Pharmacogn. Rev.
A multifaceted peer reviewed journal in the field of Pharmacognosy and Natural Products
www.phcogrev.com | www.phcog.net

REVIEW ARTICLE

Pea, *Pisum sativum*, and Its Anticancer Activity

Runchana Rungruangmaitree, Wannee Jiraungkoorskul[1]

Mahidol University International College, Mahidol University, Salaya Campus, Nakhon Pathom, [1]Department of Pathobiology, Faculty of Science, Mahidol University, Bangkok, Thailand

ABSTRACT

Pisum sativum (Family: Fabaceae), as known as green pea or garden pea, has long been important in diet due to its content of fiber, protein, starch, trace elements, and many phytochemical substances. It has been shown to possess antibacterial, antidiabetic, antifungal, anti-inflammatory, antihypercholesterolemia, and antioxidant activities and also shown anticancer property. Its nonnutritive biologically active components include alkaloids, flavonoids, glycosides, isoflavones, phenols, phytosterols, phytic acid, protease inhibitors, saponins, and tannins. This plant is rich in apigenin, hydroxybenzoic, hydroxycinnamic, luteolin, and quercetin, all of which have been reported to contribute to its remedial properties including anticarcinogenesis property. Based on established literature on the anticancer property of *P. sativum* and possible mode of action, this review article has focused to demonstrate that *P. sativum* could be further explored for the development of anticancer treatment.

Key words: Anticancer, pea, *Pisum sativum*, plant, traditional medicine

LEGUME

Legume or pulse is one of the traditional medicines used globally because it has the amount of nutritional substances and has the efficiency of therapeutic treatments. Legumes include beans, grains, and peas as well as alfalfa, carob, clover, copaifera, fenugreek, indigo, lentil, licorice, lupin, mesquite, natto, soybean, peanut, rosewood, and tamarind are the member of the Fabaceae family.[1] The nutritional values of legume are low fat, high protein, dietary fiber, and various of micronutrients and phytochemical substances which exhibit the medicinal properties, especially anticancer property.[2] Pea is one of the major food legumes that can grow in different regions, and it ranks the fourth in world food legume productions next to soybean, peanut, and dry bean.[3] Seed and sprout of pea have become increasingly consumed because people concern about their health problem by changing dietary habits.[4] The present review explores scientific evidences to provide updated information about the properties of green pea or garden pea (*Pisum sativum*), one of the anticancer plants that is being investigated for its mechanism.

TAXONOMICAL CLASSIFICATION

The taxonomy of *P. sativum* is in the Kingdom (*Plantae*); Subkingdom (*Viridiplantae*); Infrakingdom (*Streptophyta*); Superdivision (*Embryophyta*); Division (*Tracheophyta*); Subdivision (*Spermatophytina*); Class (*Magnoliopsida*); Superorder (*Rosanae*); Order (*Fabales*); Family (*Fabaceae*); Genus (*Pisum*); and Species (*P. sativum*).[5]

Correspondence:
Dr. Wannee Jiraungkoorskul,
Department of Pathobiology, Faculty of Science, Mahidol University,
Bangkok 10400, Thailand.
E-mail: pathobiologymu@gmail.com

Access this article online

Quick Response Code:

Website: www.phcogrev.com

DOI: 10.4103/phrev.phrev_57_16

NOMENCLATURE

The origin of *Pisum* spp. is in Southwestern Asia including Afghanistan, India, Pakistan, and then spreads to subtropic and tropic regions.[6] The vernacular names of *P. sativum* include Chinese pea, edible pod pea, field pea, garden pea, green pea, honey pea, sugar pea, and sweet pea (English); ertjie (Afrikaans); katar (Bengali); ervilha (Brazil); jia wan dou (Chinese); doperwten (Dutch); petiti pois (French); erbse (German); kacang ercis (Indonesian); endo (Japanese); sandaek (Khmer); kacang manis (Malaysia); ervilha (Portuguese); gorach (Russian); aroeja (Spanish); spritart (Swiss); thua lan tao (Thai); bezelye (Turkish); ropox (Ukranian); and dau hoa lan (Vietnamese).[7]

PLANT DESCRIPTION OF *PISUM SATIVUM*

P. sativum is an herbaceous annual, with a climbing hollow stem growing up to 2–3 m long. Leaves are alternate, pinnately compound, and consist of 2–3 pairs of 1.5–8 cm long large leaf-like stipules. Flowers have five green fused sepals and five white to reddish-purple petals of different sizes. Fruit grows into a pod, 2.5–10 cm long that often has a rough inner membrane. The pod is a seed container which composed by two sealed valves and splitted along the seam which connects the two valves. Seeds are round, smooth, and green color [Figure 1].[8]

PHYTOCHEMICAL SUBSTANCES

The active phytochemical substances of *P. sativum* are as follows: Asparaginase;[9] flavonoids including apigenin, daidzein, genistein, and kaempferol;[10] lectin;[11-13] phenolic compounds including caffeic, catechin, coumaric acids, gentisic acids, ferulic, protocatechuic, and vanillic acids;[14,15] pisatin and an allelopathic active substances;[16,17] proanthocyanidin;[18] saponins;[19,20] steroid phytohormone including brassinosteroid;[21,22] and tannins.[23]

Cite this article as: Rungruangmaitree R, Jiraungkoorskul W. Pea, *Pisum sativum*, and its anticancer activity. Phcog Rev 2017;11:39-42.

Figure 1: Fruit of *Pisum sativum* (a) external morphology (b) cut face and (c) seeds

TRADITIONAL USES

P. sativum can be consumed in raw form as well as cooked or frozen form. The various bioactive compounds' current uses or phytochemical properties of *P. sativum* from several literature reviews are antibacterial,[24,25] anti-*Helicobacter pylori*,[26,27] anticancer,[28] antidiabetic,[29,30] antifungal,[31] anti-inflammatory,[32,33] antilipidemic,[34,35] and antioxidant[36,37] activities. Moreover, it can act as insecticidal activity.[38-40]

ANTICANCER ACTIVITY

The extracts of *P. sativum* have been investigated and found to be pharmacologically active inducing anticancer activity. Clemente *et al.*[41,42] compared the effect of Bowman-Birk trypsin-chymotrypsin inhibitor, a potential cancer chemopreventive agent, with the protease inhibitors, rTl1B and rTl2B, from *P. sativum* seed from the United Kingdom. They studied the inhibitory activities on the growth of human colorectal adenocarcinoma HT-29. The rTl1B showed the effective 46 μM of IC_{50}. El-Aassar *et al.*[43] studied the *P. sativum* extracted lectins from Egypt exhibited the antiproliferative property to liver cancer cell line. Patel[12] extracted lectin from leaves and buds of *P. sativum* from Saudi Arabia and studied cytotoxicity to many cancer cell lines such as MCF-7 (breast), HepG-2 (liver), HEP-2 (larynx), and HCT-116 (colon). In recently, Stanisavljevic *et al.*[28] identified the amount of phenolic compounds from pea seeds in different colors from Croatia. They reported the darker seed color, the higher total phenolic content in the form of gallic acid, epigallocatechin, naringenin, and apigenin. The seed extracts also showed the cytotoxic effects on malignant cell lines, for example, LS174 (colon), MDA-MB-453 (breast), A594 (lung), and K562 (blood). In several review articles have mentioned the health benefits of *P. sativum* due to its concentration and properties of starch, protein, fiber, vitamins, minerals, and phytochemicals.[2,44] In addition, the plants in the same Fabaceae family also show the anticancer activities such as alfalfa, *Medicago sativa*;[45] carob, *Ceratonia siliqua*;[46] lentil, *Lens culinaris*;[47] and soybean, *Glycine max*.[48]

PHYTOCHEMICAL SUBSTANCES ACT AS ANTICANCER ACTIVITY

Several studies found that a diet high in whole grains including legumes may reduce the risk of cancer such as breast cancer,[49] colorectal cancer,[50,51] and endometrial cancer.[52,53] Various phytoconstituents in legumes have been reported their anticancer activities.

Isoflavones

The most abundant isoflavones in the legume sprouts were found as genistein followed by daidzein. Sukanya and Gayathri[54] studied the growth inhibitory properties of isoflavones extract of legume sprout from India on breast cancer MCF-7. Moreover, Pudenz *et al.*[55] reported that isoflavones worked as phytoestrogens and could inhibit tumorigenesis both *in vitro* and *in vivo* studies. Their mechanisms were DNA repair, induction of apoptosis, cell proliferation, migration, and invasion.

Lectins

There are the most abundant lectin proteins in several legume tree barks, and they have great potential as antitumor and anticancer properties.[56] Other legume lectins also have antiproliferative and anticancer properties such as concanavalin A, a lectin from Jack bean seed.[57] Several studies have suggested the cytotoxicity or tumor inhibition mechanisms of lectins to various tumor cell lines such as skin,[58] liver, bile duct, and bone cell lines.[59]

Saponins

A number of legumes contain saponins such as soybean, chickpea, peanut, and lentil, which have reported to exhibit anticancer activities. Several studies suggest that legume saponins may possess anticancer activities in melanoma cell,[60] colon cancer,[61,62] and cervical cancer.[63] The mechanism of suppressing the metastatic of cancer was mentioned by Chang *et al.*[60] using sialyltransferase inhibition activity of saponin on the cell surface. The other mechanism was saponin regulation of the apoptosis pathway enzymes, leading to programmed cell death of cancer cells.[62,64]

Phenolic compounds

It has been recognized that phenolic compounds act as antioxidants and were found high amount in peas.[65] The association of antioxidant properties of plant phenolic compounds and their effects in the prevention of various oxidative stress diseases, for example, cancer or cardiovascular diseases were explained by Dai and Mumper.[66]

CONCLUSION

Legume is considered as a good and nonexpensive of plant foods. It plays important roles in human nutrition and also in prevention in many diseases, especially cancer. Several researchers reported that *P. sativum* is rich in many nutritional and nonnutritional components which can prove to be prevention and inhibition cancer. This review article has attempted to compile the new medicinal plant *P. sativum*, to be one of the choices of anticancer plants.

Acknowledgement

A special thanks to the members of the Fish Research Unit, Department of Pathobiology, Faculty of Science, Mahidol University, for their support. The author would like to thank anonymous reviewers and editors of this review article for their perceptive comments and positive criticism in this review article.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Schneider AV. Overview of the market and consumption of pulses in Europe. Br J Nutr 2002;88 Suppl 3:S243-50.
2. Vohra K, Dureja H, Garg V. An insight of pulses: From food to cancer treatment. J Pharmacogn Nat Prod 2015;1:108.
3. Vidal-Valverde C, Frias J, Hernandex A, Martin-Alvarez P, Sierra I, Rodriquez C, *et al.* Assessment of nutritional compounds and antinutritional factors in pea (*Pisum sativum*) seeds. J Sci Food Agric 2003;83:298-306.
4. Chon SU. Total polyphenols and bioactivity of seeds and sprouts in several legumes. Curr Pharm Des 2013;19:6112-24.
5. Integrated Taxonomic Information System (ITIS). *Pisum sativum* L. Taxonomic Serial No.: 26867. Geological Survey, VA, USA; 2016.
6. Majeed H, Safdar W, Ali B, Mohannad A, Ahmad I, Mumtaz A. Genetic assessment of the genus *Pisum* L. based on sequence specific amplification polymorphism data. J Med Plants Res 2012;6:959-67.
7. Lim T. Edible Medicinal and Non-Medicinal Plants. Vol. 2. Fruits, Netherlands: Springer; 2012.
8. Pavek PL. Plant fact sheet for pea (*Pisum sativum* L.). USDA-Natural Resources Conservation Service, Pullman, Washington; 2012.
9. Chagas E, Sodek L. Purification and properties of asparaginase from the testa of immature seeds of pea (*Pisum sativum* L.). Braz Arch Biol Technol 2001;44:239-45.
10. Timoracká M, Vollmannová A. Determination of flavonoids content in coloured peas (*Pisum sativum* L.) in relation to cultivars dependence and storage duration under natural conditions. Potravinarstvo 2010;4:58-62.
11. Bala M, Nag T, Mathur K, Kumar S, Vyas M, Saini A, Tomar B. *In vitro* callus induction for determination of lectin activity in pea (*Pisum sativum* L.) variety (AP-1). Rom Biotechnol Lett 2010;15:5781-7.
12. Patel A. Isolation, characterization and production of a new recombinant lectin protein from leguminous plants. Biochem Comp 2014;2:1-9.
13. Ng TB, Chan YS, Ng CC, Wong JH. Purification and characterization of a lectin from green split peas (*Pisum sativum*). Appl Biochem Biotechnol 2015;177:1374-85.
14. Troszynska A, Ciska E. Phenolic compounds of seed coats of white and coloured varieties of pea (*Pisum sativum* L.) and their total antioxidant activity. Czech J Food Sci 2002;20:15-22.
15. Duenas M, Estrella I, Hernandez T. Occurrence of phenolic compounds in the seed coat and the cotyledon of peas (*Pisum sativum* L.). Eur Food Res Technol 2004;219:116-23.
16. Kato-Noguchi H. Isolation and identification of an allelopathic substance in *Pisum sativum*. Phytochemistry 2003;62:1141-4.
17. Hadwiger LA, Tanaka K. EDTA a novel inducer of pisatin, a phytoalexin indicator of the non-host resistance in peas. Molecules 2014;20:24-34.
18. Ferraro K, Jin AL, Nguyen TD, Reinecke DM, Ozga JA, Ro DK. Characterization of proanthocyanidin metabolism in pea (*Pisum sativum*) seeds. BMC Plant Biol 2014;14:238.
19. Tsurumi S, Takagi T, Hashimoto T. A gamma-pyronyl-triterpenoid saponin from *Pisum sativum*. Phytochemistry 1992;31:2435-8.
20. Reim V, Rohn S. Characterization of saponins in peas (*Pisum sativum* L.) by HPTLC coupled to mass spectrometry and a hemolysis assay. Food Res Int 2015;76:3-10.
21. Nomura T, Ueno M, Yamada Y, Takatsuto S, Takeuchi Y, Yokota T. Roles of brassinosteroids and related mRNAs in pea seed growth and germination. Plant Physiol 2007;143:1680-8.
22. Fedina E, Yarin A, Mukhitova F, Blufard A, Chechetkin I. Brassinosteroid-induced changes of lipid composition in leaves of *Pisum sativum* L. during senescence. Steroids 2017;117:25-28.
23. Wang X, Warkentin T, Briggs C, Oomah B, Campbell C, Woods S. Total phenolics and condensed tannins in field pea (*Pisum sativum* L.) and grass pea (*Lathyrus sativus* L.). Euphytica 1998;101:97-102.
24. Nair S, Madembil N, Nair P, Raman S, Veerabadrappa S. Comparative analysis of the antibacterial activity of some phytolectins. Int Curr Pharm J 2013;2:18-22.
25. Habib H, Fazili K, Zargar M, Ganie B. Protease inhibitor associated antimicrobial activity of pea *Pisum sativum* L. cv. Arkel. Int J Pure Appl Biosci 2016;4:172-9.
26. Ho C, Lin Y, Labbe R, Shetty K. Inhibition of *Helicobacter pylori* by phenolic extracts of sprouted peas (*Pisum sativum* L.). J Food Biochem 2006;30:21-34.
27. Niehues M, Euler M, Georgi G, Mank M, Stahl B, Hensel A. Peptides from *Pisum sativum* L. enzymatic protein digest with anti-adhesive activity against *Helicobacter pylori*: Structure-activity and inhibitory activity against BabA, SabA, HpaA and a fibronectin-binding adhesin. Mol Nutr Food Res 2010;54:1851-61.
28. Stanisavljevic NS, Ilic MD, Matic IZ, Jovanovic ŽS, Cupic T, Dabic D, *et al.* Identification of phenolic compounds from seed coats of differently colored European varieties of pea (*Pisum sativum* L.) and characterization of their antioxidant and *in vitro* anticancer activities. Nutr Cancer 2016;68:988-1000.
29. Dun XP, Li FF, Wang JH, Chen ZW. The effect of pea albumin 1F on glucose metabolism in mice. Peptides 2008;29:891-7.
30. Marinangeli CP, Jones PJ. Whole and fractionated yellow pea flours reduce fasting insulin and insulin resistance in hypercholesterolaemic and overweight human subjects. Br J Nutr 2011;105:110-7.
31. Sitohy M, Dohein M, Badr H. Isolation and characterization of a lectin with antifungal activity from Egyptian *Pisum sativum* seeds. Food Chem 2007;104:971-9.
32. Masini E, Bani D, Marzocca C, Mateescu M, Mannaioni P, Federico R, *et al.* Pea seedling histaminase as a novel therapeutic approach to anaphylactic and inflammatory disorders. A plant histaminase in allergic asthma and ischemic shock. Sci World J 2007;7:888-902.
33. Utrilla MP, Peinado MJ, Ruiz R, Rodriguez-Nogales A, Algieri F, Rodriguez-Cabezas ME, *et al.* Pea (*Pisum sativum* L.) seed albumin extracts show anti-inflammatory effect in the DSS model of mouse colitis. Mol Nutr Food Res 2015;59:807-19.
34. Alonso R, Grant G, Marzo F. Thermal treatment improves nutritional quality of pea seeds (*Pisum sativum* L.) without reducing their hypocholesterolemic properties. Nutr Res 2001;21:1067-77.
35. Martins JM, Riottot M, de Abreu MC, Lança MJ, Viegas-Crespo AM, Almeida JA, *et al.* Dietary raw peas (*Pisum sativum* L.) reduce plasma total and LDL cholesterol and hepatic esterified cholesterol in intact and ileorectal anastomosed pigs fed cholesterol-rich diets. J Nutr 2004;134:3305-12.
36. Amarowicz R, Karamac M, Weidner S. Antioxidant actiivty of phenolic fraction of pea (*Pisum sativum*). Czech J Food Sci 2001;19:139-42.
37. Saha H, Prakash A, Venkat Kumar S, Manimegalai S, Devi Rajeswari V. Evaluation of antioxidant activity of *Pisum sativum* (pod and grain) and detection of its bioactive compounds by GCMS analysis. Pharm Lett 2014;6:359-65.
38. Taylor WG, Fields PG, Sutherland DH. Insecticidal components from field pea extracts: Soyasaponins and lysolecithins. J Agric Food Chem 2004;52:7484-90.
39. Sahito H, Arain M, Mal B, Channa M, Dhiloo K. Efficacy of different insecticides against thrips on peas, *Pisum sativum* (L.) *in vivo* condition. J Agric Sustain 2013;3:56-77.
40. Pretheep Kumar P, Balasubramanian A, Mohan S. Efficacy of extracts of pea (*Pisum sativum* L.) in the management of saw-toothed beetle, *Oryzaephilus surinamensis* (L.) infesting stored neem (*Azadirachta indica* A. Juss) seeds. Sky J Agric Res 2015;4:67-71.
41. Clemente A, Gee JM, Johnson IT, Mackenzie DA, Domoney C. Pea (*Pisum sativum* L.) protease inhibitors from the Bowman-Birk class influence the growth of human colorectal adenocarcinoma HT29 cells *in vitro*. J Agric Food Chem 2005;53:8979-86.
42. Clemente A, Carmen Marín-Manzano M, Jiménez E, Carmen Arques M, Domoney C. The anti-proliferative effect of TI1B, a major Bowman-Birk isoinhibitor from pea (*Pisum sativum* L.), on HT29 colon cancer cells is mediated through protease inhibition. Br J Nutr 2012;108 Suppl 1:S135-44.
43. El-Aassar MR, Hafez EE, El-Deeb NM, Fouda MM. Microencapsulation of lectin anti-cancer agent and controlled release by alginate beads, biosafety approach. Int J Biol Macromol 2014;69:88-94.
44. Dahl WJ, Foster LM, Tyler RT. Review of the health benefits of peas (*Pisum sativum* L.). Br J Nutr 2012;108 Suppl 1:S3-10.
45. Rosenthal GA, Nkomo P. The natural abundance of L-canavanine, an active anticancer agent, in alfalfa, *Medicago sativa* (L.). Pharm Biol 2000;38:1-6.
46. Custodio L, Escapa A, Patarra J, Aligue R, Albericio F, Neng N, *et al.* Sapwood of carob tree (*Ceratonia siliqua* L.) as a potential source of bioactive compounds. Rec Nat Prod 2013;7:225-9.
47. Chan YS, Yu H, Xia L, Ng TB. Lectin from green speckled lentil seeds (*Lens culinaris*) triggered apoptosis in nasopharyngeal carcinoma cell lines. Chin Med 2015;10:25.
48. Suthar AC, Banavalikar MM, Biyani MK. Pharmacological activities of Genistein, an isoflavone from soy (*Glycine max*): Part I – Anti-cancer activity. Indian J Exp Biol 2001;39:511-9.
49. Thompson MD, Thompson HJ, Brick MA, McGinley JN, Jiang W, Zhu Z, *et al.* Mechanisms associated with dose-dependent inhibition of rat mammary carcinogenesis by dry bean (*Phaseolus vulgaris*, L.). J Nutr 2008;138:2091-7.
50. Wang Y, Wang Z, Fu L, Chen Y, Fang J. Legume consumption and colorectal adenoma risk: A meta-analysis of observational studies. PLoS One 2013;8:e67335.
51. Zhu B, Sun Y, Qi L, Zhong R, Miao X. Dietary legume consumption reduces risk of colorectal cancer: Evidence from a meta-analysis of cohort studies. Sci Rep 2015;5:8797.

52. Terry P, Vainio H, Wolk A, Weiderpass E. Dietary factors in relation to endometrial cancer: A nationwide case-control study in Sweden. Nutr Cancer 2002;42:25-32.
53. Ollberding NJ, Lim U, Wilkens LR, Setiawan VW, Shvetsov YB, Henderson BE, *et al*. Legume, soy, tofu, and isoflavone intake and endometrial cancer risk in postmenopausal women in the multiethnic cohort study. J Natl Cancer Inst 2012;104:67-76.
54. Sukanya S, Gayathri G. Variability in the distribution of daidzein and genistein in legume sprouts and their anticancer activity with mcf-7 breast cancer cells. Acad J Cancer Res 2014;7:173-8.
55. Pudenz M, Roth K, Gerhauser C. Impact of soy isoflavones on the epigenome in cancer prevention. Nutrients 2014;6:4218-72.
56. Liu B, Bian HJ, Bao JK. Plant lectins: Potential antineoplastic drugs from bench to clinic. Cancer Lett 2010;287:1-12.
57. Lei HY, Chang CP. Lectin of concanavalin A as an anti-hepatoma therapeutic agent. J Biomed Sci 2009;16:10.
58. Sames K, Schumacher U, Halata Z, Van Damme EJ, Peumans WJ, Asmus B, *et al*. Lectin and proteoglycan histochemistry of Merkel cell carcinomas. Exp Dermatol 2001;10:100-9.
59. Wang H, Ng TB, Ooi VE, Liu WK. Effects of lectins with different carbohydrate-binding specificities on hepatoma, choriocarcinoma, melanoma and osteosarcoma cell lines. Int J Biochem Cell Biol 2000;32:365-72.
60. Chang WW, Yu CY, Lin TW, Wang PH, Tsai YC. Soyasaponin I decreases the expression of alpha2,3-linked sialic acid on the cell surface and suppresses the metastatic potential of B16F10 melanoma cells. Biochem Biophys Res Commun 2006;341:614-9.
61. Gurfinkel DM, Rao AV. Soyasaponins: The relationship between chemical structure and colon anticarcinogenic activity. Nutr Cancer 2003;47:24-33.
62. Ellington AA, Berhow MA, Singletary KW. Inhibition of Akt signaling and enhanced ERK1/2 activity are involved in induction of macroautophagy by triterpenoid B-group soyasaponins in colon cancer cells. Carcinogenesis 2006;27:298-306.
63. Xiao JX, Huang GQ, Zhu CP, Ren DD, Zhang SH. Morphological study on apoptosis Hela cells induced by soyasaponins. Toxicol *In Vitro* 2007;21:820-6.
64. Zhu J, Xiong L, Yu B, Wu J. Apoptosis induced by a new member of saponin family is mediated through caspase-8-dependent cleavage of Bcl-2. Mol Pharmacol 2005;68:1831-8.
65. Khang D, Dung T, Elzaawely A, Xuan T. Phenolic profiles and antioxidant activity of germinated legumes. Foods 2016;5:27.
66. Dai J, Mumper RJ. Plant phenolics: Extraction, analysis and their antioxidant and anticancer properties. Molecules 2010;15:7313-52.