Introduction

Nature has been a source of medicinal treatments for thousands of years. Human kind has been co-evolving with plant pasts for more than two million years. In the process, humanoids ingested many, if not all, of the phytochemicals that the plants evolved to defend themselves from diseases and leaf eating pests (Duke et al., 1999). While plants were the major source of medicines for millennia, the discovery of the penicillin in 1930 ushered in the golden age of antibiotics and a revolution in chemotherapy. More recently, marine organisms have provided a host of novel bioactive chemotypes. Advances in the description of the human genome, as well as the genomes of pathogenic microbes and parasites, are resulting in the determination of the structure of many of the proteins associated with the disease processes. Novel molecular targets based on these proteins are being developed as high throughput assays, which require expanded and novel chemical diversity for screening. Much of the world biodiversity remain unexplored as a source of novel drug leads, and the search for new bioactive agents from natural sources, include extreme environmental niches, is expanding. The potential for drug discovery from natural sources is being further enhanced, with advances in the procedures for microbial cultivation and the extraction of nucleic acids from microbial samples providing access to the vast untapped reservoir of microbial genetic and metabolic diversity. Genetic manipulation of microbial biosynthetic pathways is further expanding this potential to include the biosynthesis of bioactive products not generated naturally. The unique molecules generated by nature provides scaffolds for elaboration by combinatorial chemical techniques, as well as challenges to organic chemists, not only in their total synthesis, but also in the identification of simpler pharmacophores, which may provide to be equal or more effective chemotherapeutic agents. Nature thus provides access to unique molecular
diversity, but the investigation of these resources requires multi-disciplinary, international collaboration in the discovery and the development process (Anonymous, 2002). Medicinal chemists appreciate chemical diversity as a means of generating new structures, exploiting novel mechanisms and sometimes uncovering new targets. In some situations, half the productivity battle is won when druggable, unique structures are discovered. Although chemical diversity is constant, the road to achieving it is not always clear.

Traditionally, natural products have been a major source of new drugs, and many successful drugs were originally synthesized to mimic the action of molecules found in nature (Kingston, 1996). Natural compounds are highly diverse and often provide highly specific biological activities. This follows from the proposition that essentially all natural products have some receptor binding capacity (Verdine, 1996). For the most part, the discovery of the drugs stems from knowledge that their extracts are used to treat one or more diseases in humans. The more interesting of the extracts are then subjected to pharmacological and chemical tests to determine the nature of the active components. Therefore, it should be of interest to ascertain just how important plant drugs are throughout the world when used in the form of crude extracts. The World Health Organization (WHO) estimates that 80% of the people in developing countries of the world rely on traditional medicine (Anonymous, 1986) for their primary health care needs, and about 85% of traditional medicine involves the use of plant extracts. This means that about 3.5 to 4 billion people in the world rely on plants as sources of drugs (Farnsworth et al., 1985).

Natural products have made a major impact on the modern pharmaceutical industry. 50% of all drugs sold in the developed world have their origins from nature sources. 9 out of the top 20 selling drugs were derived from natural sources. Up to 80% of all anti-cancer and anti-bacterial drugs have come from natural sources. 25% of prescription drugs today are derived from plants. More than 60% of all drugs are synthesized from a compound originally derived from a plant. Organic synthesis is used to modify what nature has already invented. Approximately 119 pure chemical substances extracted from higher plants are used in medicine throughout the world (Farnsworth et al., 1985). The search for biologically active natural products for the development of new drugs has a long tradition. Most such compounds are isolated from plants, animals, fungi, and microorganisms like bacteria, which exist in great variety on earth. Total synthesis is playing a major role in the drug discovery process since it allows exploration in chemical biology through molecular design and mechanistic study. Natural products are the most consistently successful source of drug leads and continue to provide greater structural diversity than standard combinatorial chemistry. They offer major opportunities for finding novel low molecular weight lead structures that are active against a wide range of assay targets. Current commercial evidence also supports this statement. More than 60% of the available anti-cancer drugs were either directly based on or developed from natural products. A very important example of plant-derived drug, taxol, originally isolated from the bark of the pacific yew tree (Taxus baccata L.), was subsequently synthesized and has recently been released for cancer therapy by
Bristol-Myers-Squibb in the U.S. An example of a previously ignored group of organisms is the myxobacteria, also known as gliding bacteria; these are common but unusual soil bacteria that can form fruiting bodies. Many diverse structures have been isolated from myxobacteria, including the epothilones, macrolides that show a taxol-like effect on tubulin. Many other compounds of microbial origin are already in use: e.g., as agents such as antibiotics in human and veterinary health care, as feeding additives for animals and as insecticides or herbicides for agricultural use.

There is a great deal of interest in and support for the search for new and useful drugs from higher plants in countries such as the People's Republic of China, Japan, India, and the Federal Republic of Germany. Virtually every country of the world is active in this search to a limited degree. However, in light of its size and resources, the United States must be regarded as an underdeveloped country with regard to productivity and programs designed to study higher plants as sources of new drugs, both in terms of industrial and university-sponsored research.

Estimates of the number of higher plants that have been described on the face of the Earth vary greatly from about 150,000 to 250,000. How many of these have been studied as a source of new drugs? This is an impossible question to answer for the following reason. The National Cancer Institute in the United States has tested 35,000 species of higher plants for anticancer activity. Many of these have shown reproducible anticancer effects, and the active principles have been extracted from most of these and their structures determined. However, none of these new drugs have yet been found to be safe and effective enough to be used routinely in humans. The question then arises, could any of these 35,000 species of plants contain drugs effective for other disease states, such as arthritis, high blood pressure, acquired immuno deficiency syndrome (AIDS), or heart trouble? Of course they could, but they must be subjected to other appropriate tests to determine these effects. In reality, there are only a handful of plants that have been exhaustively studied for their potential value as a source of drugs, i.e., tested for several effects instead of just one. Thus, it is safe to presume that the entire flora of the world has not been systematically studied to determine if its constituent species contain potentially useful drugs. This is a sad commentary when one considers that interest in plants as a source of drugs started at the beginning of the nineteenth century and that technology and science have grown dramatically since that time. It is possible to present certain types of data showing the relative interest in studying natural products as a source of drugs by means of the NAPRALERT database that is maintained at the University of Illinois at Chicago (Farnsworth et al. 1981, 1983; Loub et al., 1985). This specialized computer database of information on natural products was derived from a systematic search of the world literature. Data that can be retrieved from the system include folkloric medicinal claims for plants, the chemical constituents contained in plants (and other living organisms), the pharmacological effects of naturally occurring substances, or the pharmacological effects of crude extracts prepared from plants. More than 80,000 articles have been entered into the database since 1975, and about 6,000 new articles are added each year. The system contains folkloric, chemical, or pharmacological information on about
25,000 species of higher plants alone. To give some idea as to the interest (or lack thereof) in studying the pharmacological effects of natural products, we can cite the following data from NAPRAERT. In 1985, approximately 3,500 new chemical structures from natural sources were reported. Of these, 2,618 were obtained from higher plants, 512 from lower plants (lichens, filamentous fungi, and bacteria), and 372 from other sources (marine organisms, protozoa, arthropods, and chordates). A significant 56.6% of the new chemicals obtained from lower plants (primarily antibiotics produced in industrial laboratories) have been tested for biological effects. About 23.9% of those obtained from marine sources, protozoa, arthropods, and chordates were studied for biological effects, but only 9.5% of the new structures obtained from higher plants were tested for pharmacological effects.

The drug development from higher plants should include a careful evaluation of historical as well as current claims of the effectiveness of plants as drugs from tribal cultures. Such information is rapidly disappearing. The lack of interest of discovery from natural drugs is because of following reasons:

- To recover the costs of developing such drugs, solid patent protection must be secured. It is generally believed that natural products cannot be patented with the same degree of assurance, as can synthetic compounds. This of course cannot be a valid deterrent, since patent protection for vincristine and vinblastine was sufficiently secure that the Eli Lilly Company had exclusive marketing rights to these substances for the full term of patent protection.
- Most promising plants seem to be indigenous to developing countries, many of which do not have stable governments and thus cannot provide assurance that there will be a continued supply of the raw material needed to produce the useful drugs. This of course may be true in a strict sense; however, as history shows, it is rare when a useful plant grows only in one isolated developing country. In the course of developing a full program involving plants as a source of raw material, it would be normal logic to immediately seek sources of the useful plant from a large number of geographic areas. Cultivation programs should also be initiated. In the early stages of development of vincristine and vinblastine, the plant source Catharanthus roseus was collected from many different countries of the world and was also cultivated in eastern European countries and in the United States.
- Biological variation from lot to lot of plant drugs, but scientific documentation for this statement is difficult to find.

By the use of new strategies to discover natural products of interest, many molecules with novel structural features have been isolated and their structures have been elucidated. This led to very interesting and novel structures with outstanding biological properties that require further development of strategies for total synthesis and new methodology to synthesize these molecules. Especially for the use in drug discovery in pharmaceutical industry flexible entries to biologically active molecules need to be developed. A major advantage will be the target-oriented search of new low molecular weight natural products, because the understanding of the biological mechanism of action will provide a useful tool to generate analogues. In addition, structure-activity-relationships (SAR) play a
very important role to discover new drugs and this requires flexible approaches in synthesis to make these molecules in mega scale. In addition, computer modeling and receptor studies will be of importance.

The stake in drug developments are high and the payoff is uncertain. Finding a valuable compound has a high cost since the probability of locating one with a desired action is low. It is often necessary to test as many as 10,000 substances in order to find one that may reach the drug market. Developing a successful drug can require screening of some 1000 plant species. Research and development cost is generally high, at an average of $231 million per drug, with nearly 12 years needed to go from source to market (Godwin et al., 1999). There is both general and industrial interest in further searches for new secondary metabolites. Strategies for the total synthesis of biologically active natural products are a major subject of this action. This provides flexible entries to a variety of analogues in order to find the common pharmacophoric model. In light of that there is a demand for "Natural Products as a Source for Discovery, Synthesis, and Application of New Pharmaceuticals".

1.1 DIABETES

Diabetes mellitus is one of the oldest diseases known to mankind. There are more than 125 million persons with diabetes in the world today, and by 2010 this number is expected to approach 220 million (Amos et al., 1997). Diabetes mellitus is a group of syndromes characterized by hyperglycemia, altered metabolism of lipids, carbohydrates, and proteins and an increased risk of complications from vascular diseases. Most patients can be classified clinically as having either type 1 diabetes mellitus (type 1 DM formally known as insulin dependent diabetes or IDDM) or type 2 diabetes mellitus (type 2 DM, formally known as non-insulin-dependent diabetes or NIDDM). In certain tropical countries, the most common cause of diabetes is chronic pancreatitis associated with nutritional or toxic factors (a form of secondary diabetes). Also, on rare occasions, diabetes results from point mutations in the insulin gene. There are genetic and environmental components to both type 1 DM and type 2 DM. A positive family history is predictive for the disease. Studies of identical twins show 70-80% concordance for developing type 2 DM. Furthermore there is high prevalence of parents with disease (up to 70%) and also in siblings of affected individuals (Devis et al., 2001). Yet with the tremendous scientific advances witnessed in this century, medical science cannot claim that it knows all that needs to be known about this disease, including its management. This is the main reason for the persistent interest all over the world to explore alternative remedies from the so-called ‘alternative systems’ of medicine. The disease was well known to the ancient Indian medical experts. All the renowned classic texts of Ayurveda like Charaka Samhita (1000 B.C.), Sushruta Samhita (600 B.C.) and subsequent works refer to this disease under the term Madhumeha or Ikshumeha (literally meaning sugar in the urine). Apart from detailed description of its etiopathogenesis (according to Ayurvedic concepts), the two types of diabetic patients (obese and lean) and a definite familial prediction to the disease are referred to in Ayurveda, besides the importance given to dietary regulations, physical exercises and baths, in addition
to the use of a number of plant drugs in the management of the disease (Sharma, 1983).

Large number of plants screened in India and elsewhere for their hypoglycemic/antidiabetic effect, have yielded certain interesting leads, but (with the possible exception of gum guar) no plant-based drug has so far reached such an advanced stage of investigation or development as to replace or reduce the need for the currently available oral antidiabetics. The research for alternate remedies (from the plant kingdom) for diabetes mellitus will continue all over the world as the disease poses many challenges not only to the physician but also to the researcher. In future studies on plant/plant based products; it would be worthwhile to explore the other possible beneficial effects of plant-based drugs on not only blood levels but also other aspects of diabetes mellitus including its complications. Such an approach is particularly called for in case of plants selected from ancient systems of medicine like Ayurveda which advocate a 'holistic' outlook on health and disease with emphasis on modified life style including dietary regulation, alterations in physical and mental status, combined with a judicious use of selected plant based drugs.

Table 1.1. List of Indian Plants with Hypoglycemic Activity Screened on Normal Animal (Satyavati et al., 1989)

<table>
<thead>
<tr>
<th>S. No</th>
<th>Name of the Plant</th>
<th>Part Used</th>
<th>Animal Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Acacia arabica</em></td>
<td>Seeds</td>
<td>Rats</td>
</tr>
<tr>
<td>2.</td>
<td><em>A. benthamii</em></td>
<td>Seeds</td>
<td>Rats</td>
</tr>
<tr>
<td>3.</td>
<td><em>A. catechu</em></td>
<td>Wood (flavonoid)</td>
<td>Rats</td>
</tr>
<tr>
<td>4.</td>
<td><em>A. modesta</em></td>
<td>Seeds</td>
<td>Rats</td>
</tr>
<tr>
<td>5.</td>
<td><em>Adhatoda vasica</em></td>
<td>Leaves</td>
<td>Rats</td>
</tr>
<tr>
<td>6.</td>
<td><em>Adiantum cappilus-tenoris</em></td>
<td>Whole plant</td>
<td>Rabbits</td>
</tr>
<tr>
<td>7.</td>
<td><em>Alyssia stipulata</em></td>
<td>Seeds</td>
<td>Albino rats</td>
</tr>
<tr>
<td>8.</td>
<td><em>Allium cepa</em></td>
<td>Bulbs (oil)</td>
<td>Mice</td>
</tr>
<tr>
<td>9.</td>
<td><em>A. sativum</em></td>
<td>Bulbs</td>
<td>Rabbits</td>
</tr>
<tr>
<td>10.</td>
<td><em>Azadirachta indica</em></td>
<td>Seed oil, (Nimbidi)</td>
<td>Rabbits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leaves</td>
<td>Dogs &amp; rats</td>
</tr>
<tr>
<td>11.</td>
<td><em>Cassia esculenta</em></td>
<td>Roots</td>
<td>Rats</td>
</tr>
<tr>
<td>12.</td>
<td><em>Cassia auriculata</em></td>
<td>Seeds</td>
<td>Rabbits</td>
</tr>
<tr>
<td>13.</td>
<td><em>C. fistula</em></td>
<td>Seeds</td>
<td>Rats</td>
</tr>
<tr>
<td>14.</td>
<td><em>Cocinia indica</em></td>
<td>Fruits</td>
<td>Rats</td>
</tr>
<tr>
<td>15.</td>
<td><em>Cryptostegia grandiflora</em></td>
<td>Aerial parts</td>
<td>Rabbits</td>
</tr>
<tr>
<td>16.</td>
<td><em>Cyamopsis tetragonolobus</em></td>
<td>Fruits, seeds</td>
<td>Normal &amp; glucose fed fasting rabbits</td>
</tr>
<tr>
<td>17.</td>
<td><em>Dolichos biflorus</em></td>
<td>Seeds</td>
<td>Rats</td>
</tr>
<tr>
<td>18.</td>
<td><em>Enicostemma littorale</em></td>
<td>Whole plant</td>
<td>Rats</td>
</tr>
<tr>
<td>19.</td>
<td><em>Ensete superbum</em></td>
<td>Seeds</td>
<td>Rats</td>
</tr>
<tr>
<td>20.</td>
<td><em>Euphorbia prostrata</em></td>
<td>Whole plant</td>
<td>Rabbits</td>
</tr>
<tr>
<td></td>
<td>Species</td>
<td>Part Used</td>
<td>Animals Tested</td>
</tr>
<tr>
<td>---</td>
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<td>----------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>21</td>
<td><em>Ficus bengalensis</em></td>
<td>Root bark (Phytosterolin) Bark</td>
<td>Rabbits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Flavonoids) (Glycosides)</td>
<td>Fasting rabbits, Rabbits, rats &amp; mice</td>
</tr>
<tr>
<td>22</td>
<td><em>F. glomerata</em></td>
<td>Bark</td>
<td>Rabbits, rats</td>
</tr>
<tr>
<td>23</td>
<td><em>Fumaria parviflora</em></td>
<td>Whole plant</td>
<td>Rabbits</td>
</tr>
<tr>
<td>24</td>
<td><em>Glycine max</em></td>
<td>Seeds</td>
<td>Rats</td>
</tr>
<tr>
<td>25</td>
<td><em>Gynema sylvestre</em></td>
<td>Leaves</td>
<td>Rats</td>
</tr>
<tr>
<td>26</td>
<td><em>Hamiltonia suaveolens</em></td>
<td>Roots</td>
<td>Rats, dogs</td>
</tr>
<tr>
<td>27</td>
<td><em>Lannaea nudicaulis</em></td>
<td>(Glycoside)</td>
<td>Rats</td>
</tr>
<tr>
<td>28</td>
<td><em>Luncaena leucophala</em></td>
<td>Seed</td>
<td>Rats</td>
</tr>
<tr>
<td>29</td>
<td><em>Momordica charantia</em></td>
<td>Fruits, Seeds, Fruits, Leaves, Fruits &amp; Seed (Polypeptide)</td>
<td>Rabbits, dogs, Rats, rabbits, Rats, Gerbils, monkeys &amp; langur</td>
</tr>
<tr>
<td>30</td>
<td><em>Mucuna pruriens</em></td>
<td>Seed</td>
<td>Rats</td>
</tr>
<tr>
<td>31</td>
<td><em>Murraya koenigii</em></td>
<td>Leaves</td>
<td>Dogs</td>
</tr>
<tr>
<td>32</td>
<td><em>Musa paradisiaca</em></td>
<td>Flower</td>
<td>Rabbits</td>
</tr>
<tr>
<td>33</td>
<td><em>Phyllanthus fraternus</em></td>
<td>Leaves</td>
<td>Rabbits</td>
</tr>
<tr>
<td>34</td>
<td><em>Pinus roxburghii</em></td>
<td>Bark &amp; root</td>
<td>Rabbits</td>
</tr>
<tr>
<td>35</td>
<td><em>Pongamia pinnata</em></td>
<td>Bark</td>
<td>Rabbits</td>
</tr>
<tr>
<td>36</td>
<td><em>Prunus persica</em></td>
<td>Leaves</td>
<td>Dogs &amp; rabbits</td>
</tr>
<tr>
<td>37</td>
<td><em>Pterocarpus marsupium</em></td>
<td>Heart-wood, Wood</td>
<td>Dogs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rabbits</td>
</tr>
<tr>
<td>38</td>
<td><em>Rauwolfia serpentina</em></td>
<td>(Total alkaloid &amp; Ajmaline)</td>
<td>Cats</td>
</tr>
<tr>
<td>39</td>
<td><em>Salatia macrocarpa</em></td>
<td>Leaves &amp; roots</td>
<td>Rabbits</td>
</tr>
<tr>
<td>40</td>
<td><em>S. premodes</em></td>
<td>Root bark</td>
<td>Rabbits</td>
</tr>
<tr>
<td>41</td>
<td><em>Securigera securidaca</em></td>
<td>Seeds</td>
<td>Cats &amp; rabbits</td>
</tr>
<tr>
<td>42</td>
<td><em>Syzygium cumini</em></td>
<td>Seeds, Fruits &amp; seeds</td>
<td>Albino rats, Rabbits</td>
</tr>
<tr>
<td>43</td>
<td><em>Tephrosia purpurea</em></td>
<td>Seeds</td>
<td>Rabbits</td>
</tr>
<tr>
<td>44</td>
<td><em>Tinospora cordifolia</em></td>
<td>Stem</td>
<td>Rats &amp; rabbits</td>
</tr>
<tr>
<td>45</td>
<td><em>Triosanthes dioica</em></td>
<td>Seeds</td>
<td>Albino rats</td>
</tr>
</tbody>
</table>
Table-1.2. List of Indian Plants with Hypoglycemic Activity Screened on streptozotocin induced diabetic Animal (Satyavati et al., 1989)

<table>
<thead>
<tr>
<th>S. No</th>
<th>Name of the Plant</th>
<th>Part Used</th>
<th>Animal Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Acacia melanoxylon</em></td>
<td>Seeds</td>
<td>Normal and alloxan diabetic albino rats</td>
</tr>
<tr>
<td>2.</td>
<td><em>Allium cepa</em></td>
<td>Bulbs</td>
<td>Alloxan diabetic rabbits</td>
</tr>
<tr>
<td>3.</td>
<td><em>A. sativum</em></td>
<td>Bulbs</td>
<td>Alloxan diabetic rabbits</td>
</tr>
<tr>
<td>4.</td>
<td><em>Aloe vera</em></td>
<td>Leaves</td>
<td>Normal &amp; alloxan diabetic rabbits</td>
</tr>
<tr>
<td>5.</td>
<td><em>Azadirachta indica</em></td>
<td>Seed oil</td>
<td>Normal &amp; hyperglycemic rabbits</td>
</tr>
<tr>
<td>9.</td>
<td><em>Cassia auriculata</em></td>
<td>Seeds</td>
<td>Alloxan rabbits and dogs</td>
</tr>
<tr>
<td>10.</td>
<td><em>Coccinia indica</em></td>
<td>Roots</td>
<td>Alloxan diabetic rabbits</td>
</tr>
<tr>
<td>12.</td>
<td><em>Cuminum nigrum</em></td>
<td>Seeds</td>
<td>Normal &amp; alloxan diabetic rabbits</td>
</tr>
<tr>
<td>13.</td>
<td><em>Cyamopsis tetragonolobus</em></td>
<td>Fruit, seeds</td>
<td>Alloxan diabetic rabbits</td>
</tr>
<tr>
<td>14.</td>
<td><em>Dolichos lablab</em></td>
<td>Green pods</td>
<td>Alloxan diabetic rats</td>
</tr>
<tr>
<td>15.</td>
<td><em>Ficus bengalensis</em></td>
<td>Bark</td>
<td>Normal and alloxan rabbits</td>
</tr>
<tr>
<td>16.</td>
<td><em>F. glomerata</em></td>
<td>Bark</td>
<td>Normal &amp; alloxan rabbits</td>
</tr>
<tr>
<td>17.</td>
<td><em>Grewia asiatica</em></td>
<td>Stem bark</td>
<td>Diabetic cats and rabbits</td>
</tr>
<tr>
<td>18.</td>
<td><em>Gymnema sylvestre</em></td>
<td>Leaves</td>
<td>Hyperglycemic rats</td>
</tr>
<tr>
<td>19.</td>
<td><em>Hamiltonia suaveolens</em></td>
<td>Roots</td>
<td>Alloxan</td>
</tr>
<tr>
<td></td>
<td>Species</td>
<td>Part Used</td>
<td>Effects</td>
</tr>
<tr>
<td>----</td>
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<td>-----------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>20</td>
<td>Inula racemosa</td>
<td>Roots</td>
<td>Glucose induced hyperglycemia in diabetic rats</td>
</tr>
<tr>
<td>21</td>
<td>Lumnata nudicaulis</td>
<td>Roots</td>
<td>Alloxan diabetic rabbits</td>
</tr>
<tr>
<td>22</td>
<td>Momordica charantia</td>
<td>Fruits</td>
<td>Diabetic rabbits</td>
</tr>
<tr>
<td>23</td>
<td>Murraya koenigii</td>
<td>Leaves</td>
<td>Alloxan diabetic dogs</td>
</tr>
<tr>
<td>24</td>
<td>Pongamia pinnata</td>
<td>Bark</td>
<td>Alloxan diabetic rabbits</td>
</tr>
<tr>
<td>25</td>
<td>Pterocarpus marsupium</td>
<td>Aqueous infusion</td>
<td>Pituitary diabetes in rats, Alloxan diabetic rats</td>
</tr>
<tr>
<td>26</td>
<td>Pterocarpus marsupium</td>
<td>Bark</td>
<td>Alloxan induced necrosis</td>
</tr>
<tr>
<td>27</td>
<td>Rivea cuneata</td>
<td>Heartwood &amp; leaves</td>
<td>Diabetic rats</td>
</tr>
<tr>
<td>28</td>
<td>Syzygium cumini</td>
<td>Seed kernel</td>
<td>Alloxan diabetic rats</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seeds</td>
<td>Alloxan diabetic rats &amp; rabbits</td>
</tr>
<tr>
<td>29</td>
<td>Tephrosia purpurea</td>
<td>Extract</td>
<td>Alloxan diabetic rabbits</td>
</tr>
</tbody>
</table>

### 1.2. Fungal Infection

Fungi differ from higher plants in their structure, reproduction, and nutrition. They lack chlorophyll, leaves, true stems, and roots, reproduce by spores, and live as saprophytes or parasites. The method of sexual reproduction of most pathogenic fungi is unknown. Fungi that infect skin (dermatophytes) are classified according to their predominant ecological site. Relatively few species of fungi are pathogenic and pathogenicity results due to mycotoxin production, allergenicity and tissue invasion.

Zoophilic species tend to cause highly inflammatory skin reactions in humans, while anthropophilic species produce mild chronic lesions. The reactions are site dependent and altered by the host's immune status. Opportunistic pathogens are important causes of disease in immunosuppressed patients. (Page et al., 2002).

The antifungal agents (griseofulvin, azole derivatives, allylamines and morpholines) used in the treatment of dermatophyte infections, can sometimes have adverse side effects such as gastrointestinal disturbances, cutaneous
reactions, hepatotoxicity and leucopenia (Carazao et al., 1999; Gupta et al., 1998). Besides these factors, the acquired resistance to certain antifungals (Chee-Leok et al., 1994; 1998; Zaias et al., 1996) and the high cost of these synthetic medicines limit the treatment of the pathogenic fungi. Hence now there is search for new antifungal drugs in view of the increased frequency of fungal infections, particularly the systemic mycoses in compromised hosts and the problems associated with the currently available antifungal drugs. Therefore new natural products are being explored for their antifungal activity.

Extensive research has been carried out into the membrane-permeabilising, immunostimulant, hypocholesterolaemic and anticarcinogenic properties of saponins and they have also been found to significantly affect growth, feed intake and reproduction in animals. These structurally diverse compounds have also been observed to kill protozoans and mollusks, to be antioxidants, to impair the digestion of protein and the uptake of vitamins and minerals in the gut, to cause hypoglycaemia, and to act as antifungal and antiviral agents. These compounds can thus affect animals in different ways both positive and negative (Francis et al., 2002).

The natural xanthones have been reported to show good inhibitory activity against the three fungi. The antifungal activity of several xanthones isolated from the fruit hulls of Garcinia mangostana and some derivatives of mangostin against three phytopathogenic fungi, Fusarium oxysporum f. vasinfectum, Alternaria tenuis and Dreschlera oryzae, has been evaluated. These have been found to show significant antifungal activity (Gopalakrishnan et al., 1997).

Ethanolic extracts from leaves of Hypitis ovalifolia, H. suaveolens, H. saxatilis, Hypidendrum canum, Eugenia uniflora, E. dysenterica, Caryocar brasiliensis and Laphotisia pacari were investigated for their antifungal activity against dermatophytes. The most effective plants were H. ovalifolia and E. uniflora. (Souza et al., 2002).

Alpinia officinarum, Chrozophora verbasafalia, Cinnamomum zeylanicum, Dianthus coryophyllus, Helleborus nigra, Helleboreus persicum, Myrtus communis, Terminalia chebula and Trachysterum cotisium were found effective mostly against Candida albicans and C. utilis (Bonjar, 2004).

Twenty-eight South Indian medicinal plants were screened for their anti-fungal activity against six species of fungi (Trichophyton mentagrophytes, T. rubrum, T. soudanense, Candida albicans, C. kruiser and Torulopsis glabrata). Three plant species extracts, Calotus paniculatus, Eriodendron anfractuosum and Ficus glomerata showed inhibitory activity. An aqueous extract of galls of Terminalia chebula showed inhibitory effects on three dermatophytes (Trichophyton spp.) and three yeasts (Candida spp.). Seeds extract of T. chebula inhibited only the growth of T. glabrata. An aqueous extract of T. chebula showed inhibitory effects higher than those measured in ethanol extracts (Vonshak et al., 2003).

Motsei et al., in 2003 screened out twenty-four South African medicinal plants against Candida albicans standard strain ATCC 10231 and two clinical isolates from a 5-month-old baby and an adult, in an attempt to find a traditional remedy to
treat oral candidiasis, which is prevalent in HIV-patients. *Allium sativum* and *Tulbaghia violacea* aqueous bulb extracts had MIC values of 0.56 and 3.25 mg/ml respectively, whilst *Polygala myrtifolia* leaves and *Glycyrrhiza glabra* rhizome extracts had MIC values of 1.56 mg/ml when tested against the 5-month-old isolate. Fresh water extracts stored at 4, 23 and 33°C over a period of a week, were used to determine the stability of these extracts. *A. sativum* and *T.violacea* maintained activity at 4°C, but not at higher temperatures, whereas *P. myrtifolia* and *G. glabra* lost activity within a day even at 4°C. The unpleasant taste of the two species with a garlic smell, could however not be masked, and as the smell following the eating of the two species would lead to HIV-patients being recognized, these two plants where not considered for further investigation. Therefore, *P. myrtifolia* and *G. glabra* are being further investigated for use as an oral mouthwash in clinics and homes.

Here in the present work efforts are directed on isolating, characterizing and identifying the biologically active leads from selected medicinally important seed drugs for antidiabetic and antifungal activities.
The search for bioactive compounds from medicinal sources and foodstuffs is beautifully depicted in the presentation as below:

Search for Bioactive Constituents from Medicinal Resources and Foodstuffs

Search for the Promising Materials
Traditional Medicines,
Spices, Herbs, Medicinal
Foodstuffs, etc.

Isolation of Bioactive Constituents
Structure Determination
(Absolute Stereostructure,
Conformation analysis)

1) In vivo Screening Test
(Extract, Fraction Level)
2) In vitro Bioassay-guided Separation

Syntheses of Derivatives and Analogues
Construction of Chemical Compound Library

Developments of Medicines
and Functional Materials

Evaluation of Activity
Elucidation of Mode of Action
Elucidation of Active Site
Structure-activity Relationship

salacinol
antidiabetic activity
α-glucosidase inhibitor

6-hydroxythiocinhydrandine
immunosuppressive activity

polycodiol
antioxidant activity
1.3 REFERENCES


2.1 PLANT DESCRIPTION

2.1.1 Family: Anacardiaceae

2.1.2 Common Names: Arabic-Summac, Bangla-Kankrasringi; English-Shumac, Sicilian Sumac; Hindi-Kankrasing; Punjabi-Arko, Titi; Tamul-Karkhadagachtingi; Telugu-Karkkararingi.

2.1.3 Distribution: General distribution of the *Rhus coriaria* is in the Mediterranean countries and Canary Island, reaching Iran and Afghanistan in the East. It is found normally growing in the Aegean, Mediterranean, southeastern, central and northern regions of Turkey (Kurucu et al.; 1993).

2.1.4 Morphology: *R. coriaria* is a deciduous shrub growing to 3m height. Leaves alternate, 3-foliate or imparipinate. Flowers small, in terminal and axillary panicles, polygamous. Calyx small, 4-6 partite, persistent; segment subequal. Petals 4-6, equal, spreading, imbricate. Stamens 4, 5, 6 or 10, inserted at the base of the disc, free; filaments subulate; anthers short, imperfect in the female flower. Ovary sessile, ovoid or globose, 1-celled; ovule pendulous from a basal funicle; styles 3, free or connate, short or long; stigmas simple or capitate. Drupe small, dry, compressed; stone coriaceous, crustaceous or bony. Seed pendulous from the funicle; testa membranous; cotyledons flattish, radicle hooked, short, superior (Kirtikar & Basu, 2000).

2.1.5 Medicinal Properties: The genus contains various species, which have the property of so violently irritating susceptible skins as to produce dermatitis. The fruits have been recommended for treatment of paralysis, colitis, diarrhea
The crushed fruit, mixed with *Origanum syriacum*, is a principal ingredient of 'Zatar', a popular spice mixture used in the Middle East. The seed is used as an appetizer in a similar manner to mustard. The leaves and the seeds are astringent, diuretic, styptic and tonic. They are used in the treatment of dysentery, haemoptysis and conjunctivitis (Chopra *et al.*, 1986). Leaves contain gallo-tannins, gallic acid, flavonoids together with biflavonoids, sugars, wax and volatile oil. They have been and are still being utilized in folk medicine for diarrhea, diabetes and for mouth and throat diseases. The leaves are also utilized as tanning agents in the leather industry (Baytop, 1963, 1984; Baytop and Tanker, 1982).

### 2.2 CHEMICAL CONSTITUENTS

Myricitin, quercetin-3-O-α-L-rhamnopyranosides, avicularin (quercetin-3-O-α-L-arabinofuranoside), and astragalin (kaempferol-3-O-β-D-glucopyranoside) were isolated from leaves by Buzaishvilli *et al.*, in 1970.

Hamdany and Osman in 1977 isolated palmitic, stearic, oleic, linoleic acids and phospholipids from the seeds of *R. coriaria*.

A dimeric flavone-sumaflavone along with agathisflavone, amentoflavone and hinokiflavone have been reported by Van *et al.*, in 1988.

Limonene, nonanal, and dec-2(Z)-enal was obtained from pricarp oil whereas leaf oil contained β-caryophyllene and patchoulane. Cembrene and β-caryophyllene have been reported from branch and bark oil, respectively. (Kürncu *et al.*, 1993).

Sisi *et al.*, in 1971 isolated raffinose, sucrose, glucose, fructose, rhamnose, myricitin, quercitin, kaempferol, gallic acid, m-digallic acid, methyl galate, ellagic acid and gallotannins from the leaves of the plant.

Gallic acid esters were reported from leaves by Balansard *et al.*, in 1978.

α-Pinene, β-caryophyllene, cembrene, oxygenated hexahydrofarnesylacetone and anthocyanins (chrysanthemin, myetillin, delphinidin), organic acids (malic acid) were isolated from fruits (Brunke *et al.*, 1993 and Mavlyanov *et al.*, 1997).

### 2.3 BIOLOGICAL ACTIVITIES

Antioxidant activities of 35 methanolic extracts and 20 essential oils from Turkish species were tested in sunflower oil stored at 70°C, by measuring peroxide values after regular intervals. *Rasmarinus officinalis*, *Salvia fruticosa* and *R. coriaria* extracts were found to be most effective in stabilizing sunflower oil (Ozcan and Akgul, 1995).

The antimicrobial effect of water extracts of *R. coriaria* at concentrations of 0.1%, 0.5%, 1.0%, 2.5% and 5.0% (w/v), non-neutralized and after neutralization to pH 7.2+/−0.1, was studied on the growth of 12 bacterial strains (six Gram positive strains and six Gram negative strains), mostly food-borne bacteria including...
pathogens. It was found to be effective against all the test organisms with Gram-positive strains being more sensitive than Gram-negative strains. Significant differences \((p<0.01)\) were found among the bacteria and between the non-neutralized and neutralized extracts with non-neutralized being more effective against all the bacteria. The minimal inhibitory concentration (MIC) of the extract for each bacterial strain was studied by a gradient plate method. Among the Gram positive organisms, \(Bacillus\) species \((B.\ cerus, B.\ megaterium, B.\ subtilis, \text{and} B.\ thuringiensis)\) were found to be the most sensitive showing MICs of 0.25-0.32\% (after 24 hr incubation) followed by \(Staphylococcus\ aureus\) (0.49\%), while \(Listeria\ monocytogenes\) was found to be the least sensitive demonstrating a MIC of 0.67\%. Of the Gram negative organisms, \(Salmonella\ enteritidis\) was found to be the most resistant with a MIC of 0.67\% followed by \(Escherichia\ coli\) Type I \((\text{Nassar and Halkman, 2005})\).

In another study, the antibacterial and antifungal activities of \(R.\ coriaria, Stachys\ pannila, Laurus\ nobilis, Allium\ neapolitanum, Salvia\ viridis, \text{and} Nicotina\ rustica\) species were investigated. The anti-microbial effects of these plants were tested by a disk diffusion method using \(Bacillus\ megaterium, B.\ brevis, B.\ subtilis, B.\ cerus, Escherichia\ coli, Enterobacter\ aerogenes, Pseudomonas\ aeruginosa, Staphylococcus\ aureus, Listeria\ monocytogenes\) and \(Micrococcus\ luteus, Candida\ tropicalis\) and \(Candida\ albicans\). The results showed that the fruit extract of \(R.\ coriaria\) had the strongest antimicrobial effect with an inhibition zone of 35-51 mm against all the bacteria used, while \(S.\ viridis\) demonstrated the weakest antibacterial effect, inhibiting only the development of \(S.\ aureus\), with an inhibition zone of 11 mm \((\text{Digrak et al., 2001})\).

\(Candan\) in 2003 found methanolic extract of \(R.\ coriaria\), was found to be an uncompetitive inhibitor of xanthine oxidase and scavenger of superoxide radical \(\text{in vitro}\) with IC\(_{50}\) values of 172.5 \(\mu\)g/mL and 232 \(\mu\)g/mL, respectively. Superoxide radicals were generated either by an enzymatic or a non-enzymatic system, and scavenging ability was evaluated by the inhibition of nitroblue tetrazolium reduction. This study provides evidence that a crude extract of \(R.\ coriaria\) exhibits interesting antioxidant properties, expressed either by the capacity to scavenge superoxide radical or to uncompetitively inhibit xanthine oxidase.

In another study, the antibacterial activity of ethanolic extracts of 15 plant species used in the traditional medicine in Jordan and other Middle East countries were tested. Extracts of certain parts of these plants were tested \(\text{in vitro}\) against 14 pathogenic bacterial species and strains using the agar diffusion method. Results evaluated as the diameter of inhibition zone of bacterial growth showed that 25 mg/well of 12 plant extracts have antibacterial activity on one or more of the tested bacteria. Three plants exhibited broad-spectrum antibacterial activity: \(Punica\ granatum, Quercus\ infectoria, \text{and} R.\ coriaria\). The most susceptible bacteria were \(Pseudomonas\ aeruginosa, Bacillus\ cerus\) and \(Streptococcus\ pyogenes\), and the most resistant species were \(Escherichia\ coli, Klebsiella\ pneumoniae, Shigella\ dysenteriae, \text{and} Yersinia\ enterocolitica\). The minimum inhibitory concentrations (MIC) of active extracts ranged from 4-32 mg/ml while the minimum bactericidal concentrations (MBC) were exerted at higher doses 8-62 mg/ml \((\text{Nimri et al., 1999})\).
The antioxidant efficacy of rosemary (*Rosmarinus officinalis*), sage (*Salvia fruticosa*), and sumac (*R. coriaria*) extracts and combinations at 4% concentrations (w/v, extract/oil) were investigated. Methanolic extracts of rosemary, sage, sumac, and their combinations were applied to peanut oil stored at 80°C for 24 hr. The antioxidant effect was determined by measuring the peroxide value. All extracts showed antioxidant effects compared with control. But the antioxidant effect of all extracts was low compared with that of butylated hydroxytoluene. Rosemary extract (except for 3 and 4 hr) exhibited the most antioxidant effect compared with other individual extracts. Of blends, the most effective ones were sage plus sumac combinations. Sumac extract seemed to be promising source of natural antioxidants (Ozcan, 2003).

Sokmen *et al.*, in 1999 assayed a total of 76 extracts from 35 plants available in the Turkish flora for their *in vitro* antibacterial activities against five pathogenic bacteria and a yeast. Sixteen crude extracts from eight plant species including *R. coriaria* were found to possess an activity against at least one or more test microorganisms. Bioassay-guided fractionation of the most active crude extracts was also carried out with the most active extracts. Activity was carried against *Staphylococcus aureus*, *Bacillus cereus*, *Branhamella catarrhalis*, *Escherichia coli*, *Clostridium perfringens* and *Candida albicans*.

The antibacterial activity of *R. coriaria* leaf methanol extract was assayed against Gram-positive and Gram-negative bacteria; antymycotic activity was assayed against some *Candida* species. MICs were determined by a broth microdilution assay in microlitre plates using Mueller-Hinton medium. MBCs were determined by plating 0.01 mL samples from clear 1 mL tubes on to agar plates (Fukak *et al.*, 1998).

In another study the antimicrobial activity of *R. coriaria* in the Kahramanmaraş region of Turkey, has been tested against *Aeromonas hydrophila*, *Bacillus megaterium*, *Corynebacterium xerosis*, *Pseudomonas aeruginosa*, *Micrococcus luteus*, *Escherichia coli*, *Enterococcus faecalis* and *Staphylococcus aureus* bacteria. The acetone extract has been found to be highly active against all the used bacterial species showing an inhibition zone of 16-23 mm (Dolaz *et al.*, 2002).

Based on ethnopharmacological and taxonomic information the antibacterial activity of some medicinal plants of Iran was determined by *in vitro* bioassay using agar diffusion method against standard strains of *Pseudomonas aeruginosa*, *P. florescens*, *Bacillus subtilis*, *B. pumilis* and *B. cereus* at 20 mg/ml. *R. coriaria* showed action against all the tested microorganisms (Bonjar *et al.*, 2003).

Plant extracts including *Achillea wilhelmsii*, *Buxus hyrcana*, *Chrysanthemum cinerariaefolium*, *Colutea persica*, *Hyoscyamus niger*, *Mentha pulegium*, *Myrtus communis*, *Nerium oleander*, *Paliurus spin-a-christi*, *Peganum harmala*, *Pterocarya fraxinifolia*, *Rhus coriaria*, *Rosa canina*, *Smilax excelsa*, *Thymus mircicus*, *Thymus pubescens*, *Verbascum alcyoides* and *Ziziphus clinopodioides* subsp. *rigida* showed more than 70% inhibition, using 4 μg of each plant extract (Souri *et al.*, 2004).
In another antimicrobial study, activity of *Rhododendron ponticum*, *Prunus laurocerasus*, *Agrimonia eupatoria*, *Corus mar*, *Vitis vinifera*, *Punica granatum*, *Anthemis cotula*, *Cichorium intybus*, *Viscum album*, *Papaver hybridum*, *Malva rotundifolia* and *R. coriaria* were investigated. The ethanolic extracts of these plants were tested against *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Proteus vulgaris*, *Bacillus cereus*, *Mycobacterium smegmatis*, *Listeria monocytogenes*, *Micrococcus luteus*, *Candida albicans*, *Rhodotorula rubra* and *Kluyveromyces fragilis* by disc diffusion method. Of the 12 plants tested, nine showed antimicrobial activity. Each plant species has unique mechanism against different microorganisms. The fruit extract of *R. coriaria* had the highest antimicrobial effect with an inhibition zone of 12-52 mm against all the bacteria, but did not show antifungal effect. Except for the extracts of *R. coriaria*, *Agrimonia eupatoria* and *Anthemis cotula*, all additional extracts, generated inhibition zones smaller than those generated by several reference antibiotics (Dulger and Gonuz, 2004).

Chemical Constituents Reported from *R. coriaria*

![Sumiflavone](image1.png) ![Agathisflavone](image2.png)

2.4 EXPERIMENTAL

2.4.1 Materials and Methods

2.4.2 General: Mps were uncorrected; Perfit melting point apparatus; IR: Bio-Rad FTIR Spectrophotometer KBr; UV: Lambda Bio 20 Spectrophotometer, MeOH; ¹H-NMR (300 MHz): DPX 300, Bruker Spectrospin, CDCl₃ and DMSO-d₆; ¹³C-NMR (300 MHz): DPX 300, Bruker Spectrospin, CDCl₃ and DMSO-d₆ with TMS as an internal standard; MS: ESIMS JEOL-JMS-DX 303; CC: Silica gel (Qualigens), 60-120 mesh; TLC: Silica gel G (Qualigens). Spots were visualized by
exposure to iodine vapours, UV radiation and by spraying with ceric ammonium sulphate and perchloric acid.

2.4.3 Collection of material: *R. coriaria* seeds were procured from the Khari Baoli market of Delhi and was identified by Dr. M.P. Sharma, Department of Botany, Jamia Hamdard, New Delhi. A voucher specimen is deposited in the herbarium of the Phytochemical Research Laboratory, Faculty of Pharmacy.

2.4.4 Extraction and Isolation: The dried drug (2 kg) was coarsely powdered, defatted with petroleum ether and then exhaustively extracted with ethanol (95%). The combined extracts were then concentrated on a water bath and dried under reduced pressure to get 110 g (5.5% yield) of dark brown mass. The viscous dark brown mass was dissolved in little quantity of methanol and adsorbed on silica gel (60-120 mesh) for the preparation of slurry. It was dried, packed and chromatographed over silica gel column packed in petroleum ether. The column was eluted with petroleum ether, chloroform and methanol successively in the order of increasing polarity to isolate following compounds:

**n-tetracosane (RC-1)**

Elution of the column with petroleum ether (fraction No. 1-7) furnished buff white semisolid mass of RC-1, recrystallised from CHCl₃, 250 mg (0.0125% yield).

Rₚ 0.85 (petroleum ether).

IR νₘₐₓ (KBr): 2911, 2850, 1210, 725, 710 cm⁻¹.

¹H NMR (DMSO-d₆): δ 1.23 (44H, brs, 22xCH₂), 0.85 (3H, t, J=6.1 Hz, Me-1), 0.82 (3H, t, J=6.0 Hz, Me-24).

+ve ESI MS m/z 338 [M⁺] (C₂₄H₅₀).

**n-pentacosane (RC-2)**

Elusion of the column with petroleum ether-CHCl₃ (9:1) (fraction No. 8-47) furnished buff white semisolid mass of RC-2, recrystallised from CHCl₃, 300 mg (0.0150% yield).

Rₚ 0.75 (Petroleum ether).

IR νₘₐₓ (KBr): 2950, 2845, 1470, 1250, 1010, 725, 715 cm⁻¹.

¹H NMR (DMSO-d₆): δ 1.23 (46H, brs, 23xCH₂), 0.85 (3H, t, J=6.1 Hz, Me-1), 0.82 (3H, t, J=6.0 Hz, Me-25).

+ve ESI MS m/z 352 [M⁺] (C₂₅H₅₂).

**Coriaria phosphoglyceride (RC-3)**

Elusion of the column with petroleum ether-CHCl₃ (1:1) (fraction No. 59-73) furnished colourless semisolid mass of RC-3, recrystallized from CHCl₃, 220 mg (0.011% yield).

Rₚ 0.72 (petroleum ether-CHCl₃, 9:1).

UV νₘₐₓ (MeOH): 240 nm (log ε 3.2).

IR νₘₐₓ (KBr): 3424, 2923, 2853, 1712, 1640, 1527, 1210, 1025, 725 cm⁻¹.

¹H NMR (CDCl₃): δ 5.27 (2H, m, H-9', 10'), 4.25 (1H, d, J=11.7 Hz, H₂-3a), 4.21 (1H, d, J=11.7 Hz, H₂-3b), 4.10 (1H, d, J=5.7 Hz, H₂-1a), 4.06 (1H, d, J=5.7 Hz, H₂-1b).
Hz, H₂-b), 3.59 (1H, m, H-2), 2.26 (2H, m, H₂-8'), 2.24 (1H, d, J=6.9 Hz, H₂-2'a), 2.22 (1H, d, J=6.9 Hz, H₂-2'b), 1.94 (2H, m, H₂-11'), 1.51 (4H, m, H₂-7', H₂-12'), 1.22 (12H, brs, 6xCH₂), 1.18 (6H, brs, 3xCH₃), 0.81 (3H, t, J=6.9 Hz, Me-18').

+ve ESI MS m/z 420 [M]+ (C₂₁H₄₂O₆P).

Coriaria diglyceride A (RC-4)
Elution of column with CHCl₃ (fraction No. 90-95) furnished colourless sticky mass of RC-4, recrystallised from Petroleum ether:CHCl₃ (9:1), 310 mg (0.0155%).

Rf: 0.56 (Chloroform:Petroleum Ether, 7:3).

UV λmax (MeOH): 202 nm (log ε 4.1).

IR νmax (KBr): 3490, 2921, 2850, 1725, 1640, 1310, 1115, 795 cm⁻¹.

¹H NMR (DMSO-d₆): δ 5.32 (1H, m, H-5), 5.19 (1H, m, H-6), 3.98 (1H, m, H-2''), 3.35 (4H, brs, H₂-1'', H₂-3''), 2.56 (2H, brs, CH₂), 1.47 (2H, m, CH₂), 1.47 (2H, m, CH₂), 1.23 (14H, brs, 7xCH₂), 1.16 (6H, brs, 3xCH₃), 0.77 (3H, t, J=6.1 Hz, Me-9'), 0.65 (3H, t, J=6.0 Hz, Me-12).

¹³C NMR (DMSO-d₆): 173.01 CO-1'), 171.25 (CO-1), 129.71 (C-5), 129.50 (C-6), 79.02 (C-2''), 65.13 (C-1''), 61.89 (C-3''), 33.70 (C-4), 31.58 (C-7), 29.32 (8xCH₂), 28.96 (2xCH₂), 26.88 (CH₂), 24.62 (C-9'), 22.37 (C-12).

+ve ESI MS m/z (rel. int.): 412 [C₂₄H₄₄O₅]+ (51.3), 397 (11.6), 301 (13.6), 299 (100).

Coriaria diglyceride B (RC-5)
Elution of the column with CHCl₃-MeOH (24:1) (fraction 108-140) yielded a brown amorphous powder of RC-5, recrystallised from CHCl₃-acetone (8:2), 540 mg (0.027 % yield).

Rf 054 (CHCl₃-MeOH; 9:1).

m.p.: 301-302°C.

UV λmax (MeOH): 205 nm (log ε 3.1).

IR νmax (KBr): 3450, 1725, 1527, 1420, 115, 1090, 795, 774 cm⁻¹.

¹H NMR (DMSO-d₆): δ 4.46 (1H, m, H-2''), 3.36 (4H, brs, H₂-1'', H₂-3''), 2.50 (2H, brs, H₂-2), 2.25 (2H, brs, H₂-2'), 1.23 (36H, brs, 18xCH₃), 0.85 (3H, t, J=6.1 Hz, Me-8'), 0.83 (3H, t, J=6.0 Hz, Me-16).

+ve ESI MS m/z (rel. int.): 456[M]+ (C₂₇H₅₄O₅) (92.3), 413 (71.6), 379 (18.5), 352 (23.8), 313 (100), 255 (30.3).

Coriaria naphthaquinone A (RC-6)
Elution of column with CHCl₃-MeOH (93:7) (fraction No. 155-157) furnished green coloured powder of RC-6 recrystallised from CHCl₃, 550 mg (0.0275% yield).

Rf 0.70 (CHCl₃:Acetone; 3:1).

m.p.: 171-73°C.

UV λmax (MeOH): 218, 274 nm (log ε 5.8, 2.1).

IR νmax (KBr): 2950, 2845, 1703, 1695, 1655, 1561, 1544, 1403, 1020, 950 cm⁻¹.
1H NMR (DMSO-δd): δ 9.29 (2H, s, H-6, H-9), 8.96 (1H, s, H-7), 6.94 (2H, s, H-2, H-3), 3.74 (3H, oil, OCH3).

13C NMR (DMSO-δd): δ 182.16 (C-1), 175.23 (C-4), 166.34 (C-8), 156.97 (C-5), 152.83 (C-10), 145.65 (C-9), 137.13 (C-6), 119.28 (C-7), 108.50 (C-2, C-3), 51.63 (OCH3).

+ve ESI MS m/z: 188 [M]+ (C11HsO3).

p-methoxy bezyl alcohol (RC-7)

Elution of column with CHCl3-MeOH (93:7) (fraction No. 158-159) afforded yellow amorphous powder of RC-7 recrystallised with acetone, 275 mg (0.013% yield).

Rf CHCl3-acetone (8:2).

m.p.: 184-188°C.

UV λmax (MeOH): 256 nm (log ε 4.8).

IR νmax (KBr): 3448, 1655, 1543, 1219, 784 cm⁻¹.

1H NMR (DMSO-δd): δ 9.31 (2H, s, H-3, H-5), 8.79 (1H, s, H-2), 6.86 (2H, s, H-2, H-6), 3.74 (2H, s, H-2, H-6), 3.43 (3H, oil, OCH3).

NMR (DMSO-d6): 8 166.36 (C-1), 145.60 (C-4), 138.44 (C-6), 119.32 (C-2), 108.53 (C-3, C-5), 66.99 (C-7), 51.63 (OCH3).

+ve ESI MS m/z: 138 [M]+ (C11H10O2).

Coriarianaphthyl ether (RC-8)

Elution of column with CHCl3-MeOH (93:7) (fraction No. 160-164) furnished light brown amorphous mass of RC-8, recrystallised from acetone, 550 mg (0.0275% yield).

Rf 0.66 (Toluene-ethyl acetate-formic acid, 8.5:1:0.5).

m.p.: 238-239°C.

UV λmax (MeOH): 217, 274 nm (log ε 5.9, 1.8).

IR νmax (KBr): 3450, 3400, 1640, 1541, 1390, 1219, 890 cm⁻¹.

1H NMR (DMSO-δd): δ 8.03 (1H, dd, J=8.7, 3.0 Hz, H-9), 7.96 (1H, d, J=9.5 Hz, H-2), 7.30 (1H, d, J=9.5 Hz, H-3), 7.03 (1H, dd, J= 9.1, 2.9 Hz, H-6), 6.79 (1H, m, H-7), 6.50 (1H, m, H-8), 3.70 (2H, s, H-2, H-6), 3.41 (3H, oil, OCH3).

13C NMR (DMSO-δd): δ 166.68 (C-1), 145.78 (C-10), 138.68 (C-5), 137.80 (C-4), 119.58 (C-2), 116.31 (C-3), 115.41 (C-7), 114.28 (C-9), 113.54 (C-6), 108.78 (C-8), 67.20 (C-11), 51.91 (OMe).

+ve ESI MS m/z: 176 [M]+ (C11H12O2).

Coriariaxanthone tetraol (RC-9)

Elution of column with CHCl3-MeOH (93:7) (fraction No. 165-172) afforded light brown amorphous powder of RC-9, recrystallised from acetone, 580 mg (0.029% yield).

Rf 0.74 (CHCl3-MeOH, 7:3).

m.p.: 295°C (dec.).

UV λmax (MeOH): 202, 305 nm (log ε 5.4, 2.8).
Coriaria xanthone glycoside (RC-14)
Elution of column with CHCl₃-MeOH (9:1) (fraction No. 200-204) afforded light brown amorphous powder of RC-14, recrystallised from methanol, 240 mg (0.012% yield).

Rf: 0.70 (CHCl₃-acetone-MeOH; 6:2:2).

m.p.: 251-253°C.

UV λ_max (MeOH): 202, 223 nm (log ε 5.1, 4.9).

IR ν_max (KBr): 3447, 3350, 3290, 2850, 2362, 1710, 1690, 1541, 1219, 794, 773 cm⁻¹.

¹H NMR (D₂O): δ 7.20 (IH, d, J=8.1 Hz, H-1), 7.04 (IH, d, J=8.1 Hz, H-2), 5.02 (IH, d, J=6.99 Hz, H-1'), 4.86 (IH, m, H-5'), 3.65 (IH, dd, J=5.4, 5.4 Hz, H-4'), 3.52 (IH, d, J=7.5 Hz, H-2'), 3.47 (3H, brs, OCH₃), 3.13 (IH, m, H-3'), 3.03 (IH, d, J=7.5 Hz, H-2'-a), 3.01 (1H, d, J=7.5 Hz, H-2'-b), 2.13 (3H, brs, H-3').

¹³C NMR (D₂O): δ 117.40 (C-1), 122.13 (C-2), 110.15 (C-3), 131.15 (C-4), 128.96 (C-5), 191.07 (C-6), 130.17 (C-7), 131.15 (C-8), 158.37 (C-9), 156.35 (C-10), 159.16 (C-11), 149.38 (C-12), 147.51 (C-13), 28.55 (C-14), 182.57 (C-15), 179.75 (C-16), 100.55 (C-1'), 76.53 (C-2'), 73.34 (C-3'), 69.84 (C-4') 75.97 (C-5'), 60.95 (C-6'), 56.44 (OMe).

+ve ESI MS m/z (rel. int.): 522 [M]+ (C₂₃H₂₂O₁₄) (10.5), 477 (9.2), 388 (16.3), 359 (75.6), 344 (100), 181 (63.2), 136 (21.3).

Coriariaic acid (RC-15)
Elution of column with CHCl₃-MeOH (9:1) (fraction No. 205-206) afforded brown crystals of RC-15, recrystallised from MeOH-acetone (7:3), 310 mg (0.0155% yield).

Rf: 0.55 (CHCl₃-acetone-MeOH; 7:2:1).

m.p.: 226-228°C.

UV λ_max (MeOH): 294 nm (log ε 5.3).

IR ν_max (KBr): 3144, 2925, 2860, 1710, 1690, 1541, 1219, 794, 773 cm⁻¹.

¹H NMR (DMSO-d₆): δ 12.27 (1H, D₂O exchangeable COOH), 9.20 (1H, brs, CHO), 8.84 (1H, brs, H-3), 6.91 (1H, brs, H-6), 3.36 (3H, brs, OCH₃), 2.50 (3H, brs, CH₃-8).

+ve ESI MS (rel. int.) m/z: 194 [M]+ (C₁₀H₁₀O₄).

Coriarianthracenyl ester (RC-16)
Elution of column with CHCl₃-MeOH (8.5:1.5) (fraction No. 207-210) afforded brown crystals of RC-16, recrystallised from MeOH, 330 mg (0.0165% yield).
Coriariaxanthone diol (RC-17)
Elution of column with CHCl₃-MeOH (8.5:1.5) (fraction No. 211-212) afforded light brown amorphous powder of RC-17, recrystallised from MeOH, 470 mg (0.0235% yield).

RF: 0.75 (CHCl₃-acetone-MeOH; 7:2:1).
m.p.: 270-272°C.
UV λ<sub>max</sub> (MeOH): 302 (log ε 4.2).
IR ν<sub>max</sub> (KBr): 3448, 2950, 2861, 2341, 1541, 1218, 930 cm⁻¹.
¹H NMR (DMSO-d₆): δ 7.97 (1H, d, J=8.4 Hz, H-1), 7.87 (1H, brs, H-11), 7.01 (1H, d, J=3.0 Hz, H-4), 6.93 (1H, d, J=8.4 Hz, H-2), 6.79 (1H, brs, H-8), 6.75 (1H, brs, D₂O exchangeable OH), 6.55 (1H, brs, D₂O exchangeable, OH), 2.50 (3H, brs, CH₃-I).
¹³C NMR (DMSO-d₆): δ 181.64 (C-6), 164.05 (C-10), 161.42 (C-9), 161.05 (C-12), 159.27 (C-13), 148.61 (C-5), 130.97 (C-7), 129.55 (C-8), 127.14 (C-11), 115.96 (C-4), 102.56 (C-1), 93.95 (C-2), 28.99 (C-14).
+ve ESI MS m/z 242[M]+ (C₁₄H₁₀O₄).

2.5 RESULTS AND DISCUSSION
Compound RC-1 was obtained as buff white sticky mass from petroleum ether eluents. It did not respond to bromine water and tetrinitromethane (TNM) test for unsaturation. It didn’t react with any oxidizing or acetylating reagents. Its IR spectrum exhibited absorption bands at 725, 710 cm⁻¹ due to long saturated aliphatic chain and did not show any absorption bands in the functional group region. Its +ve ESI MS showed a molecular ion peak at m/z 338 corresponding to molecular formula C₂₄H₃₀. Most of the fragments ion peaks were separated by 14 mass units and their intensities decreased with increasing molecular weight confirming the presence of long chain hydrocarbon (Stoianova & Hadjieva, 1969). ¹H NMR displayed two three-proton triplets at δ 0.85 (J=6.1 Hz) and 0.82 (J=6.0 Hz) assigned to terminal Me-1 and Me-24 primary methyl protons, respectively. The methylene protons resonated as broad signal at δ 1.23 (22xCH₂). On the basis of these findings the structure of RC-1 has been elucidated as n-tetracosane.

Compound RC-2 was obtained as buff white sticky mass from petroleum ether CHCl₃ (9:1) eluents. It did not respond to bromine water and TNM test for
basis of these discussions the structure of RC-6 has been elucidated as 8-methoxy naphthaquinone.

Compound RC-7 named p-methoxy bezyl alcohol, was obtained as yellow amorphous powder from CHCl₃-MeOH (93:7) eluents. It exhibited molecular ion peak at m/z 138 corresponding to molecular formula C₈H₁₀O₂. It had UV absorption maxima at 219 and 275 nm, characteristic of a conjugated nucleus. Its IR spectrum demonstrated the presence of hydroxyl group (3448 cm⁻¹) and aromatic nucleus (1543, 1010, 784 cm⁻¹). The ¹H NMR of RC-7 showed two broad signals of two-protons each, at δ 9.31 and 6.86 due to H-3, H-5 and H-2, H-6 aromatic protons, respectively. Two more broad signals, integrating for two and three-protons, at δ 3.74 and 3.43 were assigned to CH₂-7 carbinol protons and methoxy protons. A D₂O exchangeable proton at δ 8.79 was due to hydroxyl group. Further evidences of structure were provided by its ¹³C NMR, which displayed eight carbons to be present in the compound. A signal at δ 166.36 was assigned to C-1 oxygenated carbon. The remaining aromatic carbons resonated between δ 145.60-108.53. A hydroxymethylene carbon (C-7) and a methoxy carbon (OCH₃) appeared at δ 66.99 and 51.63, respectively. On the basis of the aforementioned spectral data analysis the structure of RC-7 has been elucidated as 4-methoxy-benzyl alcohol.

Compound RC-8 named coriarianaphthyl ether, was obtained as light brown amorphous powder from CHCl₃-MeOH (93:7) eluents. It showed UV absorption maxima at 217 and 274 nm characteristic of highly conjugated system. Its IR spectrum showed absorption bands for hydroxyl group (3450, 3400 cm⁻¹) and aromatic nucleus (1541, 1219, 890 cm⁻¹). The ESI MS of RC-8 showed molecular ion peak at m/z 176 corresponding to molecular formula C₁₁H₁₂O₂ of a naphthalene derivative. The ¹H NMR of RC-8 exhibited two one-proton double doublet at δ 8.03 (J=8.7, 3.0 Hz) and 7.03 (J=9.1, 2.9 Hz) assigned to ortho-ortho and ortho-meta coupled H-9 and H-6 aromatic protons. Two ortho-coupled protons appearing as doublets at δ 7.96 (J=9.5 Hz) and δ 7.30 (J=9.5 Hz) were assigned to H-2 and H-3 protons, respectively. The H-7 and H-8 aromatic protons appeared as one-proton multiplet at δ 6.79 and 6.50, respectively. A two-proton broad signal at δ 3.70 and another three-proton broad signal at δ 3.41 in the spectrum were due to oxygenated methylene and methoxy protons, respectively. The ¹³C NMR of RC-8 exhibited signal for C-11 carbinol carbon at δ 67.20 and methoxy carbon at δ 51.91. The oxygenated aromatic carbon C-1 appeared at δ 166.68 whereas remaining aromatic carbons of the naphthalene ring appeared between δ 145.78-108.78. On the basis of the foregoing discussions the structure of RC-8 has been elucidated as 1-methoxy-4-hydroxymethylene naphthalene.

Compound RC-9, named coriariaxanthone tetraol, was obtained as light brown amorphous powder from CHCl₃-MeOH (93:7) eluents. Its IR spectrum displayed characteristic absorption band for hydroxyl group (3410 cm⁻¹), carboxylic group (2860, 1705 cm⁻¹) and unsaturation (1690 cm⁻¹). Its ESI MS spectrum displayed molecular ion peak at m/z 318 corresponding to molecular formula C₁₃H₁₀O₄. Its


\[ \text{HNMR showed a downfield signal at } \delta 13.24 \text{ assignable to carboxylic proton. Three one-proton broad signals at } \delta 8.15, 7.56 \text{ and } 7.08 \text{ were assigned to H-11, H-1 and H-4 aromatic protons, respectively. A two-proton broad singlet at } \delta 3.43 \text{ was attributed to C-14 oxygenated methylene protons. The } ^{13} \text{C NMR of RC-9 exhibited signals for three carbinol carbons at } \delta 152.6 (C-2), 153.53 (C-9) \text{ and } 168.15 (C-10). \] 

Other important signals at \( \delta 183.04, 174.13 \) and 67.22 were correspondingly ascribed to carbonyl carbon C-6, carboxylic carbon C-15 and hydroxymethylene carbon C-14. On the basis of foregoing discussions the structure of RC-9 has been elucidated as 2,9,10-trihydroxy-3-hydroxymethylene xanthone-8-oic acid.

Compound \text{RC-10, named coriariasteryl xanthone glycoside, was obtained as brown sticky mass from CHCl\textsubscript{3}-MeOH (93:7) eluents. It decolourized bromine water and gave yellow colour with tetranitromethane indicating the unsaturated nature of the compound. Its IR spectrum exhibited absorption bands for hydroxyl group (3410, 3380 cm\textsuperscript{-1}), carboxylic group (2950 cm\textsuperscript{-1}), carbonyl group (1725 cm\textsuperscript{-1}) and unsaturation (1690 cm\textsuperscript{-1}). The ESI MS of RC-10 displayed a fragment ion peak at \( m/z \) 346 [C\textsubscript{16}H\textsubscript{10}O\textsubscript{9}]\textsuperscript{+} and 413 [C\textsubscript{29}H\textsubscript{49}O\textsubscript{11}]\textsuperscript{+} indicating the presence of a xanthone derivative and 3-sitosterol linked through a glycone moiety. The \text{\textsuperscript{1}H NMR of RC-10 exhibited an important downfield broad signal at } \delta 13.29 \text{ assignable to the carboxylic proton. Three one-proton broad signals at } \delta 8.05, 6.54 \text{ and } 6.25 \text{ were attributed to three } D\textsubscript{2}O \text{ exchangeable hydroxyl protons. One-proton broad signal at } \delta 7.84 \text{ was attributed to aromatic H-11'' proton. Two one-proton doublets at } \delta 7.11 (J=8.5 \text{ Hz}) \text{ and } 6.92 (J=8.5 \text{ Hz}) \text{ that were assigned to ortho-coupled aromatic protons H-1''' and H-2''}. \text{ Vinylic proton H-6 of the sterol nucleus appeared as a broad signal at } \delta 5.38. \text{ The anomeric proton H-1' of a sugar molecule appears as a broad signal at } \delta 4.96 \text{ whereas other sugar protons resonated between } \delta 4.27-3.47. \text{ A two-proton broad signal at } \delta 3.19 \text{ was assigned to hydroxyl methylene protons (H-14''). Another broad signal at } \delta 4.51 \text{ with half width of } w_{1/2}=16.5 \text{ Hz was assigned to H-3 carbinol proton. Two three-proton doublets at } \delta 1.19 (J=6.5 \text{ Hz}) \text{ and } 0.96 (J=6.0 \text{ Hz}) \text{ were ascribed correspondingly to secondary Me-21 and primary Me-29 methyl protons. Two broad signals at } \delta 1.28 \text{ and 0.70, integrating for three protons each, were associated with C-19 and C-18 tertiary methyl protons, respectively. A six-proton broad signal at } \delta 0.86 \text{ was attributed to C-26 and C-27 secondary methyl protons. The appearance of all the methyl signals in the range } \delta 1.28-0.76 \text{ indicate their location on the saturated carbons. The } ^{13} \text{C NMR of RC-10 exhibited important signals at } \delta 125.11 \text{ and 141.23 for vinylic carbons C-6 and C-5; signals at } \delta 71.78 \text{ and 99.23 for carbinol carbon C-3 and anomeric carbon C-1', respectively. Carbonyl carbon C-6'', C-16'' and carboxylic carbon C-15'' appeared at } \delta 186.11, 169.82 \text{ and 173.17, respectively. The remaining carbon signals for anthracene moiety resonated between } \delta 107.26-165.28. \text{ On the basis of foregoing discussions the structure of RC-10 has been} \]
elucidated as stigmast-5-en-3-0-β-D-glucopyranosido- (6'→8'')-oxy-9'', 10''-dihydroxy-3''-hydroxymethylene xanthone-4''-oic acid.

Compound RC-11 named β-sitosterol glycoside, gave a positive Liebermann-Burcghard test and a negative Ehrlich reaction. Its IR spectrum exhibited strong bands at 3450 and 1080 cm⁻¹ characteristic of a glycoside. The +ve ESI MS of RC-11 gave a fragment ion at m/z 413 [M-glucose]+, 398 [413-Me]+, 396 [576-C₆H₄(OH)+], 381 [396-Me]+, 273 [413-C₁₀H₂₁, side chain]+, 255 [273-H₂O]+, 240 [255-Me]+ and 213 [255-ring D fission]+ which were characteristic for sitosterol-3β-D-glucoside. The ¹H NMR spectrum of RC-11 exhibited a one-proton doublet at δ 5.33 (J=5.21 Hz) assigned to C-6 vinyl proton. Anomeric proton H-1' appeared as a doublet at δ 4.89 (J= 9.61 Hz) A one-proton broad multiplet at δ 3.38 with ν₁/₂ 18.5 Hz showed the presence of 3α-methine proton (axial) interacting with C-2 equatorial, C-2 axial, C-4 axial and C-4 equatorial protons. Four doublets at δ 0.94 (J=6.5 Hz), 0.82 (J=5.69 Hz), 0.80 (J=6.39 Hz) and 0.89 (J=7.0Hz); integrating three protons each, were ascribed corresponding to C-21, C-26, C-27 secondary methyl and C-29 primary methyl protons. The C-18 and C-19 tertiary methyl protons appeared as broad signals at δ 0.65 and 0.95, respectively. The ¹³C NMR spectrum of RC-11 displayed 35 carbon signals for steroidal glycoside including two vinylic carbons at δ 140.54 (C-5) and 121.58 (C-6) and one carbinol carbon at δ 76.82 as well as six glucose carbons at δ 101.12 (C-1'), 73.62 (C-2'), 76.82 (C-3') 70.12 (C-4'), 78.19 (C-5') and 61.42 (C-6'). Acid hydrolysis of RC-11 yielded D-glucose and an aglycone C₁₈H₂₂O₈ was identified as β-sitosterol by spectral data and by direct comparison with the authentic samples (co-TLC, m.p.). On the basis of these finding the structure of RC-11 was established as stigmast-5-en-3-0-β-D-glucopyranoside.

Compound RC-12 named Coriaria naphthaquinone B, was obtained as light brown amorphous mass from CHCl₃-MeOH (93:7) eluents. It showed UV absorption maxima at 217 and 272 nm, characteristic of a highly conjugated system. Its IR spectrum showed absorption band for hydroxyl group (3510 cm⁻¹), carbonyl group (1653 cm⁻¹), unsaturation (1551, 1370 cm⁻¹) and aromatic moiety (1050, 925 cm⁻¹). The ESI MS of RC-12 showed molecular ion peak at m/z 188 corresponding to molecular formula C₁₈H₁₈O₈. Its ¹H NMR exhibited two-proton downfield broad singlet at δ 9.20 (2H) assigned to H-6 and H-9 and at δ 6.93 (2H) ascribed to H-2 and H-3 aromatic protons. A one-proton multiplet at δ 8.10 was attributed to H-7. Another two one-proton broad signals appeared at δ 4.27 and 4.25 accounted for H₂-11 hydroxy methane protons. The ¹³C NMR of RC-12 showed important signals for carbonyl carbons and one oxygenated carbon C-1, C-4 and C-11 at δ 175.10, 172.40 and 69.17, respectively. The remaining aromatic carbons appeared between δ 168.03-109.18. On the basis of these spectral data analysis the structure of RC-12 has been elucidated as 8-hydroxymethylene naphthaquinone.

Compound RC-13 named β-hydroxy bezyl alcohol, was obtained as light brown amorphous mass from CHCl₃-MeOH (9:1) eluents. It showed a light purple
colour with FeCl₃ due to phenolic group. Its +ve ESI MS displayed a molecular ion peak at m/z 124 corresponding to molecular formula C₇H₄O₂. The UV absorption maxima at 215 and 267 nm displayed by the compound were characteristic of a conjugated nucleus. Its IR spectrum demonstrated the presence of free hydroxyl group (3510 cm⁻¹) and aromatic nucleus (1541, 1218, 920 cm⁻¹). The ¹H NMR of RC-13 showed a downfield two-proton broad signal at δ 9.20 assigned to H-2 and H-6 aromatic protons. Two other broad signals at δ 6.92 and 3.74, integrating for two-protons each, were ascribed to H-3, and H-5 methine and H₂-7 hydroxymethylene protons, respectively. A D₂O exchangeable proton signal at δ 8.84 was due to hydroxyl group. Further evidence for the structure was provided by its ¹³C NMR spectrum, which showed existence of seven carbon atoms. The signals at δ 168.07 and 67.39 were due to C-1 carbinol and C-7 hydroxymethylene carbons. The aromatic carbons at C-4, C-2 and C-6 appeared at δ 145.78, 138.48 and 120.86, respectively. The carbons at C-3 and C-5 appeared at δ 109.21. On the basis of these spectral data analysis the structure of RC-13 has been elucidated as 4-hydroxymethylene phenol.

Compound RC-14 named Coriaria xanthone glycoside, was obtained as a light brown amorphous mass from CHCl₃-MeOH (9:1) eluents. IR spectrum of RC-14 exhibited absorption bands for hydroxyl group (3447 cm⁻¹), carboxylic group (2850, 1541 cm⁻¹) and unsaturation (1527 cm⁻¹). Its ESI MS exhibited molecular ion peak at m/z 522 corresponding to molecular formula C₂₁H₂₂O₁₄. The other significant fragment peaks appeared at m/z 359 [M-sugar moiety]+ and 477 [M-COOH]+ confirming the presence of glucose and carboxylic group in the compound. A base peak at m/z 344 [C₆,₇-C₁₃-O fission]+ and other fragment peak at 388 [C₅,₆-C₁₅-O fission]+ supported the presence of xanthone derivative glucoside. The ¹H NMR of RC-14 displayed two two-proton doublets at δ 7.20 (J=8.1 Hz) and 7.04 (J=8.1 Hz) assigned to ortho-coupled H-1 and H-2, respectively. A one-proton doublet at δ 5.02 (J=6.99 Hz) was ascribed to H-1’ anomeric protons. The sugar protons appeared as a double doublet at δ 3.65 (J=5.4, 5.4 Hz) for C-4’. Two one-proton doublets at δ 3.03 (J=7.5 Hz), δ 3.01 (J=7.5 Hz) were accounted to oxygenated H₂-6’ protons. The H-5’ and H-3’ appeared as one-proton multiplet at δ 4.86 and 3.13, respectively. Two three-protons broad singlets at δ 3.47 and 2.13 were associated with methoxy and methyl protons attached to aromatic ring, respectively. The ¹³C NMR of RC-14 displayed important signals at δ 191.07, 182.57 and 179.75 for C-6 carboxyl and C-15 and C-16 carboxylic carbons, respectively. The aromatic carbons resonated between δ 159.16-110.15 whereas C-14 methyl and C-17 methoxy carbons appeared at δ 28.55 and 56.44, respectively. The anomeric carbons appeared at δ 100.55 whereas remaining sugar carbons resonated between δ 76.53-60.95. On the basis of foregoing discussions the structure of RC-14 has been elucidated as 9-methoxy-11-hydroxy-3-methyl xanthone-4, 8-dioic acid-10-β-D-glucopyranoside.

Compound RC-15 named Coriariaioic acid, was obtained as brown crystals from CHCl₃-MeOH (9:1) eluents. It responded positively to bromine water and
tetranitromethane test for unsaturation and gave effervescence with sodium bicarbonate solution suggesting acidic nature of the compound and responded positively to the DNP test for carbonyl group. Its IR spectrum showed absorption bands for carboxylic group (2860, 1710 cm⁻¹), carbonyl group (1690 cm⁻¹) and aromatic nucleus (1541, 794 and 773 cm⁻¹). It exhibited UV maxima at 294 nm characteristic of conjugated moiety. The ESI MS spectrum of RC-15 showed a molecular ion peak at m/z 194 corresponding to molecular formula C₁₀H₁₀O₄. The ¹H NMR spectrum of the compound exhibited a downfield D₂O exchangeable signal integrating for one-proton of a carboxylic group at δ 12.27.

Another one-proton broad signal at δ 9.20 was assigned to carbonyl protons. The aromatic proton H-2 and H-5 resonated as a broad signals at δ 8.84 and 6.91 whereas two three-proton broad signals at δ 3.36 and 2.50 were assigned to methoxy protons and Me-8 protons, respectively. On the basis of these chemical reactions and spectral data analysis the structure of RC-15 has been elucidated as 4-methoxy-5-methyl benzen-2-al-l-oic acid.

Compound RC-16, named coriariaanthracetyl ester, was obtained as brown crystals from CHCl₃-MeOH (17:3) eluents. Its IR spectrum exhibited absorption bands for hydroxyl group (3448, 3380 cm⁻¹), ester group (2855, 1725 cm⁻¹), carboxylic group (1695 cm⁻¹) and aromatic moiety (1541, 1075, 990 cm⁻¹). Aromaticity in the compound was supported by the UV absorption maxima at 266, 294 and 358 nm characteristic of an conjugated system. The ESI MS displayed a molecular ion peak at m/z 452, which corresponds to molecular formula C₁₇H₁₃₂O₆. The ¹H NMR of RC-16 exhibited a downfield one-proton broad signal at δ 13.24 assignable to carboxylic proton. Two one-proton ortho-coupled doublets at δ 7.99 (J=8.1 Hz) and 6.96 (J=8.1 Hz) were assigned for ortho-coupled H-3 and H-4 aromatic protons, respectively. A set of one-proton doublet at δ 7.05 (J=8.85 Hz) and 6.83 (J=8.85 Hz) was ascribed for ortho-coupled H-9 and H-10 protons. Four broad signals at δ 7.79 (1H), 6.63 (1H), 2.50 (2H) and 1.23 (18H) arose due to H-13 and H-6 aromatic protons, CH₂-2' oxygenated protons and 9 x CH₂ aliphatic protons, respectively. Primary methyl proton due to Me-12' appeared as a triplet at δ 0.84 (J=6.2 Hz). On the basis of the foregoing discussions the structure of RC-16 has been elucidated as 1-dodecanoxy-2, 8-dihydroxy-anthracene-15-oic acid.

Compound RC-17, named coriariaxanthone diol, was obtained as a light brown amorphous mass from CHCl₃-MeOH (17:3) eluents. Its IR spectrum showed absorption bands at 3448 cm⁻¹ (hydroxyl group) and 1541 cm⁻¹ (unsaturation) and 930 cm⁻¹ (aromaticity). The ESI MS displayed a molecular ion peak at m/z 242 corresponding to the molecular formula C₁₄H₁₀O₄. Its ¹H NMR exhibited three one-proton doublets at δ 7.97 (J=8.4 Hz) and 6.93 (J=8.4 Hz) for ortho-coupled aromatic protons H-1and H-2, respectively. Another doublet at 7.01 (J=3.0 Hz) was assigned to H-4 aromatic protons. Two one-proton broad signals at δ 7.87 and 6.79 were assigned to other aromatic protons H-11 and H-8, respectively. Two D₂O exchangeable one-proton signals at δ 6.75 and 6.55 were assigned to two hydroxyl protons. Another three-proton broad singlet at δ 2.50 was due to
Me-14 methyl protons attached to aromatic ring at C-3. The $^{13}$C NMR of RC-17 exhibited signals at δ 181.64, 164.05 and 161.42 for C-6 carboxylic carbon, C-9 and C-10 carbinolic carbons, respectively. The remaining aromatic carbons resonated between δ 161.05-93.95. The C-14 methyl carbon attached to aromatic ring appeared at δ 28.99. On the basis of the foregoing discussions the structure of RC-17 has been elucidated as 3-methyl-9, 10-dihydroxyxanthone.