Vaishali Murade. *et al.* / *International Journal of Phytopharmacology.* 5(4), 2014, 328-334.

e- ISSN 0975 – 9328
Print ISSN 2229 – 7472

International Journal of Phytopharmacology

Journal homepage: www.onlineijp.com

IJP

A COMPREHENSIVE REVIEW OF PHYTOPHARMACOLOGY OF *RICINUS COMMUNIS (*LINN.)

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ABSTRACT

The importance of natural product research in treatment of disease has been increased because of its natural source and comparatively lesser side effects. The *Ricinus communis* (RC) has high traditional and medicinal value for maintain the disease free healthy life. The plant is reported to possess anti-oxidant, antihistaminic, antinociceptive, antiasthmatic, antiulcer, immunomodulatory, antidiabetic, hepatoprotective, antifertility, anti-inflammatory, anti-microbial, central nervous system stimulant, lipolytic, wound healing, insecticidal, larvicidal, insecticidal, molluscicidal activity. The pharmacological activities are due to the presence of variety of phytoconstituents in the plant, the major phytoconstituent reported in this plant are quercetin, quercetin-3-O-beta-D-xylopyranoside, quercetin-3-O-beta-D-glucopyranoside, kaempferol-3-*O*-beta-d-rutinoside, kaempferol-3-*O*-beta-d-glucopyranoside, kaempferol-3-*O*-beta-d-xylopyranoside, ricinine, N-demethylrecinine. The objective of the present review was focused on phytochemical and pharmacological aspects of the RC.

Key words: *Ricinus communis*, phytochemical constituents, pharmacological activity.

INTRODUCTION

Natural product research is a fast-moving field whose continuous developments have far-reaching implications for world health. There are many natural crude drugs that have the potential to treat many diseases; one of them is RC is perennial shrub of the Euphorbiaceae family. It is a tropical plant, commonly known as castor bean, the palm of Christ or *Palma Christi*, which is distributed widely across the globe (Eudmar *et al.*, 2011). The plant is native of India and cultivated throughout the country in gardens and fields and also grows wild in waste places. RC plant have been used for the treatment of inflammation (Ilavarasan *et al.*, 2006) and liver disorders (Prince *et al.*, 2011), anticancer (Darmanin *et al.*, 2009), antidiabetic (Shokeen *et al.*, 2008) and diuretic, antifertile (Sani and Sule, 2007) and laxative activity (Singh *et al.*, 2010, Scarpa *et al.*, 1982).

After exhaustive literature survey of RC, prominent pharmacological activities are reported by researchers. The aim of the present review is to document the literature on pharmacological and phytochemical aspects of RC plant.

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PHARMACOLGICAL ACTIVITIES OF RC

Hepatoprotective activity

Prince *et al.*, (2011) studied the hepatoprotective effect ethanolic extract of RC leaves at different doses, the presence of flavonoids and tannins exhibited inhibitory effect on the activities of serum transaminases and the liver lipid peroxidation level and the activities of acid and alkaline phosphatase in liver induced by carbon tetrachloride. N-demethyl ricinine showed anticholestatic and hepatoprotective potential in paracetamol-induced hepatic damage (Shukla *et al.*, 1992, Visen *et al.*, 1992, Natu *et al.*, 1997).

Antiasthmatic activity

Taur and Patil (2011) investigated antiasthmatic activity of ethanol root extract of RC in clonidine induced catalepsy in mice probably due to its antiallergic and mast cell stabilizing potential effects of saponins present in RC. It was investigated that, flavonoids viz. apigenin and luteolin exhibited inhibition of histamine release from basophils and neutrophils β-glucuronidase release. The ethanol extract of roots of RC decreases milk induced leucocytosis and eosinophilia.

Anti-fertility activity

Sani and Sule (2007) studied methanol extract of RC seed and revealed the presence of steroids and alkaloids. The sex hormone being steroidal compound's (phytosterols) and the presence of steroids in methanol extract of RC seed may be produces anti-fertility effects (Sandhyakumary *et al.,* 2003). Sandhyakumary et al., (2003) reported antifertility effects of ethanol extracts of RC in male rats. The sperm count reduced, the motility, mode of movement and morphology of the sperms were found during the study. Reductions in the fructose and testosterone levels were suggestive of reduced reproductive performance.

Immunomodulatory activity

Kumar *et al.,* (2011) studied immunomodulatory activity of RC. The presence of tannins improved phagocytosis of microorganisms by leucocytes. It improved the immune responsiveness against pathogens by activating the non-specific immune system.

Antinociceptive activity

Taur and Patil (2011) investigated antinociceptive activity of the methanolic leaves extract of RC against acetic acid induced writhing test, formalin induced paw licking and tail immersion methods in mice. The activity may be due to presence of chemical constituents like saponins, steroids, alkaloids.

Anti-inflammatory activity

Ilavarasan *et al.,* (2006) reported the anti-inflammatory activity of the leaves and root extract of RC in rats. The 250 and 500 mg/kg dose of RC methanolic leaves extract possess protective effect in prevention of cellular events during edema formation and in all the stages of acute inflammation (Valderramas *et al.,* 2008). The anti-inflammatory potential of RC methanolic extract was due to the presence of flavonoids against carragennan-induced paw edema in rats (Saini *et al.,* 2010).

Antidiabetic activity

Shokeen *et al.,* (2008) investigated the activity of ethanol extract of roots of RC possess significant effects on fasting blood glucose, total lipid profile, liver and kidney functions and no significant difference on alkaline phosphatase, serum bilirubin, creatinine, serum glutamate oxaloacetate transaminases, serum glutamate pyruvate transaminases and total protein which was observed even after the administration of the extract at a dose of 10 g/kg body weight.

Wound healing activity

Prasad *et al.,* 2011 reported wound healing activity of castor oil which showed antioxidant activity and inhibit lipid peroxidation may be due to presence of tannins, flavonoids, triterpenoids and sesquiterpenes. It promotes the wound healing process, resulted in wound contraction and increased rate of epithelialisation. The wound healing activity of castor oil was evaluated in terms of scar area, percent closure of scar area and epithelization in excision wound model. The 10 % w/w castor oil ointment possesses comparatively better wound healing property.

Antimicrobial activity

Mathur *et al.,* 2011 reported antimicrobial potential of RC wide variety of microorganisms. The petroleum ether and acetone extracts of RC showed higher zone of inhibition than ethanolic extract. The different solvent extracts of roots of RC possess antimicrobial activity by using well diffusion method against pathogenic microorganisms such as *Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, Salmonella typhimurium, Proteus vulgaris, Bacillus subtilis, Candida albicans* and *Aspergillus niger*. The hexane and methanol extracts showed maximum antimicrobial activity where the aqueous extracts has no significant antimicrobial properties.

Lipolytic activity

Lombard *et al.,* (2001) reported the presence of ricin primarily act on lipase and hydrolyze lipids. The RC plant shown lipolytic activity in different substrates viz. analogue of triacylglycerol, BAL-TC4; various chromogenic substrates such as *P*-NP esters of aliphatic short to medium chain acids and monomolecular films of a pure natural diacylglycerol, DC_{10} in emulsion and in a membrane-like model. The lipolytic activities are maximal at pH 7.0 in the presence of 0.2 M galactose.

Molluscicidal, Insecticidal and Larvicidal activity

The active ingredients like castor oil and ricinine of RC possess molluscicidal activity against *Lymnaea acuminata* and the seed extracts showed better insecticidal and insectistatic activity than the leaf extracts against *S. frugiperda* (Sharma *et al.,* 2009, Upasani *et al.,* 2003, Ramos-lopez *et al.,* 2010). Elimam *et al.,* (2009) reported the effect of aqueous leaves extracts of RC

against *Anopheles arabiensis*, *Callosobruchus chinensis* and *Culex quinquefasciatus* mosquitoes.

Antiulcer activity

The antiulcer property of castor oil of RC seed was investigated by Rachhadiya *et al.,* (2011) at different dose level, more compelling action against the ulceration caused by pylorus ligation, aspirin and ethanol in rats at 1000 mg/kg dose of RC seed oil. The antiulcer activity of RC may be due to the cytoprotective action of the drug or strengthening of gastric mucosa and thus enhancing the mucosal defence.

Antioxidant activity

Singh *et al.,* (2010) reported the RC seed extracts showed presence of methyl ricinoleate, ricinoliec acid, 12-octadecadienoic acid and methyl ester primarily responsible for the antioxidant activity by in lipid peroxidation by ferric thiocynate method and free radical scavenging effect on DPPH and hydroxyl radical generated from hydrogen peroxide. The RC stems and leaves extracts showed antioxidant activity due to presence of flavonoids in their extracts (Singh *et al.,* 2010, Gupta *et al.,* 2006).

Bone regeneration activity

The RC polyurethane (RCP) has been studied for its biocompatibility and its ability to stimulate bone regeneration. Results showed that RCP blended with calcium carbonate or calcium phosphate could promote matrix mineralization and are biocompatible materials (Beloti *et al.,* 2003a). Incorporating alkaline phosphatase to RCP with subsequent incubation in synthetic body fluid could improve the biological properties of RCP. The advantage seen in RCP as compared to demineralised bone is that the former has a slower reabsorption process (Beloti *et al.,* 2008b).

Cytotoxic activity

Darmanin *et al.,* (2009) observed cytotoxic effect of leaves extract of RC on SK-MEL-28 human melanoma cells. The leaves showed presence of cytotoxic phytochemicals which induces apoptosis via translocation of phosphatidyl serine to the external surface of cell membrane and loss of mitochondrial potential. These compounds included three monoterpenoids: 1, 8-cineole, camphor and α-pinene and a sesquiterpenoid: β-caryophyllene.

PHYTOCHEMISTRY OF RC

The RC plant has shown the presence of various constituents such as quercetin, quercetin-3-O-beta-D-xylopyranoside, quercetin-3-O-beta-D-glucopyranoside, kaempferol-3-*O*-beta-d-rutinoside, kaempferol-3-*O*- beta-d-glucopyranoside, kaempferol -3 –*O* –beta –d -xylo pyranoside, gallic acid, ricinine, N-demethylrecinine. The analytical data of chemical constituents is shown below and structures of important phytoconstituents are shown in Figure 1.

Kaempferol-3-O-β-D-glucopyranoside (Chunpeng *et al.,* 2011)
UV (λ_{max}, nm, MeOH): 265, 346.
IR (KBr) cm^{-1}: 3440-3290, 1670, 1100-1000.
^{1}HNMR (δ Acetone-d6): 6.21 (1H, d, *J* =1.8 Hz), 6.44 (1H, d, *J* =1.8 Hz), 8.04 (2H, d, *J* =8.9 Hz, H-2′, 6′), 6.89 (2H, d, *J* =8.9 Hz, H-3′, 5′), 5.47 (1H, d, *J* =7.2 Hz).
^{13}CMR (DMSO-d6, 25.15 MHz): 156.3, 133, 177.4, 161.1, 98.7, 164.1, 93.6, 156.3, 104.1, 121.0, 130.7, 115.0, 159.8, 115.0, 130.7, 101.4, 74.2, 76.5, 70.1, 77.2, 61.0.
MS: 448 $[M]^+$, $[M-H]^-$ ion at *m/z* 447, $[M+H]^+$ ion at *m/z* 449, $[M+H-162]^+$ ion at *m/z* 287.

Kaempferol-3-O-β-D-xylopyranoside (Chunpeng *et al.,* 2011, Olszewska and Wolbis, 2001)
UV (λ_{max}, nm): 265**,** 296sh, 348, NaOMe 272, 326, 404, $AlCl_3$ 273, 306, 349, 398; $AlCl_3$-HCl 273, 304, 346, 396; NaOAc 273, 307, 382; NaOAc-H_3BO_3 267 302sh, 352.
IR (KBr) cm^{-1}: 1670, 1100 -1000, 3440-3290.
^{1}HNMR (500 MHz): 12.58 (1H,s, OH-5), 8.02 (2H,d, J=8.8 Hz, H-2'& H-6') 6.89 (2H,d, J=8.8 Hz, H-3' & H-5'), 6.43 (1H,d,J=1.7 Hz, H-8), 6.20 (1H,d,J-1.7Hz,H-6'), 5.33 (1H,d,J=7 Hz,H-1''), 3.61 (1H,dd,J=11.55.1 Hz.H-5''eq) 3.15-3.33 (3H,m,H-2'',H-3'' and H-4'')2.95 (1H,dd.J=10.1 and 9.9 Hz, H-5''ax).
^{13}CMR (125.76 MHz): 177.37 (C-4), 164.23 (C-1), 161.17 (C-5), 160.08(C-4'), 156.31 (C-9), 156.14 (C-2), 133.07 (C-3), 130.79 (C-2' and C-6'), 120.66 (C-1'), 115.23 (C-3' and C-5'), 103.89 (C-10), 101.66 (C-1''), 98.72 (C-6), 93.68 (C-8), 75.80 (C-3'''), 73.67 (C-2''), 69.38 (C-4''), 65.92 (C-5'').

Kaempferol-3-O-β-rutinoside (Chunpeng *et al.,* 2011, Song *et al.,* 2007)
UV (λ_{max}, nm MeOH):225, 270, 350.
IR (KBr) cm^{-1}: 1670, 1100 -1000, 3440-3290.
^{1}HNMR (δ DMSO-d_6, 300MHz): 7.98 (2H, d, J= 8.7Hz, H-2', 6'), 6.88 (2H, d, J= 8.7Hz, H-3', 5'), 6.40 (1H, br.s, H-8), 6.20 (1H, br.s, H-6), 5.30 (1H, d, J= 6.9 Hz, H-1''), 4.39 (1H, br.s, H-1'''), 3.0~4.0 (16H, rut), 1.10 (3H, d, *J*=6.4, -CH_3).
^{13}CMR (δ DMSO-d_6, 75 MHz): 156.4 (C-2), 133.1 (C-3), 177.2 (C-4), 161.1 (C-5), 98.7 (C-6), 164.0 (C-7), 93.7 (C-8), 156.7 (C-9), 103.7 (C-10), 120.7 (C-1'), 130.7 (C-2', 6'), 115.0 (C-3', 5'), 159.8 (C-4'), 101.3 (C-1''), 74.1 (C-2''), 76.3 (C-3''), 69.8 (C-4''), 75.6 (C-5''), 66.8(C-6''), 100.7 (C-1'''), 70.2 (C-2'''), 70.5 (C-3'''), 71.7 (C-4'''), 68.1 (C-5'''), 17 (C-6''').

MS: 594.5 (m/z), 267, 257, 229.

Quercetin (Sonar *et al.*, 2012, Guvenalp and Demirezer, 2005**)**
UV (λ_{max}, nm): 369.
IR (KBr) cm^{-1}: 3417, 1662, 1612, 1560, 1521, 1458.
^{1}HNMR (δ DMSO, 300MHz): 6.17 (1H, *d*, *J* = 2.0 Hz, H-6), 6.37 (1H, *d*, *J* = 2.0 Hz, H-8), 6.87 (1H, *d*, *J* = 8.0 Hz, H-5*'*), 7.62(1H, *dd*, *J* = 2.0, 7.5 Hz, H-6*'*), 7.73 (1H, *d*, *J* = 2.0 Hz, H-2*'*).
^{13}CMR (MeOH, 75 MHz): 147.9(C-2), 137.2 (C-3), 177.3 (C-4), 162.5 (C-5), 99.3 (C-6), 165.7 (C-7), 94.4 (C-8), 158.2 (C-9), 104.4 (C-10), 124.1 (C-1'), 116.0 (C-2'), 146.2 (C-3'), 148.7 (C-4'), 116.2 (C-5'), 121.6 (C-6').
MS: 304.09 (M+2), 303.08.

Quercetin-3-O-β-D-glucopyranoside (Guvenalp and Demirezer, 2005, Lee *et al.*, 2007)
UV (λ_{max}, nm): 207, 254.8.
IR (KBr) cm^{-1}: 3400, 2919, 1656, 1606, 1508.
^{1}HNMR (MeOH, 300 MHz): 6.10 (1H,*d*, *J* = 2.0 Hz, H-6), 6.26 (1H, *d*, *J* = 2.0 Hz, H-8), 6.85 (1H, *d*, *J* = 8.0 Hz, H-5*0*), 7.57 (1H, *dd*, *J* = 2.0, 7.5 Hz, H-6*'*), 7.70 (1H, *d*, *J* = 2.0 Hz, H-2*0*), 5.10 (1H, *d*, *J* = 7.7 Hz, H-1*00*), 3.30-3.80 (6H, *m*, H-2*''*, H-3*''*, H-4*''*, H-5*''*, H-6*''*)
^{13}CMR (MeOH, 75 MHz): 158.0 (C-2), 135.1 (C-3), 178.9 (C-4), 163.2 (C-5), 101.4 (C-6), 167.3 (C-7), 95.4 (C-8), 158.6 (C-9), 105.2 (C-10), 123 (C-1'), 116 (C-2'), 145.9 (C-3'), 149.5 (C-4'), 117.4 (C-5'), 122.7 (C-6'), Glc- 101.4 (C-1''), 74.3 (C-2''), 76.8 (C-3''''), 70.3 (C-4''), 77.5 (C-5''), 61.3 (C-6'').
MS: (FAB/MS) m/z 463 $[M-H]^-$, 447, 423, 389, 297, 204.

Quercetin-3-O-β-D-xylopyranoside (Park *et al.*, 2011, Olszewska, 2005)
UV (λ_{max}, nm): 257, 267, 300sh, 354, NaOMe 270, 326, 410; $AlCl_3$ 274, 305sh, 335, 436; $AlCl_3$-HCl 270, 301sh, 362, 404; NaOAc 268, 323sh, 394; NaOAc-H_3BO_3 261, 268sh, 303sh, 378.
IR (KBr) cm^{-1}: 3412, 1662, 1510.
^{1}HNMR (400 MHz, CD_3OD): 7.60 (1H, d, J=2.4 Hz, H-2'), 7.57 (1H, dd, J=8.6, 2.2 Hz, H-6'), 6.84(1H, d, J=8.4 Hz, H-5'), 6.37 (1H, d, J=2.0 Hz, H-8), 6.18 (1H, d, J=2.0 Hz, H-6), 5.17 (1H, d, J=7.2 Hz, H-1'').
^{13}CMR (100 MHz, CD_3OD): 158 (C-2), 135 (C-3), 179.3 (C-4), 163.0 (C-5), 100(C-6), 166.4 (C-7), 94.8 (C-8), 158.8 (C-9), 105.5(C-10), 123.0 (C-1'), 116.0 (C-2'), 146 (C-3'), 149.9 (C-4'), 117.2 (C-5'), 123.3 (C-6'), 104.7 (C-1''), 75.3 (C-2''), 77.5 (C-3'), 71.0 (C-4'), 67.2 (C-5').

MS: 448 $[M]^+$, m/z 489 $[M-H]^-$.

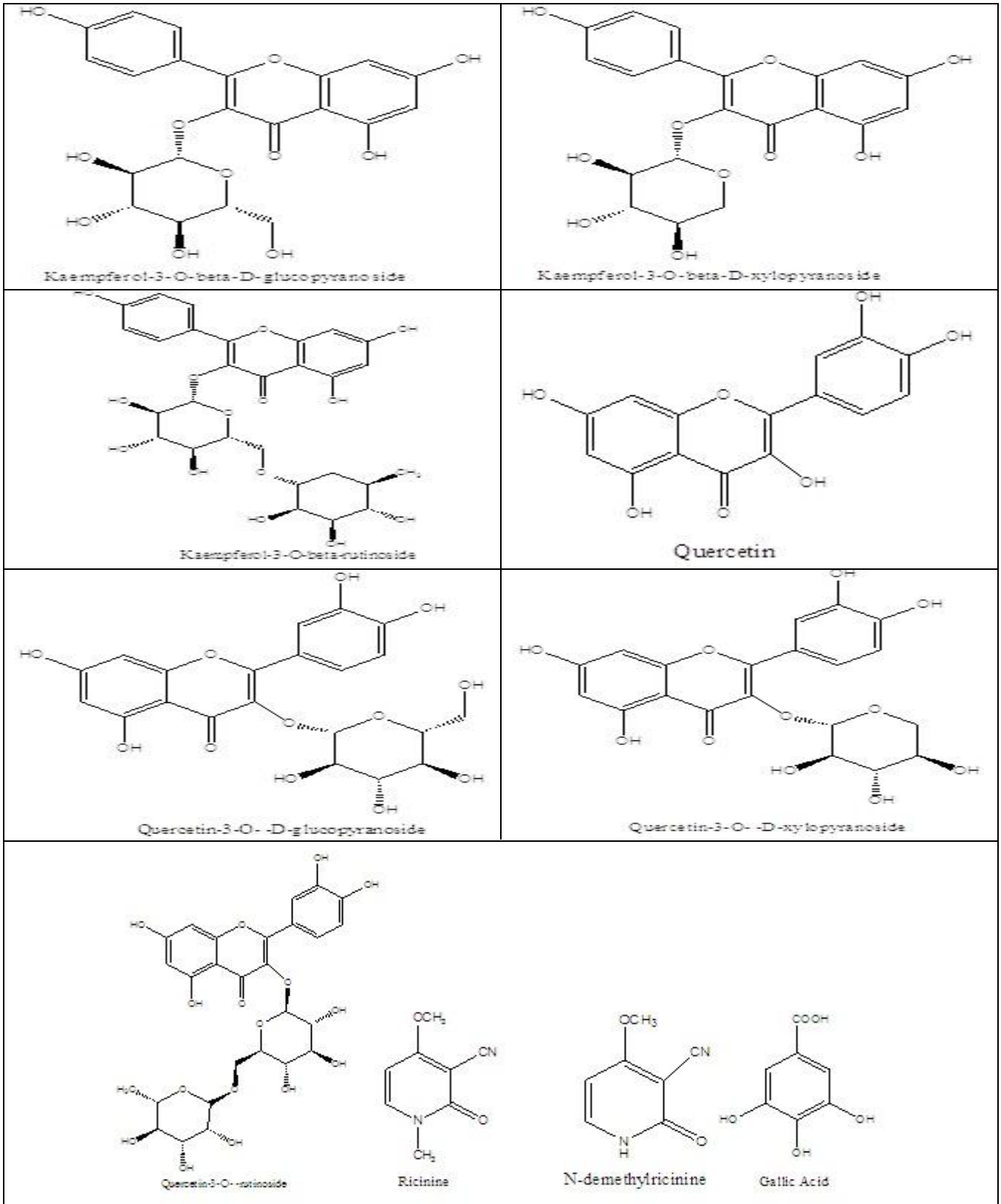
Quercetin-3-O-β-rutinoside (Chunpeng *et al.*, 2011, Sonar *et al.*, 2011)
UV (λ_{max}, nm): 258, 356.
IR (KBr) cm^{-1}: 3434, 2902, 1677, 1585, 1498, 1282.
^{1}HNMR ($CDCl_3$): 6.20 (1H, d, *J* = 2.0 Hz), 6.40 (1H, d, *J* = 2.0 Hz), 7.54 (1H, d, *J* = 2.2 Hz, H-2'), 7.59 (1H, dd, *J*= 2.0 Hz, 9.0 Hz, H-6') and 6.85 (1H, d, *J* = 9.0 Hz, H-5'), 5.32 (1H, d, *J* =7.2 Hz) and 4.39 (1H, d, *J*= 1.6 Hz), 0.99 (3H, d, *J* =6.2 Hz).
^{13}CMR ($CDCl_3$): 154.9 (C-2), 135.1 (C-3), 178.3 (C-4), 163.9 (C-5), 98.3 (C-6), 166.4 (C-7), 98.0 (C-8), 124.4 (C-1'), 113.6 (C-2'), 147.2 (C-3'), 146.5 (C-4'), 117.2 (C-5'), 120.4 (C-6'), 92.7 (C-1''), 73.9 (C-2''), 73.5 (C-3''), 71.8 (C-4''), 75.9 (C-5''), 64.5 (C-6''), 104.5 (C-1'''), 73.8 (C-2'''), 73.1 (C-3'''), 77.7 (C-4'''), 70.5 (C-5'''), 16.9 (-CH_3).
ESI-MS: (*m/z)* 611.4 $[M]^+$, 610.4, 609.5, 300.7.

Ricinine (Sule and Sani, 2008)
UV (λ_{max}, nm): 255, 313.
IR (KBr) cm^{-1}: 2224, 2852.76, 2958.50, 1636.64.
^{1}HNMR (500 Hz, $CDCl_3$): 6.070 (1H, d, J = 7. 5 Hz), 7.5 (1H, d, J = 7.5 Hz,), 3.9 (3H, s, OCH3), 3.5 3H, s, NCH_3).
^{13}CMR (500 Hz, $CDCl_3$): 163.27 (C-2), 88.6 (C-3), 172.37 (C-4), 93.55 (C-5), 143.59 (C-6), 57.10 (-OCH_3), 37.51 (-NCH_3), 113.68 (-CN).
MS: 164 (M^+), 149, 134, 121, 105, 94, 82, 71, 66, 52.

N-demethylricinine (Sule and Sani, 2008)
UV (λ_{max}, nm): 254, 313
IR (KBr) cm^{-1}: 2224, 2852.76, 2958.50, 3408.78, 1636.64
^{1}HNMR (500 Hz, $CDCl_3$): 6.070 (1H, d, J = 7.5 Hz,), 7.5 (1H, d, J = 7.5 Hz,), 3.9 (3H, s, -OCH3),
^{13}CMR (500 Hz, $CDCl_3$): 163.27 (C-2), 88.6 (C-3), 172.37 (C-4), 93.55 (C-5), 143.59 (C-6), 113.68 (-CN)
MS: 150 $[M^+]$

Gallic Acid (Chanwitheesuk *et al.*, 2007)
UV (λ_{max}, nm, EtOH): 220, 271.
IR (KBr) cm^{-1}: 3491, 3377, 1703, 1617, 1539, 1453, 1254.
^{1}HNMR (Acetone-d6): 7.15 (2H, s, H-3 and H-7).
^{13}CMR: 167.39 (C-1), 44.94 (C-4 and C-6), 137.77 (C-5), 120.81 (C-2), 109.14 (C-3 & C-7).
ESI-MS: $[M-H]^-$ m/z 169.0137.

1



Chemical structures redrawn from ChemDraw Ultra 8.0 (www.cambridgesoft.com)

CONCLUSION

The aim of the present review was focused on phytopharmacology of RC. It is wild plant commonly found across the world with wide variety of pharmacological activities viz. analgesic, anti-inflammatory, antidiabetic, antioxidant, antimicrobial, hepatoprotective, cytotoxic, larvicidal etc. All plant parts of the RC showed promising biological actions due to the presence phytoconstituents viz. ricinine, N-demethylrecinine, quercetin, quercetin-3-O-β-D-xylopyranoside, quercetin-3-O-beta-D-glucopyranoside, kaempferol-3-*O*-β-d- rutinoside, kaempferol -3- *O*- β -d-glucopyranoside and kaempferol-3-*O*-β-d-xylopyranoside etc. Overall, all these pharmacological activities and phytoconstituents exhibited by the RC have great potential and significance in the field of medicinal plant research.

ACKNOWLEDGEMENTS

Authors are sincerely thankful to Dr. S. R. Walunj (Principal, P.V.P. College, Loni), Dr. G. R. Pandhare (Head, Department of Chemistry, P.V.P. College, Loni) and Dr. D. G. Zinzad.

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