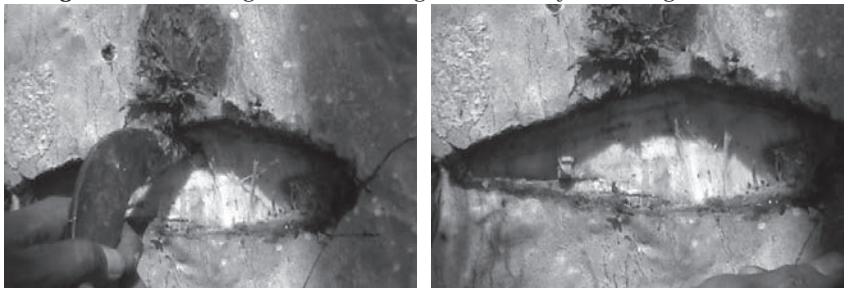


Fig. 21 Use of hand drill for making hole in karaya tree for injecting gum inducer

mum gum production was found to be 650 g and 10 g respectively, from trees having girth 500 cm and 76 cm. They recommended that gum inducer technique of gum tapping from *Sterculia urens* trees showed least damage to the tree under gum tapping experiment therefore, the technique need to be promoted among gum pickers (Anonymous, 2011).

Effect of Tapping Technique on *Karaya* Gum Yield

Sharma and Prasad, 2013 conducted experiment on nine trees of *Sterculia urens* for *karaya* gum tapping growing in Taimara Valley about 25 km from ICAR – Indian Institute of Natural Resins and Gums, Ranchi on Ranchi – Jamshedpur National Highway 33.

Fig. 23 Karaya gum exudation using gum inducer (ethephone)

Out of nine trees, three trees were used for gum tapping through semi circular blazing developed and standardized by Koval Foundation, Visakhapatnam in collaboration with Girijan Co-operative Corporation, Visakhapatnam (Andhra Pradesh) for *karaya* gum tapping and six trees by gum inducer technique using ethephon developed by researchers from ICAR – Central Arid Zone Research Institute, Jodhpur (Rajasthan) under ICAR – All India Network Project on Harvesting, Processing and Value Addition of Natural Resins and Gums for gum arabic tapping from *Acacia senegal*. It was observed that gum started oozing out after 4 hours in treated holes in gum inducer technique and immediately in case of semi-circular blazing technique and mean *karaya* gum collection was found to be 753.68 g in cases of semi-circular blazing technique while 2,307.16 g for inducer technology during the experimentation period. Nair et al., 1995 also reported that ethephon enhances gum formation and wound healing in *S. urens*. It was also found that gum production was higher in case of inducer technology over semi-circular blazing almost in all the months during the duration of investigation. Inducer technology was found better for *karaya* gum tapping from *Sterculia urens* trees in Jharkhand region with 17 times less damage to trees on volume basis and about 200% more gum production compared to semi circular blazing technique (Sharma et al., 2018).

Conclusions

The gum production systems need to be improved for efficient utilization of natural resource with higher yield and reduced manpower requirement. Increase in sustainable livelihood of rural and tribal people might be possible with adoption of scientific methods of *karaya* gum tapping to get remunerative prices of the products. Tools and equipments developed for *karaya* gum tapping may be used to enhance productivity of the gum tappers, reduction in time of operation, drudgery and manpower requirement with increase in *karaya* gum production. Wireless/battery operated tools/ equipments may be given preference in *karaya* gum tapping work especially in remote areas where electricity is a problem so that productivity of the person involved in *karaya* gum tapping work may be further enhanced.

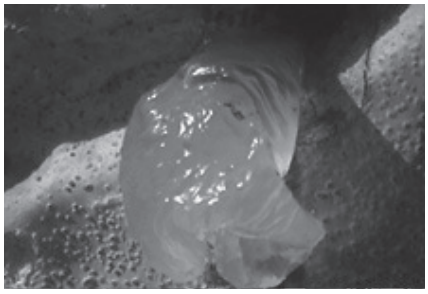
Acknowledgement

The authors express their sincere thanks to Dr. K. K. Sharma, Director, ICAR – Indian Institute of Natural Resins and Gums, Ranchi for constructive suggestions and technical guidance provided in preparation of the manuscript. Authors are also thankful to Principal Investigators of different cooperating centers under All India Network Project on Harvesting, Processing

Fig. 22 Gum exudation in karaya after gum inducer treatment

Use of battery operated drill for making hole in karaya tree for injecting gum inducer

Gum inducer injection using syringe



Gum exudation in gum inducer method

and Value Addition of Natural Resins and Gums for their support in providing technical information related to mechanization in gum production. Financial support provided by Indian Council of Agricultural Research, New Delhi for the All India Network Project on HPVA of NRG is thankfully acknowledged.

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