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# Soybean: is it the most useful plant for animals

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**ABSTRACT**

*Soybean is an important crop, with processed soybeans being the second largest source of vegetable oil and the largest source of animal protein feed in the world. The aim of this study was to review its pharmacological effects for animals. This review article was carried out by searching studies in PubMed, Medline, Web of Science, and Iran Medex databases .The initial search strategy identified about 105 references. In this study 53 studies was accepted for further screening and met all our inclusion criteria (in English, full text, therapeutic effects of soybean and dated mainly from the year 1998 to 2016).The search terms were "soybean", "therapeutic properties", "pharmacological effects", "application for animals" . The result of this study was indicated that this plant is useful for Milk yield activity, Photosynthetic yield activity, Phagocytic capacity, Effect on growth, anticancer effect in animals. This plant is beneficial for both human and animal usage. Various combinations and numerous medicinal properties of its coat, cake, extract, oil, and leaves demand further and more studies about the other useful and unknown properties of this multipurpose plant.*

**Key words**: soybean, pharmacology, Pharmacognosy, animal usage

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## INTRODUCTION

The soybean**(** Glycine max) belong to Leguminosae[1]is indigenous to East Asia, widely grown for its edible bean[2]. Soybeans can be broadly classified as "vegetable" (garden) or field (oil) types. Vegetable type cook more easily, have a mild, nutty flavor, better texture, are larger in size, higher in protein, and lower in oil than field types. This plant possess various uses. One of the main uses of soybeans globally is as livestock feed, predominantly in the form of soybean meal. Its seeds are rich in omega-3 fatty acids, while soy is mainly rich in omega-6.processed soybeans is the second largest source of vegetable oil and the largest source of animal protein feed in the world.

Soybean is important for the high protein meal used for livestock feed formulations. Carbohydrates contribute positively or negatively to the potential metabolizable energy in soybean meal. Nodules on soybean roots are responsible for symbiotic nitrogen fixation, enabling soybean plants to obtain sufficient nitrogen for growth and seed production. Because nitrogen is an essential, but often limiting, nutrient for plant growth, improvements in nitrogen fixation are highly required in agriculture [3].

Soy protein products can be good substitutes for animal products because, unlike some other beans, soy offers a 'complete' protein profile. Soy protein products can replace animal-based food possessing complete proteins; however, it contain more fat, especially saturated fat without requiring major adjustments elsewhere in the diet [4].

Soybean seed contains 18-19% oil. To extract soybean oil from seed, the soybeans are cracked, adjusted for moisture content, rolled into flakes and solvent-extracted with commercial hexane. The oil is then refined, blended for different applications, and sometimes hydrogenated. Soybean oils, both liquid and partially hydrogenated, are exported abroad, sold as "vegetable oil", or end up in a wide variety of processed foods [5].

Soybean meal, or soymeal, is the material remaining after solvent extraction of oil from soybean flakes, with a 50% soy protein content. The meal is 'toasted' and ground in a hammer mill. Ninety-seven percent of soybean meal production globally is used as livestock feed. Soybean meal is also used in some dog foods.

In addition to their use in livestock feed, soybean products are widely used for human consumption [6].

**Chemical compound**

Protein and soybean oil content account for 56% of dry soybeans by weight (36% protein and 20% fat. The remainder consists of 30% carbohydrates, 9% water and 5% ash . Soybeans comprise approximately 8% seed coat or hull, 90% cotyledons and 2% hypocotyl axis or germ[7].Saponins, a class of natural surfactants (soaps), are sterols that are present naturally in a wide variety of food-plants, including vegetables, legumes, and cereals–ranging from beans [8] and spinach to tomatoes, potatoes and oats [9]. Whole soybeans contain from 0.17 to 6.16% saponins, 0.35 to 2.3% in defatted soy flour and 0.06 to 1.9% in tofu. Legumes such as soybean and chickpeas are the major source of saponins in the human diet. Sources of non-dietary saponins include alfalfa, sunflower, herbs and barbasco[10].Soy contains isoflavones like genistein and daidzein. It also contains glycitein, an O-methylated isoflavone which accounts for 5–10% of the total isoflavones in soy food products. Glycitein is a phytoestrogen with weak estrogenic activity, comparable to that of the other soy isoflavones[11]. Soybeans also contain the isoflavones genistein and daidzein, types of phytoestrogen. Soy's content of isoflavones are as much as 3 mg/g dry weight. Isoflavones are polyphenol compounds, produced primarily by beans and other legumes, including peanuts and chickpeas. Isoflavones are closely related to the antioxidant flavonoids found in other plants, vegetables and flowers. Isoflavones such as genistein and daidzein are found in only some plant families, because most plants do not have an enzyme, chalconeisomerase which converts a flavone precursor into an isoflavone.

Glyceollins are molecules belonging to the pterocarpans family. They are also found in the soybean and have been found to have an antifungal activity against *Aspergillussojae*, the fungal ferment used to produce soy sauce. They are phytoalexins with an antiestrogenic activity.

## MATERIALS AND METHODS

**Methods**

Methods: This review article was carried out by searching studies in PubMed, Medline, Web of Science, and Iran Medex databases .The initial search strategy identified about 105 references. In this study53studies was accepted for further screening and met all our inclusion criteria (in English, full text, therapeutic effects of *soybean* and dated mainly from the year 1998 to 2016).The search terms were “soybean”, “therapeutic properties”, pharmacological effects.

**Milk yield activity**

The effect of soybeans roasted at different temperatures on milk yield and milk fatty acid composition was evaluated in mid-lactation Holstein cows.it showed that Milk from cows fed roasted soybeans had more long-chain fatty acids and fewer medium-chain fatty acids than milk from cows fed Ca-FA. Compared with milk from cows fed the CON diet, total milk fat contents of conjugated linoleic acid were higher for cows fed the roasted soybean diets. Among different roasting temperatures, soybeans roasted at 115°C led to higher milk production and lower DMI. Thus, it can be concluded that the use of roasted soybeans in dairy cow could improve the health indices of milk for human nutrition.[12]

Effect of One kind of soybean supplements called SFSB was evaluated in diets for lactating dairy Holstein cows. It showed that Animals were fed lactating dairy cow diets be similar in Dry matter intake, milk production, milk fat

percentage, and feed efficiency. Besides, it demonstrated that SFSB can be substituted for soybean meal and commercial fat sources while maintaining milk and milk component production and decrease milk urea nitrogen concentration[13]

The effects of rapeseed and soya bean expeller (SBE) supplementation on digestion and milk production responses in dairy cows were investigated. the milk protein production increased only 9% and energy-corrected milk production by 7% when high level of protein supplementation (on average 2.9 kg DM/day) was compared with the control diet without protein supplementation showing that dairy production could be sustained at a high level even without external protein supplements, at least in the short term. The economic and environmental aspects need to be carefully evaluated when decisions about protein supplementation for dairy cows are taken.[14]

the effects of different sources of FA supplementation on apparent total tract nutrient digestibility, milk yield and composition, and energy balance (EB) of cows during the transition period and early lactation were evaluated.it showed Calculated efficiency of milk yield was not altered by diets. FA supplementation increased EB during the postpartum period. Experimental diets increased long-chain FA in milk. In addition, cows fed CSFA had higher C18:1 trans-11 and cis-9, trans-11 FA than cows fed WS. Although supplemental C18:2 and C18:3 FA did not affect the milk yield of cows, they positively affected EB and increased unsaturated long-chain FA in milk fat.[15].

**Photosynthetic yield activity**

The effects of varied populations and duration of soybean aphids on soybean photosynthetic rates and yield in two experiments was examined and it was recommended that modern soybean plants can withstand higher aphid pressure than previously assumed. Moreover, soybean plants also responded positively through a compensatory photosynthetic effect to moderate population pressure, contributing to stable or increased yield.[16]

A drought-resistant soybean cultivar Jinda 70 and a drought-sensitive soybean cultivar Jindou 26 were examined and The results showed that as the degree of drought stress was aggravated, all of the indices including leaf area, chlorophyll content, net photosynthetic rates (Pn), stomatal conductance (g(s)), transpiration rate (Tr), intercellular CO2 concentration (Ci), plant mass, plant height, seed yield, and harvest index in the two cultivars declined. [17]

**Phagocytic capacity**

The effects of supplemental n-3 and n-6 fatty acid (FA) sources on cellular immune function of transition dairy cows was examined. Diets containing n-3 and n-6 FA sources increased phagocytosis capacity of leukocytes and monocytes and phagocytosis activity of monocytes. Furthermore, n-3 FA source increased phagocytic capacity of leukocytes and neutrophils and increased phagocytic activity in monocytes and neutrophils when compared with n-6 FA sources. Supplemental FA effects on adaptive immune system included increased percentage of T-helper cells, T-cytotoxic cells, cells that expressed IL-2 receptors, and CD62 adhesion molecules. The results of this study suggest that unsaturated FA can modulate innate and adaptive cellular immunity and trigger a proinflammatory response. The n-3 FA seems to have a greater effect on phagocytic capacity and activity of leukocytes when compared with n-6 FA.[18]

**Effect on growth**

The effects of different levels of soya bean oil in the total diet on the growth rate, metabolic changes, and oestrogen and progesterone release in Saanen goats was investigated. It was demonstrated that although the inclusion of 4% soya bean oil in the diet decreased dry matter intake and growth rate, it increased progesterone concentration and the percentage of goats with a functional Corpus luteum, suggesting that the inclusion of soya bean oil accelerated puberty in prepubertal goats.[19]

120 commercial broiler chicks randomly allocated to two experimental groups. The experimental diets, differing only in protein source, either solvent-extracted soya bean meal (SBM) or traditional (non-genetically modified) full-fat soya bean seeds (FFS), were prepared using practical corn-based formulation designed to meet nutritional requirements of broilers. In many cases, skeletal abnormalities resulted in considerable changes in gait pattern, and in some instances, the pathology of leg bones was so advanced that the affected individuals were unable to walk, but this deformity was not seen in SBM group. From this study, it can be inferred that raw soya beans contain factors that have some specific detrimental effects on skeletal system of chickens.[20]

the efficacy of β-mannanase supplementation to a diet based on corn and soya bean meal (SBM) on growth performance, nutrient digestibility, blood urea nitrogen (BUN), faecal coliforms and lactic acid bacteria, and noxious gas emission in growing pigs was examined and it was found that mannanase supplementation had no influence on growth performance and nutrient digestibility but showed a positive effect on reducing coliform population and tended to reduce NH3 emission. Dehulled SBM increased G:F ratio and hulled SBM tended to reduce NH3 emission[21].

In a study, it was examined if variation in planting date and maturity group of soybeans had an impact on management of *M. cribraria* populations. Three experimental fields were located in North Carolina (2) and South Carolina (1), and the tests replicated during 2012 and 2013. Treatments consisted of three planting dates, four maturity groups, and insecticide treated versus untreated, at each location. More *M. cribraria* were found in untreated early planted soybeans than late planted soybeans. Generally, maturity group did not influence population densities of *M. cribraria*. Yield was significantly influenced by the interaction between planting date and maturity group. There was a negative linear relationship between *M. cribraria* populations and soybean yield. Although early planted soybeans may avoid drought conditions and potentially large populations of defoliators, these fields may be at greater risk for infestation by *M. cribraria*.[22]

**Anticancer effect**

A comprehensive phytochemical study of the chemical constituents of green vegetable soybeans resulted in the isolation of two new alkaloids, soyalkaloid A, 1, and isoginsenine, 2, together with four known ones, ginsenine, 3, (1S,3S)-1-methyl-1,2,3,4-tetrahydro-β-carboline-3-carboxylic acid, 4, (1R,3S)-1-methyl-1,2,3,4-tetrahydro-β-carboline-3-carboxylic acid, 5, and indole-3-carboxylic acid, 6. All of the alkaloids were isolated from soybeans for the first time, and compound 1 was a new indole-type alkaloid with a novel carbocyclic skeleton. Their inhibitory activities on the proliferation of concanalin A-activated lymphocytes were assessed by CCK8 assay[23].

Soya bean meal with maggot meal at difference percentages was replaced and it showed that tenderness and juiciness increased significantly in group C and B respectively. The colour and flavour were most accepted in group B and C. The results indicate that replacement of soya bean meal at the rate of 30% in broiler feed produced most favourable results.[24]

an ex situ conservation collection, the USDA germplasm collection, genotyped at 32,416 SNPs to identify population structure and test for associations with bioclimatic and biophysical conditions variables in Glycine soja, the wild progenitor of Glycine max (soybean) was investigated. Candidate loci were detected that putatively contribute to adaptation to abiotic stresses. The identification of potentially adaptive variants in ex situ collection may permit a more targeted use of germplasm collections.(25)

the reduction in OA level in soya bean (up to 73%) and grass pea (up to 75%) seeds by constitutive and/or seed-specific expression of an oxalate-degrading enzyme, oxalate decarboxylase (FvOXDC) of Flammulinavelutipes were reported. these results demonstrated improved seed quality and tolerance to the fungal pathogen in two important legume crops, by the expression of an oxalate-degrading enzyme.[26]

The effect of prenatal CSB Plus supplementation on birth weight and secondary outcomes of low birth weight (<2500 g), small for gestational age, birth length and head circumference, preterm birth (<37 wk), maternal weight gain, and anemia. In Cambodian women, CSB Plus consumed during pregnancy did not significantly increase maternal weight gain or improve birth size but did reduce maternal anemia in late gestation and preterm birth in comparison with women consuming a normal diet. The unexpectedly higher rate of fetal loss in the treatment group is concerning and warrants further investigation[27]

The occurrence of fumonisins (FBs) and fungi in dry soybeans sold for human consumption was examined. The variation levels were 138-1495 $\mu g\ kg^{-1}$ and 178-552 $\mu g\ kg^{-1}$ for $FB_1$ and $FB_2$, respectively. In addition, potentially toxigenic fungi as Fusarium, Aspergillus and Penicillium genera were isolated in the samples. These can be considered as indicator-toxin and can produce considerable amounts of mycotoxins. Despite FB presence in the soybeans for human consumption, there is no legal regulation. Therefore, it is important to emphasise the need for frequent monitoring of these contaminants in soybeans.[28]

Microencapsulation method was adopted to resolve the stability problem and for this hydrogenated soya bean oil (HSO) was used as encapsulating agent .The results from the study showed that coating of 90% and 60% CBT was successful with respect to all desired evaluation parameters. Optimized formulation was kept for 6 months stability study as per ICH guidelines, and there was no change in color, moisture content, drug content, and no fishy odor was observed[29]

The impact of gain of virulence mutation(s) on fitness of virulent variants derived from three avirulent SMV strains in a soybean genotype lacking the Rsv4 gene was investigated and it was found that gain of virulence mutation(s) by all avirulent viruses on Rsv4-genotype soybean is associated with a relative fitness loss in a susceptible host. Implication of this finding on durable deployment of the Rsv4 gene in soybean is discussed. This article is protected by copyright. All rights reserved[30].

The effects of high levels of whole raw soya beans in the diets of lactating cows was evaluated. This diet resulted in significantly lower milk and protein yield ($p < 0.05$) in comparison with C diet. Significant C18:2 cis fatty acids were observed in milk concentrations ($p < 0.05$) for G240 diet. The use of high level of whole raw soya beans in dairy cow diets improves the unsaturated fatty acid profile in milk, and the diets led to minor alterations in the digestive processes and animal metabolism[31].

The effects of high hydrostatic pressure (HHP) at elevated temperature (60 °C) and 2 dielectric heating (DH) methods (radio frequency [RF], and microwaving [MW]) on the nutritional compositions and removal of antinutritional factors in black soybeans were studied. The most abundant saponins was decreased >22% in DH treated samples. MW and HHP led to higher in vitro protein digestibility, RF and MW promoted protein aggregation from atomic force microscope topography, but HHP caused more damages on protein subunits as seen from SDS-PAGE image.[32]

It was proposed that the SYCMV-derived vector can be used for gene function study or expression of useful heterologous proteins in soybeans.[33]

The prevalence of depressive symptoms and the association between soybeans consumption and depressive symptoms among older residents was examined. The result was shown that Women had significantly higher prevalence of depressive symptoms than men in rural China. Individuals who rarely consume soybeans or soybean products are more likely to suffer depressive symptoms. Rural elderly residents should be cautiously screened to prevent or treat depression[34].

Factors that affected the acceptability and consumption of CSBP supplements among pregnant women was examined.CSBP was generally well accepted in this population. However, organoleptic factors and perceptions regarding nutrition and weight gain in pregnancy, particularly for first-time mothers, were barriers to increasing acceptance among Cambodian women.[35]

The protective effects and mechanisms of traditional (TFC) and standardized Chungkookjang fermented with Bacillus licheniformis (BLFC) against ischemia/reperfusion damage in the hippocampal CA1 region and against hyperglycemia after transient cerebral ischemia in gerbils. It concluded that TFC and BLFC may prevent and alleviate neuronal cell death in the hippocampal CA1 region and neurological symptoms and post stroke hyperglycemia in gerbils with artery occlusion. This might be associated with increased isoflavonoidaglycones.(36)
The digestible energy (DE) and metabolisable energy (ME) in 22 sources of soybean meal (SBM) produced from soybeans from different countries and subsequently to establish equations for predicting the DE and ME in SBM based on their chemical composition was examined. There were no differences in the DE and ME of SBM among the different soybean sources used in this experiment. The DE and ME of SBM of different origin can be predicted based on their chemical composition when fed to growing pigs.[17]

the association between soya food consumption and serum thyroid-stimulating hormone (TSH) concentrations in North American churchgoers belonging to the Seventh-day Adventist denomination that encourages vegetarianism was examined. The result showed that In women high consumption of soya was associated with elevated TSH concentrations. No associations between soya intake and TSH were found in men.[37]

the benefit of the low FODMAP diet versus the "Milk, egg, wheat and soya" (MEWS) free diet for symptom control in patients with functional gut disorders and/or food allergy from June 2013 to June 2015 was assessed. This review suggests that although there were larger referral rates for the MEWS diet both the MEWS and low FODMAP diet appear to be equally effective dietary approaches for treating patients with functional gut disorders and/or food allergy.[38]

Seven strobilurin fungicides were pre-concentrated from soya-based drinks using dispersive liquid-liquid micro-extraction (DLLME) with a prior protein precipitation step in acid medium. Detection limits in the 4-130 and 0.8-4.5 ng g(-1) ranges were obtained for DAD and MS/MS, respectively. The DLLME-LC-DAD-MS method was applied to the analysis of 10 different samples, none of which was found to contain residues of the studied fungicides.[39]
Analysis of the community compositions of rhizosphere fungi in soybeans continuous cropping fields. The dominant eumycote fungal were identified to be Ascomycota and Basidiomycota in the three soil samples. Continuous cropping of soybean affected the diversity of fungi in rhizosphere soils and increased the abundance of Thelebolus and Mortierellales significantly. Thanatephorus, Fusarium, and Alternaria were identified to be the dominant pathogenic fungal genera in rhizosphere soil from continuously cropped soybean fields.(40).EVOO ameliorates the adverse effects of GMSB on reproductive organs in adult male albino rats. This protective action of EVOO justifies its use against the oxidative damage induced by GMSB in reproductive organs.[41]

The total uptake and translocation of seed-applied [$^{14}$ C]imidacloprid, [$^{14}$ C]clothianidin and [$^{14}$ C]flupyradifurone into different plant parts in three soybean vegetative stages (VC, V1 and V2) were investigated.it was demonstrated that uptake and distribution of insecticides used as seed treatments in soybean. The uptake and translocation of these insecticides differed in response to soil moisture stress.[42]

The clean-up effects of three dispersive sorbents were evaluated in terms of the residue mass for extracts after evaporation and recoveries. The study showed that this method is simple, sensitive, environmental, and thus suitable for the determination of the 32 sulfonylurea herbicide residues in sweet corns and green soy- beans.[43]

Changes in protein content, peroxidase activity, and isozyme profiles in response to soybean aphid feeding were documented at V1 .The differences in peroxidase activity observed between infested and control V3 stage KS4202 plants at these two time points suggest that peroxidases may be playing multiple roles in the tolerant plant. Native gels stained for peroxidase were able to detect differences in the isozyme profiles of aphid-infested and control plants for both KS4202 and SD76R.[44]

Six soybean cultivars ('ZH13', 'ZH57', 'LD10', 'HH35', 'HH43', and 'ZGDD') were evaluated in terms of yield, photosynthetic efficiency, insoluble dietary fiber and ions uptake efficiency.it showed that 'HH35' had the higher photosynthetic efficiency of soybean leaves with regard to photosynthetic rate and instantaneous carboxylation efficiency, whereas chlorophyll ratio and carotenoids content were no difference with the other cultivars[45].

The effects of soya consumption on the lipid profile using published trials was examined. This study illustrated the beneficial effects of soya proteins on serum LDL, HDL, TAG and TC concentrations. The effect was stronger in hypercholesterolaemic subjects. Whole soya foods appeared to be more beneficial than soya supplementation, whereas isoflavone supplementation had no effects on the lipid profile.[46]

The circular bacteriocinenterocin AS-48, applied singly or in combination with phenolic compounds or with 2-nitro-1-propanol was investigated and it showed that the potential of enterocin AS-48 in combination with 2NPOH for inactivation of staphylococci.[47]

WaaL knock-out mutant and its complemented strain named JS015 and CS015 was evaluated and the result was revealed that JS015 failed to nodulate the host plant soybean, indicating that the rhizobialwaaL gene is responsible for the establishment of a symbiotic relationship between soybean and B. japonicum.[48]

The antioxidative and anti-inflammatory activities of non-fermented or Bacillus subtilis-fermented soybeans and sword beans (red and white) was investigated. The results was shown that B. subtilis-fermented sword beans are potential natural antioxidant sources and anti-inflammatory agents for the food industry[49]

In a review study, recent advances and patents regarding soybean or processed soy food compounds which exhibit immunomodulatory activity in immune diseases, particularly allergy, by mediating the suppression of inflammatory pathways was discussed and its preventive role was confirmed[50]

Relevant patents and bioactive proteins and peptides obtainable from soybeans were reviewed and it was suggested that processes for the production and formulation of these peptides are given, together with specific examples of their therapeutic potential and possible areas of application.[51]

The effects of two intervention diets (non-soya legume-based therapeutic lifestyle change (TLC) diet v. isoenergetic legume-free TLC diet) on inflammatory biomarkers among type 2 diabetic patients was investigated. Compared with the legume-free TLC diet, the non-soya legume-based TLC diet significantly decreased high-sensitivity C-reactive protein, IL-6 and TNF-α in overweight diabetic patients. The replacement of two servings of red meat by non-soya legumes in the isoenergetic TLC diet for a period of 3 d per week reduced the plasma concentrations of inflammatory markers among overweight diabetic patients, independent of weight change.[52]

**Potential side effects**

**Allergy**

Only a few reported studies have confirmed allergy to soybean by direct challenge with the food under controlled conditions[53]. Soybean can also trigger symptoms via food intolerance, a situation where no allergic mechanism can be proven. In an animal study, soybeans showed to be safe, wholesome, and nutritionally valuable as the other soybean meals tested, including those varieties for which histories of safe use have been established and well documented.[54]

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