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PHARMACOLOGY OF *ECHINOCHLOA CRUS-GALLI* - A REVIEW

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Abstract:
The preliminary phytochemical studies showed that *Echinochloa crus-galli* contained alkaloids, glycosides, carbohydrates, flavonoids, phytosterols/terpenes, proteins, and saponins. Nutritional analysis of plant grains showed that they contained protein 9.0-13.7%, fat 2.3-3.5%, carbohydrates 63.8-79.9%, fiber 5.2-29.9%, energy 310-364 k cal, Ca 8 mg/ 100g, Fe 2.9 mg/ 100g, thiamin 0.41 mg/ 100g, riboflavin 0.28 mg/ 100g and niacin 4.5 mg/ 100g. The previous pharmacological studies revealed that the plant possessed antidiabetic, anticancer, antioxidant, antimicrobial hypolipidemic and anti-obesity effects. The current review highlights the chemical constituents and pharmacological effects of *Echinochloa crus-galli*.

Ketwords: *Echinochloa crus-galli*, Pharmacology, contents

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INTRODUCTION:

In the last few decades there has been an exponential growth in the field of herbal medicine. It is getting popularized in developing and developed countries owing to its natural origin and lesser side effects. Plants are a valuable source of a wide range of secondary metabolites, which are used as pharmaceuticals, agrochemicals, flavours, fragrances, colours, biopesticides and food additives [1-14]. The preliminary phytochemical studies showed that *Echinochloa crus-galli* contained alkaloids, glycosides, carbohydrates, flavonoids, phytosterols/terpenes, proteins, and saponins. Nutritional analysis of plant grains showed that they contained protein 9.0-13.7%, fat 2.3-3.5%, carbohydrates 63.8-79.9%, fiber 5.2-29.9%, energy 310-364 k cal, Ca 8 mg/ 100g, Fe 2.9 mg/ 100g, thiamin 0.41 mg/ 100g, riboflavin 0.28 mg/ 100g and niacin 4.5 mg/ 100g**.** The previous pharmacological studies revealed that the plant possessed antidiabetic, anticancer, antioxidant, antimicrobial hypolipidemic and anti-obesity effects. The current review will discuss the chemical constituents and pharmacological effects of *Echinochloa crus-galli*.

Synonyms:

Echinochloa caudata, Echinochloa commutata, Echinochloa crus-corvi,Echinochloa crus-galli var. aristata, Echinochloa crus-galli forma atra, Echinochloa crus-galli var. austrojaponensis, Echinochloa crus-galli var. breviseta, Echinochloa crusgalli var. caudata, Echinochloa crus-galli var. crus-corvi, Echinochloa crus-galli var. crus-galli, Echinochloa crus-galli var. echinata, Echinochloa crus-galli subsp. erecta, Echinochloa crus-galli forma exigua, Echinochloa crus-galli var. formosensis, Echinochloa crus-galli var. kasaharae, Echinochloa crus-galli var. longiseta, Echinochloa crus-galli var. michauxii, Echinochloa crus-galli var. mitis, Echinochloa crus-galli forma mixta, Echinochloa crus-galli var. muricata, Echinochloa crus-galli var. mutica, Echinochloa crus-galli var. praticola, Echinochloa crus-galli forma purpurea, Echinochloa crus-galli forma rohlenae, Echinochloa crus-galli subsp. spiralis, Echinochloa crus-galli var. submutica, Echinochloa crus-galli forma. vittata, Echinochloa crus-galli var. zelayensis, Echinochloa crus-pavonis var. austrojaponensis, Echinochloa crus-pavonis var. breviseta, Echinochloa crus-pavonis var. praticola, Echinochloa crusgalli var. breviseta, Echinochloa crusgalli subsp. submutica, Echinochloa dubia, Echinochloa echinata, Echinochloa formosensis, Echinochloa glabrescens, Echinochloa hispida, Echinochloa macrocarpa var. aristata, Echinochloa macrocarpa var. mutica, Echinochloa macrocorvi, Echinochloa madagascariensis, Echinochloa micans, Echinochloa muricata, Echinochloa muricata var. occidentalis, Echinochloa occidentalis, Echinochloa paracorvi, Echinochloa persistentia, Echinochloa pungens, Echinochloa pungens var. coarctata, Echinochloa pungens var. occidentalis, Echinochloa spiralis, Echinochloa tzvelevii and *Echinochloa zelayensis* [15-17].

Taxonomic classification:

Kingdom: Plantae; **Subkingdom:** Tracheobionta; **Superdivision**: Spermatophyta; **Division**: Magnoliophyta; **Class**: Liliopsida**; Subclass**: Commelinidae; **Order**: Cyperales**; Family**: Poaceae / Gramineae; **Genus**: *Echinochloa*; **Species**: *Echinochloa crus-galli* [16].

Common names:

Arabic: Danãn, Denieba, Dhunaybah; **Chinese**: Bai, Bai cao; **English**: barnyard grass, barnyard millet, cocksfoot grass, cockshin grass, cockspur , cockspur, cockspur-panic, water grass, wild millet; **French**: echinochloa pied-de-coq, panic pied-de-coq, pied de coq; **German**: gewöhnliche Hühnerhirse, Hühnerhirse; **India**: Samak, Sanwak; **Italian**: Giavone comune, Giavone, Panicastrella; **Japanese**: hie; **Korean**: pi; **Norwegian**: Hønsehirse; **Portuguese**: Capim-arroz; **Spanish**: arrocillo, pata de gallo, pie de gallina, zacate de agua; **Swedish**: hönshirs; **Turkish**: Dineba [18].

Distribution:

The plant is distributed in **Africa** (Tanzania, Uganda, Sudan, Egypt, Morocco, Tunisia, Mozambique, South Africa, Swaziland, Guinea, Senegal, Madagascar and Mauritius); Asia (China, Japan, Korea, Taiwan, Uzbekistan, Afghanistan, Iran, Iraq, Palestine, Lebanon, Bangladesh, Bhutan, India, Nepal; Pakistan, Sri Lanka, Cambodia, Laos, Myanmar, Thailand, Vietnam, Indonesia, Malaysia and Philippines); **Australasia**; **Europe** (Belarus, Estonia, Ukraine, Austria, Belgium, Czech Republic, Germany, Netherlands, Switzerland, Denmark and Norway); **Northern America** (Mexico); **Pacific** (U.S. Outlying Islands - Johnston Atoll, Midway Islands, United States – Hawaii, Marshall Islands, Micronesia, French Polynesia and New Caledonia); **Southern America** (Brazil, Venezuela, Argentina, Chile, Paraguay, Uruguay, Colombia and Peru) [18].

Description

Annual, culms erect to decumbent, 0.8-1.5 m tall, rather thick, branching at base; leaves flat, glabrous, elongate, 30-50 cm long, 1-2 cm broad, scabrous, slightly thickened at margin; ligules absent; sheaths smooth, lower ones often reddish; panicle 8-30 cm long, green or purple, exserted, somewhat nodding, densely branched, the branches to 5 cm long, erect or ascending, sessile; spikelets 3-4 mm long, densely arranged on branches, ovoid, awnless, but move often long-awned, pale green to dull purple, short-bristly along veins; racemes spreading, ascending or appressed, the lower somewhat distant, as much as 10 cm long, sometimes branched; glumes and lower

lemma minutely hairy on surface with longer more rigid hairs on veins; first glume about two-fifths as long as spikelet, deltoid, the second as long as the spikelet, short-awned; sterile lemma membranous, with a straight scabrous awn, 2-4 cm long or awnless; fertile lemma ovate-elliptic, acute, pale yellow, lustrous, smooth, 3-3.5 mm long[19].

Traditional uses:

Seed can be cooked whole or ground into a flour and used in porridges, macaroni, dumplings etc. The seed characterized by somewhat bitter flavor [20]. It was used traditionally as preventative and tonic, for carbuncles, hemorrhage, sores, spleen trouble, cancer and wounds [21].

Chemical constituents:

The preliminary qualitative phytochemical studies of 70% (v/v) hydroalcoholic extract of *Echinochloa crus-galli* grains revealed that the grains contained alkaloids, glycosides, carbohydrates, flavonoids, phytosterols/terpenes, proteins, and saponins [22].

Nutritional analysis of plant grains showed that they contained moisture 9.7%, protein 9.0-13.7%, fat 2.3-3.5%, carbohydrates 63.8-79.9%, fiber 5.2-29.9%, ash 8.4-11.2%, energy 310-364 k cal, Ca 8 mg/ 100g, Fe 2.9 mg/ 100g, thiamin 0.41 mg/ 100g, riboflavin 0.28 mg/ 100g and niacin 4.5 mg/ 100g [23-26].

Amino acid analysis showed that the plant seed contained alanine, arginine, asparagines, aspartic acid, glutamic acid, glutamine, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine, valine and gamm amino butyric acid [27].

Total phenolic and total flavonoid contents of 1% acidified methanol extract of seeds of *Echinochloa crus-galli* were 1.2083±0.013 GAE/g and 845.33±2.49 Qu.E/g. However, the total phenolic and total flavonoid contents in 95% ethanol extracs of seeds of *Echinochloa crus-galli* were 245.33±2.49 GAE/g and 1.078±0.014 Qu.E/g, while, the total phenolic and total flavonoid contents in the aqueous extract of seeds of *Echinochloa crus-galli* were 345.33±7.45 GAE/g and 0.302±0.0078 Qu.E/g respectivily [28].

The phenolic content of the selected extracts of *Echinochloa crus-galli* were determined with chromatographic techniques (thin layer chromatography, high performance thin layer chromatography and high performance liquid chromatography) while the total phenol was determined by UV method. All the results of analytical methods were compared with standard phenolic compounds. The methanol macerated extract contained maximum total phenolic content (0.719 ± 0.67 mg GAE/g) than other extract by soxhlation. Eleven compounds identified by chromatographic techniques in the plant. The dominant phenolic compounds were flavonoids and phenol carboxylic acids including myricetin, quercetin, artemisinin, cyanidin, kaempferol, luteolin, 5,7-dihydroxy-3',4',5'-trimethoxy flavones, bilobol and its derivatives [29-30].

The chloroform and ethyl acetate fractions were subjected to several chromatographic separations to render pure phenolic compounds. 5,7-dihydroxy-3′,4′,5′-trimethoxy flavone, 5,7,4′-trihydroxy-3′,5′-dimethoxy flavone (tricin), quercetin, flavone, apigenin-8-*C*-sophoroside, 2-methoxy-4-hydroxy cinnamic acid, *p*-coumaric acid and quercetin-3-*O*-glucoside were isolated from the plant grains [31].

Pharmacological effects:

Antidiabetic effect:

The anti-diabetic activity of 70% hydroalcoholic extract of *Echinochloa crus-galli* grains (HAEC) was studied in normal and alloxan induced diabetic rats. A single dose was studied in the normal rats for 12 hrs. Oral glucose tolerance test (OGTT) was performed in normal rats after receiving 2g/kg glucose orally. Diabetes was induced by alloxan (120mg/kg, ip) and three different doses of HAEC (200, 400 and 600mg/kg, po) were administered orally to experimental diabetic induced rats for 21 days. Glibenclamide (5mg/kg po) was used as standard reference. Fasting blood glucose levels, changes in body weight and organ weight, serum albumin, urea, total protein, creatinine, total lipid profile, haemoglobin, GSH, SOD and TBARS were evaluated. Histopathological examination of pancreas was also performed. Oral glucose tolerance test clearly indicated that 400 and 200mg/kg po HAEC significantly reduced blood glucose levels. Single dose of HAEC on normal rats showed a significant decrease in the fasting blood glucose levels when compared with the normal control rats. In diabetic rats, treatment with 400 and 200mg/kg, po showed significant reduction in the fasting blood glucose levels, serum cholesterol, serum triglycerides, LDL-C and VLDL-C levels. A significant escalation was seen in the levels of HDL-C, haemoglobin, body weight and liver weight. The anti-oxidant TBARS, GSH and SOD levels were improved in HAEC treated groups compared with untreated diabetic rats [22].

Anticancer effect:

Bioassay-guided fractionation of the seeds of *Echinochloa crus-galli* lead to isolation of two cytotoxic flavonoids. They showed cytotoxic effect when screening against four human cancer cell lines [MCF-7 (breast cells), HCT-116 (colon cells), HELA (cervical cells) and HEPG-2 (liver cells)] using the sulforhodamine B (SRB) colorimetric assay. Different extracts of the seeds of *Echinochloa crus-galli* showed a dose dependent inhibition in a range of 5–50µg/ml. The ethanolic extract (95%) proved to be the most active extract against HELA cell line (IC_{50}=12µg/ml). On the other hand, the hexane and

chloroform fractions exhibited moderate activities against HEPG-2 (IC_{50}=15.5µg/ml) and HCT-116 (IC_{50}=17.1µg/ml) cell lines, respectively. Two flavonoids were isolated from the chloroform fraction, they were identified as 5,7-dihydroxy-3',4',5'-trimethoxy flavone and quercetin. 5,7-dihydroxy-3',4',5'-trimethoxy flavones, they exhibited potent cytotoxic activities against HELA cell line (IC_{50}=4.5µg/ml) and HEPG-2 cell line (IC_{50}=4.5µg/ml), which were comparable to doxorubicin (IC_{50}=4.3µg/ml). Quercetin showed moderate cytotoxic effects against MCF-7, HCT-116, HELA and HEPG-2 cell lines with IC_{50} values of 12.7, 20.4, 13.9 and 11.3µg/ml, respectively [29].

The sulforhodamine B assay was used to assess the cytotoxicity of *Echinochloa crus-galli* against four human cancer cell lines. The ethanolic extract (70%) was the most active extract against HCT-116 and HELA cell lines (IC_{50} = 11.2 ± 0.11 and 12.0 ± 0.11 µg/ml, respectively). The chloroform and ethyl acetate fractions exhibited highest activities against HCT-116 cell lines. The chloroform and ethyl acetate fractions were subjected to several chromatographic separations to render pure phenolic compounds. 5,7-dihydroxy-3′,4′,5′-trimethoxy flavone, 5,7,4′-trihydroxy-3′,5′-dimethoxy flavone (tricin), quercetin, flavone, apigenin-8-*C*-sophoroside, 2-methoxy-4-hydroxy cinnamic acid, *p*-coumaric acid and quercetin-3-*O*-glucoside were isolated from the plant grain. All the isolated phenolic compounds exhibited various significant activities against the four human carcinoma where the methoxylated flavones were the most active, it showed effect comparable to doxorubicin [31].

Hypolipidemic and anti-obesity effects:

The anti-obesity effect of hydroalcoholic extracts of *Echinochloa crus-galli* grains was evaluated in high fat diet induced obesity in albino rats. Obesity was induced by administration of high fat diet for 4 weeks, the obtained obese rats were treated with hydroalcoholic extracts of *Echinochloa crus-galli* grains in a dose of 200, 400 and 600 mg/kg, bw orally for next 4 weeks. *Echinochloa crus-galli* caused significant decrease in body weights, adipose tissue weight, SGOT and SGPT levels, blood glucose levels, LDL-C, VLDL-C, total cholesterol, triglyceride levels, atherogenic index, with a significant increase in HDL-C levels compared with high fat diet control group [32].

The effect of *Echinochloa crus-galli* extract as antihypercholesterolemic therapy was evaluated by performing *in vivo* studies and identifying its effects on food consumption, weight gain, fecal fat excretion, serum lipid and biochemical profiles. The animal group administered methanolic extract of the plant showed decreased levels of TC, LDL, VLDL, TG, HDL+VLDL, VLDL+LDL, LDL/TC, AI, SGOT, SGPT and elevated levels of HDL, HDL/TC significantly ($P< 0.01$ and $P< 0.05$) in a dose dependent manner. Body weight and food intake in treated groups were significantly lower than that in model control [33].

Antioxidant effect:

The results of scavenging activity indicated that all seeds extracts showed excellent scavenging activities in all tests at a concentration range from 10-50 µg /ml. IC_{50} for scavenging effects of 1% acidified methanol extract of *Echinochloa crus-galli* were: DPPH scavenging activity 686.0497±8.0304 µg/ml, β-carotene bleaching effect 140.165±2.49 µg/ml and H_2O_2 26.947±0.55 µg/ml. However, IC_{50} of 95% ethanol extracs of *Echinochloa crus-galli* were: DPPH scavenging activity 226.4637±13.086 µg/ml, β-carotene bleaching effect 143.656±1.96 µg/ml and H_2O_2 21.5875±0.52 µg/ml, while, IC_{50} of aqueous extract of *Echinochloa crus-galli* were: DPPH scavenging activity 199.5967±8.2838 µg/ml, β-carotene bleaching effect 130.67±4.81 µg/ml and H_2O_2 39.624±1.542 µg/ml [28].

Antioxidant property of *Echinochloa crus-galli* aerial parts extracts was investigated *in vitro*. IC_{50} for various extracts were determined for DPPH scavenging, bleaching of β- carotene and % inhibition of H_2O_2 and compared with standard positive controls viz. butylated hydroxytoluene (BHT) for DPPH, propyl gallate for β-carotene and ascorbic acid for H_2O_2 assay. All extracts (1% methanol, 95% ethanol and aqueous) exerted antioxidant activity by all antioxidant tests utilized in the study [34].

Antimicrobial effect:

The 1% acidified methanol and ethyl acetate extracts of *Echinochloa crus-galli* seeds showed zone of inhibition ranged from 9 mm to 16 mm for all of the bacteria tested (*B. megaterium, S. aureus, E. Coli, P. aeruginos*). Seed extracts of *Echinochloa grus-galli* also showed good impact on both fungal pathogens (*A. Niger* and *F. oxysporum*) with a zone of inhibition ranged between 10 mm and 13 mm. Seed extract of *Echinochloa crus-galli* in water had good impact on *F. oxysporum* with 10 mm disc diffusion. The 95% ethanol and 1% acidified methanol extracts of *Echinochloa crus-galli* showed largest disc diffusion for *F. oxysporum* 12 mm and 13 mm disc diffusion respectively [28].

Echinochloa crus-galli extracts (50,100 and 200 mg/ml) were prepared in six different solvents (water, ethyle Acetate, acetone, 95% ethanol, chloroform and 1% acidified methanol). The antibacterial effects of these extracts were investigated against Gram positive [*Staphylococcus aureus* (MTCC 96) and *Bacillus megaterium* (MTCC-428)] and Gram negative [*Escherichia coli* (MTCC 443) and *Pseudomonas aeruginos* (MTCC1688)] bacteria. All extracts at concentration of 200 mg/ml possessed antibacterial activity against all the tested microorganism [34].

Anovel antifungal peptide EcAMP1 was isolated from kernels of *Echinochloa crus-galli*. The peptide

adopted a disulfide-stabilized α-helical hairpin structure in aqueous solution, it represented a novel fold among naturally occurring antimicrobial peptides. Micromolar concentrations of EcAMP1 were shown to inhibit growth of several fungal phytopathogens The EC_{50} values were in the range of 1–10 μM. *F. graminearum* and *F. solani* were the most affected species (EC_{50} of ~ 4 μM), whereas *F. oxysporum* appeared to be the least affected. *P. betae* was also highly susceptible to the peptide action (EC_{50} of ~ 6 μM). EcAMP1 also inhibited germination of *A. alternata*, A. *solani*, and *B. sorokiniana* spores and of *P. infestans*, *P. debaryanum*, and *P. ultimum* zoosporangia with EC_{50} in the range of 10–20μM. The peptide induced morphological changes in some of the affected fungi only at higher concentrations (~ 20 μM). *A. niger*, *C. graminicola*, *D. maydis*, and *T. album* all insensitive to the peptide [35].

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