IOSR Journal Of Pharmacy
(e)-ISSN: 2250-3013, (p)-ISSN: 2319-4219
Volume 10, Issue 9 Series. I (September 2020), PP. 33-43
www.iosrphr.org

A review on *Nasturtium officinale*: A potential medicinal plant

Ali Esmail Al-Snafi
Department of Pharmacology, College of Medicine, Thi qar University, Iraq.
Received 17 September 2020; Accepted 02 October 2020

ABSTRACT:
The chemical analysis of *Nasturtium officinale* showed the presence of alkaloids, flavonoids, saponins, terpenoids/steroids, protein, essential and volatile oils, glycosides, tannins, folic acid, vitamins and elements. The previous pharmacological studies revealed that *Nasturtium officinale* possessed hypolipidemic, anti-inflammatory, hepato and reno protective, antidiabetic, antioxidant, anticancer, antimicrobial, dermatological, antigenotoxic, anti-urolithiatic and antigenotoxic effects. The current review highlighted the chemical ingredients and pharmacological effects of *Nasturtium officinale*.
KEYWORDS: *Nasturtium officinale*, ingredients, pharmacology, therapeutic

I. INTRODUCTION:

Plants generally produce many secondary metabolites which are used as pharmaceuticals, agrochemicals, flavours, fragrances, colours, biopesticides and food additives. Recent reviews showed that the medicinal plants possessed wide range of biological effects included central nervous, cardiovascular, antioxidant, endocrine and reproductive, gastro-intestinal, respiratory, antidiabetic, antimicrobial, antiparasitic, dermatological, anticancer, anti-inflammatory, antipyretic, analgesic, immunological[1-20] and many other pharmacological effects[1-20]. The chemical analysis of *Nasturtium officinale* showed the presence of alkaloids, flavonoids, saponins, terpenoids/steroids, protein, essential and volatile oils, glycosides, tannins, folic acid, vitamins and elements. The previous pharmacological studies revealed that *Nasturtium officinale* possessed hypolipidemic, anti-inflammatory, hepato and reno protective, antidiabetic, antioxidant, anticancer, antimicrobial, dermatological, antigenotoxic, anti-urolithiatic and antigenotoxic effects. The current review will highlight the constituents and pharmacological effects of *Nasturtium officinale*.

Synonyms:

Arabis nasturtium, Baeumerta nasturtium, Baeumerta nasturtium-aquaticum, Cardamine aquatica, Cardamine fontana, Cardamine nasturtium, Cardamine nasturtium-aquaticum, Cardaminum nasturtium, Crucifera fontana, Nasturtium aquaticum, Nasturtium aquaticum, Nasturtium fontanum, Nasturtium nasturtium, Nasturtium nasturtium-aquaticum, Nasturtium officinale subsp. rotundifolium, Nasturtium siifolium, Radicula nasturtium, Radicula nasturtium-aquaticum, Rorippa nasturtium, Rorippa nasturtium-aquaticum, Rorippa nasturtium-aquaticum, Rorippa officinalis, Sisymbrium amarum, Sisymbrium cardaminefolium, Sisymbrium fluviatile, Sisymbrium nasturtium, Sisymbrium nasturtium-aquaticum[21].

Taxonomic classification:

Kingdom: Plantae, **Subkingdom**: Viridiplantae, **Infrakingdom**: Streptophyta, **Superdivision**: Embryophyta, **Division**: Tracheophyta, **Subdivision**: Spermatophytina, **Class**: Magnoliopsida, **Superorder**: Rosanae, **Order**: Brassicales**, Family**: Brassicaceae, **Genus**: Nasturtium, **Species**: *Nasturtium officinale*[22].

Common names:

Arabic: HabbArreshad; **Chinese**: dou ban cai; **English**: Watercress, bronkors; **French**: cressond'eau; **German**: Brunnenkresse, echte Brunnenkresse; **Indonesian**: selada-air; **Japanese**: mizu-garashi, oranda-garashi; **Portuguese**: agrião; **Spanish**: berro[3].

Distribution:

Nasturtium officinale is native to Western Asia, India, Europe, and Africa, However, It is distributed in **Africa** (Algeria, Egypt, Libya, Morocco, Tunisia); **Asia** (Afghanistan, Iran, Iraq, Palestine, Jordan, Lebanon, Syria, Saudi Arabia, Turkey, Armenia, Azerbaijan, Georgia, Russian Federation, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, India, Pakistan, Nepal, Sri Lanka, Indonesia, Malaysia, Philippines, China, Japan); **Europe** (Denmark, Ireland, Sweden, United Kingdom, Austria, Belgium, Czech Republic, Germany, Hungary,

Netherlands, Poland, Slovakia, Switzerland, Ukraine, Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Macedonia, Montenegro, Romania, Serbia, Slovenia, France, Portugal, Spain); **Australasia** (Australia, New Zealand); **Northern America** (Canada, Mexico, United States) and **Southern America** (Barbados, Cuba, Dominica, Dominican Republic, Guadeloupe, Haiti, Jamaica, Martinique, St. Lucia, St. Vincent and Grenadines, Trinidad and Tobago, United States, Guatemala, Nicaragua, Venezuela, Brazil, Bolivia, Ecuador, Peru , Argentina, Chile, Uruguay)[23].

Description:

It is perennial, rhizomatous, aquatic, 10-70(-200) cm tall, glabrous throughout or sparsely pubescent with simple trichomes. Stems 1-11 (-20) dm. Cauline leaves: petiole not winged, base auriculate; blade 3-9(-13)-foliolate, (1-) 2-15(-22) cm; lateral leaflets sessile or petiolulate, rachis not winged, blade smaller than terminal; terminal leaflet (or simple blade) suborbicular to ovate, or oblong to lanceolate, (0.4-)1-4(-5) cm × (3-)7-25(-40) mm, base obtuse, cuneate, or subcordate, margins entire or repand, apex obtuse. Fruiting pedicels divaricate or descending, straight or recurved, 5-17(-24) mm. Flowers: sepals 2-3.5 × 0.9-1.6 mm; petals white or pink, spatulate or obovate, 2.8-4.5(-6) × 1.5-2.5 mm, (base to 1 mm), apex rounded; filaments 2-3.5 mm; anthers 0.6-1 mm. Fruits (0.6-)1-1.8(-2.5) cm × (1.8-)2-2.5(-3) mm; ovules (28-)36-60 per ovary; style 0.5-1(-1.5) mm. Seeds biseriate, reddish brown, ovoid, (0.8-) 0.9-1.1 (-1.3) × (0.6-)0.7-0.9(-1) mm, coarsely reticulate with 25-50(-60) areolae on each side[24-25].

Traditional uses:

It was eaten as a vegetable or salads. The leaves were widely used as a depurative, diuretic, expectorant, hypoglycaemic, hypolipidemic, odontalgic, stimulant, for the treatment of pulmonary diseases, hypertension and cardiovascular diseases[26-28]. It was also used in abdominal pain, as anti-ulcerogenic, in the treatment of scurvy, tuberculosis, bronchitis, influenza and asthma[29-31].

Physicochemical characteristics:

The physicochemical properties of *Nasturtium officinale* extracts (%) were: moisture 98.39-99.53, dry material 0.5-1.61, ethereal extract 0.27-20.35, crude fiber12.06- 15.42, crude protein 33.51-47.91, ashes 13.67-23.64 and carbohydrates 9.26-25.44g % [32].

Chemical constituents:

The preliminary phytochemical analysis of *Nasturtium officinale* showed that it contained alkaloids, flavonoids, saponins, terpenoids/steroids, , protein, essential and volatile oils, glycosides, tannins, folic acid, vitamin C, A, E and K, iodine, iron, potassium, sodium and calcium[33-36],

Quantitative nutritional analysis of *Nasturtium officinale* showed that the plant contained (Quantity/80 g): calories 18 kcal, protein 2.4g, fat 0.8g, fiber 1.2g, β- carotene 2016 mcg, vitamin A equivalent 336 mcg, vitamin B1 0.13 mg, vitamin B6 0.18mg, vitamin C 50mg, vitamin E 1.17mg, folate 36mcg, vitamin K 200mcg, calcium 136mg, iodine 12mcg, iron 1.8mg, magnesium 12mg, manganese 0.5mg, phosphorus 42mg, potassium 184mg, zinc 0.6mg, selenium 1.6mcg.

It also contained sodium 68.8mg/100g and copper 0.58 mg/100 g[37-38].

Nasturtium officinale was a rich source of phenyl ethyl glucosinolate (PEGSL) and benzyl glucosinolate (BGSL), the precursors of phenyl ethyl isothiocyanate (PEITC) and benzyl isothiocyanate (BITC). Glucosinolate, (gluconasturtin, 5.32 g of gluconasturtin/ 100 g of defatted seed) was the most abundant glucosinolate in *Nasturtium officinale* followed by the indole glucosinolates (glucobrassicin, 4-methoxy glucobrassicin, 4-hydroxyglucobrassicin and the aliphatic glucosinolate glucoibarin)[39-41].

Sixteen compounds were isolated from the methanolic extract of *Nasturtium officinale* included [6-O-hydrocinnamoyl-bis(1-deoxy-1-thioβ-D-glucopyranosyl)-1,1′-disulfide; 3-O-hydrocinnamoyl-bis (1-deoxy-1-thio-β-D-glucopyranosyl) -1,1′-disulfide; 2-O-hydrocinnamoyl-bis(1-deoxy-1- thio-β-D-glucopyranosyl) -1,1′-disulfid; bis(1-deoxy-1-thio-β-Dglucopyranosyl)-1,1′-disulfide; indole-3-acetonitrile-4- methoxy-2-S-β-D-glucopyranoside; 8-(methylsulfonyl) octanonitrile;, 9-(methylsulfonyl) nonanenitrile; 7-(methylsulfinyl) heptanenitrile; 8-(methylsulfinyl) heptanenitrile; 9-(methylsulfinyl) heptanenitrile; syringing; sinapic aldehyde 4-O-β-D-glucopyranoside; 1-sinapoyl-β-Dglucopyranoside; 1,2-di-O-E-sinapoyl-β-gentiobiose; β-D-glucopyranoside-6-O-β-D-glucopyranosyl-1-[3-(4-hydroxy-3,5- dimethoxyphenyl)- 2propanate] and lycibarbarphenylpropanoid C][42].

Fourteen phenolic compounds were identified in the leaves included (gallic acid derivative, gallic acid derivative, ferrullic acid derivative, proanthocynidin B1, p-coumaric acid derivative, apigenin, p-hydroxybenzoic acid, sinapic acid, p-coumaric acid, caftaric acid, quercetin-3- (cafferoyldiglucoside)-7-glucoside, kaempferol-3-(caffeoyl diglucoside)- 7-rhamnoside, caffeoylmalic acid, and coumaric acid derivative). In roots, a total of 20 compounds was identified included (gallic acid, gallic acid derivative,

hydroxybenzoic acid derivative, gallic acid, derivative, p-coumaric acid, p-coumaric acid derivative, caftaric acid, sinapic acid, pro-anthocynidintrimer, caffeic acid hexoside, caffeic acid derivative, sinapic acid glucoside, kaempferol-3- (caffeoyldiglucoside)- 7-rhamnoside, quercetin-3,7-diglucoside, hydroxybenzoic acid, vanillic acid, spincetine glucuronide, dihydro kaempferol hexoside, quercetin-3-O-rutinoside 7-O-glucoside and quercetin-3-O-triglucoside)[43].

The total phenolic contents of aerial parts of *Nasturtium officinale* were 8.03 to 9.35 mgGAE in vegetative period and 6.5 to 7.65 mg GAE in generative period. While, the total flavonoids contents were 26.5 to 31.11 mg Qu E in vegetative period and 36.89 to 42.65 mg QuE in generative period[44].

However, *Nasturtium officinale* water and ethanol extracts contained 88.60 ±2.41 and 74.18 ±1.72 µg pyrocatechol equivalent of phenolic compounds in 1000 mg, respectively[29].

Many pigments were determined in the different parts of *Nasturtium officinale*. Lycopene in root, stem and leaves of *Nasturtium officinale* methanolic extract were 8.6, 16.4 and 17.5 mg/100 g, respectively. Chlorophyll-a contents in root, stem and leaves of *Nasturtium officinale* methanolic extract were 47.03, 59.1 and 85.6 mg/100 g, respectively, while, chlorophyll-b contents in the root, stem and leaves methanolic extract were 21.0, 28.2 and 31.0 mg/100 g, respectively. Furthermore, the β-carotene contents in the root, stem and leaves methanolic extract were 1.5, 4.3 and 15.0 mg/100 g, respectively[43].

Anthocyanin in the petals of *Nasturtium officinale* was 71.67 mg/100 g, and pelargonidin 3-sophoroside represented 91% of the total anthocyanin content [45].

GC and GC/MS analysis of volatile constituents of the dried leaves and stems of *Nasturtium officinale* showed that the major volatile constituents of the leaves were 2-phenylethyl isothiocyanate (72.9%), pulegone (8.0%), heptylisothiocyanate (4.9%) and 4-phenylbutyl isothiocyanate (3.2%), while the main volatile constituents of the stems were 2-phenylethyl isothiocyanate (83.5%), 4-phenylbutyl isothiocyanate (6.9%), pulegone (2.2%) and sec-butyl isothiocyanate (1.9%)[46].

The stems of *Nasturtium officinale* showed higher oil yield (1.5%) compared with leaves (1.2%) and flowers (1.0%) v/w. The essential oil of flowers of *Nasturtium officinale* contained 15 constituents, among which limonene (43.6%), α-terpinolene (19.7%), p-cymene-8-ol (7.6%) and caryophyllene oxide (6.7%) were the major components. Nine compounds were identified in the essential oil of the leaves. Myristicin (57.6%), -terpinolene (8.9%) and limonene (6.7%) were the main components. Eight compounds were identified in the essential oil of the stem, caryophyllene oxide (37.2%), p-cymene-8-ol (17.6%), α-terpinolene (15.2%) and limonene (11.8%) were the most abundant[47].

Pharmacological effects:

Hypolipidemic effect:

The effect of *Nasturtium officinale* hydroalcoholic extract (NOE) on serum lipid profile was studied in high-fat diet rats. Intragastric administration of the extract (500 mg/kg bw/day) lowered serum TC, TG and LDL-C by 34.2, 30.1, and 52.9%, respectively, and raised the serum HDL-C level by 27.0% after 10 days of treatments. The extract also reduced serum ALT and AST levels compared to high-fat diet groups[48].

Intragastric administration of *Nasturtium officinale* (500 mg/kg bw/day) to groups of hypercholesterolaemic rats for 30 days lowered their blood total cholesterol (TC), triglyceride (TG), and low density lipoprotein cholesterol (LDL-C) levels by 37, 44 and 48%, respectively. However, the blood high density lipoprotein cholesterol (HDL-C) levels was increased by 16%. Treatment of hypercholesterolaemic rats with *Nasturtium officinale* extract significantly increased the reduced glutathione level along with enhanced catalase and superoxide dismutase activities in liver tissues. In addition, *Nasturtium officinale* extract significantly decreased hepatic malondialdehyde level as well as glutathione peroxidase and glutathione reductase activities in extract-treated rats[49].

Antiinflammatory effect:

The topical anti-inflammatory activity of *Nasturtium officinale* leaves crude extract (solutions and gel) was investigated in irritant contact dermatitis induced by croton oil- in mice. Irritant contact dermatitis models were induced by a single (1 mg/ear; acute) or repeated (0.4 mg/ear; chronic; 9 days total) croton oil application. *Nasturtium officinale* extract and gel inhibited croton oil- induced ear edema, reduced the inflammatory cells infiltration and reduced the pro-inflammatory cytokines levels in acute and chronic model[50].

In studying the anti-inflammatory effect of hydroalcoholic extract of *Nasturtium officinale* (250, 500 and 750 mg/ kg, orally) in two animal models of inflammation (carrageenan and formalin-induced paw edema) in rats, and the topical anti-inflammatory effect of *Nasturtium officinale* (2 and 5 mg/ear) in 12-O-tetradecanoylphorbol-13-acetate (TPA)-induced mouse ear edema. It appeared that the extract significantly inhibited carrageenan-induced paw edema 1, 2, 3 and 4 h after carrageenan challenge ($P < 0.001$). The extract (500 mg/ kg) also showed considerable activity against formalin-evoked paw edema over a period of 24 h

($P< 0.001$). Histopathologically, the extract decreased swelling and the tissue damage induced by carrageenan. Topical application of *Nasturtium officinale* (5 mg/ear) reduced TPA-induced ear edema ($P< 0.05$)[51].

Sixteen compounds isolated from the methanolic extract of *Nasturtium officinale* were evaluated for their inhibitory effects on nitric oxide (NO) levels in lipopolysaccharide (LPS)- stimulated murine microglia BV-2 cells. One of the isolated compounds (indole-3-acetonitrile-4- methoxy-2-S-β-D-glucopyranoside) possessed strong inhibitory effect on NO production, two other compounds (bis(1-deoxy-1-thio-β-Dglucopyranosyl)-1,1′-disulfide and β-D-glucopyranoside-6-O-β-D-glucopyranosyl -1- [3-(4-hydroxy-3,5-dimethoxyphenyl)-2 propanate]) showed moderate inhibitory activities, suggesting the neuroprotective and anti-neuroinflammatory effects of bis-thioglycosides from *Nasturtium officinale* [42].

Protective effect:

The hepatoprotective and antioxidant activity of hydroalcoholic extract of watercress was evaluated against acetaminophen -induced hepatotoxicity in rats. The results showed that acetaminophen caused significant increase in aspartate amino transferase, alanine amino transferase, ferric reducing ability of plasma and protein carbonyl content. Furthermore, there was a significant reduction in total thiol levels and glutathione peroxidase activity in acetaminophen group compared to control. However, administration of the extract and silymarin significantly decreased aspartate amino transferase activity, and markedly increased total thiol content and glutathione peroxidase activity compared to acetaminophen group[52].

The hepatoprotective effects of hydroalcoholic extract of watercress against oxidative stress and liver injury were investigated in bile duct ligation- induced cholestatic rats. Bile duct ligation considerably induced hepatocyte necrosis, this effect was significantly attenuated by the hydroalcoholic extract. Attenuation of liver damage in bile duct ligation- rats was associated with decreasing the hydroxyproline content and histopathological indexes. The extract also reduced oxidative stress by preventing the hepatic protein oxidation and enhancing the activity of the glutathione peroxidase (GPx) enzyme via antioxidative effect and free-radical scavenging[53].

The protective effect of *Nasturtum officinalis* (twice a week for 31 days) on CCl_4 induced nephrotoxicity was studied in rats. In treatment groups, after twenty one day and at the end of experiment, serum BUN, Alb, creatinine, blood urea and uric acid levels were significantly decreased in *Nasturtum officinalis* treated group compared with the control group[54].

The protective effects of *Nasturtium officinale* hydroalcoholic extract (50, 100 and 200 mg/kg/day) against gentamicin -induced nephrotoxicity was investigated inr rats. The administration of gentamicin for 10 day increased urea nitrogen and creatinine and histopathological changes in kidney tissue. It was also caused oxidative stress and inflammatory process (increase in NO and TNF-α). Administration of *Nasturtium officinale* hydroalcoholic extract protected against deterioration in nephrotoxic markers and suppressed the increase in oxidative stress and inflammation markers[55].

The effect of *Nasturtium officinale* hydro-alcoholic extract and vitamin E against vancomycin-induced nephrotoxicity was studied in adult rats. Vancomycin significantly increased serum creatinine and urea levels, MDA levels, relative kidney weight, as well as reduced creatinine clearance. The extract (250, 500 mg/kg) and vitamin E (500 mg/kg) pretreatment considerably alleviated all of these changes compared with vancomycin treated alone. Histological examination of vancomycin -treated group showed a marked renal injury with tubular epithelial cell desquamation, swelling, and tubular dilatation. These changes were mitigated with extract and vitamin E[56].

The effect of the consumption of watercress (*Nasturtium officinale*), on acetaminophen metabolism, the pharmacokinetics of acetaminophen and its metabolites were studied in a crossover trial of human volunteers. The results showed that the consumption of watercress caused a decrease in the levels of oxidative metabolites of acetaminophen, probably due to inhibition of oxidative metabolism of this drug[31].

The protective effect of *Nasturtium officinale* (25, 50 and 100 mg/kg, for 40 days) in oxymetholone -induced oxidative testis injury was studied in mice. 100 mg/kg of *Nasturtium officinale* extract significantly reduced the serum level of testosterone and significantly increased the levels of LH and FSH in comparison with the control group. At the same dose, it also significantly improved the stereological factors and sperm parameters. 50 and 100 mg/kg of *Nasturtium officinale* extract significantly increased the testis tissue ferric reducing ability of power (FRAP) levels, and 100 doses reduced the serum levels of NO[57].

The protective effect of *Nasturtium officinale* juice (orally, 0.5 and 1g/kg bw, for 15 consecutive days before intraperitoneal injection of cyclophosphamide 100 mg/kg bw) was studied in cyclophosphamide induced oxidative stress in mice. Intake of watercress prior to cyclophosphamide administration enhanced superoxide dismutase activity in erythrocytes with no effect on catalase activity. Watercress juice counteracted the effect of cyclophosphamide in bone marrow and liver tissues. Glutathione was increased by watercress supplementation and lipid oxidation was diminished compared to untreated groups[58].

The effects of hydroalcoholic extract of *Nasturtium officinale* (500mg/kg, bw) on blood cells and antioxidant enzymes were studied in rats exposed to sodium (meta) arsenite (5.5mg/kg of bw of $NaAsO_2$). WBC, RBC and Hct were decreased in the rats exposed to NaAsO2 ($P<0.05$). A significant increase was seen in RBC and Hct after treatment with the plant extract ($P<0.05$), The extract also elevated the antioxidant capacity, which significantly declined by $NaAsO_2$[59].

Antidiabetic effect:

The hypoglycemic effect of *Nasturtium officinale* extracts was evaluated in streptozotocin induced-diabetic rats. Rats were orally administered with various concentrations of *Nasturtium officinale* extracts (ethyl acetate, methanol and aqueous) for short (one week) and long period (two months). Only 800 and 1000 mg/kg of the methanol extract of *Nasturtium officinale* caused a significant decrease in the blood glucose level after one week treatment. At the end of two months treatment, ethyl acetate extract significantly reduced blood glucose level at 100 mg/kg. Long period treatment with methanol and aqueous extracts showed no hypoglycemic effects[60].

The hypoglycemic and antioxidant activities of orally administered aqueous, acetonic, and alcoholic extracts of *Nasturtium officinale* were studied in alloxan and streptozotocin induced diabetic rats. Extracts showed high concentrations of phenols, polyphenols, and flavonoids, in addition to a very high antioxidant effect. The hypoglycemic effect of the aqueous upon acute administration was 76.6% higher than that of insulin. When administered chronically, glucose levels were normalized on the third week up to the eighth week, and the antioxidant enzymes and biochemical parameters were improved[32].

The effect of oral administration of *Nasturtium officinale* [plant-mixed pelleted food (6.25%) for 6 weeks, orally] on serum glucose and lipids, as well as morphology of Langerhans islets was investigated in streptozotocine induced- diabetic rats. *Nasturtium officinale* feeding caused significant hypoglycemic effect ($P<0.01$), but it caused no significant changes in the serum total cholesterol, HDL- and LDL-cholesterol levels in treated diabetic group as compared to untreated diabetic group. Furthermore, treated diabetic group showed a significant lower level of serum triglyceride as compared to untreated diabetic group ($P<0.05$). Histological study showed that *Nasturtium officinale* feeding caused no beneficial effect in Langerhans islets, regarding the number of beta cells[61].

The antidiabetic and antihyperlipidemic effects of the hydroalcoholic leaf extract (daily in drinking water for 4 weeks) of *Nasturtium officinale* were investigated in streptozotocin-induced diabetic rats. There was a significant increase in serum glucose, triglycerides, total cholesterol, and LDL in streptozotocin-induced diabetic rats, accompanied by a decrease in HDL. The hydroalcoholic leaf extract of *Nasturtium officinale* significantly reduced serum glucose, total cholesterol and LDL in comparison with untreated diabetic rats[62].

Antioxidant effect:

Nasturtium officinale extract possesses potent reducing power in a ferric reducing antioxidant power assay, concentration-dependent scavenging ability on 2,2'-azinobis 3-ethylbenzothiazoline-6-sulfonate, 1,1-diphenyl-2-picrylhydrazyl, nitric oxide radicals, and hydrogen peroxide, in addition to chelating effect on ferrous ions. The extract also dose-dependently prevented thiobarbituric acid reactive substances formation in ferrous ion/ascorbate induced lipid peroxidation in rat liver homogenate[63].

The Anti-radical properties and the phenolic, flavonoid, and anthocyanin contents of the watercress hydroalcoholic extract was examined by using the radical scavenging activity test of DPPH. The hydroalcoholic extract obtained by soxhlet showed more potent antioxidant activity than the incubated extract, and had more phenolic and flavonoid compounds. The IC_{50} value of the hydroalcoholic extract of watercress was 105.20± 2.28 µg/ml for the soxhlet extract and 108.68± 5.41 µg/ml for the incubated extract[64].

The antioxidant effect of the ethanolic extract of the leafy stems of *Nasturtium officinale* was investigated *in vitro* using DPPH radical scavenging test. The extract of *Nasturtium officinale* at the concentration of 10 mg/ml, showed low reducing power (I%=3.396%, IC_{50}=11.60 mg/ml) compared to ascorbic acid (I%= 92.62%, IC_{50}=0.89 mg/ml), but it increased at the dose of 100 mg/ml (I%=60.38%)[65].

The antioxidative properties of aqueous and ethanolic extracts of the leaf of *Nasturtium officinale* were evaluated using *in vitro* and *in vivo* tests. The ethanolic extract showed more antioxidant activity, reducing power, DPPH radicals and superoxide anion radicals scavenging activities. Administration of the ethanol extract to rats decreased lipid peroxidation in liver, brain and kidney[29].

The antioxidant activity of *Nasturtium officinale* essential oil was evaluated using DPPH. The essential oil possessed antioxidant effect less than BHT, when tested at concentrations of 50, 100, 200, 300, 400, 500 and 1000 ppm. It gave inhibition of 37.99% at concentration of 1000ppm compared with 93.75% inhibition for BHT at the same concentration[66].

Nasturtium officinale extracts and oils were investigated for antioxidant activities using DPPH and β-carotene-linoleic acid assays. Methanol extracts of leaves showed higher antioxidant activity than the oils and

methanol extracts of stems and flowers. Compared with essential oils and methanol extracts, the leaves polar sub-fraction of methanol extract possessed the highest antioxidant activity (IC_{50} = 20.1 0.3 mg/ ml), which was comparable to that of the synthetic antioxidant BHT (18.0 0.3 mg/ ml)[47].

The antioxidant activity of aerial parts of *Nasturtium officinale* at various altitudes and periods of growth was investigated *in vitro*. The highest antioxidant activity and radical scavenging effect were observed in the aerial parts of the plant in vegetative period, whereas, aerial parts of the plant in generative period showed weak antioxidant activity[44].

The antioxidant efficacy of various organic solvent extracts of watercress was evaluated by DPPH free radical scavenging assay. Methanolic extract of watercress showed the best antioxidant activity in comparison with ethyl acetate and hexane extracts[33].

The possibility of watercress to reduce cancer risk by inducing detoxification enzymes was investigated using human peripheral blood mononuclear cells (PBMC). Watercress showed ability to modulate the enzymes SOD and GPX in blood cells *in vitro* and *in vivo*[67].

A randomized controlled investigation was designed to test the attenuating effect of consumption of watercress supplementation (acute: 2h before exercise) and (chronic: 8 weeks consumption) on exercise-induced oxidative stress. Each subject completed an incremental exercise test to volitional exhaustion following chronic and acute watercress supplementation or control. The results showed an exercise-induced increase in DNA damage and lipid peroxidation over both acute and chronic control supplementation phases, while acute and chronic watercress attenuated DNA damage and lipid peroxidation and decreased H_2O_2 accumulation following exhaustive exercise ($P<0.05$ vs control). A marked increases in the main lipid-soluble antioxidants (a-tocopherol, g-tocopherol and xanthophyll) were observed following watercress supplementation ($P<0·05$ vs control) in both experimental phases[68].

Anticancer effect:

The anticancer effect of the watercress hydroalcoholic extract was studied against the growth of cancerous Hela cells, and fibroblasts. The extract was applied at concentrations from 0.625 to 2 mg/ml, and cell mortality rates were examined after 24, 48, and 72 h incubation. The survival rate of the cancerous Hela cells was decreased with time and increasing concentrations of watercress extract. IC_{50} values after 24, 48 and 72 h were 373, 349, and 333 µg/ml, respectively[64].

The effects of daily intake of an aqueous solution of watercress on the growth of the experimental Ehrlich tumor was investigated in mice. Mice showed a suppression of tumor growth and a small area of necrosis compared to the control[69].

The chemoprotective effects of crude watercress extract against three important stages of the carcinogenic process, [initiation, proliferation, and metastasis (invasion)] were studied using *in vitro* models. HT29 cells were used to investigate the protective effects of the extract on DNA damage and the cell cycle. The extract was not genotoxic but inhibited DNA damage induced by two [hydrogen peroxide and fecal water] of genotoxins, indicating that it inhibited initiation. The extract also caused an accumulation of cells in the S phase of the cell cycle, which indicated cell cycle delay at S phase. The extract also significantly inhibited invasion of HT115 cells[70].

Phenylethyl isothiocyanate inhibited the migration and invasion of human colorectal carcinoma cells and inhibited the proliferation of cancer cells. Phenylethyl isothiocyanate also decreased matrix-metalloprotease-9 and ALDH1 marker of human breast cancer and also inhibit tumor invasion[71-73].

A single-blind, randomized, crossover study was performed to, determine the effects of watercress supplementation on biomarkers related to cancer risk, in healthy adults (fed 85 g raw watercress daily for 8 wk in addition to their habitual diet). Watercress supplementation ameliorated the DNA damage and increased the blood antioxidant potential in human subjects[74].

The effects of watercress consumption on the metabolism of nicotine in smokers were examined. Watercress was a rich source of phenethyl isothiocyanate (PEITC), an effective chemopreventive agent for cancers of the lung and esophagus induced in rodents by nitrosamines, including the tobacco-specific carcinogen 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone [75-76].

Antimicrobial effect:

The antibacterial effect of aqueous and alcoholic extracts of *Nasturtium officinale* was studied against *Escherichia coli, Salmonella typhimurium, Staphylococcus aureus* and *Listeria monocytogenes*. The antibacterial activity of the alcoholic and aqueous extracts of *Nasturtium officinale* was higher against Gram-positive bacteria than Gram-negatives. *S. aureus* and *L. monocytogenes* were the most sensitive bacteria with MIC of 8 µg/ml. the lowest MIC (6.25 µg/ml) and MBC (12.5 µg/ml) of the plant extract were recorded against *S. aureus*. While, *E. coli* and *S. typhimurium* resisted the aqueous and alcoholic extracts[77].

The antibacterial activities of *Nasturtium officinale* essential oil were investigated against some important food borne bacteria (Gram positive bacteria: *Staphylococcus aureus* and *Bacillus cereus*, and Gram negative bacteria: *Escherichia coli* and *S. enteric*). *S. enteric* and *E. coli* were the most resistance, and *B. cereus* isolates were the most sensitive to the essential oil[66].

The methanolic extract of *Nasturtium officinale* was tested for its antimicrobial activity against *Bacillus cereus*, *Enterococcus faecalis*, *Klebsiella pneumonia* and *Escherichia coli*. The MICs of the extract against these microorganisms were 0.6, 0.4, 0.8 and 0.6, while MBCs were 0.10, 0.8, 0.10 and 0.8 mg/ml, respectively[78].

The antimicrobial activities of silver nanoparticles (Ag-NPs) of leaves aqueous extract of *Nasturtium officinale* was studied against the growth of Gram-positive (*S. aureus*). The inhibition was observed in the Ag-NPs against *S. aureus*. The results showed that most of *S. aureus* was damaged and extensively disappeared by the addition of Ag-NPs[79].

The *in vitro* synergism between aqueous and methanolic extracts of *Nasturtium officinale* and 2-phenylethyl isothiocyanate, identified in *Nasturtium officinale*, with standard antibiotics, was carried out against 11 isolates of extended-spectrum β-lactamases-*Escherichia coli*. The results showed that there was an increase in antibacterial activity of the antibiotics when they were combined with plants extracts and 2-phenylethyl isothiocyanate[80].

Dermatological effect:

The wound healing potential of watercress oil in thermal and chemical burn injuries was studied in rabbits. Watercress oil was applied to the experimental chemically and direct heat induced burns. Animals treated by watercress oil restored the normal architecture more rapidly with significant reduction in closure time of burn[81].

Protective effects of indole 3-acetonitrile-4- methoxy -2- *S*-β-d-glucopyranoside (IAMG) from *Nasturtium officinale* was studied against ultraviolet B-induced photodamage in normal human dermal fibroblasts. The results showed that IAMG enhanced human dermal fibroblast cell migration. The UVB-induced increases in MMP-1 and decrease in type I procollagen which were ameliorated by IAMG treatment. The result strongly suggested that IAMG from *Nasturtium officinale* reduced UVB-induced photodamage[82].

Anti-urolithiatic effects:

The protective effects of hydrophilic extract of *Nasturtium officinale* (750 mg/kg and 1.5 g/kg of extract) on ethylene glycol-induced renal stone was studied in rats. Percentage of calcium oxalate crystals in negative control groups was 75%, in preventive groups treated with low dose (28.6%) and high dose (57.1%) in comparison to healthy control group (12.5%). Urinary oxalate concentration in preventive and negative control groups were more than healthy control group ($P< 0.05$)[83].

Antigenotoxic effect:

The effect of aqueous extract (two concentrations :13.2 and 26.4 mg/ml) on cell viability and its potential antigenotoxic properties against induced oxidative damage was studied using a comet assay and peripheral blood cells as an *in vitro* model. No differences were found in cell viability between the control and treated groups at any time. Significant antigenotoxic effects were observed for both concentrations ($p = 0.005$ at 30 min; $P< 0.001$ at 60 and 90 min), the percentage reductions in damage being similar between the concentrations used (67.1 and 75.2% respectively)[84].

Side effects and toxicity:

The *in vivo* acute toxicity was studied in mice. During the acute oral toxicity, the plant extract exerted a stressful effect on mice at different doses, especially at doses of 80 mg/kg and 100 mg/kg. Some clinical signs were recorded within eight hours after gavage included strong agitation followed by immobility. Several deaths were observed after 72 hours with an LD_{50} ranged between 50 and 500 mg/kg bw[45]. The safety of the standardized extract of *Nasturtium officinale* with phenylethyl glucosinolate 5.0 mg/ml was studied using acute and sub-acute oral dosage in rats. LD_{50} was in the range of 2-5g/kg. The results revealed that *Nasturtium officinale* extract at dose up to 5 g/kg in acute study was safe, and no adverse effects were observed in the sub-acute administration, up to 1 g/kg[51, 85].

However, the acute toxicity of ethanolic extract (0,5, 5, 50, 500, 1000, 2000, and 4000 mg/kg bw) of *Nasturtium officinale* was studied in mice. The maximal dose caused no deaths, animals were still in normal circumstances. No significant differences in relative organ weights liver, heart, kidneys in mice a in all doses. Histopathological study showed that the highest doses caused necrosis and hydropic degeneration of the liver and kidneys, and heart inflammatory manifestation with myofibril irregular heart[36].

The current review discussed the chemical constituents, pharmacological and therapeutic characteristics of *Nasturtium officinale* as a promising medicinal plant with wide range of pharmacological activities which could be utilized in several medical applications as a result of its effectiveness.

REFERENCES

[1]. Al-Snai AE. Iraqi medicinal plants with antifungal effect- A review. IOSR Journal of Pharmacy 2019; 9(7): 16-56.

[2]. Al-Snai AE. Iraqi medicinal plants with antiviral effect- A review. IOSR Journal of Pharmacy 2019; 9(7): 57-75.

[3]. Al-Snai AE. Iraqi medicinal plants with antibacterial effect- A review. IOSR Journal of Pharmacy 2019; 9(8): 22-103.

[4]. Al-Snai AE, Al-Kamel ML, Esmail ME. Antifungal effect of *Alhagi maurorum* phenolic extract. IOSR Journal of Pharmacy 2019; 9(8): 7-14.

[5]. Al-Snafi AE. Medical benefit of *Lallemantia iberica*- A review. To Chemistry Journal 2019; 3: 128-133.

[6]. Al-Kamel ML and Al-Snafi AE. Antibacterial effect of the phenolic extract of *Alhagi maurorum*. IOSR Journal of Pharmacy 2019; 9(9):47-55.

[7]. Al-Snai AE. Pharmacological and therapeutic effects of *Lippia nodiflora* (*Phyla nodiflora*). IOSR Journal of Pharmacy 2019; 9(8):15-25.

[8]. Al-Snafi AE. Constituents and pharmacology of *Luffa cylindrica*- A review. IOSR Journal of Pharmacy 2019; 9(9):68-79.

[9]. Al-Snafi AE. A review on *Lawsonia inermis*: A potential medicinal plant. International Journal of Current Pharmaceutical Research 2019; 11(5):1-13.

[10]. Al-Snafi AE. Medicinal value of *Lagerstroemia speciosa*: An updated review. International Journal of Current Pharmaceutical Research 2019; 11(5):18-26.

[11]. Al-Snafi AE. Chemical constituents and pharmacological activities of *Lantana camara*- A review. Asian J Pharm Clin Res 2019; 12912):10-20.

[12]. Al-Snafi AE. Chemical constituents and pharmacological effects of *Lepidium sativum*- A review. International Journal of Current Pharmaceutical Research 2019; 11(6):1-10.

[13]. Al-Snafi AE. Constituents and pharmacology of *Fumaria officinalis*- A review. IOSR Journal of Pharmacy 2020; 10(1):17-25.

[14]. Al-Snafi AE. Chemical constituents and pharmacological effects of *Melilotus Officinalis*- A review. IOSR Journal of Pharmacy 2020; 10(1):26-36.

[15]. Al-Snafi AE. Bioactive metabolites and pharmacology of *Cistanche tubulosa*- A review. IOSR Journal of Pharmacy 2020; 10(1): 37-46.

[16]. Al-Snafi AE. Pharmacological potential of *Orchis mascula*- A review. IOSR Journal of Pharmacy 2020;10(3):1-6.

[17]. Al-Snafi AE. Constituents and pharmacology of *Onopordum acanthium*. IOSR Journal of Pharmacy 202; 10(3):7-14.

[18]. Al-Snafi AE. The traditional uses, constituents and pharmacological effects of *Ononis spinosa*. IOSR Journal of Pharmacy 2020; 10(2):53-59.

[19]. Al-Snafi AE. Oils and fats contents of medicinal plants, as natural ingredients for many therapeutic purposes- A review. IOSR Journal of Pharmacy 2020; 10(7): 1-41.

[20]. Al-Snafi AE. Phenolics and flavonoids contents of medicinal plants, as natural ingredients for many therapeutic purposes- A review. IOSR Journal of Pharmacy 2020; 10(7): 42-81.

[21]. The plant list, *Nasturtium officinale*, http://www.theplantlist.org/ tpl1.1/ record/kew-2381026

[22]. ITIS, *Nasturtium officinale*, https://www.itis.gov/servlet/SingleRpt/SingleRpt? search_ topic=TSN&search_value=23255#null

[23]. U.S. National Plant Germplasm System, *Nasturtium officinale*, https://npgsweb. ars-grin.gov/gringlobal/taxonomydetail.aspx?id=25072

[24]. Flora of North America, *Nasturtium officinale*, http://www.efloras.org/ florataxon. aspx ? flora_id=1&taxon_id=200009627

[25]. Flora of China, *Nasturtium officinale*, http://www.efloras.org/florataxon. aspx? flora_ id=2&taxon_id=200009627

[26]. Bown D. Encyclopaedia of herbs and their uses. London: Dorling Kindersley, 1995.

[27]. Zargari A. Medicinal plants, Vol 1. Tehran University Press, 1987: 199-204.

[28]. Zargari F, Ghorbanihaghjo A, Babaei H, Farajnia S and Roodbari NH. The effect of hydroalcoholic extract of *Nasturtium officinale* R. Br on antioxidant status and DNA damage in liver and kidney rats exposed to arsenic. Med J Tabriz Univ Med Sci 2014; 36(3): 44-49.

[29]. Ozen T. Investigation of antioxidant properties of *Nasturtium officinale* (Watercress) leaf extracts. Acta Poloniae Pharmacutica Drug Research 2009; 66 (2): 187-193.
[30]. Palaniswamy UR, Richard J, Bible MBB and Stuart JD. Ontogenic variations of ascrobic acid and phenathyl isothiocyanate concentration in watercress (*Nasturtium officinale* R. Br.) leaves. Journal of Agriculture and Food Chemistry 2003; 51(18): 5504-5509.
[31]. Chen L, Mohr SN and Yang CS. Decrease of plasma and urinary oxidative metabolites of acetaminophen after consumption of watercress by human volunteers. Clin Pharmacol Ther 1996; 60(6): 651-660.
[32]. Fenton-Navarro B, UrquizaMartínez MV, Fiscal Castro BB, Medrano Castillo OI, López-Rodríguez M, Padilla Arellanes S and Vázquez Hernández A. Antioxidant and hypoglycemic effects of watercress (*Nasturtium officinale*) extracts in diabetic rats. Afr J Tradit Complement Altern Med 2018; 15 (2): 68-79.
[33]. Haro G, IksenI, Rumanti RM, Marbun N, Sari RP and Gultom RPJ. Evaluation of antioxidant activity and minerals value from watercress (*Nasturtium officinale* R. Br.). Rasayan J Chem 2018; 11(1): 232-237.
[34]. Ginting H, Aminah F and Dalimunthe A. Penelitian Hibah Bersaing: Ekstrak Etanol Selada air (*Nasturtium officinale* R. Br.) Sebagai Bahan Baku Pembuatan Tablet Diuretika, Medan- Universitas Sumatera Utara, 2014.
[35]. Gonçalves EM, Cruz RMS, Abreu M, Brandao TRS and Silva CLM. Biochemical and colour of watercress (*Nasturtium officinale* R. Br) during freezing and frozen storage. J Food Eng 2009; 93(1): 32-39.
[36]. Ginting H, Dalimunthe A and Reveny J. Acute toxicity effect of the ethanolic extract of watercress herb (*Nasturtium officinale* R. Br.) in mice. Indonesian Journal of Cancer Chemoprevention 2017; 7(1): 9-16.
[37]. Pandey Y, Bhatt SS and Debbarma N. Watercress (*Nasturtium officinale*): A potential source of nutraceuticals. Int J Curr Microbiol App Sci 2018; 7(02): 2685-2691.
[38]. Pradhan S, Manivannan S and Tamang JP. Proximate, mineral composition and anti-oxidant properties of some wild leafy vegetables. Journal of Scientific and Industrial Research 2015; 74: 155-159.
[39]. Al-Snafi AE. Encyclopedia of chemical constituents and pharmacological effects of Iraqi medicinal plants. Rigi Publication, 2015.
[40]. Gill V and Leod AJ. Degradation of glucosinolates of *Nasturtium officinale* seeds. Phytochemistry 1980; 19(8): 1657-1660.
[41]. Rubin E, Aziz ZA and Surugau N. Glucosinolates content of *in vitro* grown *Nasturtium officinale* (watercress). ASM Sc J 2018;11(2): 132-139.
[42]. Lee TH, Khan Z, Subedi L, Kim SY and Lee KR. New bis-thioglycosyl-1,1'-disulfides from *Nasturtium officinale* R. Br. and their anti-neuroinflammatory effect. Bioorg Chem 2019;86:501-506.
[43]. Zeb A. Phenolic profile and antioxidant potential of wild watercress (*Nasturtium officinale* L.). Springerplus 2015;4:714. doi: 10.1186/s40064-015-1514-5.
[44]. Mazandarani M, Momeji A and Zarghami Moghaddam P. Evaluation of phytochemical and antioxidant activities from different parts of *Nasturtium officinale* R. Br. in Mazandaran. Iranian Journal of Plant Physiology 2003; 3(2): 659-664.
[45]. Ganie SA, Ara S and Agarwal S. Utilization of *Nasturtium officinale* R. Br. dye available in Kashmir valley for value added paper and products: A way forward towards green chemistry. Int J Adv Res SCi and Eng 2017; 6(3): 276-284.
[46]. Afsharypuor S and Salehi M. Volatile constituents of leaves and stems of *Nasturtium officinale* R. Br. Journal of Essential Oil Research 2008; 20(6): 517-518.
[47]. Amiri H. Volatile constituents and antioxidant activity of flowers, stems and leaves of *Nasturtium officinale* R. Br. Nat Prod Res 2012; 26(2): 109-115.
[48]. Bahramikia S and Yazdanparast R. Effect of hydroalcoholic extracts of *Nasturtium officinale* leaves on lipid profile in high-fat diet rats. J Ethnopharmacol 2008; 115(1): 116-121.
[49]. Yazdanparast R, Bahramikia S and Ardestani A. *Nasturtium officinale* reduces oxidative stress and enhances antioxidant capacity in hypercholesterolaemic rats. Chem Biol Interact 2008; 172: 176‑184.
[50]. Camponogara C, Silva CR, Brusco I, Piana M, Faccin H, de Carvalho LM, Schuch A, Trevisan G and Oliveira SM. *Nasturtium officinale* R. Br. effectively reduces the skin inflammation induced by croton oil via glucocorticoid receptor-dependent and NF-κB pathways without causing toxicological effects in mice. J Ethnopharmacol 2019; 229:190-204.
[51]. Sadeghi H, Mostafazadeh M, Sadeghi H, Naderian M, Barmak MJ, Talebianpoor MS and Mehraban F. *In vivo* anti-inflammatory properties of aerial parts of *Nasturtium officinale*. Pharm Biol 2014;52(2):169-174.

[52]. Azarmehr N, Afshar P, Moradi M, Sadeghi H, Sadeghi H, Alipoor B, Khalvati B, Barmoudeh Z, Abbaszadeh-Goudarzi K and Doustimotlagh AH. Hepatoprotective and antioxidant activity of watercress extract on acetaminophen-induced hepato-toxicity in rats. Heliyon 2019;5(7): e02072.

[53]. Sadeghi H, Azarmehr N, Razmkhah F, Sadeghi H, Danaei N, Omidifar N, Vakilpour H, Pourghadamyari H and Doustimotlagh AH. The hydroalcoholic extract of watercress attenuates protein oxidation, oxidative stress, and liver damage after bile duct ligation in rats. J Cell Biochem 2019; 120(9):14875-14884.

[54]. Hosseini SA, Mohammadi J, Delaviz H and Shariati M. Effect of *Juglans regia* and *Nasturtum officinalis* on biochemical parameters following toxicity of kidney by CCl_4 in Wistar rats. Electron J Gen Med 2018; 15(3):1-7.

[55]. Shahani S, Behzadfar F, Jahani D, Ghasemi M and Shaki F. Antioxidant and anti-inflammatory effects of *Nasturtium officinale* involved in attenuation of gentamicin-induced nephrotoxicity. Toxicol Mech Methods 2017; 27(2): 107-114.

[56]. Karami M, Mostafazadeh M, Sadeghi H, Sadeghi H, Mehraban F, Kokhdan EP, Sayahi M and Abtahi SR. Nephroprotective effect of *Nasturtium officinale* (watercress) ethanol extract and vitamin E on vancomycin-induced nephrotoxicity in rats. Jundishapur J Nat Pharm Prod 2018;13(1):e67178.

[57]. Akbari Bazm M, Khazaei M, Khazaei F and Naseri L. *Nasturtium officinale* L. hydroalcoholic extract improved oxymetholone-induced oxidative injury in mouse testis and sperm parameters. Andrologia 2019; 51(7):e13294.

[58]. Casanova NA, Simoniello MF, LópezNigro MM and Carballo MA. Modulator effect of watercress against cyclophosphamide-induced oxidative stress in mice. Medicina (B Aires) 2017;77(3):201-206.

[59]. Zargari F, Ghorbanihaghjo A and Babaei H. Protective effects of hydroalcoholic extract of *Nasturtium officinale* on rat blood cells exposed to arsenic. Iranian Journal of Toxicology 2015; 9 (29) :1331-1335.

[60]. Hoseini HF, Gohari AR, Saeidnia S, Majd NS and Hadjiakhoondi A. The effect of *Nasturtium officinale* on blood glucose in diabetic rats. Pharmacologyonline 2009; 3: 866-871.

[61]. Qeini M, Roghani M and Alagha A. The effect of *Nasturtium officinale* feeding on serum glucose and lipid levels and reorganization of beta cells in diabetic rats. RJMS 2010; 17(73): 53-61**.**

[62]. Hadjzadeh MA, Rajaei Z, Moradi R and Ghorbani A. Effects of hydroalcoholic extract of watercress (*Nasturtium officinale*) leaves on serum glucose and lipid levels in diabetic rats. Indian J Physiol Pharmacol 2015; 59(2): 223-230.

[63]. Bahramikia S and Yazdanparast R. Antioxidant efficacy of *Nasturtium officinale* extracts using various *in vitro* assay systems. J Acupunct Meridian Stud 2010; 3(4): 283-290.

[64]. Moradi R, Ebrahimi S, Taravati A, Asrardel F, Khorasani HR, Aghajanpour M and Rezaizad M. Cytotoxic effects of the hydroalcoholic extract of *Rorippa nasturtium aquaticum* on hela cell line. IBBJ 2017; 3(2): 73-79.

[65]. Meriem T, Soumia K and Fairouz S. Oral acute toxicity and antioxidant activity of the watercress ethanolic extract: *Nasturtium officinale* R. Br (Bracicasseae). Research & Reviews. Journal of Botanical Sciences 2017; 6(4): 14-18.

[66]. Mahdavi S, Kheyrollahi M, Sheikhloei H and Isazadeh A. Antibacterial and antioxidant activities of *Nasturtium officinale* essential oil on food borne bacteria. The Open Microbiology Journal 2019; 13(1): 81-85.

[67]. Hofmann T, Kuhnert A, Schubert A, Gill C, Rowland IR, Pool-Zobel BL and Glei M. Modulation of detoxification enzymes by watercress: *in vitro* and *in vivo* investigations in human peripheral blood cells. Eur J Nutr 2009; 48(8): 483-491.

[68]. Fogarty MC, Hughes CM, Burke G, Brown JC and Davison GW. Acute and chronic watercress supplementation attenuates exercise-induced peripheral mononuclear cell DNA damage and lipid peroxidation. British Journal of Nutrition 2013; 109: 293-301.

[69]. De souza DA, Costa PM, Ribeiro RI, Vidigal PV and Pinto FC. Daily intake of watercress causes inhibition of experimental Ehrlich tumor growth. J Bras Patol Med Lab 2016; 52(6): 393-399.

[70]. Boyd LA, McCann MJ, Hashim Y, Bennett RN, Gill CI and Rowland IR. Assessment of the anti-genotoxic, anti-proliferative, and anti-metastatic potential of crude watercress extract in human colon cancer cells. Nutr Cancer 2006; 55(2):232-241.

[71]. Rose P, Huang Q, Ong CN and Whiteman M. Broccoli and watercress suppress matrix metalloproteinase-9 activity and invasiveness of human MDA-MB-231 breast cancer cells. Toxicol Appl Pharmacol 2005; 209(2): 105-113.

[72]. Syed Alwi SS, Cavell BE, Telang U, Morris ME, Parry BM and Packham G. *In vivo* modulation of 4E binding protein 1 (4E-BP1) phosphorylation by watercress: a pilot study. The British Journal of Nutrition 2010; 104(9):1288-1296.

[73]. Cavell BE, Syed Alwi SS, Donlevy A and Packham G. Anti-angiogenic effects of dietary isothiocyanates: mechanisms of action and implications for human health. Biochem Pharmacol 2011; 81(3): 327-36.
[74]. Gill CI, Haldar S, Boyd LA, Bennett R, Whiteford J, Butler M, Pearson JR, Bradbury I and Rowland IR. Watercress supplementation in diet reduces lymphocyte DNA damage and alters blood antioxidant status in healthy adults. Am J Clin Nutr 2007; 85(2): 504-510.
[75]. Hecht SS, Carmella SG and Murphy SE. Effects of watercress consumption on urinary metabolites of nicotine in smokers. Cancer Epidemiol Biomarkers Prev 1999; 8(10):907-913.
[76]. Hecht SS, Chung FL, Richie JP Jr, Akerkar SA, Borukhova A, Skowronski L and Carmella SG. Effects of watercress consumption on metabolism of a tobacco-specific lung carcinogen in smokers. Cancer Epidemiol Biomarkers Prev 1995; 4(8):877-884.
[77]. Derhami SF, Rad MG and Mahmoudi R. Evaluation of antibacterial effects of aqueous and alcoholic extracts of *Nasturtium officinale* on some pathogenic bacteria. Medical Laboratory Journal 2016; 10(6): 49-53.
[78]. Zafar R, Zahoor M, Shah A and Majid F. Determination of antioxidants and antibacterial activities, total phenolic, polyphenol and pigment contents in *Nasturtium officinale*. Pharmacologyonline 2017; 1:11-18.
[79]. Sadeghi B. Synthesis of silver nanoparticles using leaves aqueous extract of *Nasturtium officinale* and its antibacterial activity. International Journal of Molecular and Clinical Microbiology 2014; 2:428-434.
[80]. Freitas E, Aires A, Rosa EA and Saavedra MJ. Antibacterial activity and synergistic effect between watercress extracts, 2-phenylethyl isothiocyanate and antibiotics against 11 isolates of *Escherichia coli* from clinical and animal source. Letters in Applied Microbiolgy 2013; 57(4): 266-73.
[81]. Zinadah OA. Effects of watercress oil on the thermal and chemical burn injuries in rabbits. JKAU: Med Sci 2008;15:3-17.
[82]. Kim Y and Bae KS. Protective effects of indole 3-acetonitrile-4- methoxy -2- *S*-β-d-glucopyranoside from *Nasturtium officinale*R. Br. against ultraviolet B-induced photodamage in normal human dermal fibroblasts. Natural Product Communications2019: 1–4
[83]. Mehrabi S, Askarpour E, Mehrabi F and Jannesar R. Effects of hydrophilic extract of *Nasturtium officinale* on prevention of ethylene glycol induced renal stone in male Wistar rats. J Nephropathol 2016; 5(4):123-127.
[84]. Casanova NA and Carballo MA. Antigenotoxic activity of watercress extract in an *in vitro* mammalian system using comet assay. Phytother Res 2011; 25(12): 1743-1746.
[85]. Clemente M, Miguel MD, Felipe KB, Gribner C, Moura PF, Rigoni AGR, Fernandes LC, Carvalho JLS, Hartmann I, Piltz MT, Henneberg R, Montrucchio DP and Miguel OG. Acute and sub-acute oral toxicity studies of standardized extract of *Nasturtium officinale* in Wistar rats. Regul Toxicol Pharmacol 2019;108:104443.

Ali Esmail Al-Snafi. "A review on Nasturtium officinale: A potential medicinal plant." *IOSR Journal of Pharmacy (IOSRPHR)*, 10(9), 2020, pp. 33-43.