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Phytochemical and Biological Activity of Rice Bran: A Review

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Abstract: ***Rice is most commonly food consumed by human beings all over the world. It is easily cultivated by the various countries. Rice is an annual plant. It grows in an area with a rich supply of water. The height of rice bran depends on the depth of water. 13500 years ago, Oryza sativa was the first rice plant which is cultivated in the Yangtze River basin. Rice bran is a milling product of rice. Various study shows that rice bran consists of various phytochemical constituent. This constituent consists of vitamin E, thiamine, Niacin, and minerals, Tocotrienol, oryzanol, tocopherol, gallic acid, vanillic acid, etc and nutritional components like carbohydrates, protein, fat and dietary fiber, vitamins, and minerals, etc. rice bran useful for health and contain antioxidant property due to presence of tocopherol, tocotrinol and gama-oryzanols. Traditionally rice bran is used as a treatment for various diseases like diabetes, cancer, liver disease, heart disease, etc. It is also used as a skincare product. Due to the presence of tocopherol, Tocotrienol, and gama-oryzanols rice bran is used for the treatment of various diseases or disorders like cancer, hypertension, lowering serum cholesterol, skin-related problems, insulin sensitivity, etc. during various studies shown by various scientists that rice bran has a rich source of a nutritional constituent, medicinal value as well as neutraceutical value. Various food industries use rice bran as a neutraceutical ingredient. Rice bran is rich source of gama-oryzanol. Hence it is used to improve disease conditions. Several studies prove the biological effect of rice bran improving hypertension, diabetes, hypercholesteremia, lowering cholesterol levels, cancer, skin problems, and various diseases.***

Keyword: ***Rice bran, Oryza Sativa, Vitamins, Minerals, Gama-Oryzanols, Tocotrienol.***

I. INTRODUCTION

Rice is the most important crop and important food in the world because 20% of dietary energy is obtained from rice [1]. Rice is an amphibian plant i.e. it grows in water as well as without water containing land. Rice belongs to the family Poaceae. It is a monocotyledon plant. Rice is the most commonly consumed cereal grain by the human population (50%) (Liu1). In Africa and Asia, it is the third highest agricultural plant after maize and sugarcane [1]. Rice produces the maximum energy for the body required for various uses of human beings. The traditional method for cultivating rice plants is first to develop rice plants in the nursery.

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After one month nursery was shown on the irrigated land. High irrigation planting reduces the growth of weeds and pest plants. Various methods are required for pest and weed control, fertilizing the soil during the growth period. Rice cultivation occurs in the region where high rainfall occurs, most commonly in Asia and Africa. Rice plant height is 1-2m (3-6 ft.). The height of the plant depends on soil verity and soil fertility. It bears long leaves i.e. 50-100 cm (20-40 inch long) 2-2.5 cm (3/4-1 inch) broad. Rice flower is very small and pollinated through wind. Flowers are produced in branched arching and pendulous inflorescence 30-45 cm long. Seed lengths are 5-12mm and 2-3mm thick. Production of rice all over the country is about 25% of all cereal production. Rice bran is a brownish portion of rice. It is collected during dehusking and milling of paddy rice. 20% of rice seeds constitute hull. Rice contains white rice kernel. Rice kernel made up of starch and covered with bran, inside a tough siliceous hull. After removing the rice husk bran layer comes in contact with air. When bran comes in contact with air produces off-flavor in the presence of endogenous lipase. Further milling of bran produces white rice [2]. The percentage and composition of rice bran depend on rice verity, degree of milling, type of milling, etc. Rice bran is a sweet test, has a light color, nutty flavor, and is slightly oily [2]. It contains fiber 10% oil 20% moisture 13 % protein 16% and ash18%. It is also a rich source of vitamin E, thiamine, Niacin, and minerals [2]. Rice bran is a rich source of nutritional compounds like tocotrinol, oryzanol, and tocopherol. The protein of rice bran contains lysine, hence it is used in food recipes. Rice bran consists of 9% of total rice weight and 65%of nutrients of whole rice grain. Rice bran oil extracted from rice bran. This is produced and consumed by Asian countries. Medicinally it is healthy oil because it has antioxidant properties, anti-inflammatory activity, and other medicinal value. Hence it is used as an antidiabetic, antihypertensive, anti-obesity, anti-carcinogenic, etc property. The main active ingredient responsible for medicinal value is gamma-oryzanol, ferulic acid esters of cholesterol. In 2020, 756 million metric tons of rice was produced. India and China produce 52% of total word production. Other most important rice-producing countries are Bangladesh, Indonesia and Vietnam. They produce 72% of the total rice. A broad study show that 8-26% of total rice is destroyed by developing country per year, due to poor harvesting technique, lack of knowledge, etc [3].

Fig. 1: Bran of Rice

II. BOTANICAL CLASSIFICATION

Taxonomy

Kingdom:-	Plantae
Subkingdom:-	Tracheobionta
Superdivision :-	Seed plant(spermatophyta)
Division: -	Flowering plant (magnoliophyta)
Class: -	Liliopsida Monocotyledons
Subclass :-	Commelinidae
Order :-	Cyperales
Family :-	Poaceae
Genus :-	Oryza L.
Species :-	Oryza sativa L.

III. BOTANICAL DESCRIPTION

Rice is an annual plant belonging to the family Poaceae. There are various varieties available but only two species i.e. Oryza sativa and Oryza glaberrima are commercially available. Oryza sativa is found all over the world, it is most commonly cultivated by people while Oryza glaberrium commonly grows in South Africa. Rice is a self-pollinated, semi-aquatic plant. It consists of arenchymatic tissue. Arenchymatic tissue helps in the movement of oxygen downward, from the areal part (leaf) to root. The height of the plant depends on the depth of water which is 1m to 5m (in deep water).

Root:-Rice consists of fibrous roots. Initially, Rice produces seminal roots. Seminal roots are temporary. The main root is an adventitious root that is produced from the column node.

Shoot:-Rice shoots are known as Colum. It is hollow. It consists of nodes and internodes. Leaf and buds develop from nodes. Buds are developed into shoot and tiller/plant. Tillering is the vegetative phase of the plant. during the reproductive phase, some tillers die due to a shortage of nutrients.

Leaf: leaf developed from nodes. Leave consist of the following part:

***Leaf Sheath*:** The leaf sheath develops from the column node. It encloses the colum and it is part of leaves.

Leaf blade- it originates from the node and extends to the upper part of the leaf. The leaf sheath helps in joining with leaf blade and node.

Auricle: it is a hairy outgrowth. It is found on the base of the leaf blade.

***Ligules*:** It is situated above the auricles. It is a thin and paper-like structure. Flag leaf-it is the last leaf present just below the panicle. It is shorter than other leaves and erect at a certain angle.

Panicle: Panicle is originated from flag leaf. The flower of the rice plant is attached to the terminal shoot. It is known as a panicle. At maturity, the flower dropped from the terminal shoot. The panicle consists of spikelets.

Spikelets: Flower units of rice plants are known as spikelets. It consists of a flower, a lemman, and a palea.

***Lemma*:** It is a hard and bract structure with filiform outgrowth known as awn.

***Palea*:** it is thinner than lemma.

***Flower*:** it consists bilobed anther, six stamen, one pistle, a pair of stigma, and a single ovary.

***Grain*:** ripe ovary converted into rice grain. Lemma and palea remain attached to rice grain. During milling lemma and palea are removed with hull. Rice seeds consist of an embryo and endosperm. The embryo consists of radical and plumule. On sowing, plumules develop into the shoot and radicles grow into the root.

Cultivation: Oryza sativa was the first rice plant which is domestically cultivated in the Yangtze River basin, 13500 years ago. Now wild variety of rice is cultivated in different geographical locations. Rice is the most important crop as well as food all over the word [4].

Fig. 2: Plant of Rice

IV. GEOGRAPHICAL SOURCE

The most common rice-producing countries are Asia Africa and America. Rice is the second most consumed grain in the world in Asian countries like China, India Bangladesh, Indonesia, and Vietnam. It is a primary food for 40% of the world's population **[**5**]**. It is found in India in a place like Tamil Nadu, Karnataka, West Bengal, Andhra Pradesh, and Assam. It is the common food of West Bengal, Bihar, and utter Pradesh etc.

Rice is an annual plant. The height of the plant is up to 1-2 meters. The height of the plant depends on fertilizer and soil type. The leaves are 50-99cm long and 2-3 cm wide. The flower is small and pollinated throw wind. The grain length is 5.1-11.9mm and 2-3 mm thick. The temperature required for rice cultivation is 200C-400 C [6].

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V. CHEMICAL CONSTITUENT AND BIOACTIVE COMPOUND

Rice bran is a rich source of fiber, fat, protein, saturated and polyunsaturated fatty acids, and phenolic compounds [7]. Rice bran consists of nutritional and bioactive compounds. Nutritional compounds consist of carbohydrates, protein fats, etc while bioactive compounds consist of gama-oryzanol, phenolic compounds, and antioxidants. Due to the presence of nutritional value rice bran is used in the formation of bread, ice cream, cornflakes, and other various food products. Rice bran protein is high quality hence it is used in pharmaceutical preparation and the food industry.

Rice bran contains anthocyanin. It is a strong antioxidant. There are several anthocyanin monomers, dimmers, and polymers present in rice bran e. g. Apigenin, cyanidin glucoside, luteolin, hesperetin, etc. Major anthocyanins to be found in rice bran are peonidin-3-O-glucose, cyanidin 3-O-glucoside followed by Flavan [8]. Flavonoids are found in rice bran in a free or bound form in black rice bran. The most commonly extracted phenolic compound of rice bran is p-coumaric acid and ferulic acid. Brown and red rice bran extract contain myricetin while Apigenin and quercetin are obtained from black rice bran. Zhou et al found that brown rice consists of a large amount of ferulic acid and less amount of gallic acid, vanillic acid, etc [9].

Table-1: Rice Bran Extracts Contain Several Chemical Constituents. The Details Are Given Below:

S. No.	Chemical Constituents	Figure No.
	Fiber	
1	Cellulose	1
2	Hemicellulose	2
3	1,6-Anhydro-beta-D-glucopyranose	3
4	Pectin	4
5	beta glucan	5
	Fatty Acid	
6	Linoleic acid	6
7	Linolenic acid	7
8	palmitic-acid	8
9	Myristic acid	9
10	Stearic acid	10
	Oryzonol	
11	gamma-Oryzanol	11
12	β-sitosterol	12
13	Cycloartenyl ferulate	13
14	24-methylenecycloartanyl ferulate	14
15	Campesterol ferulate	15
16	Vitamin E	16
17	Tocotrienol	17
18	Tocopherols	18
19	Ferulate	19
	Protein	
20	Gluten (prolamins) protein	20
21	Albumin	21
22	Human Gamma Globulin	22

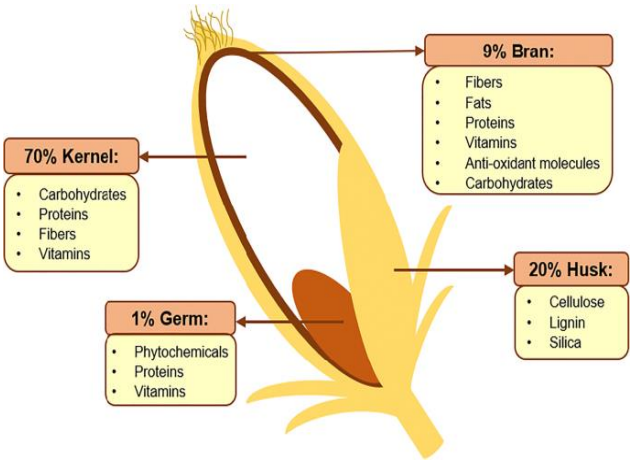


Fig. 3 Part of Rice Bran Through Which Different Chemical Obtained.

Dietary fiber

Rice bran contains 6–14% fiber. The major part of dietary fiber is cellulose and hemicelluloses. Cellulose is the most abundant polymer on Earth. Cellulose contains carbon, hydrogen (44 to 45% and 6 to 7 %), and a large amount of oxygen. Cellulose is polysachiride whose formula is $(C_6H_{10}O_5)_n$. It is a linear chain of beta 1-4 linkage of D-glucose unit (D-anhydrobetaglucopyranose, AUG). This unit is linked together by beta (1-4) glycosidic linkage formed between carbons no 1 and carbon no 4 of adjacent of glucose molecule [10].

Dietary fiber is a polysaccharide. It cannot be absorbed by humans and is not digested by the intestinal enzyme. Dietary fiber is an essential component of a healthy diet. It has several health benefits including body weight, serum lipid, and reduced cholesterol level. Dietary fiber is obtained from rice bran by milling process. Dietary fiber has two types i.e. Soluble and insoluble. Dietary fiber obtained from rice bran is mostly insoluble and trace amounts of soluble fiber i.e. Pectin and beta-glucan are present. Soluble dietary fiber is superior to insoluble fiber [11].

Fatty acid

Rice bran oil contains 40.5% oleic acid, 35.8% linoleic and linolenic acid and 23.2% palmitic, myristic, and stearic acid. Fatty acids are two types i.e. essential (body not synthesized, taken from diet) and nonessential fatty acid (synthesis in the body). Essential fatty acids are used in the cosmetic industry because they regenerate skin and prevent aging [12]. Unsaturated fatty acid undergoes oxidation or thermal decomposition during cooking. Rice bran oil contains some amount of unsaponifiable substance and gamma oryzanol. Rice Bran oil consists of quercetin, ferulic aid, some fraction of sterol, gama-oryzanol, and squalene. These are unsaponifiable substances. The high-temperature stability of rice bran oil is due to the presence of these substances. Rice bran oil has low viscosity hence during frying less oil uptake occurs. The smoke point of rice bran oil is high; hence it is good cooking oil.

Several researchers studied the stability of rice bran oil and also studied the stability of rice bran oil with a mixture of other oils like groundnut oil, sunflower oil, mustard oil, etc. They found that oil and its mixture show good stability than the other oil [13].

Gama Oryzonol

Rice Bran oil contains 1-2% of gama-oryzanol, which serves as a natural antioxidant. Initially, it is considered that gama oryzanol is a single compound present in rice bran oil. However, after several studies (1999) It is found that polysteryl ferulate ester is present in gama-oryzanol. This ferulate ester contains beta sitosteryl ferulate as a main bioactive compound, and also consists of compesteryl ferulate, cycloartenyl ferulate, and methylenecycloartanyl ferulate [14].

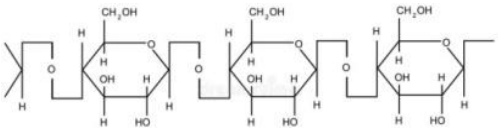
γ-Oryzanol helps in reducing cholesterol, and lipoprotine, inhibiting aggregation of platelets, and increasing high-density lipoprotein. Several studies show that γ-oryzanol has potent antioxidants. Other compounds like Vitamin E, tocotrienols, and tocopherols are fat soluble. These compounds cannot be synthesized in the body and taken from diet or food sources. These compounds have antibacterial and antioxidant properties. 182-313mg/kg of tocopherol and tocotrienols are present in bran oil, while rice bran oil contains 585 mg/l of total tocotrienol. In 2015 Pengkumsri et al observed that gama-oryzanol obtained from normal rice is less than red and brown rice. Tocopherol and tocotrinols are natural antioxidants. Tocotrienols have more antioxidant properties than tocopherols. However, the composition and amount of γ-oryzanol depend upon the variety of rice plants, and extraction methods [15].

Protein

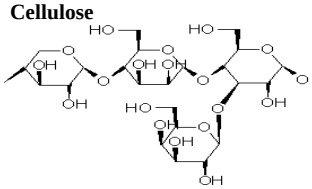
Generally, whole rice grain contains 5.8-7.7% protein. White rice has a soft texture and gorgeous appearance hence it is eaten by most the human. The soft texture of rice contains 76.7% carbohydrate, 7.4% protein. Certain research shows that it is the source of approximately 13-15% hypoallergenic and high-quality protein, with a protein efficiency ratio (PER) 1.5-2 when compared with casein (2.5). Starch is the first most abundant constituent in milled rice and the second one in protein. The amount of protein content ranges from 10% to 16% depending on its cultivars. According to protein solubility by Osborne fractionation protein they are divided into four types i.e. 32.6% glutelin, 31% albumin, 25% globulin, and 11.5% prolamine (11.6%) [16].

Gluteline consists of a major component of rice protein. It contains 23-40.3 % of the total protein of rice bran [16]. Glutelin has limited solubility in water due presence of disulfide bonds and hydrophobic interactions [17]. Glutelin is soluble in 1-3pH and above pH 10. Its molecular weight is 64-500 kDa. Its molecular weight is higher than the other rice protein. Rice glutelin consists of two types of subunit i.e. acidic and basic subunit. The molecular weight of the acidic subunit is 30-39 kDa and the basic subunit is 19-25 kDa. Both subunits come from 57kDa polypeptide precursors. In 1997 Hamada observed that the molecular weight of glutelin protein was 46-149 KDa, While in 2009(Chanput) and 2012(scientist Xia) observed the molecular weight of glutelin was 11-61KDa.

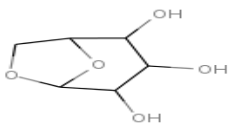
Water soluble protein is albumin. Albumin is contaminated by globulin protein during extraction with water because minerals present in the rice grain dissolve in water solvent and contaminate it. About 6.3 -10 % albumin is present in rice grains [16]. The molecular weight of albumin is about 100kDa or less when analyzed in size exclusion HPLC. In 2009 Cao et al found that albumin has major polypeptide with molecular weight 18-20 kDa. In the same year (2009) Chanput et al found the two main bands of albumin with the help of SDS-PAGE. Globuline is sulfur sulfur-rich protein. It is soluble in salt. It contains 12.5 to 25% of total storage protein in rice bran [16]. In 2012 Xia et al found that the molecular weight of globulin is 26kDa in broken rice and also the molecular weight of Thai rice verity globuline is about 15.4 and 50 kDa [16]. Prolamine is soluble in alcohol. Prolamine is extracted at the end of the extraction of protein i.e. albumin and globuline. Prolamines contain 3.3-11.5 % of total protein in rice bran [16]. Prolamine is extracted by ethanol (70%) or propanolol (50 %). In 2009 Chanput et al observed various prolamine fractions i.e. 10, 15 and 25 kDa. In the same year (2009) Cao et al proved that prolamine consists of three subunits of polypeptide of molecular weight 10 and 16 kDa.



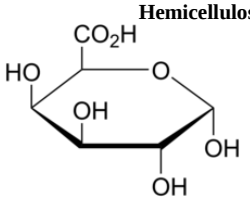
Cellulose



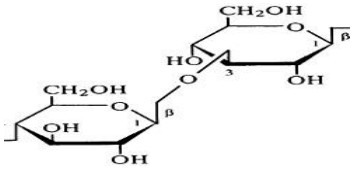
Hemicellulose



1,6-Anhydro-beta-D-glucopyranose



Pectin



beta glucan

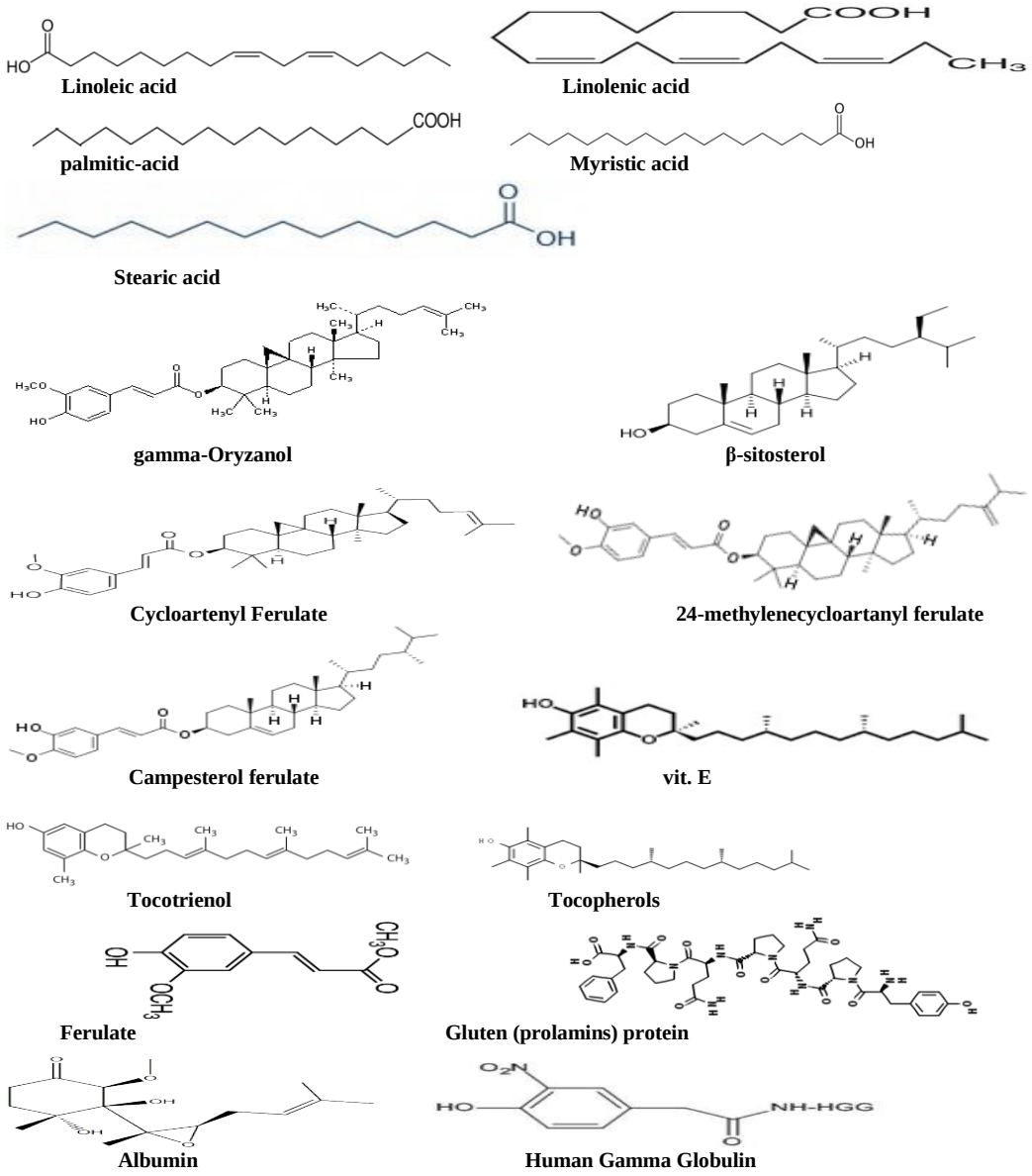


Fig. 4: Chemical Structure of Phytoconstituents of Rice Bran

VI. TRADITIONAL USE

Traditionally rice is considered of medicinal value in Chhattisgarh, India. Insects that attack on rice are used as traditional healers in common and complicated diseases. Laicha rice variety is used to treat Laicha disease. Hence it is known as Laicha. Laicha is a type of skin infection. Anciently rice plants and rice bran are used as animal feed. Now rice bran oil is extracted from rice bran. It has high medicinal value. Rice straw is used for making bags, mats, etc. These bags help in the packaging of nuts, beans potatoes, etc [18]. Some Indian rice varieties like Black Kavuni rice have antimicrobial activity. Kaivara Samba- Lower blood glucose levels. kuruvi kar rice varies grown in drought and consumed by the local population for health benefits. The Poongar Rice variety consumed by women after puberty it is associated with the reproductive system. kuliyal variety rice is used as a special dish. Mappillai Samba has hypocholesterolemic properties and anticancer properties and improves men's fertility. Rice is stored in the form of paddy in steed of milled rice. Because husk prevents the degradation of rice grain and protects against insects.

VII. FOOD AND NUTRITIONAL COMPONENTS

The amount and quality of rice grain depend on the genetic factor, type of fertilizer, milling process, storage condition, and environmental effect [19]. Rice bran consists of dietary fiber, carbohydrates, protein, vitamins, fatty acids and minerals, etc. There are two types of nutrients present in rice bran: micronutrients and macronutrients.

A. Macronutrients

Macronutrients are established by autoclaving and parboiling at 4 to 8% milling. Milling degree also affects the chemical and nutritional quality of bran. Rosniyana et al. in 2005 [20] observed that milling rice at 4% milling degree yields more nutritional compounds in compared to milling at other degree. Macronutrients of rice bran are carbohydrates, fat, and proteins. The composition of carbohydrates, fats, and proteins is 26%, 20%, 17% respectively.

These amounts of macronutrients are obtained if rice is milled at 4% milling degree.

B. Micronutrients

Rice bran contains a high degree of vitamins and minerals. Hence its consumption leads to a high intake of minerals and vitamins. The amount of minerals and vitamins depends on the milling process and stabilization process [21]. Rice bran contains niacin, pyridoxine, thiamine, and riboflavin. Niacin amount in rice bran is high. Minerals present in rice bran are potassium and phosphorus. Other trace amounts of minerals are calcium sodium, iron and magnesium. There amounts vary in autoclaved to parboiled rice bran. The amount of these minerals is higher in autoclaved rice bran than in parboiled rice bran. While iron is higher in parboiled rice bran than in autoclaved rice bran. The outer covering of rice is known as rice bran. It is brown in color. Rice bran consists of a seed coat, pericarp, and aleuronic layer. Rice bran is composed of various nutrients like carbohydrates, protein, fat and dietary fiber. The nutritional composition of rice bran depends on the milling system and the variety of rice [22]. The nutritional component of rice bran is given as in the table.

Table. 2: Composition of Nutrients in 100 Grams of Rice Bran

Sn	Nutrient	Amount	Sn	Nutrient	Amount
1	Energy	316 (Kcal)	13	Manganese	780 mg
2	Saturated Fat	4.15 g	14	Calcium	57 mg
3	Fat	20.8 g	15	Mangnesium	780 mg
4	Unsaturated fatty acid	15 g	16	Thiamine	2.7 mg
5	Protein	13.5 g	17	Pantothenic acid	7.4 mg
6	Carbohydrate	50 g	18	Folate	63 mg
7	Dieatory fiber	21 g	19	Riboflavin	0.28 mg
8	Iron	18.5 mg	20	Vitamin B6	4 mg
9	Potassium	1485 mg	21	Niacin	34 mg
10	Phosphorus	1677 mg	22	Choline	32 mg
11	Selenium	14.2 mg	23	Vit K	2 mg
12	Zinc	6 mg	24	Vit E	5 mg

VIII. BIOLOGICAL ACTIVITY

A. Antioxidant

Natural antioxidants are present in rice bran and rice bran oil. These antioxidants have significant health benefits. This study is supported by several previous studies which show that rice bran has disease-preventing properties like cancer. It is an important source of antioxidants and phytochemicals [23]. Antioxidant activity was observed in rice bran in another study by DPPH radical method. Rice bran is a rich source of an antioxidant compound like tocopherol, tocotrinols, Gamaoryzanol, polyphenol etc. They prevent oxidative degradation of body tissue DNA. Some component of rice bran shows synergistic effect and they potentiate antioxidant activity example tocotrienols and tocopherols. In 2011 Norhaizan et al. observed the antioxidant activity of phytic acid of rice bran extract. They observed antioxidant activity by using thiobarbituric acid (TBA), ferric reducing antioxidant power (FRAP), Thiocyanate capacity (FTC), and beta-carotene bleaching method. They also discovered the antioxidant mechanism of phytic acid for reducing the production of oxygen free radicals. Antioxidants work on molecular and cellular levels. They deactivate the metabolic byproduct which is free radicals. Rice bran contains gama-oryzanol, phytosterols. They have antioxidant properties. Ferulic acid is component of gama-oryzanol. It is a potent antioxidant and stable at very high temperatures [24]. Vitamin E also has antioxidant properties. Several studies show that gama-oryzanol more potent antioxidant than vitamin E for cellular oxidation. All these properties of rice bran are used by the pharmaceutical industry for the development of nutraceuticals and other food ingredient. The antioxidant activity of rice bran is produced due to the presence of flavonoid and phenolic compounds such as hydroxycinnamic acid, haempferol and hydroxybenzoic acid. Total flavonoid and phenolic content of rice bran is approx 2.9 to 3.5 mg retinol equivalent/g and 3to4 mg/ gallic acid respectively [25]. Rice bran is a good source of rice bran. It's amount present in rice bran is 3-5 mg/g. tocopherols present in alpha and gama form which concentrations varying from 63-95 µg/g and 5-5.2 µg/g respectively[25]. Antioxidant effect significantly shows on the liver and serum levels of rats [26]. Hypercholesterolemia is produced by the formation of active oxygen free radicals and reduces serum antioxidant activity. Nutrition supplement containing aqueous enzymatic extract of rice bran 750 mg/kg BW given for 42 days. They restore the antioxidant capacity in rats feed high fatty diet. Rice feed high fatty diet and rice bran supplementation increase liver catalase and reduce carbonyl protein content in the liver compared to rats feeding only a fatty diet [26]. In hyperlipidemic adult clinical study shows the consumption of 30 ml of rice bran oil containing more than 4000 ppm gama-oryzanols for 28 days shows significantly increased plasma oxygen-free radical scavenging capacity. Hence the antioxidant activity of rice bran is also shown by the presence of bioactive peptides [27]. Boonla et al proved that rice bran supplements containing rice bran protein hydrolysate 60-99 mg/kg given for 42 days reduce plasma malondialdehyde (MDA) and protein carbonyl [27].

B. Anticancer

Rice bran contains various biologically active compounds which are very useful effect for the treatment and prevention of many cancerous diseases. Phytonutrients present in rice bran help in the prevention of certain cancerous diseases like lung, liver, Breast, colon and other cancers. Rice bran consists of Inositol. It is chemoprotective and low cytotoxic effect. These compounds prevent and inhibit the development of cancer in various organs. Like mammary glands, lungs and colon [28]. Several scientist i.e. Nishino et. al in 1998 and Shamsuddin & Ullah in 1989 proved the effect of rice bran on liver carcinogenesis in mice and colon carcinogenesis in rats respectively. Nurul-Husna et al in 2010 and Shafie et al in 2013 proved the chemoprotective properties by in vivo and in vitro models [29]. Shafie et al in 2013 observed anticancerous properties of phytic acid in rats by giving phytic acid with drinking water [29].

Norazalina et al in 2010 and Shafie et al in 2013 observed reduced formation of crypt foci and tumor growth by administration of 0.2% phytic acid in diet [29].

All these studies show that phytic acid inhibits the various pathways of carcinogenesis which is responsible for the formation of cancer. Phytosterols are capable of inhibiting chemically induced cancer in animal cells. Formation of coprostanol, sterol and bile acid by colonic microorganisms responsible for inhibition of colon cancer. Several studies also show that the intake of phytosterol reduces fecal cholesterol, by inhibiting the proliferation of epithelial cells. Bingham et al proved that dietary fiber intake is inversely proportional to the occurrence of colorectal cancer. The less protective effect is shown on the rectum and the highest protective effect is shown on the left side of the colon [30]. All cancer is not hereditary. Only 5% to 10% of cancer is hereditary. The most common causes of cancer are modern diet and lifestyle habits. By improving diet habits incidence of cancer is reduced by up to 30% in humans. Phytic acid extracted from rice bran. It shows anticancerous activity against hepatocellular carcinoma cell (HepG2) and their apoptotic activity observed by the expression of apoptosis regulatory genes i.e. p53, Bcl-2, etc. Tocotrienol present in Rice bran oil. δ- Tocotrienol is effective against colorectal cancer. In an in vivo study, oral administration of tocotrienols 10 mg/day in mice significantly inhibits tumor growth in nude mice. The cancerous cell produces free oxygen radical which is responsible for the progression of cancer. Cycloarttenyl ferulate is a component of ɣ-oryzanol. It is an antioxidant hence it reduces the proliferation of colorectal adenocarcinoma [31].

C. Anti-Hypercholesterolaemic

Tocotrienol reduces cholesterol levels by inhibiting of 3-hydroxy 3-methyle-gluteryl coenzyme A (HMG-CoA) reductase enzyme. In endogenous cholesterol synthesis, it is a rate-limiting enzyme. A study shows that the combination of tocotrinols and the American Heart Association Step 1 diet reduces serum cholesterol and LDL-cholesterol in hypercholesterolemia. RBO reduces total cholesterol and LDL-Cholesterol demonstrated in the human model. In 2005 Most et al [32] observed that rice bran oil given with controlled oil blend has a significant effect on serum cholesterol concentration. Due to the presence of unsaponifiable compounds. Various kinds of literature show that RBO reduces the cholesterol level in various laboratory animals like rats, humans and hamsters. Various studies show that rice bran oil decrease cholesterol level in hypercholesterolemic patient. Who taking rice bran oil instead of cooking oil and elderly and middle-aged people take rice bran oil and low-fat diet [33]. Rice bran oil has significantly reduced Low-density Lipoprotein (LDL) cholesterol levels. This property of rice bran oil is due to the presence of Phytosterol, Tocotrienol and oryzanol. Science 1950s, phytosterols were reported as cholesterol-lowering agents. Several studies show that beta-sitosterol has the capability to reduce the LDL and circulating cholesterol levels. These results show that rice bran contains lipid-lowering agents. Which reduces lipid concentration by affecting lipid metabolism [34]. Feeding 4 weeks of rice bran oil containing low and high gama-oryzanol, reduce 6% of total plasma cholesterol, 10.2% of low-density lipoprotein cholesterol. Various studies on human model conducted for 84 day intervention with 20g/day rice bran show a decrease in total cholesterol, LDL, and LDL to HDL ratio ratio [34]. When gama-oryzanol was given with PUFA n-3 and Vitamin-E was given to dyslipidemic patients, they maintained a normal lipid profile after 4 months of intervention as compared to a placebo given with PUFA n-3 and Vitamin E. A study on obese Japanese humans having high LDL cholesterol, given rice bran extract 50 mg/day for 84 days showed a significant reduction of total cholesterol, and LDL level. In 1998 jariwala [35] said that phytic acid present in rice bran reduces cholesterol and triacylglycerol in blood having significantly reduced heart disease. In hyperlipidemia total cholesterol and triglycerol levels become high in blood. It is associated with cardiovascular disease. Phytic acid and high cholesterol diet given to rats show reduced serum cholesterol and triglycerol levels and regulates marks of hypercholesterolemia including zinc and copper ratio. This lipid-lowering compound (phytic acid) has no toxic effect in rats. In 1998 Katayama showed the combined effect of inositol and phytic acid. They show that the combination of phytic acid and inositol significantly reduces hepatic lipid and triacylglycerol via inhibition of lipogenesis enzyme rather than enzyme inhibiting intestinal enzyme. Phytic acid is also responsible for inhibiting aggregation of platelets to increase inflammatory response, and calcification ofaorta and lipid peroxidation in the kidney [36].

D. Anti-Diabetic

Type 2 diabetes is caused by less production of insulin by the pancreas, leading to hyperglycemia that results in reduced entry of glucose into the cell, which leads to reduced glucose utilization in the body and glucose levels become high [36]. In various human study consumption of rice bran by insulin-dependent diabetic patient show a reduction of blood glucose level. Which is the active component of diabetes? This study proved that 25% of patients have significantly reduced hyperglycemia and a decrease in daily insulin injections and hypoglycemic drugs [37]. In-vivo studies on mice and rats show the antidiabetic effect of rice bran. Fermented rice bran regulates adiponectin expression and induces insulin resistance by neutralizing free radicals. Gama-oryzanols stimulate insulin secretion by the pancreas. Various in vitro studies proved that rice bran extract increases the uptake of glucose in 3T3-L1 adipocytes and reduces α-glycosidase and α-amylase activity. Hence reduces glucose absorption glycemic response [38]. Rice bran extract activates glucose reabsorption in cells by activating messenger ribonucleic acid (mRNA). By expressing glucose transporter (GLUT1 and GLUT4) and reducing insulin signaling pathway proteins. These insulin signaling pathways are insulin receptor gene (INSR) and insulin receptor substance (IRS)1[38]. Glucokinase enzyme is a regulator of blood glucose that activates the utilization of glucose in the liver by promoting the phosphorylation of glucose to glucose-6-phosphate.

Other studies show that a diet containing low fiber and 40g/day rice bran fiber for 7 days show a significant effect in lowering glucose level in diabetic patients than a low fiber diet alone. After 12 weeks of a diet containing 20g/day stabilized RB, there was a significant reduction in glucose level in fasting condition, glycated hemoglobin and postprandial glucose [39]. Rice bran supplements increase insulin resistance by increasing the level of adiponectin. Adiponectin is related to insulin sensitivity.

E. Anti-Allergic

The allergic reaction is produced by exposure to environmental substances like protein, pollen, spores etc. in the body. Those substances which produce allergy are known as allergens. β- hexosaminidase and histamine are inhibited by the bleach rice bran. In vitro study allergic reaction mediated by the mast cell and basophilic leukemia cell inhibited by the black rice bran. Rice bran activates the natural killer cells, monocytes and T cells. In vitro studies show that it also activates monocyte dendritic cells. Hence it is used as a dendritic cell-based vaccine against various inspections and potentiates dendritic cell maturation [40].

F. Anti-Inflammatory

Methanolic extract of rice bran contains feruloyl ester of triterpene alcohols. Feruloyl ester of triterpene alcohols shows an anti-inflammatory effect against 12-O-tetradecaolylphorbol-13-acetate-induced inflammation in mice [41]. Feruloyl ester of oligosaccharide suppresses inflammatory mediates and proves it is an anti-inflammatory agent. Hydrolyzed rice bran contains immunomodulatory properties and hence it is used to prevent common cold syndrome in elderly individuals. RBO contains cycloartenyl ferulate which reduces nitric oxide production induced by lipopolysaccharide and expression of mRNA of NO synthetase and COX-2 as well as upregulated superoxide dismutase activity. This evidence proved its efficiency in the therapy of inflammatory disease. Previous studies proved the inhibitory effect of rice bran on pro-inflammatory enzymes like COX-1, 5-LOX, and COX-2 [42]. In vivo, the study also proved that the prebiotic form of rice bran mediates immune cell differentiation, inhibits clostridium growth and increases short-chain fatty acid content in colitis. Hou et al in a 2013 study on the effect of anthocyanin rich extract of black rice bran for 49 days at a concentration of 200,400 and 800 mg/kg in tetrachloride treated mice [43]. The result of this study shows that the anthocyanin rich extract of rice bran increase plasma antioxidants (SOD and glutathione peroxidase), normalized liver enzyme lower the amount of thiobarbituric acid reactive substance (expressed as MDA, TBARS) and 8-hydroxy-2'deoxyguanosine (8-OHdG). 8-OHdG is a biochemical substance that is responsible for the oxidative stress as guanine in DNA. In the repair process, Guanine is transformed into 8-oxo-gua and removed from the body as 8-OHdG. Release of 8-OHdG increases in certain diseases like atherosclerosis and diabetic mellitus [43]. MDA is released during lipid peroxidation as a secondary byproduct. It is widely used as a biomarker of oxidative stress. The level of MDA becomes high during various inflammations related to diseases like cancer, cardiovascular disease and liver disease diabetes mellitus Alzheimer's disease and Parkinson's disease. RBP shows anti-inflammatory effect by reducing pro-inflammatory cytokines like TNF-α, IL-6 and increasing anti-inflammatory cytokines like IL-10 in macrophage cells. RBP is obtained by hydrolyzing rice bran protein through flavourzyme or alcalase. These hydrolyzed proteins contain ACE inhibiter and antioxidant properties [44]. The fraction of RBP lower than 3kDa has strong antioxidant activity and high amount of phenolic compound and potent ACE inhibitor activity [44]. A study was performed on 105 obese and overweight adults. They administered rice bran 70 mg/day, rice husk 25g/day and a placebo with an energy less diet. After 84 days of administration, they observed that high sensitivity C-reactive protein (hs-CRP) was reduced in serum. Reduction of hs-CRP level is more in the Rice bran treated group than placebo-treated group. Placebo treated group does not show a significant change in hs-CRP concentration. Weight management Obesity is an important factor for many diseases like type 2 diabetes, cardiovascular diseases, cancer and hypertension [45]. It is not only common in adults but also in children. There is certain region through which obesity is produced like economic imbalance, changing dietary pattern and globalization [45]. Giacco et al found that grain intake lowers the body weight by reducing glycemic index, lowering energy density, modulating gut bacteria and increasing short-chain fatty acid (SCFAs). However, the recent study fails to explain the mechanisms of weight loss promoted by the consumption of grain. Justo et al [46] studied the enzymatic extract of rice bran (1% and 5% supplemented diet) on biochemical, metabolic and adipose tissue change in diet induced obesity mice. Mice fed with a high-fat diet with 1% and 55 rice bran extract did not show any changes in body weight compared to mice feeding only with a high-fat diet.

G. Gastrointestinal Effect

Consumption of fiber improved gut health. Excess amount of fiber in the diet produces blotting and gastrointestinal disturbance due to the fermentation of fiber in the colon by gut bacteria [47]. In colorectal cancer patient diet containing 30/g rice bran for 4 week help to maintain a significant amount of DF without producing gastrointestinal discomfort and changing stool constancy. Other studies show that the arabinoxylans obtained from rice bran given in inflammatory bowel syndrome (IBS) patients for weeks, will improve diarrhea, reflux, and constipation [48]. Fermentation of rice bran stimulates mucosal balance and shifts gut micro-bacteria in the intestinal tract. Hence consumption of rice bran improves gut health [48].

H. Prebiotic Properties of RB

Some studies show dietary fiber has prebiotic properties. [49]. Kurdi and Hansawadi in 2015 showed that the rice bran treated hydrothermally at 0.22 Mpa, at 1350C for 0.5 to 3 hours produced oligosaccharide. This oligosaccharide is suitable for the growth of Bifidobacterium and lactobacillus and increases the population of F.prausnitzii, without affecting the production of SCFAs. Zhang et al [49].

Performed in vitro study in gastrointestinal digestion and colonic fermentation of dietary fiber fraction of rice bran and phenolic removed rice bran dietary fiber. The study proved that rice bran dietary fiber increases the population of lactobacillus after 24 and 48 hours. While phenolic removed rice bran dietary fiber improved bifidobacterium, A. muciniphila. Finally, this study show that the fiber fraction of rice bran as well as the phenolic compound in rice bran dietary fiber help to prebiotic property of rice bran. A diet containing 4% enzyme-treated RB for 6 days prevents colitis by decreasing clostridium and Eubacterium and increasing the production of SCFAs hence the final result is reduced inflammation in colitis [50]. 1-5 g/day intake of rice bran for 6 months in Nicaraguan infants of 6-12 months of age reduced the diarrhea. This intake of rice bran changes the gut bacteria such as Lachnospiraceae, Bifidobacterium, Veillonella, Bacteroides, and Lactobacillus [51].

I. Kidney and Liver Function

The kidney maintains the water and electrolyte balance in the body. Various diseases like cardiovascular disease and diabetes mellitus affect kidney function by producing inflammatory mediators. In diabetic nephropathy albumin and creatinine levels increase in urine which produce complication in the kidney. Diabetic mice feeding rice bran containing food 100 to 500 mg/kg/day for 8 weeks show a reduction in the creatinine and albumin levels in urine. Certain studies proved that gama-oryzanol or its combination with gama-oryzanol and rice bran oil improved liver and kidney function in rats. which was treated with high fat and cisplatin diet [52]. Cisplatine help to reduce kidney complication in rat treated with sucrose/high-fat fees. These rats treated with gama-oryzanol 50mg/kg with/ without rice bran oil 300 mg significantly improved health [52]. During this study, it is believed that the gama-oryzanol inhibits inflammatory mediators like PG2 which is responsible for kidney disease [52]. High-fat diet produces nonalcoholic fatty liver disease (NAFLD) and increases the secretion of liver enzymes. NAFLD is produced by the accumulation of fatty acid and triglyceride in the liver. This leads to oxidative disturbance, dysfunction of mitochondria and stimulation of inflammatory mediators. Dietary supplements of Gama - oryzanol alone or in combination with rice bran oil improved liver function by reducing alanine and aspartate transaminase levels in rats previously treated with high-fat high sucrose and cisplatin [46]. Intake of food containing 0.5% gama-oryzanol for 49 days improved Glucokinase activity in the liver, which reduced glucose -6-phosphate (G-6-P) and phosphoenol pyruvate carboxylase kinase (PEPCK) enzyme in mice [53].

J. Effect on Metabolic Disorder

Abnormal metabolism produces various metabolic diseases like hyperglycemia, hypercholesterolemia, hypertriglyceridemia and insulin resistance, cardiovascular disease etc. Rice bran products reduce metabolic risk. Enzymatic extract of rice bran-containing diet preventing the change of adipose and macrophage in obese mice [54]. Lowering triglyceride and cholesterol levels is known as antihyperlipidemia. Antihyperlipidemic effect of α-tocopherol proved in F344 rats fed a western diet. Anthocyanins and proanthocyanidins are present in the pigment of the rice bran layer. which activate the uptake of glucose by 3T3-L1 adipocytes. 3T3-L1 is a key factor for glucose homeostasis. Fatty acid ester and gama-oryzanol with phytosterol are abundant in rice bran. Gama-oryzanol, a fatty acid ester prevents metabolic syndrome induced by a high-fat and high-fructose diet. Treatment with gama-oryzanol significantly reduces the liver index and hepatic triglyceride concentration. Reduction of serum C-reactive protein and IL-6 and increased concentration of serum adiponectin proved that gama-oryzanol and fatty acid esters were used as a dietary supplement to reduce the risk of high fat and high fructose (HFFD) diet. Adenosine is responsible for the reduction of SHRSP syndrome. Single-dose and long-term use of adenosine improved hyperinsulinemia and hyperlipidemia. Several studies show that the administration of adenosine for three weeks reduces the synthesis of glucose-6-phosphatase enzyme by inhibiting mRNA regulation. Glucose-6-phosphatase enzyme is a rate-limiting enzyme of hepatic gluconeogenesis. Adenosine is also involved in β-oxidation, fatty acid synthesis and AMP-activated protein kinase by regulating hepatic mRNA expression [55].

K. Health Improvement

Rice bran and its active compound have immunomodulatory effects. Rice bran consists of gama-oryzanol, phytosterol and other antioxidant compounds that stimulate the immune system. Rice bran rich diet enhance gut health by improving the growth and colony of lactobacillus rhamnosus and protect against rotavirus diarrhea in pig by altering gut permeability. A long-term RB-containing diet improved brain mitochondrial function and altered Alzheimer's disease. It also controls menopausal symptoms like bone loss in older women suffering from osteoporosis and hot flashes. Rice bran is a plan derived active compound and alternative source of various vitamins [56]. Bodybuilders and athletes use rice bran as an ergogenic supplement. Driselase enzyme treated rice bran is used to prevent high blood pressure, hyperglycemia and hyperlipidemia. Driselase is esterase esterase-free plant cell wall degrading enzyme consisting of cellulase, laminarinase and xylanase. Rice bran derivatives containing beta-sitosterol induce apoptosis in cancerous cells. Many colored rice verities are rich reserves of β-carotene. B-carotene converted into vitamin A which is essential for eye disease [57].

L. Anti - Aging Property

Gama oryzanol protects light-induced lipid peroxidation by UV rays. It is used as a sunscreen agent. Gama-oryzanol consists of ferulic acid and its ester. Ferulic acid and its ester stimulate hair growth and skin aging [58]. Rice bran also consists of tocotrienols. It is also an antioxidant agent. Tocotrinol easily penetrates the skin, is rapidly absorbed and acts as the first line of defense by accumulating in the stratum corneum. Free radicals are produced within the skin when the skin is exposed to toxic rays. They stabilized free radicals produced in the skin by exposure to toxic rays. They protect the skin from exposure to UV ray induced skin damage and also help in skin repair [58].

IX. CONCLUSION

According to various researches, rice bran has huge biological and nutritional value. The rice plant is a common herbal plant traditionally used for the treatment of various diseases and has diverse pharmacological value. Various chemical constituents present in plants which have more pharmacological activity. Hence more research and evaluation needs to identify the chemical present and its use for innumerable application of human welfare in the future.

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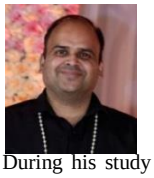

Dr. Neeraj Sharma provides support and guides the author to write the article Phytochemical and Biological Activity of Rice Bran: A Review. He has a good moral character and friendly behavior hence students are easily attracted to communicating their problems. Dr. Neeraj Sharma passed his initial education in his hometown. During his study period, he was a brilliant student. After completing his pharmacy degree, he joined Bhagwant University, Sikar Road, Ajmer (Rajasthan) India. Dr. Neeraj Sharma is a very hard-working person. During his teaching period, he published in various national and international journals. They also published several journals of the Scopus index. based on their intelligence and hard-working nature, after some time he became H.O.D. in the Department of Pharmacy of Bhagwant University, Sikar Road, Ajmer (Rajasthan) India. During his teaching period, he guided several Ph.D. scholars. At present time he is one of the best faculty in Bhagwant University.