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Unraveling the Complexities of Inflammation: A Comprehensive Review

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ABSTRACT:

As a vital part of the immune system's defence mechanism against infections, tissue damage, and other insults, inflammation is a complex biological response brought on by a variety of triggers. Although persistent or dysregulated inflammation can cause a variety of pathological illnesses, such as cancer, metabolic problems, and autoimmune diseases, it is necessary for preserving tissue homeostasis and fostering repair. With an emphasis on the complex interactions between immune cells, signalling chemicals, and tissue microenvironments, this thorough analysis seeks to clarify the complex mechanisms behind inflammation. We explore the molecular mechanisms underlying the start, spread, and resolution of inflammation, emphasising the functions of important mediators such cytokines, chemokines, and lipid mediators. Moreover, we investigate the dynamic interplay of immune cells, such as neutrophils, lymphocytes, and macrophages, and their roles in both beneficial and harmful aspects of inflammation. Additionally, the impact of genetic inclination, environmental variables, and lifestyle decisions on the susceptibility to and advancement of inflammation is covered. Furthermore, new approaches to treating inflammation being studied, including immunomodulatory treatments, innovative biologics, and conventional anti-inflammatory drugs. This study offers a thorough overview of inflammation by combining knowledge from several disciplines, including immunology, molecular biology, and clinical medicine. It also elucidates its complexities and makes recommendations for potential directions for further study and methods of treatment.

KEYWORDS: - Inflammation, Inflammatory Signaling Pathways, Chemokines, Cytokines,Medicinal plants

1.Introduction

The immune system's reaction to adverse stimuli, such as infections, damaged cells, poisonous substances, or radiation, is inflammation**[1]**. It functions by eliminating harmful stimuli and starting the healing process[2]. Inflammation is therefore a defense mechanism that is vital to health[3]. Cellular and molecular processes and interactions typically effectively reduce the risk of harm or infection during acute inflammatory reactions. This mitigating action helps to end the acute inflammation and restore tissue homeostasis. A range of chronic inflammatory disorders are influenced by unchecked acute inflammation, which can turn chronic[4]. Inflammation results from local immunological, vascular, and inflammatory cell responses to infection or injury, and at the tissue level is characterised by redness, swelling, heat, discomfort, and loss of tissue function[5]. Leukocyte recruitment and accumulation, inflammatory mediator release, and alterations in vascular permeability are all significant microcirculatory events that take place throughout the inflammatory process[2,3,4,5,6]. Various pathogenic factors, such as infection, tissue injury, or cardiac infarction, can induce inflammation by causing tissue damage. The etiologies of inflammation can be infectious or non-infectious. **(Table 1)**.

The body triggers a chemical signalling cascade in reaction to tissue damage, which in turn triggers reactions targeted at repairing damaged tissue. These signals cause leukocytes to migrate from the general circulation to the damaged areas. These leukocytes are activated, and they release cytokines that cause inflammation[7].

2. Inflammatory Response Mechanisms

The inflammatory response is the coordinate activation of signaling pathways that regulate inflammatory mediator levels in resident tissue cells and inflammatory cells recruited from the blood[8]. Inflammation is a common pathogenesis of many chronic diseases, including cardiovascular and bowel diseases, diabetes, arthritis, and cancer[9]. All inflammatory response processes share a basic mechanism, which can be summed up as follows, albeit depending on the specifics of the original stimulus and where it occurs in the body: 1) Detrimental stimuli are recognised by cell surface pattern receptors; 2) inflammatory pathways are triggered; 3) inflammatory markers are produced; and 4) inflammatory cells are drawn in.

Table 1: Etiology of inflammation

Non-infectious factors	**Infectiousfactors**
Physical: burn, frostbite, physical injury, foreign bodies, trauma, lionizing radiation	Bacteria
Chemical: glucose, fatty acids, toxins, alcohol, chemical irritants (including fluoride, nickel and other trace elements)	viruses
Biological: damaged cells	other microorganisms
Psychological: excitement	

3. Activation of pattern recognition receptors

Pathogen-associated molecular patterns (PAMPs), which are microbial structures, have the ability to initiate the inflammatory response by means of activating pattern-recognition receptors (PRRs) encoded in germlines that are expressed in both immune and nonimmune cells[10,11]. Some PRRs, referred to as danger associated molecular patterns (DAMPS), are also capable of identifying a variety of endogenous signals that are triggered when tissue or cell damage occurs[11]. Host biomolecules known as DAMPs have the ability to start and maintain a noninfectious inflammatory response[12]. By generating DAMPs, disrupted cells can also attract innate inflammatory cells when pathogens are not present[13]. Toll-like receptors (TLRs), C-type lectin receptors (CLRs), retinoic acid-inducible gene (RIG)-I-like receptors (RLRs), and NOD-like receptors (NLRs) are among the classes of PRR families[5]. TLRs are a family of mammalian PRRs that are highly conserved and involved in initiating the inflammatory response[14]. The TLR family comprises more than 10 members, and among the known PRRs, TLRs have received the greatest research attention[15]. Together with TLRs, myeloid differentiation factor-88 (MyD88) mediates the transmission of PAMPs and DAMPs. An intracellular signalling cascade is triggered by signalling via TLRs[16,17] that leads to nuclear translocation of transcription factors, such as activator protein-1 (AP-1) and NF-κB or interferon regulatory factor 3 (IRF3) (Figure 1). Similar receptors, including TLR4, are shared by DAMPs and PAMPs, indicating that infectious and noninfectious inflammatory responses are similar[18].

4. Inflammatory pathway activation

Numerous chronic diseases are impacted by inflammatory pathways, which also involve common inflammatory mediators and regulatory processes. Intracellular signalling pathways are triggered by inflammatory stimuli, and this in turn triggers the synthesis of inflammatory mediators. Primary inflammatory stimuli mediate inflammation by interaction with TLRs, IL-1 receptor (IL-1R), IL-6 receptor (IL-6R), and the TNF receptor (TNFR). These stimuli include microbial products and cytokines such as interleukin-1β (IL-1β), interleukin-6 (IL-6), and tumour necrosis factor-α (TNF-α)[19]. Important intracellular signalling pathways, such as the nuclear factor kappa-B (NF-κB), Janus kinase (JAK)-sign transducer and activator of transcription (STAT) pathways, and mitogen-activated protein kinase (MAPK) pathways, are initiated by receptor activation[20,21,22].

4.1 NF-κB Pathway

The transcription factor NF-κB is involved in immune response, survival, inflammation, and apoptosis[23]**.** P50, p52, RelA (p65), RelB, and c-Rel are the five related transcription factors that make up the NF-κB family[24]. Numerous chemicals, including those originating from pathogens, intercellular inflammatory cytokines, and enzymes, can all trigger NF-κB activity[25,26,27]. IκB kinase (IKK) is activated by PRRs by comparable signal transduction pathways. IKK is made up of two kinase subunits, IKKα and IKKβ, and one regulatory subunit, IKKγ. IKK controls the activation of the NF-κB pathway by phosphorylating IκB[8]. When IκB is phosphorylated, the proteasome degrades it, releasing NF-κB, which then activates gene transcription and nuclear translocation[27]. This route controls the recruitment of inflammatory cells and the synthesis of pro-inflammatory cytokines, both of which enhance the inflammatory response (Figure 2).

4.2 MAPK Pathway

The family of serine/threonine protein kinases known as MAPKs controls how cells react to a range of stimuli, such as heat shock, mitogens, osmotic stress, and inflammatory cytokines (like IL-1, TNF-α, and IL6) that control cell survival, proliferation, differentiation, and apoptosis[19,28]. Mammalian MAPKs consist of p38 MAP Kinase, c-Jun N-terminal kinases (JNK), and extracellular signal-regulated kinase (ERK1/2)[29]. At least three elements make up each MAPK signalling pathway: a MAPK, a MAPK kinase (MAPKK), and a MAPK kinase kinase (MAPKKK). The phosphorylation and activation of MAPKKs by MAPKKKs subsequently phosphorylates and activates MAPKs[29].Stress and inflammatory stimuli activate JNK and p38, whereas mitogens and differentiation signals typically stimulate ERKs[31]. MKK1 and MKK2 trigger JNK, MKK4 and MKK7 trigger ERK1/2, while MKK3 and MKK6 trigger p38. The inflammatory response is started when the MAPKs, such as Erk1/2 and JNK, are activated. This causes the p38 transcription factors that are found in the cytoplasm or nucleus to be phosphorylated and activated[28,29,30,31,32]. (Figure 3).

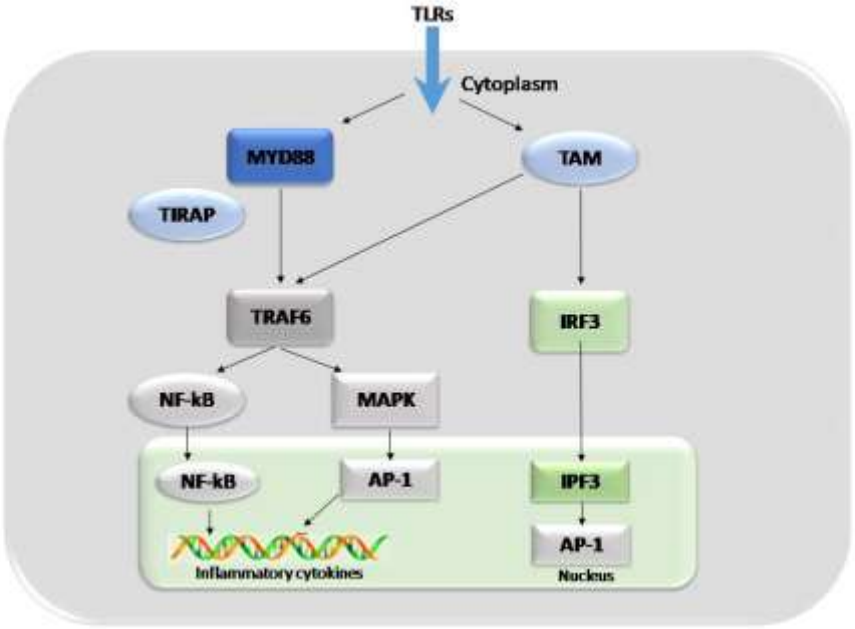

Figure 1: TLR signaling. MyD88-dependent and TRIF-dependent pathways are shown. Signaling through TLRs activates intracellular signaling cascades that lead to nuclear translocation of AP-1 and NF-κB or IRF3, which regulates the inflammatory response

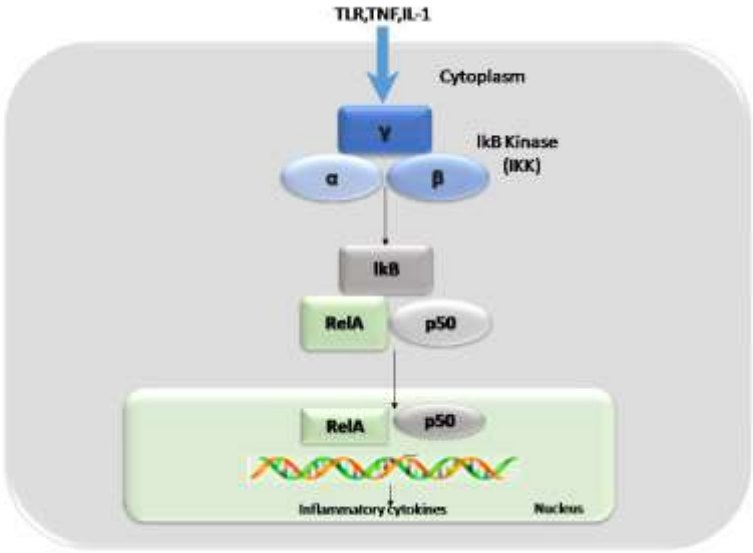

Figure 2: NF-κB pathway. This pathway is triggered by TLRs and inflammatory cytokines, such as TNF and IL-1, leading to activation of RelA/p50 complexes that regulate expression of inflammatory cytokines. NF-κB signaling requires IKK subunits. which regulate pathway activation through IκB phosphorylation.

4.3 JAK-STAT Pathway

The highly conserved JAK-STAT system is a signalling pathway that external substances use to influence the expression of genes. It involves a variety of cytokines, growth factors, interferons, and related compounds like growth hormone and leptin[33]. Ligands activate receptor-associated JAKs, which then phosphorylate one another to form docking sites for latent cytoplasmic transcription factors called STATs. Before being translocated to the nucleus, cytoplasmic STATs that are attracted to these locations are phosphorylated and then dimerize[34]. For STAT dimerization and DNA binding, tyrosine phosphorylation is necessary[35]. Consequently, an extracellular signal can be directly translated into a transcriptional response thanks to JAK/STAT signalling. For instance, the JAK-STAT proteins are activated when members of the IL-6 family connect to receptors on the plasma membrane. In order to control the transcription of inflammatory genes, STAT proteins translocated into the nucleus bind target gene promoter regions (Figure 4)[36].

Dysregulation of JAK-STAT, MAPK, or NF-κB activity is linked to cancer, autoimmune, and metabolic disorders as well as inflammatory conditions[37]**.** Cytokine secretion is the outcome of transcription factor-mediated signaling[38,39]**.** Numerous transcription factors govern several genes associated with inflammation, including IL-1, TNF-α, and IL-6[40]**.** chemokines, transforming growth factor (TGF), interferons, and colony stimulating factor (CSF).

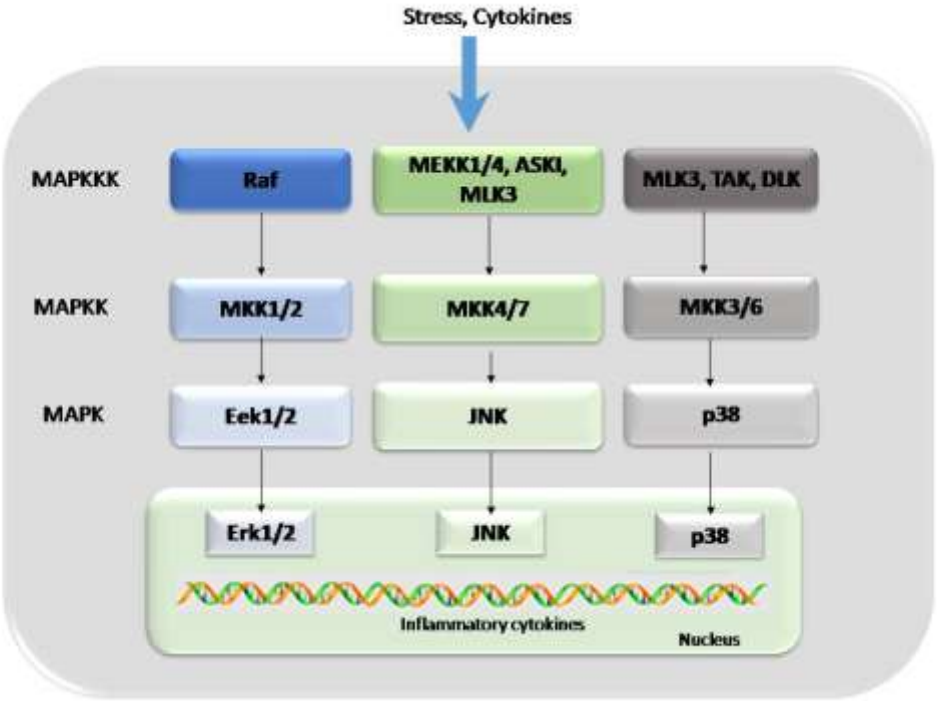

Figure 3: MAPK pathway. This pathway mediates intracellular signaling initiated by extracellular stimuli, such as stress and cytokines. MAPKKKs phosphorylate and activate MAPKKs, which in turn phosphorylate and activate MAPKs. The mammalian MAPK family includes Erk1/2, JNK, and p38. In the Erk1/2 pathway, Erk1/2 is activated by MKK1/2, which is activated by Raf. In the JNK pathway, JNK is activated by MKK4/7, which is activated by MEKK1/4, ASK1, and MLK3. In the p38 pathway, p38 is activated by MKK3/6, which is activated by MLK3, TAK, and DLK. Activated MAPKs phosphorylate various proteins, including transcription factors, resulting in regulation of inflammatory responses.

5. Inflammatory Markers

In clinical settings, markers are employed to distinguish between healthy and unhealthy biological processes and evaluate how well therapeutic interventions work. It's possible to anticipate inflammatory disorders based on inflammatory indicators[41,42,43,44,45,46]. and are associated with the aetiology and outcomes of a number of inflammatory illnesses, including infections, endothelial dysfunction, and cardiovascular disorders[47,48]. In addition to causing the production of inflammatory cytokines like TNF-α, IL-1β, and IL-6, as well as inflammatory proteins and enzymes, stimuli also activate inflammatory cells including macrophages and adipocytes. These compounds may be used as biomarkers in the diagnosis, prognosis, and treatment selection of illnesses[49,50,51,52,53].

6. Inflammatory Cytokines

The main sources of cytokines (Table 2) are immune cells such as lymphocytes, macrophages, and monocytes. Inflammation is facilitated and inhibited by pro- and anti-inflammatory cytokines, respectively. The primary function of inflammatory cytokines, which include ILs, colony stimulating factors (CSF), IFNs, TNFs, TGFs, and chemokines, is to attract leukocytes to the site of infection or injury[54]. Through a complex web of interconnections, cytokines control inflammation and the immune system's reaction to infection or inflammation. On the other hand, overproduction of inflammatory cytokines can result in organ failure, hemodynamic alterations, tissue damage, and eventually death[55,56]. Treatment of inflammatory illnesses and more precise detection of agent-mediated inflammation would be made possible by a deeper comprehension of the regulation of cytokine pathways[54].

7. Inflammatory Proteins and Enzymes

Blood inflammatory proteins, such as alpha 1-acid glycoprotein, serum amyloid A, fibrinogen, haptoglobin, and C-reactive protein (CRP) [57] independently of antibodies, assist in restoring homeostasis and inhibiting microbial development in the event of trauma, stress, or infection[58]. High-mobility group box 1 (HMGB1), superoxide dismutase (SOD), glutathione peroxidase (GPx), NADPH oxidase (NOX), inducible nitric oxide synthase (iNOS), and cyclooxygenase (COX)-2 are just a few of the enzymes whose abnormal activation plays a major role in the development of inflammation-

related diseases like cancer and cardiovascular disease[59,60,61,62]. For instance, TLR-coupled signalling pathways may be activated to mediate extracellular HMGB1 effects[63]. TLR4 is the principal target of extracellular HMGB1[64]**.** This sets off intracellular signalling cascades dependent on MyD88 that activate the NF-κB and MAPK pathways. As a result, pro-inflammatory cytokines including TNF-α and IL-1β are released[63]. Inflammatory proteins and enzymes have been used as inflammation, infection, and trauma biomarkers in medicine.

8. Some other inflammatory markers

Oxidative stress is influenced by antioxidant defence mechanisms, which include antioxidant enzymes. Reactive oxygen species (ROS), malondialdehyde (MDA), 8-hydroxy-2-deoxyguanosine (8-OHdG), and isoprostane can all be produced in response to elevated oxidative stress[60,61,62,63,64,65] Each of which has the ability to activate different transcription factors, such as STAT, NF-κB, AP-1, and p53. As a result, this cascade can enhance the expression of genes that code for chemokines, inflammatory cytokines, and growth factors[66]. Numerous diseases, including atherosclerosis, diabetes, cancer, cardiovascular disease, and hypertension, are linked to oxidative stress in their aetiology. Thus, products of oxidative stress may potentially serve as indicators of the inflammatory response.

9. Cell types in inflammatory responses

The inflammatory response involves a highly coordinated network of many cell types. Activated macrophages, monocytes, and other cells mediate local responses to tissue damage and infection. At sites of tissue injury, damaged epithelial and endothelial cells release factors that trigger the inflammatory cascade, along with chemokines and growth factors, which attract neutrophils and monocytes. The first cells attracted to a site of injury are neutrophils, followed by monocytes, m lymphocytes (natural killer cells [NK cells], T cells, and B cells), and mast cells [67,68].Chemotaxis is the mechanism by which monocytes are drawn into injured tissues and can transform into macrophages and dendritic cells. Numerous illnesses, such as asthma, cancer, chronic inflammatory diseases, atherosclerosis, diabetes, autoimmune, and degenerative diseases, are linked to inflammation-mediated immune cell changes.

Targeting bodily bacteria, neutrophils can harm host cells and tissues as well[3].The inflammatory response is mediated mostly by neutrophils, which programme antigen-presenting cells to activate T cells and produce localised factors that draw monocytes and dendritic cells[7]. Macrophages are essential elements of the mononuclear phagocyte system and play a pivotal role in the genesis, maintenance, and resolution of inflammation. In an inflammatory state, macrophages present antigens, carry out phagocytosis, and produce growth factors and cytokines to influence the immunological response. Effector cells called mast cells live in epithelial interfaces and connective tissue matrices, where they trigger inflammatory reactions. Many inflammatory mediators are released by activated mast cells, such as histamine, proteases, prostaglandins, leukotrienes, cytokines, chemokines, and serglycin proteoglycans[70]. Platelets affect inflammatory processes, including infection and atherosclerosis, as several studies have shown. Inflammatory cell interactions with platelets may mediate pro-inflammatory effects. Studies have shown that platelets can trigger the acute phase response (APR), which is the first reaction to an infection or injury[71]. Immune cells are drawn to inflammatory stimuli, and upon recruitment, they release local inflammatory mediators that sustain and magnify the APR.

Table 2: Overview of cytokines and their roles

Cytokine	Family	Main sources	Function
IL-1β	IL-1	Macrophages, monocytes	Pro-inflammation, proliferation, apoptosis, differentiation
IL-4	IL-4	Th-cells	Anti-inflammation, T-cell and B-cell proliferation, B-cell differentiation
IL-6	IL-6	Macrophages, T-cells, adipocyte	Pro-inflammation, differentiation, cytokine production
IL-8	CXC	Macrophages, epithelial cells, endothelial cells	Pro-inflammation, chemotaxis, angiogenesis
IL-10	IL-10	Monocytes, T-cells, B-cells	Anti-inflammation, inhibition of the pro-inflammatory cytokines
IL-12	IL-12	Dendritic cells, macrophages, neutrophils	Pro-inflammation, cell differentiation, activates NK cell
IL-11	IL-6	Fibroblasts, neurons, epithelial cells	Anti-inflammation, differentiation, induces acute phase protein
TNF-α	TNF	Macrophages, NK cells, $CD4^+$ lymphocytes, adipocyte	Pro-inflammation, cytokine production, cell proliferation, apoptosis, anti-infection
IFN-γ	INF	T-cells, NK cells, NKT cells	Pro-inflammation, innate, adaptive immunity anti-viral
GM-CSF	IL-4	T-cells, macrophages, fibroblasts	Pro-inflammation, macrophage activation, increase neutrophil and monocyte function

TGF-β	TGF	Macrophages, T cells	Anti-inflammation, inhibition of pro-inflammatory cytokine production

10. An Inflamation Resolution

The inflammatory response needs to be inhibited to stop further tissue damage in order to stop the evolution of acute inflammation into persistent, chronic inflammation. The creation of mediators under temporal and geographical control, which results in the gradual dilution of chemokine gradients, is a well-managed process in the resolution of inflammation. Eventually, circulating white blood cells lose their ability to detect these gradients and are not drawn to damage sites. Chronic inflammation that is out of control can result from this process' dysregulation[72].The processes of inflammation resolution that restore tissue homeostasis include counterregulating chemokines and cytokines, macrophage conversion from classically to alternatively activated cells, decreasing or stopping neutrophil infiltration of tissue and apoptosis of spent neutrophils, and the start of the healing process[73,74].When acute inflammatory systems are unable to completely eradicate tissue harm, chronic inflammation results[75], It may result in a variety of illnesses, including cancer, atherosclerosis, type 2 diabetes, rheumatoid arthritis, and cardiovascular problems[76]. Improved tailored medicines can be developed and produced if common processes coordinating malfunction in the various organ systems are understood.

11. Natural Anti-Inflammatory Agents

The combination of centuries-long indigenous medical practices and restorative experiences has resulted in herbal medications. The treatment of many major disorders, including pain and inflammation, remains challenging despite the enormous advancements in medical science over the past few decades[77]. The creation of strong analgesic and anti-inflammatory medications with fewer side effects is necessary because the anti-inflammatory and analgesic medications already in use are linked to some serious negative effects[78]. Many phytoconstituents, including sterols, alkaloids, flavonoids, xanthone, coumarin, withaferin-A, and andrographolide, have also been shown to be useful as analgesics and anti-inflammatory agents[79].Thus, research into herbal therapy and its application to daily life is imperative. A selection of plants that have been shown to have analgesic and anti-inflammatory effects are enumerated in Table.

Table 3: SOME PLANT SOURCES ACTIVATED AGAINST ANALGESIC AND ANTI-INFLAMMATORY

S.No.	**Botanical Name And Family**	**Local Name**	**Part used**	**Ethano Medicinal uses**
1.	Boenninghausenia albiflora(Hook) Rehb.ex Meisn [Rutaceae]	Pissumar	Whole Plant	Hepatoprotective,Antioxidative,Anti inflammatory &Immunomodulating
2.	Boswellia Serrata Roxb. [Burseraceae]	Sallai	Bark	Wound Healing,Chronic inflammatory diseases
3.	Butea Monosperma [Lam]. Kuntze [Fabaceae]	Dhak palash	Flower, Gum	Ulcer,Diarrhea,Antioxidative,Anti inflammatory,Hepatoprotective &Anticancer activities
4.	Lablab purpureus (L.) Sweet[Fabaceae]	Chimi	Whole Plant	Anti inflammatory,Analgesic & Hepatoprotective Activity
5.	Melia azedarach L. [Meliaceae]	Dekrain	Root	Analgesic,anti inflammatory
6.	Morella Esculenta(Buch.Ham.ex D.Don)L.M. Turner [Myricaceae]	Kafal,Kaphal	Fruit,Bark	Anti inflammatory activity
7.	Nyctanthes arbortristis L. [Oleaceae]	Siyari	Leaf	Anti inflammatory activity, Anti pyretic
8.	Polygonatum Cirrhifolium (Wall.)Royle [Asparagaceae]	Mahamedа	Root	Analgesic,Anti inflammatory Activity

9.	Pumica Granatum L. [Lythraceae]	Dadim	Fruit	Anti inflammatory Activity, Anti-oxidant
10.	Ricinus Communis L. [Euphorbiaceae]	Ein	Leaf	Wound Healing with antimicrobial toxicological & anti inflammatory activity
11.	Vachellia Nilotica (L.) J.H.Hurter & Mabb. [Fabaceae]	Babul	Whole plant	Anti bacterial, Anti microbial & Anti inflammatory Activity
12.	Verbascum Thapsus L. [Scrophulariaceae]	Kalber	Leaf	Inflammatory diseases
13.	Vitex Negundo L. [Lamiaceae]	Nirgundi	Leaf	Anti inflammation,Anticonvulsant, Hepatoprotective Properties
14.	Achillea millefolium [Asteraceae]	Yarrow	Whole Plant	Inflammation,Pain & Gastrointestinal disorders
15.	Aconitum heterophyllum [Valeraneaceae]	Atis or Ativisha	Root	Expectorant,Antihelmintic,Anti emetic & Anti inflammatory
16.	Adhatoda vasica Nees [Acanthaceae]	Malabar or Vasaka	Leaves	Headache,Cold,Fever,Inflammation
s17.	Aloe vera [Asphodelaceae]	Gwarpath a or Ghrit kumari	Leaves	Wound healing & Anti inflammatory activities
18.	Azardirachta indica [Meliaceae]	Neem	Leaves	Anti inflammatory,Antipyretic & Anti tumour activities
19.	Bacopa Monnieri [Scrophulariaceae]	Brahmi	Whole Plant	Inflammation,Imsomnia & Axiolytic
20.	Boswellia serrata [Burseraceae]	Salai guggul	Resin	Inflammation,Osteoarthritis
21.	Cassia fistula [Caesalpiniaceae]	Golden Shower	Leaves	Wound healing & Gastrointestinal illness
22.	Citrus auranticum [Rutaceae]	Bitter Orange	Fruit	Nausea,Indigestion,Constipation & Inflammation
23.	Commiphora mukul [Burseraceae]	Guggul	Resin	Anti inflammatory & Antioxidative properties
24.	Curcuma longa [Zingiberaceae]	Turmeric	Rhizome	Wound healing,Hepatic disorder & Sinusitis
25.	Elephantophs scaber [Compositae]	Elephant' s Foot	Leaves	Inflammation,Cardiac tonic & diuretic
26.	Emblica officinalis [Euphorbiaceae]	Indian gooseberr y or amla	Fruit	Antioxidant, Anti inflammatory,Anticancer & Immunomodulatory potensial
27.	Lippia nodiflora	Jal buti	Leaves	Anti inflammatory,Antipyretic & Astrigent

28.	Mangifera indica [Anacardiaceae]	Mango	Bark	Wound healing,Strong antioxidant & Immunomodulation
29.	Moringa olifera [Moringaceae]	Drumstick tree	Root, Flowers	Wound healing property
30.	Paederia foetida [Rubiaceae]	Chinese fever vine	Leaves	Inflammation,Piles & Diarrhea
31.	Palisota hirsuta [Commelineceae]	Liberian Bassa	Leaves	Inlammation,Analgesic & Antiseptic
36.	Pluchea indica [Asteraceae]	Indian camphorw eed	Root	Inflammation,Abdominal pain & itchy skin
37.	Ricinus communis [Euphorbiaceae]	Caster oil	Roots, leaves	Menstrual pain, Inflammation,Wound healing & Muscle ache
38.	Rubrus ellipticus [Rubiaceae]	Raspberry	Leaves	Anti inflammatory,Analgesic,Anti pyretic & Wound healing
39.	Saussurea costus [Asteraceae]	Kuth or putchuk	Whole Plant	Chronic gastritis,Stomach ulcers & Anti inflammatory activities

12. Conclusion

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