Brown Rice as a Healthy Food and Lowering Blood Sugar in Rats

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Abstract: This investigation was carried out to evaluate and compared between brown and white rice high and low amylose. Chemical composition, total dietary fiber fractions, minerals content and total phenolic compounds were determined in brown and white rice. Biological experimental was determined in diabetic rats fed on brown and white rice high and low amylase for four weeks (30 days). Glucose blood level, total lipid, triglycerides, total cholesterol, high density lipoprotein (HDL) and low density lipoprotein (LDL) were evaluated after end of the biological experimental period four weeks. The results showed that the brown rice high and low amylose had contained the highest amount from crude protein, fat, ash and crude fiber content (8.85, 1.65, 1.9 and 1.25 % in high amylose and 8.42, 1.38, 1.83 and 1.24% in low amylose, respectively) compared with white rice. Brown rice contained a large amount of total dietary fiber soluble and insoluble dietary fiber. This is due to the fact that the whole grain contains all three components: bran, germ and endosperm. Minerals content (magnesium, potassium and calcium) and total phenolic compounds were significant increased in brown rice compared with white rice. The results after the end of biological experimental period showed that the rats fed on brown rice high and low amylose significantly decreased in serum glucose blood level (160.3 and 166.0 mg/dl), followed by rats fed on white rice high amylose (171.5 mg/dl). It is clear that feeding on rice high amylose reducing serum glucose level than white rice low amylose. The rats fed on brown rice high and low amylose significantly lowered in total cholesterol (150.0 and 160.0 mg/dl, respectively) than white rice high and low amylose (163.0 and 172.5 mg/dl, respectively). The results from HDL- cholesterol, LDL-cholesterol, total lipids and triglycerides were paralleled for total cholesterol. From this study it could be recommended that the brown rice is reach in protein, fiber, minerals and phenolic compound and it is more beneficial food for lowering glucose blood level and lipid parameters than white rice. Therefore, the brown rice is a benefit healthy food and alternative for white rice.
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1. Introduction

Rice is a staple food for over half of the world's population. Today people are going for whole food, to the days our forefather had been eating. You hardly heard of cancer, heart attack and diabetics and so on. All these degenerative deceases in our present society are caused by the pollutants from within and without. White food, better known as refined carbohydrates was once a delicacy affordable only to the financially wealthy. However, financial wealth does not equate to a wealth of health. A primary reason for the development of refining wheat for white flour products is to establish a longer shelf life. Whole wheat flour left in sacks for long periods of time cause bugs to appear within it. In their natural form, whole grains contain natural nutrients vital to our health **(Dinesh Babu *et al.*, 2009).**

Milling is the primary difference between brown and white rice. The varieties may be identical, but it is in the milling process where brown rice becomes white rice. Milling, often called "whitening", removes the outer bran layer of the rice grain. Milling affects the nutritional quality of the rice milling strips off the bran layer, leaving a core comprised of mostly carbohydrates. In this bran layer resides nutrients of vital importance in the diet, making white rice a poor competitor in the nutrition game The following chart shows the nutritional differences between brown and white rices. Fiber is dramatically lower in white rice, as are the oils, most of the B vitamins and important minerals. Unknown many, the bran layer contains very important nutrient such as thiamine, an important component in mother's milk **(Wood, 1988).**

White rice tends to be converted into sugars rapidly in the body, a characteristic known as having a high glycemic index (GI) of 64. This causes blood glucose levels to rise quickly and then fall off, which can cause problems in those who are already diabetic or have tendency for diabetes. It also means that one is left feeling hungry sooner than if one had eaten a low GI foods like porridge. This could prompt people to overeat and become overweight, which are known to raise the risk of developing Type2 diabetes. Brown rice and basmati rice tend to be converted into sugars in the body more slowly than white rice **(Mir, 2012).**

The health benefits of brown rice are immeasurable. Brown rice is a whole grain meaning it contains a large amount of fiber. This is due to the fact that the whole grain contains all three components: bran, germ and endosperm. Conversely, when grain is processed, all that is left is the endosperm **(Ensminger *et al.,* 1983).**

Brown rice is unpolished whole grain rice that is produced by removing only the hull or husk using a mortar and pestle or rubber rolls. It may be distinctly brown, reddish or purplish. The embryo may or may not be left intact depending on the hulling process. It becomes milled or white rice when the bran layer is stripped of in the milling or 'whitening' process. Thus, the distinguishing factor should be its unpolished feature and not the color **(Anon, 2000).**

In clinical studies, it could be showed that both non diabetic patients and brown rice had lower postprandial blood-glucose levels than those who ate white rice (white rice)-supplemented diets **(Ito *et al.,* 2005a, b).** It has been suggested that the reduction in blood-glucose levels and the incidence of diabetic vascular complications in diabetic patients fed a brown rice-rich diet may result from the substantially higher dietary fiber content of germinating rice bran (**Seiki *et al.,* 2005).** Moreover, the whole rice with different levels of amylose, a straight-chin starch, and amylopectin, a branched-chain starch was fed to subjects as part of meal tolerance test to evaluate the effect of the structure of starch on serum glucose response curves **(Goddard *et al.,* 1984).** The amylose content ranged from 0 to 24% of the carbohydrate with the remaining carbohydrate as amylopectin. Serum glucose was significantly lower at 30 min when the high amylose rice was consumed and the return to fasting levels more gradual than that observed when rice containing the lower levels of amylase was a consumed. Insulin levels at 30 and 60 min after the carbohydrate meals with high-amylose rice were significantly lower than levels after the rice with no amylase.

Phenolic compounds are universally distributed in the plant kingdom as secondary metabolic products **(Martinez-Valverde *et al.,* 2000).** Evidence indicates that phenolic compounds have potent antioxidant properties and free radical scavenging capabilities **(Shashidi and Wanasundara, 1992).** Phenolic compounds are known to exert various physiological effects in humans, such as preventing oxidative damage of lipid and low-density lipoproteins **(Morton *et al.,* 2000),** inhibiting platelet aggregation **(Daniel *et al.,* 1999),** and reducing the risk of coronary heart disease and cancer **(Newmark, 1996) and Martinez-Valverde *et al.,* 2000)** Fruits and vegetables are known to be major dietary sources of phenolic compounds, whereas substantial research has demonstrated that cereal consumption is also an excellent way to increase phenolic compound intake **(Scalbert and Williamson, 2000).** Cereal grains contain unique free phenolic compounds and their glycosides, which exist in solution, and a significant amount of insoluble phenolic compounds, most of which are bound to polysaccharides in the cell wall **(Miller *et al.,* 2000).** Both types are important sources of phenolic compounds; however, consumption of these phenolic compounds is currently neglected. The major reason for this is that these compounds are concentrated in the bran layers and are lost with the separation of seed coat during processing. By the same token, most phenolic compounds in rice, which is a major staple cereal all over the world, particularly in Asia, are also lost with rice bran.

The aim of this studied to investigate the brown rice high and low amylose as a benefit health food and there effect of replacing white rice with brown rice to prevent diabetes risk factors in rats.

2. Materials and Methods

Materials:

Rice (*Oryze sativa* L.) milled and brown, Giza 175 (high amylase and Giza 185 (low amylase) varieties were obtained from Rice Research and Training Center (RRTC) at Sakha, Experimental Station Kafr El-Sheik Governorate, Egypt. Rice varieties were milled to give rice power and pass through a 60-80 mesh screen.

Kits of glucose and lipid parameters were obtained from Bicon Diagnosemittel GmbH and Co. KG Hecke 8 made in Germany.

Methods:

Chemical analysis of raw materials:

Protein content, ash, crude fiber, lipids content and total carbohydrates were determined in brown and white rice high and low amylase according to **AOAC (2005)** and also, amylase was determined using the method outlined by **Juliano (1971).** Total dietary fibers, soluble and insoluble dietary fibers were determined according to **Prosky *et al.*(1988).** Minerals content (Mg, Na, Zn, Fe, K, and Ca.) were determined using the Flam Photometer apparatus (Galienkamp, FGA330, England) and Perkin Elmer atomic absorption spectrophotometer (model 80, England) as described in **AOAC (2005).**

Phenolic acid compounds were determined in brown and white rice using High Performance Liquid Chromatography (HPLC) according to the method described by **Hakkinen *et al.* (1998).** HPLC instrument (Hewlett Packard series 1100 HP). Column hypersil BDS 5 µm C 18 and Detector UV 254 nm. Flow rate 0.3 mL/min. Mobile phase A: (0.5 mL acetic acid: 99.5 mL distilled water). B: (0.5 mL acetic acid: 99.5 mL acetonitrile), temperature ambient 25°C.

Nutritional experiments:

Male adult rats (36 rats) weight ranging 160-185 g were purchased from National Organization for Drug and Control Research, Giza, Egypt. Animals were housed in individual cages with screen bottoms and fed on basal diet for eight days. The basal diet consisted of corn starch 70%, casein 10% corn oil 10%, salt mixture 4%, vitamin mixture 1% and cellulose 5% according **AOAC (1995).**

After feeding on basal diet for eight days, rats were divided into tow groups. The first group (6 rats) was fed on the basal diet for another four weeks (30 days) and considered as negative control. The second main group (30 rats) was fasted over night and injected with strepto zootocin (dissolved in 0.1M citric acid buffer and adjusted at pH 4.5) into the leg muscle (5mg /100g body weight) to induce diabetic rats according to **Madar (1983).** After 48 hrs. of injection the second main group was divided into five sub groups (6 rats for each). The first one (6 rats) was continued to be fed on basal diet and considered as positive control. From the second to four subgroup (6 rats for each) were fed on 20% from brown and white rice high and low amylase as a substitute of corn starch in basal diet. Each rat was weighted every two days and the food consumption was calculated.

At the end of experimental period (four weeks), the blood samples were taken with drawn from the orbital plexus and centrifuged at 3000 rpm to obtain the sera. After that, the sera were kept on a deep-freezer at -20°C until their analyses. Serum glucose, total lipids, total cholesterol and triglycerides were determined according to **knight *et al.* (1972), Allain *et al.* (1974) and Fossati, Prencipe (1982) and Tietz (1986),** respectively. High and low density lipoprotein- cholesterol in serum was determined according to **Burstein (1970), Fruchart (1982**).

Statistical analysis:

Statistical analysis for each of the collected data was done of variance (ANOVA) test described the procedure outline by **Armitage and Berry (1987)**. The treatment means were compared using the least significant difference test (LSD) at 5% level of probability as outline by **Waller and Duncan (1969)**.

3. Results and Discussion

Chemical composition of brown and white rice high and low amylase:

Chemical composition of raw materials brown and white rice high and low amylose was determined and the results are recorded in Table (1). The results showed that the brown rice high and low amylose had the highest value in protein, fat, ash and crude fiber content (8.85, 1.65, 1.9 and1.25 % in high amylose and 8.42, 1.38, 1.83 and 1.24% in low amylose, respectively) compared with white rice high and low amylose. Moreover, White and brown rice high amylase had contained the highest value of amylose (30.04 and 25.19%, respectively) followed by white rice low amylose 20.97%. Main differences in the chemical composition between brown and white rice were due to milling process **(Heinemann *et al.*, 2005).**

From the same table, it could be noticed that the brown rice high and low amylose had the highest amounts of total dietary fiber (3.89 and 3.60%), insoluble dietary fiber (2.19 and 1.89 %) and soluble dietary fiber (1.70 and 1.71%), respectively compared with white rice high and low amylose. This means the brown rice contained a large amount of fiber. The results are in agreement with those reported by **Lovis (2003)** who found that total dietary fiber in white and brown rice flour was 2.4 and 4.6%, respectively.

Table (1): Chemical composition of brown and white rice high and low amylase on dry weight (g/100g).

Chemical analysis	High amylose		Low amylose	
	Brown rice	White rice	Brown rice	White rice
Protein	8.85	7.45	8.42	7.18
Ash	1.65	0.54	1.38	0.44
Lipids	1.9	0.59	1.83	0.54
Crude fiber	1.25	0.66	1.24	0.54
Amylose	25.19	30.04	19.25	20.97
T. D. F.	3.89	1.94	3.60	1.73
I. D. F.	2.19	1.61	1.89	1.36
S. D. F.	1.70	0.33	1.71	0.37
T. C.	86.24	90.69	87.17	91.37
LSD at 5%	0.034	0.030	0.033	0.132

T. D. F. Total dietary fiber.
I. D. F. Insoluble dietary fiber.
S. D. F. Soluble dietary fiber.
T. C. Total carbohydrates.

Minerals content of brown and white rice high and low amylase:

Table (2) showed the minerals content of brown and white rice high and low amylose. The results observed that the brown rice high and low amylose had the highest amounts of magnesium (68.44 and 67.83 mg/100g), potassium (62.91 and 62.61 mg/100g) and calcium (13.44 and 11.88 mg/100g), respectively. Whereas, white rice high and low amylosE was followed by brown rice and it was contained amounts 59.27 and 55.48 mg/100g in magnesium, 60.31and 59.31 mg/100g in potassium and 11.11 and 10.84 mg/100g in calcium, respectively. Moreover, sodium, zinc and iron elements were the lowest amounts in brown and white rice. **Liang *et al.* (2008)** reported that the degree of milling and polishing has significant effect on the nutrition especially on minerals such as zinc which decreased with milling due to anon-uniform distribution of nutrients in the kernel.

Table(2): Minerals content of brown and white rice (mg/ 100g).

Minerals content	High amylose		Low amylose	
	Brown rice	White rice	Brown rice	White rice
Magnesium	68.44	59.27	67.83	55.48
Sodium	0.351	0.312	0.431	0.301
Zinc	0.475	0.363	0.481	0.397
Iron	0.431	0.241	0.310	0.250
Potassium	62.91	60.31	62.61	59.31
Calcium	13.44	11.11	11.88	10.84
LSD at 5%	0.070	0.003	0.004	0.032

Phenolic fractions of brown and white rice high and low amylose:

Phenolic compounds in brown and white rice high and low amylose were fractionated using HPLC apparatus and the results are reported in Table (3). From the results it could noticed that the brown and white rice had contained the gallic, protocatechuic, hydroxy benzoic, vanillic, caffeic, syringic, ρ-cumaric, ferulic, chlorogenic and sinapic acids. Brown rice high and low amylose was the highest values from the phenolic compounds than white rice high and low amylose. The results observed that the brown rice high amylose was increased in ferulic, ρ-coumaric and sinapic acids (18.39, 4.45 and 1.2 mg/ 100g, respectively) followed by brown rice low amylose increased in ferulic and ρ-coumaric acids (15.41 and 2.20 mg/g). Whereas, white rice high and low amylose increased in ferulic acid (7.21 and 5.33 mg/ 100g, respectively).

The main phenolics in rice grains with light brown pericarp color are the phenolic acids, mainly ferulic and ρ-coumaric acids **(Tian *et al.,* 2004; Zhou *et al.,* 2004).** Other compounds identified include sinapic acid, protocatechuic acid **(Tian *et al.,* 2005),** chlorogenic acid, hidroxybenzoic acid **(Tian *et al.,* 2005),** vanillic acid, syringic acid **(Zhou *et al.,* 2004; Tian *et al.,* 2005),** caffeic acid **(Zhou *et al.,* 2004; Tian *et al.,* 2005)** and gallic acid **(Zhou *et al.,* 2004).**

Flavonoids are a class of secondary plant phenolics having potential beneficial effects on human health with significant antioxidant and chelating properties in the human diet. Over the years, they have been found to be an important part of the human diet and are considered to be active principles in some medicinal plants. The antioxidant activity of flavonoids is efficient in trapping superoxide anion (O2·**-**), hydroxyl (OH·), peroxyl (ROO·) and alcohoxyl (RO·) radicals **Wang *et al.* (2003).**

Table (3): Phenolic fractions of brown and white rice (mg /100g).

Phenolic compounds	High amylose		Low amylose	
	Brown rice	White rice	Brown rice	White rice
Gallic acid	0.27	0.17	0.19	0.15
Protocatechuic acid	0.35	0.20	0.21	0.18
Hydroxy benzoic acid	0.32	0.19	0.20	0.12
Vanillic acid	0.95	0.57	0.74	0.25
Caffeic acid	0.55	0.19	0.24	0.12
Syringic acid	0.24	0.03	0.17	0.01
ρ-Cumaric acid	4.45	0.58	2.20	0.36
Ferulic acid	18.39	7.21	15.41	5.33
Chlorogenic acid	0.80	0.50	0.30	0.30
Sinapic acid	1.21	0.30	0.52	0.10

Effect of brown and white rice high and low amylose on initial, final body weight and feed efficiency ratio in diabetic rats:

The results from Table (4) indicated that the normal negative control group was fed on basal diet had the highest in final body weight (174.5 g, increased 7.0 g about initial body weight) and feed efficiency ratio (1.5) at the end experimental period (four weeks). While, the positive control group was fed on basal diet significantly decreased in final body weight (150.0 g decreased 20.3g about initial body weight) and feed efficiency ratio. Meanwhile, the rat groups fed on brown and white rice high and low amylose were no significantly changed in final body weight between them. **Cristiane *et al.* (2007)** reported that the different amylose contents did not effect on food intake and body weight.

Table (4): Initial, final body weight and feed efficiency ratio in rats fed on brown and white rice (gram / four weeks).

Groups	Initial body weight	Final body weight	Total food intake	Feed efficiency ratio
Control negative	167.5 ±7.6 [b]	174.5 ±6.6 [a]	462.7 ±26.0 [a]	1.5 ±0.2 [c]
Control positive	170.3 ±8.0 [ab]	150.0 ±7.0 [b]	348.6 ±28.3 [c]	-5.8 ±0.6 [a]
Brown rice high amylose	181.7 ±8.6 [a]	171.8 ±7.9 [a]	450.4 ±31.3 [ab]	-2.3 ±0.2 [b]
Brown rice low amylose	182.3 ±9.1 [a]	177.8 ±8.2 [a]	445.6 ±31.1 [ab]	-1.0 ±4.7 [cd]
White rice high amylose	180.5 ±8.6 [a]	171.3 ±7.9	430.9 ±30.8 [ab]	-2.1 ±0.6 [b]
White rice low amylose	171.8 ±7.8 [ab]	173.8 ±8.1 [a]	420.0 31.2 [ab]	0.5 ±0.2 [d]
LSD at 5%	10.721	9.870	38.894	0.594

Effect of brown and white rice high and low amylose on glucose level and lipid parameter in diabetic rats:

Table (5) showed that the effect of brown and white rice high and low amylose on glucose level, total lipid, triglyceride, total cholesterol, high density lipoprotein and low density lipoprotein in diabetic rats groups during four weeks. From the results it could be noticed that the diabetic rats fed on brown rice high and low amylose significantly decreased in serum glucose blood level (160.3 and 166.0 mg/dl), followed by diabetic rats fed on white rice high amylose (171.5 mg/dl). It is clear that feeding on brown and white rice high amylose reducing serum glucose level than white rice low amylose. The results agreed with **Mitra and Roy (2007)** reported that the high resistant starches containing rice reduced fasting blood glucose. This may be due to the resistant starches behaves as dietary fiber which reduce blood glucose level.

Brown rice, a rich source of magnesium, a mineral that acts as a co-factor for more than 300 enzymes including enzymes involved in the body's use of glucose and insulin secretion. The postprandial blood glucose response of ten healthy and nine diabetes type 2 volunteers to brown rice was compared to milled rice from the same batch and variety. The total sugar released in vitro was 23.7% lower in brown rice than in milled rice. In healthy volunteers, the glycemic area and glycemic index were, respectively, 19.8% and 12.1% lower ($p < 0.05$) in brown rice than milled rice and while in diabetes type 2 volunteers, the respective values were 35.2% and 35.6% lower **Hsu *et al.* (2008)**.

The results from total cholesterol, HDL- cholesterol and LDL- cholesterol on diabetic rats fed on brown and white rice are reported that in the same table. It could be observed that the total cholesterol was significantly decreased in normal control healthy rats (91.8 mg/dl) and significantly increased in positive control diabetic rats (238.8 mg/dl). However, the rats fed on brown rice high and low amylose significantly lowered (150.0 and 160.0 mg/dl, respectively) than white rice high and low amylose (163.0 and 172.5 mg/dl, respectively). The results from HDL- cholesterol and LDL-cholesterol were paralleled for total cholesterol.

The data in the same table showed that serum total lipids and triglycerides were significantly decreased in normal control healthy rats and significantly increased in positive control diabetic rats. The other diabetic rats were fed on brown rice high and low amylose significantly decreased than positive control diabetic rats and rats fed on white rice high and low amylose. These results are agreement with **Kahlon and Woodruff (2003) and Kahlon and Smith (2004)** who reported that the rice bran in brown rice binding by bile acid may be the primary responsible for cholesterol lowering properties. **Cristiane *et al.*(2007**) reported that serum triglyceride level and cholesterol level significant decrease after consumption of a diet rich in amylose compared to diet rich in amylopectin (low amylose). **Shin *et al.*(2007)** reported that the high resistant starch in rice was reduced in serum cholesterol and LDL cholesterol may be due to resistant starch fermented to produce propionates which reduce serum and hepatic cholesterol. **Revilla *et al.*(2009)** reported that γ-oryzanol and phenolic compounds which found in brown rice has a greater effect on lowering plasma, triglyceride, total cholesterol and increasing HDL-cholesterol, possibly through a greater extent to increase fecal excretion of cholesterol and its metabolites.

From the obviously results it could be noticed the brown rice as a source of protein, total dietary fiber, some minerals (magnesium, potassium and calcium) and phenolic compounds than white rice. These contained it could may be prevention of diabetics level and lipid parameters and lowering of them. Therefore, it may be recommended that the brown rice is a benefit healthy food, lowering diabetics and alternative for white rice.

Table (5): Effect of brown and white rice on glucose level and lipid parameters in diabetic rats (mg/dl).

Groups	Total lipids	Triglycerides	Total cholesterol	HDL cholesterol	LDL cholesterol	Total glucose
Control negative	326.3 ±17.3 [e]	103.8 ±8.6 [f]	91.8 ±8.3 [d]	50.5 ±5.8 [a]	20.5 ±3.0 [g]	88.0 ±8.0 [d]
Control positive	605.0 ±25.7 [a]	235.8 ±15.4 [a]	238.8 ±14.3 [a]	23.0 ±1.9 [f]	168.3 ±8.5 [a]	250.0 ±16.5 [a]
Brown rice high amylose	417.5 ±21.9 [d]	176.8 ±8.6 [e]	150.0 ±8.0 [c]	42.0 ±2.6 [b]	72.7 ±4.3 [f]	160.3 ±12.3 [c]
Brown rice low amylose	440.5 ±22.4 [cd]	182.0 ±8.9 [de]	160.0 ±8.1 [c]	39.75 ±2.1 [bc]	83.9 ±5.2 [de]	166.0 ±12.2 [c]
White rice high amylose	471.3 ±22.5 [c]	194.8 ±8.9 [c]	163.0 ±8.2 [b]	37.5 ±1.8 [c]	86.6 ±5.4 [e]	171.5 ±11.7 [c]
White rice low amylose	566.0 ±23.9 [b]	212.0 ±8.3 [b]	172.5 ±8.1 [b]	27.3 ±1.9 [e]	102.9 ±5.3 [b]	222.3 ±12.2 [b]
LSD at 5%	28.68	12.12	11.62	3.53	7.14	15.78

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