European Journal of Medicinal Plants

25(1): 1-9, 2018; Article no.EJMP.43766
ISSN: 2231-0894, NLM ID: 101583475

Colours are Indicators of Phytochemical Components and Medicinal Properties of Plants: A Review of Natural Spectroscopy

Saganuwan Alhaji Saganuwan[1*]

[1]Department of Veterinary Physiology, Pharmacology and Biochemistry, College of Veterinary Medicine, University of Agriculture, P.M.B. 2373, Makurdi, Benue State, Nigeria.

Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/EJMP/2018/43766
Editor(s):
(1) Dr. Marcello Iriti, Professor, Plant Biology and Pathology, Department of Agricultural and Environmental Sciences, Milan State University, Italy.
Reviewers:
(1) C. S. Ezeonu, Federal University Wukari, Nigeria.
(2) Venkata Satish Kuchi, Dr. YSR Horticultural University, India.
(3) Ann A. J. Mofunanya, University of Calabar, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/26166

Received 5th June 2018
Accepted 29th August 2018
Published 10th September 2018

Review Article

ABSTRACT

Background: It is highly laborious to determine biological activities of plants using colours, despite the use of spectroscopic methods. Therefore the review is aimed at using colours to determine the phytochemical and medicinal properties of plants.

Methods: Literature was searched for medicinal plant parts whose colours solely depend on their phytochemical pigments. Primary colours (green, red and blue) were cross-matched to give yellow, orange, brown, cyan, magenta and purple.

Results: Each of the reflected colour is suggestive of phytochemical pigment(s) with specific medicinal properties. Black coloured plants and plant parts may be toxic and so can be used to treat cancer and cancer-related diseases. White phytochemical pigments may be used to treat diabetes, hypertension, asthma and some inflammatory diseases. Because previous studies have shown that the colours have the medicinal values.

Conclusion: The combination of primary colours (red, green and blue) can form over 1000 colours with different medicinal values that may be found in both lower and higher plants.

Keywords: Colour; medicinal value; plant; indicator; black; white.

**Corresponding author: E-mail: pharn_saga2006@yahoo.com;*

1. INTRODUCTION

Colour theories were developed by Empedocles, a Greek philosopher of the 400 B.C. He said colour resulted from tiny particles given off by objects. But Plato opined that colour vision was caused by short rays that emerged from the eyes towards object. Aristotle reported the relationship between colour and light. Galen believed that eyes empowered carry tiny images of objects to the eyes. But an Arab physicist, Alhazen reported that vision is caused by the reflection of light [1]. Isaac Newton, an English scientist reported that white light contains all the colours of the rainbow. Goethe, a German Poet thought that all coloured lights were actually mixtures of light and darkness. Thomas Young, an English physicist proposed three-component theory of colour in 1801 which states that the eye has three types of fibres sensitive to different wavelengths of light. The fibres called cones correspond to red, green and blue (primary colours) [2]. There are two systems of classifying colours: The Munsell colour system classifies colours according to three basic characteristics of hue, lightness and chroma, and system of colour specification adopted by International Commission on Illumination (ICI) analysis using spectrophotometer [3]. Hue gives a colour its name. Lightness is a measurement of the amount of light reflected from a coloured object. A lightness scale runs from black, through shades of grey to white. Black reflects very little light. Chroma is a measurement of the saturation concentration of a colour [4].

Chemical reactions to identify the structures of organic compounds have been replaced by instrumental methods since 1940 [5]. Betalains, porphyrin, carotenoids and anthocyanins naturally display flower colours [6]. Phenolic compounds present in the plants are responsible for the colour [7] of carotenoids (red, orange) and tetraterpenoids (yellow) [8]. Colour, the visible portion of the electromagnetic spectrum [1], can be used to determine phytochemical components and medicinal properties of plants. Hence the review is aimed at identifying the phytochemicals associated with colours that are characteristic of medicinal values of plants.

2. CROSS-MATCHING OF COLOURS

Literatures including textbooks, journals, proceedings, abstracts, periodicals and databases on colours, medicinal plants and plant parts, scientific, local and English names, pictures, phytochemical components, medicinal uses and toxic effects of relevant plants were searched. The three primary colours (red, green and blue) were cross matched to give other three (3) different colours referred to as secondary colours which were in turn cross-matched to give three other different colours referred to as tertiary colours. The principle referred to as three-combination-two of colour cross-matching. More so blue, red and green can be mixed in sufficient density and give black, but when mixed in equal amounts could give grey or white colour. Some medicinal uses and toxic effects were attributable to biological pigments of the reported plants. The flow-chart (Fig. 1) of colour cross-matching is given below.

Sesquiterpenoids are recognised for their blue and purple colours that have anti-bacterial, immunoregulating, antimicrobial and cytotoxic activities. Additive colours of light are red, green and blue (primary colours). Subtractive colours in mixing of pigments or dyes are cyan, magenta and yellow [8] and red, yellow and blue are popular among artists [9]. But three colours related to human cone cells are red, green and blue [10]. Autochrome typically used orange, green and violet as primaries [11] which are related to the physiological response of the eye to light that is a continuous spectrum of the wavelengths detected by the human eye. However, the human eye contains only three types of colour receptors called cone cells which respond to different ranges of the colour spectrum. Humans and other species with three such types of colour receptors are known as trichromats. They respond to the light stimulus via a three-dimensional sensation modelled as a mixture of three primary colours [12]. Using the principle of three-combination-two ($^3C_2$) to match primary colours would give 3 different secondary colours. When the 3 secondary colours are matched, the 3 tertiary colours can emerge. When the matching continues, up to over 1000 colour can be obtained.

Species with different number of receptor cell types have colour vision requiring a different number of primaries. But humans can only see at 380 nanometer [13]. Mixing red and green light produces yellow, orange or brown [14]. Mixing green and blue produces cyan, and mixing red and blue produces purple and magenta. Mixing equal proprotions of the additive primaries results in grey or white: The colour space generated is called Red-Green-Blue colour space (Fig. 1). But cyan, magenta and yellow are applied together in varying amounts [15]. Mixing yellow and cyan

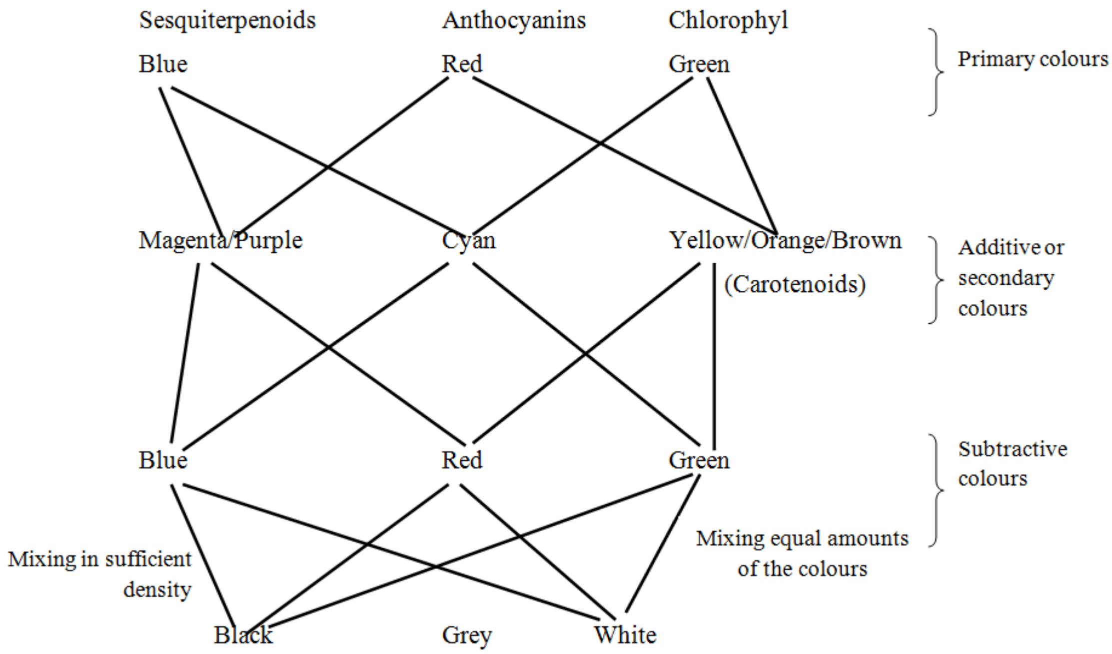

Fig. 1. The flow chart of cross-matched colours

produces green; mixing yellow and magenta produces red and mixing magenta with cyan produces blue. Mixing equal amounts of all the three pigments produce grey and, black when all the three are applied in equal sufficient density [16]. A system of subtractive colour does not have a simple chromaticity gamut analogous to the Red-Green-Blue colour triangle, but a gamut described in three dimensions. Visual colour models are possible, using various 2D chromaticity or 3D colour spaces. The black colour leaves are highly pigmented. In low light, a black plant needs more chlorophyll to make energy making leaves much more greenish or coppery than black. *Ophiopogon planiscapus* (Mondo grass), *Ajuga reptans, Centaurea cyanus* and *Cosmos atrosanguineus* are plants that have black pigment [17] and may be toxic.

3. COLOURS AS INDICES OF MEDICINAL PROPERTIES OF PLANTS

Every plant parts including root, leaf, flower, stem, rhizome and bark has one colour or the other and their colours suggest presence of chemical principles that may have biological activity. For example, Ferula lycia has a yellow flower used to treat digestive disorders, rheumatism, headache, arthritis, diabetes and toothaches [18]. The orange yellow fruit of *Annona senegalensis* contains perfumed seeds [19], with anthelmintic [20,21] antidiarrhoeic, anticonvulsant, antibacterial, antifungal, antitussive, anti-inflammatory, antipyretic, anticancer and antileukaemic [22,23] properties. *A. senegalensis* gives a pale yellow or orange yellow essential oil from all parts of the plant suggesting combination of chlorophyll with anthocyanins, which may act as natural antioxidants [24]. *Piper guineense* (African black pepper) seeds [25] are antifungal [26] and aphrodisiac [27] suggesting that the plant contains sesquiterpenoids and anthocyanins. But the yellow, orange and red berries contain ginsenoside (panoxosides), most abundant in the roots of berries. They are steroid glycosides and triterpene saponins with anti-senility, gastric ulcers [28], lupus erythromatosus [29] and anti-stress [30] activities. The essential oil of *C. cilliata* fresh leaves were light yellow dominated by monoterpenes may have insecticidal activity. The black turtle bean contains ergothionine that may have anticancer value [31]. The blue essential oil of *Matricaria chamomilla* flowers is used in medicine, cosmetics, foodstuffs, alcoholic flavour and non-alcoholic beverages [32].

The fifteen (15) most beautiful flowers; Cannas (yellow), Cherry blossom (white and pink), Colorado colourine (blue, white and yellow), Hydrangea (blue and yellow), lily of the valley (white), Cilla lily, the Black Eyed Susan (gold yellow petals and dark middle), Bleeding hearts (red, pink or white flower), Blue bells, lantana (pink and yellow petals), Rose (yellow, deep red) Oriental poppy (red and yellow petals), Begonia, Ixora and Dendrobium may have antidiabetic, antihypertensive, antiasthmatic, anticancer and potent antioxidant properties. *Jacaranda* from dark green leaves of *Jacaranda acutifolia is made up of* verbacoside, phenyl acetic –β-glucoside, scutellarein-7-glucuronide and hydroquinone [33] and the blue colour of flowers of *Jacaranda acutifolia* is due to presence of flavonoids and anthocyanins [34] which are pH sensitive [35], hence used as an indicator for acid-base tritrations [33].

Essential oil from Li*tsea cubeba* is pale yellow with citrus type fragrance resembling partly lemon grass oil and lemon peel oil [36]. The oil has antifungal, anti-yeast, anti-bacterial [37], antispasmodic, bronchodilator [38] and emenagogic activities. The cubeba oil from Thailand contain citral as the main constituent [39]. Many plants contain flavonoids that inhibit certain enzymes and possess antioxidant activities. *C. sativus* flowers known as saffron is costly and its odour is related to colourless trepan essential oil and cineole. The bitter taste of saffron is due to picrocrocin and picrocrozioide, soluble in water and alcohol [40]. The origin of saffron colour is crocin and produces glucose and crocetin ($C_{20}H_{24}O_4$) after hydrolysis [41]. Saffron is a spice, colorant, deodorant, food additive and flavour. After separation of colour styles, the remaining part of harvested flowers of saffron is anthocyanin. This pigment in combination with flavonoids of cell sap provide beautiful violet colour of saffron petioles, a proper substitute for synthetic colorant [42]. Saffron has narcotic and ecstasy effects leading to temporary paralysis and causes abortion with risk of maternal death [43,44]. The presence of yellowish to reddish brown cytoplasmic vesicles in cork cells of *C. forskohlii* tubers store secondary metabolites including forskolin [45] used for eczema, asthma, psoriasis, cardiovascular disorders and hypertension via decreased intracellular cAMP [46].

Vitis vinifera (Grape) rich in red to blue proanthocyanidins with 60 – 70% present in the seeds has dimers, trimmers, tetramers and oligomers of monomeric catechins, which can be used to treat neck squamous cells carcinoma [47]. Black raspberries reduce genetic damage induced by a chemical carcinogen, by slowing down the conversion of precarious cells to cancer cells and by down-regulating the expression of several cancer genes [48]. *Hypericum perforatum* has anti-depressive effects on the brain [49]. Isolated from the plant are over 100 phytochemicals with different biological activities [50], linked mainly to flavonoids and phloroglucinols [51,52]. *Lythrum salicarta* with purple flowers contains vescalagin with antibacterial activity. Other phytochemical components of the plant are flavon-C-glucoside, vitexin, orientin, and isoorientin [53]. Blue and purple phytochemical pigments seen in blueberries, purple grapes, red cabbage, beets and plums are attributable to anthocyanins that protect against carcinogens and may help prevent heart disease. Black pigment seen in *Abrus precatorius* seeds, African black pepper and other plant parts that have black colour may be cytotoxic and so can be used to treat various forms of cancers. White pigments as seen in garlic and onion may lower cholesterol and blood pressure. Plants with black pigments can be poisonous and may have anticancer and antitumor activities [54]. Green part of Celery (Umbelliferae) has cholesterol lowering, anti-inflammatory, anti-microbial and anti-cancer activities [55].

4. COLOURS AS INDICES OF PHYTOCHEMICAL PROPERTIES OF PLANTS

Biological pigments selectively absorb certain wavelengths of light to power chemical reactions, while the reflected wavelengths of light determined the colour pigment. Chlorophyll absorbs yellow and blue wavelengths of light reflecting green. Carotene (orange pigment), leutein (yellow pigment) and lycopene (red pigment) found in carrot, fruits, vegetable and tomatoes, respectively promote healthy eyesight in human and animals. Betalains are responsible for the deep red colour of beets used as food colorant [7]. Β-carotene is found in many yellow vegetables as well as in tomatoes and spinach. When β-carotene is cleaved, two molecules of vitamin A are produced, converted to II-cis-retinal which combines with opsin to form a protein, rhodopsin. When light strikes the rods, metarhodopsin is produced [56]. The presence of flavones and flavonols is revealed at λmax 365nm by yellowish fluorescence, but 3-hydroxy-substituted flavonoid compounds give dark spots. Anthocyanidins contributed to red, pink, mauve and blue in higher plants especially to the flowers, petals, tubers, fruits and variegated leaves. Dithiins (thiaburines) are red with potent cytotoxic, nematocidal and fungicidal properties. Chuktabularin A and tabularisin A-C are white amorphous powder and chuktabrin is a colourless crystal [57]. The yellow prenyl-flavonol glycoside, epimedokoreanoside from the Epimedium koreanum showed hypotensive activity [58]. Plant phenolics defend against pathogens, hence, they are applied in the control of human pathogenic infections [59].

Carotenoids are also very significant nutraceuticals [60] which animals are unable to synthesise denovo, although plants and animals share multiple carotenoid-modifying enzymes [61]. They are responsible for most yellow and orange flower colours in marigold (Tagetes), daffodil (Narcissus) and calendula. But carotenoids can coexist with red or purple anthocyanins giving brown and bronze hues [62]. Anthocyanin pigments are orange, red, purple and blue colours of flowers [63]. Flavonoids are modified at several positions by methylation, acylation and glycosylation, which provide flavonoids with unique properties [64]. The majority of naphthalene derivatives present in nature are quinines and are usually found in the createnchyma of the roots of about 150 plant species mostly belonging to the family Boraginaceae. The red coloration and therapeutic action of boraginaceous taxa have been attributed to naphthaquinones-isohexenylnaphthazzarins [65]. Flavonoids and vitamin C are related and synergistic [66]. Quercetin, a flavonol chemically related to kaempferol is abundant in brassica, green vegetables, berries, onions, parsley, apple, legumes, green tea, citrus fruits, red grape and vines, prevents oxidative injury cell death [67] by scavenging oxygen radicals [68,69] inhibiting xanthine oxidase [70], lipid peroxidation and chelating metal ions [71]. Pharmacological actions of quercetin include cardio-protections, cataract prevention, anticancer, antiulcer, anti-inflammatory, antiallergic, antiviral and antibacterial activities [72]. The yellow emodin pigment from *Aspergillus ochraceus* found in Japanese rice [73] and *Aspergillus wentii* from weevil-damaged Chinese chest nuts [74] has anticancer [75,76], anti-inflammatory [77], laxative [78] and suppression of tumor – associated angiogenesis [79].

Photosensitizing agents such as furanocoumarins are applied in pigment disorders. Fruits and vegetables decrease the risk of cardiovascular disease and cancer. Apples are good for diabetics and asthmatics because they contain quercetin, catechin, phloridzin, and chlorogenic acid [80]. Quinones are ketones with colour ranging from pale yellow to almost black [81]. They cause the browning reaction in cut or damaged fruits and vegetable. They also play role in the melanin synthesis. Hypericin, an anthroquinone, obtained from St. John's wort (*Hypericum perforatum*) has antidepressant, antiviral and antimicrobial properties [82]. Thymoquinone is the active principle of cumin responsible for many of the seeds beneficial effects [83]. Isoflavanquinone, an abruquinone B, and abruquinone G, were isolated from the aerial parts of Abrus precatorius. While abruquinone B exhibited antitubercular, antiplasmodial and cytotoxic activities, abruquinone G showed mild antiviral and cytotoxic activities. Saganuwan reported very significant antiplasmodial and cytotoxic activities of aqueous extract of Abrus precatorius leaf in swiss albino mice. Isolated also, are two fractions from n-hexane extract of Abrus precatorius leaf [84]. The n-hexane fraction showed significant antiplasmodial activity against chloroquine and pyrimethamine resistant P. falciparum having IC_{50} (12.1μg/ml). One of the isolates with rf = 0.201 was yellowish whereas the second with rf 0.608 was bluish in colour [85], suggesting that the bluish fraction may be more toxic and the yellowish fraction may have antidiabetic and antioxidant activities.

In low light, a black plant needs more of the green pigments [86]. The dark brown yellow of *Celastrous paniculatus* is used to treat rheumatism and gout [87] and may contain anthocyanins and carotenoids. Some families and their phytochemicals are Apocynaceae (cardioactive glycosides), Caprefoliaceae (cyanogenic glycosides), Papaveraceae (alkaloids) and Solanaceae (glycoalkaloids) [88]. The pulp of ripe pumpkins is rich in β-carotenoid, α-carotenoid and β-cryptoxanthin), precursors of vitamin A which plays role in the body growth [60]. Consumption of carotenoids reduces the risk of degeneration, eye and cardiovascular diseases, carcinomas of lung, skin, colorectum and prostate gland [89]. The colour of pumpkin puree affects consumer's preference. Polyphenols oxidases and peroxidase that cause browning of puree are inactivated during thermal treatment. Degradation of phenolic compounds and carotenoids can also lead to colour changes [90]. Carotenoids being unsaturated carbon compounds are susceptible to oxidation, isomerisation during processing and storage leading to changes in nutritional values. Oxidation, lightning of carotenoid, packaging, storage conditions and light temperature can cause loss of caroteinoids [91,92].

5. CONCLUSION

Primary colours; red, green and blue denote different phytochemical compounds which are bases of the medicinal values of the plant parts that exhibit the colours. Plants and plant parts with black colour may have anticancer effect whereas plants parts with white colour may have antidiabetic, antiasthmatic, antihypertensive and antioxidant activities. Plants with yellow, red, purple, pink and cyan colour may have antimicrobial and antioxidant activities.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. The World Book Encyclopaedia. Colour, World Book, Inc., A Scott Fetzer Company, Chicago London Sydney Toronto. 1988;4: 816–826.
2. Funk and Wagnalls New Encyclopaedia. Colour, Funk and Wagnalls Inc., Rand McNally and Company. 1983;6:446–448.
3. Swinto A. Aura Garden Handbook, Amiclare R. Millan, Italy. 1985;47.
4. The marshall carvendish encyclopaedia of gardening. Paving Plants to Pinus. 1969; 14:1457–1568.
5. Ashur A. Herbs are your natural doctor: Treatment with herbs and plants. Written in Arabic, ibn Sina Bookshop Printing-Publising-Distributing Exporting, Cairo, Egypt. 1986;192.
6. Grotewold E. The genetics and biochemistry of flora pigments. Ann Rev Plant Biol. 2006;57:761–780.
7. Verma SK, Verma M. A textbook of plant physiology, biochemistry and biotechnology, S. Chand and Company Ltd., New Delhi, India. 2007;64:112:386.
8. Lu H, Zou Y, Feng N. Overexpression of AH L20 negatively regulates defences in Arabidopsis. JIPB. 2004;1-20.
9. Vry S. Red-yellow-blue: Colours in art. Prestel. 2011;96.
10. Shevell SK. Colour perception under chromatic adaptation: Equilibrium yellow and long wavelength adaptation Vision Res. 1982;22:279–292.
11. Page WH, Page AW. The World's work: A history of our time. Volume XV. Doubleday, Page & Company. Available:http://books.com/boks
12. Sobel MI. light, University of Chicago Press. 1989;52–62.
13. Goldsmith TH. What birds see? Scientific American; 2006. Available:http://www.csulb.edu/web/Labs/bcl/elab/avian%20vision_intro.pdf
14. Strut JW. Some experiments on colour, Nature III, University Press; 1871.
15. Ferry ES. General physics and its application to Industry and Everyday Life; 1921.
16. Henry FS. Printing for school and shop: A textbook for printers' apprentices. Continuation Classes and for General Use in Schools; 1917.
17. Perry L. Black plants for green thumbs. Fall News Article; 2013. Available:http://pss.uvn.edu/ppp/articles/black.html
18. Deghan N, Akhtar-Danesh N, McMillan CR, et al. Is Plasma Vitamin C an appropriate biomarker of vitamin C intake? A systematic review and meta-analysis. Nutr J. 2007;6:41. DOI: 10.1186/1475-2891-6-41
19. Dupont F, Guignard JL. Botanique systematique. 14eme ed. Masson, Paris. 2007;285.
20. Alawa CBI, Adamu AM, Gefu JO, et al. In vitro screening of two Nigerian medicinal plants: *Vernonia amygdalina* and *Annona senegalensis* for anthelmintic activity. Vet Parasitol. 2003;113:73–81.
21. Fall D, Badiannem M, Ba D, et al. Antiparasitic activities of senegalense annonaceae used in traditional medicine. Dakar Med. 2003;84(2):112–116.
22. Kanta BF. Etude de l'activite anticandidosque de certain esplantes medicinales maliennessur Candida albicans. These de pharmacie, Bamako (Mali). 1999;13:81.
23. Noumi E, Fozi FL. Ethnomedical botany of epilepsy treatment in Fongo-Tongo village, Western Province, Cameroun. Pharmaceut Biol. 2003;41(5):330–339.

24. Zheng LP, Gao LW, Zhou JQ, et al. Antioxidant activity of aqueous extract of a *Tolypoclachium* sp. Fungus isolated from world *Cordyceps sinensis*. Afr J Biotechnol. 2008;7(17):3004-3010.
25. Udoh FV, Theodore YL, Braide VB. Effects of extract of seed and leaf of *Piper guineense* on skeletal muscle activity in rat and frog. Phytother Res. 1999;110.
26. Ngane AN, Biyiti L, Bouchet PH, et al. Antifungal activity of *Piper guineense* of Cameroun. Fitoter. 2003;4(5):564–568.
27. Mbongue FGY, Kamtchouing P, Essame OJL, et al. Effect of the aqueous extract of dry fruits of *Piper guineense* on the reproductive function of adult male rats. Ind J Pharmacol. 2005;7:30–32.
28. Zhang SC, Ni GC, Hu ZH. Shikonin in *Arnebia euchroma* and *Lithospermum erythrorhizon*. Zhong Caoyao. 1984;20: 449.
29. Yang YC, Ciarletta AB, Temple PA, et al. Human IL3 (multi CSF): Identification by expression cloning of a novel haematopoeutic growth factor related to murine IL-3. Cell. 1986;47:3-10.
30. Zhang Y, Lathigra R, Garbe T, et al. Genetic analysis of superoxide dismutase, the 23-kilodation antigen of mycobacterium tuberculosis. Molecul Microbiol. 1991;5: 381-391.
31. Ey J, Schomig E, Taubert D. Dietary sources and antioxidant effects of ergothoneine. J Agric Food Chem. 2007; 55:6466-6474.
32. Sashidara KV, Verman RS, Ram P. Essential oil composition of *Matrica riarecutita* L. from the lower region of the Himalayas. Flav Fragr J. 2005;21:274–276.
33. Patrakar R, Gond N, Jadge D. Flower extract of *Jacaranda acutifolia* used as a natural indicator in acid base titration. Int J Pharm Tech Res. 2010;2(3):1954-1957.
34. Mashelkar RA. The Wealth of India, New Delhi Raw Materials, CSIR Publications. 2003;1.
35. Jaffrey GH, Bassett J, Denny RC, et al. Vogel's Textbook of Quantitative Chemical Analysis, 5th ed., ELBS, Longman Group, England, UK. 1996;262.
36. Organization for Economic Co-operation and Development (OECD). Safety consideration for biotechnology: Scale-up of crop plants, Paris, France. 1993;43.
37. Gogol R, Baruah P, Nath SC. Antifungal activity of the essential oil of *Litsea cubeba* pers. J Essential Oil Res. 1997;9:213-215.
38. Huang Y. Genetic engineering of *Larix decidua*: Agro-bacterium-mediated genes transfer and regeneration of transgenic plants in European Larch UMI Publishing Co., Ann Arbor MI. 1993;245.
39. Tubtim S, Wasikarsiri A. 28-day repeated dose oral toxicity of *Litsea cubeba* esstial oil in Sprague-Dawley rats. That J Pharm Sci. 2007;31:74–82.
40. Hertog MG, Kromhout D, Aravanis C, Blackburn H, Buzina R, Fidanza F, Giampolis, Jansen A, Menotti A, Nedelkovic S. flavonoid intake and long-term risk of coronary heart disease and cancer in the seven countries study. Arch Intern Med. 1995;155(4):381–386.
41. Himeno H, Sano K. synthesis of crocin, Picrocrocin and safranal by saffron stigma-like structures proliferated *in vitro*. Agric and Biol Chem. 1987;51(9):2395–2400.
42. Valizadeh R. Leaf usage as feeding animal. Iran Science Research, Khorasan, Iran; 1988.
43. Zargari A. Medicinal plants. Tehran University Publication Iran; 1993.
44. Baker D, Negbi K. Use of saffron. Econ Biol. 1983;37(2):228–236.
45. Abraham Z, Srivastava SK, Bachi CA. Cytoplasmic vesicles containing secondary metabolites in the roots of *Coleus forskohlii*. Cur Sci. 1988;57:1337–1339.
46. Rupp RH, De Souga NJ, Dohadwalla NJ. Proceeding of the international symposium on Forskolin: Its chemical, biological and medical potentials. Hoechst India Limited, Bombay. 1986;19-30.
47. Nassiri-Asl M, Hosseinzadeh H. Review of the pharmacological effects of *Vitus vinifera* (Grape) and its bioactive constituents: An update. Phytother Red. 2016;30(9):1392-1403.
48. Peggy E. New data show anti-cancer effects of dietary phytochemicals. Oncol Tim. 2005;27(18):36–37.
49. Kumar A, Taylor MA, Mad Arif SA, et al. Potato plants expressing antisense and sense SAMDC transgenes show altered levels of polyamines and ethylene: antisense plants display abnormal phenotypes. Plant J. 1996;9:147–158.
50. Li-Hong H, Kenz-Yeow S. Sampsoniones A-M, a unique family of caged polyprenylated benzylphloroglucinol

derivatives, from *Hypericum sampsonii*. Tetrahedron. 2000;56:1379–1386.
51. Butterweck V, Bockers T, Korte B, et al. Long term effects of St. John's Wort and hypericin on monoamine levels in rat and hypocampus. Brain Res. 1983;930:21–29.
52. Bernadi M, Hyde JB, Seth RK, et al. The luminosities, sizes and velocity dispersions of brightest duster galaxies: Implications for formation history. Astron J. 2007;133: 1741.
53. Becker H, Scher JM, Speakman JB, et al. Bioactivity guided isolation of antimicrobial compounds from *Lythrium salicarta*. Fitoter. 2005;76(6):580-584.
54. Saganuwan SA. Some medicinal plants of Arabian Peninsula. J Med Plant Res. 2010; 4(9):766–788.
55. Cao J, Zhang X, Wang Q, et al. Influence of flavonoid extracts from celery on oxidative stress induced by dichlorvos in rats. Human Exper Toxicol. 2011;31(6): 617-625.
56. Denniston K, Topping JJ, Caret R. Minerals and cellular function. General, Organic and Biochemistry, 4th ed., McGraw Hill, Higher Education, New York, USA. 2004;797–799.
57. Zhang F, Aravanis AM, Adamantids A, et al. Circuit-breakers: Optical technologies for probing neural signals and systems. Nat Rev Neuro Sci. 2007b;8:577-581.
58. Pachaly P, Wessbarth CS, Sin KS. New prenyl flavonoid glycosides from *Epimedium koreanum*. Planta Med. 1990; 56:277-280.
59. Puupponen-pimia R, Nohynek L, Alakomi H, Oksman-Caldentey K. The action of berry phenolics against human intestinal pathogens. Biofactors. 2008;23(4):243-251.
60. Fraser PD, Branley PM. The biosynthesis and nutritional uses of carotenoids. Progress in Lipid Research. 2004;43:228-265.
61. Moise AF, Colman RA, Zhang H. Coupled model simulation of current Australian climate and its changes under greenhouse warning: An analysis of 18 CMP2 models. Aust Met Maz. 2005;54:291-307.
62. Forkmann G. Flavonoids as flower pigments: The formation of natural spectrum and its extension by genetic engineering. Plant Breeder. 1991;106:1–26.
63. Jez JM, Bowman ME, Dixon RA, et al. Structure mechanism of the evolutionary unique plant enzyme celconeisomerase. Nat Struct Biol. 2000;7:786–791.
64. Onyilagha JC, Grotewold E. The biology and structural distribution of surface flavonoids. Rec Res Develop Plant Sci. 2004;2:53–71.
65. Tabata M, Hond Y. Chemical studies of certain plants of family Cactaceae and family Boraginaceae. PhD Thesis, Cairo University, Egypt; 1988.
66. Stephencole L. Quercetin a review of clinical applications. Clinical Science. 1998;40:234–238.
67. La Rocca C, Conti L, Crebelli R, et al. PAH content and mutagenicity of marine sediments from the Venice Lagoon. Ecotoxicol Environ Saf. 1996;33:236-245.
68. Cox D, Wichelon MJ, Provoso TA. Antioxidant effect of flavonoids. Public Health Nutrition Journal. 2000;3:19–29.
69. Miller AL. Antioxidant flavonoids: Structure, function and clinical usage. Altern Med Rev. 1996;1:103–111.
70. Chang C, Kwok SF, Bleecker AB, et al. Arabidopsis ethylene-response gene ETRT similarity of product to two-component regulators. Science. 1993;262:539-544.
71. Chen J, Campbell IC, Li J, et al. Diet, lifestyle and mortality in China. A study of the characteristics of 65, Chinese countier. Joint Publication of Oxford University Press, Cornell University Press and China's Publishing House, Oxford, UK; 1990.
72. Stavric B. Quercetin in our diet: From potent mutagen to probable anti-carcinogen. Clin Biochem 1994;27:245.
73. Yamazaki M, Maebayashi Y, Miyaki K. Production of ochrotoxin A by *Aspergillus ochraceus* isolated in Japan from moldy rice. Appl Microbiol. 1970;21:452.
74. Wells JM, Cole RJ, Kirksey JW. Emodin, a toxic metabolite of *Aspergillus wentii* isolated from Weevil-damaged chestnuts. Appl Microbiol. 1975;23–28.
75. Muto H, Watahiki MK, Nakamato D, et al. Specificity and similarity of functions of the AUX/IAA genes in auxin signalling of Arabidopsis revealed by promoter exchange experiments among MSG2/IAA19, AXR21AA7 and SLR/IAA14. Plant Physiol. 2007;144:187-196.
76. Srinvas BP, Woo J, Leong WY, et al. A conserved molecular pathway mediates myoblast fusion in insects and vertebrates. Natural Genetics. 2007;39(6):781-786.

77. Dong H, Liao G, Wang H, et al. Assymetrically designed SiRNA and ShRNA enhance the strand specificity and efficacy in RNAi. J RNAi and Gene Silencing. 2008;4(1):269-280.
78. Wang W, Wu N, Zu YG, et al. Antioxidative activity of *Rosmarrinus officinalis* L. essential oil compared to its main component. Food Chem. 2008;108:1019– 1022.
79. Kaneshiro Y, Ichihara A, Takemitsu T, et al. Increased expression of cyclooxygenase-2 in the renal cortex of human prorenin receptor gene-transgenic rats. Kidney Int. 2006;70:641–646.
80. Bayer J, Liu RH. Apple phytochemicals and their health. Nutr J. 2004;3(5):1–17.
81. Harborne JB. Textbook of phytochemical methods, 1st edition. Champraan and Hall Ltd. London. 1973;110–113.
82. Lavie G, Mazur Y, Lavie D, Meruelo O. The chemical and biological properties of hypericin-a compound with broad spectrum of biological activities. Medicinal Research Review. 1995;2:111–119.
83. Gali-Muhtasib H, El-Najjar N, Schneider-Stock R. The medicinal potentials of black seed (*Nigella sativa*) and its components. In: r. Khan MYH, Anther A (eds) lead Molecules from Natural Products. 2006;133-154.
84. Saganuwan SA, Onyeyili PA, Ameh IG, et al. Antiplasmodial activity by aqueous leaf extract of *Abrus precatorius* in Swiss albino mice. Rev Latinoamer De Quin. 2011; 39(1–2):32–44.
85. Saganuwan SA. Toxicological and antimalarial effects of aqueous extract of *Abrus precatorius* leaf in Swiss Albino mice. PhD Thesis, Usmanu Danfodiyo University, Sokoto, Nigeria; 2012.
86. Bloomfield J, Vogt K, Wago PM. Three root turnover and senescence. In: Waisel, Y., Eshel, A., Kafkafi, U. (eds) Plant Roots: The Hidden Half. Mercel York. 1996;363–381.
87. Salomi SS, Shafeen SS, Roopesh C, et al. Evaluation of immuno-modulatory activity of petroleum ether extract of seeds of *Celastrus paniculatus*. Scholar Res Lib. 2011;3(5):87-93.
88. Lewis WH, Elvin-Lewis MPF. Medical botany: Plants affecting human health, 2nd edition. John Willey and Sons, Hoboken, USA; 2003.
89. Rao AV, Rao LG. Carotenoids and human health. Pharmacological Research. 2007;55:207-216.
90. Talcott ST, Howard LR. Phenolic autoxidation in responsible for colour degradation in processed carrot puree. J Agric Food Chem. 1999;47:2109-2115.
91. Rodriguez E, Aregullin M, Nishida T, et al. Thiarubine A, a bioactive constituent of Aspilia consumed wild chimpanzees. Experient. 1995;41:419-420.
92. Zepka LO, Merradante AZ. Degradation compounds of carotenoids formed during heating of a simulated cashew apple juice. Food Chemistry. 2009;117:28-34.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/26166