Wholegrain Rice and Human Nutrition

Subjects: Agriculture, Dairy & Animal Science
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Rice is one of the most widely consumed cereals in the world. The husks of harvested, unprocessed rice are not digested by humans and need to be removed to obtain edible grains, whereas the bran can be partially (brown rice) or totally removed (white rice). Brown rice is a wholegrain cereal and, as such, is known to have beneficial effects on human health.

Keywords: brown rice ; nutritional quality ; brown rice technology ; pigmented rice ; glycemic response ; cancer

1. Introduction

The harvested unprocessed rice is known as paddy rice and needs to undergo milling for human consumption [1]. As part of the processing, the protective hull is removed, leaving only the actual rice kernel which is called brown rice. Paddy rice comes in many different colors, including brown, red, purple, and even black.

The brown rice is composed of bran layers (6–7% of its total weight), embryo (2–3%), and endosperm (about 90%) [2]. It is a wholegrain cereal and, as such, is known to have beneficial effects on human health. However, the edible brown rice, is rarely consumed as most populations prefer the white polished rice for reasons connected to appearance, taste, palatability, ease of cooking, tradition, safety, shelf life, and lack of awareness about its benefits and availability, which limits market potential [3][4]. It is, in fact, well known that the polishing process has evolved to improve rice cooking and eating quality and to extend its shelf life. For example, in South India, nearly half of daily energy intake comes from refined grains and white polished rice constitutes more than 75% of refined grain intake [5]. In China, brown rice is rarely consumed [6].

Rice is rich in genetic diversity with thousands of varieties grown in the world. There are different types of rice available worldwide which generally fall under the category of short, medium, or long grain size. Moreover, rice varieties can also be categorized as Indica, Japonica, glutinous, and aromatic. Glutinous rice is common in Japan. It is a short-grain variety whereas most of the aromatic cultivars are long-grain rice. Different cultures have different preferences regarding the taste, texture, color and stickiness of the rice varieties they consume, and many countries have signature rice recipes such as sushi, paella, risotto, and curry. Many other food products are made from rice such as noodles, sweets, cakes, cookies, snacks, and beverages.

In this review, the latest scientific reports regarding the nutritional composition of brown, wholegrain rice, and the evolution of the technology for its production will be briefly reviewed together with research findings on nutritional implications of brown rice consumption also in relation to cancer development in humans. A specific chapter will be devoted to pigmented rice which, thanks to its chemical composition, has attracted the growing interest of consumers worldwide. The value of wholegrain rice in a healthy human nutrition, i.e., in a diet that favors nutrient-dense foods containing many essential nutrients per calorie and bioactive substances, are illustrated. Gaps and needs for further studies useful to promote the consumption of wholegrain rice are also discussed in the concluding chapter.

2. Nutritional Values of White and Wholegrain Rice

Both white and brown rice are low-fat foods even if brown rice has more than four times the amount of lipid found in white rice, mainly polyunsaturated fatty acids (**Table 1**). Brown rice is also richer in dietary fiber, minerals, and vitamins, in particular of the B group. Besides the mentioned substances, brown rice contains γ-oryzanol, GABA (gamma-aminobutyric acid), tocopherols, tocotrienols, carotenoids, β-sitosterol, anthocyanins, proanthocyanidins, and other phenolic compounds [4][7][8][9].

Table 1. Comparison of the nutritional components of white and brown rice (%) *.

Nutrient	White Rice	Brown Rice
Water (g)	12.0	12.0
Energy (Kcal)	334	341
Proteins (g)	6.7	7.5
Lipids (g)	0.4	1.9
Available carbohydrates (g)	80.4	77.4
Starch (g)	72.9	69.2
Soluble carbohydrates (g)	0.2	1.2
Total dietary fiber (g)	1.0	1.9
Soluble dietary fiber (g)	0.08	0.12
Insoluble dietary fiber (g)	0.89	1.8
Minerals		
Sodium (mg)	5	9
Potassium (mg)	92	214
Calcium (mg)	24	32
Magnesium (mg)	20	-
Phosphorus (mg)	94	221
Iron (mg)	0.8	1.6
Copper (mg)	0.18	-
Zinc (mg)	1.3	-
Selenium (µg)	10	-
Vitamins		
Thiamine (mg)	0.11	0.48
Riboflavin (mg)	0.03	0.05
Niacin (mg)	1.3	4.7
Vitamin C (mg)	0.0	0.0
Vitamin A retinol equivalent (µg)	0.0	0.0
Vitamin E (mg)	tr	0.7

* Data from CREA food composition tables, 2021 [10].

Being rich in several interesting substances, rice bran and defatted rice bran have been proposed to improve the nutritional and functional quality of cakes [11], pasta [12], fresh noodles [13], brown rice noodles [14], wheat bread [15], and gluten-free bread [16].

A diet rich in wholegrain cereals is considered a healthier option than one where refined cereals are consumed, and rice is no exception [17]. Recent epidemiological studies have shown that the consumption of whole grains can reduce the risk of metabolic disorders, in particular type 2 diabetes mellitus [18], cardiovascular diseases [19][20], and some types of cancer [21]. A nutrition rich in brown rice may help in appetite control and weight loss due to higher fiber content compared to white rice. This also aids in the reduction of LDL cholesterol.

The exact mechanisms by which wholegrain cereals convey beneficial effects on health are not clear. Han et al. [22] studied the effects of polished rice, refined wheat, unpolished rice, and whole wheat on short-chain fatty acids (SCFA) and gut microbiota in ileal, cecal, and colonic digesta of normal rats. They found that animals fed with unpolished rice and whole wheat diets exhibited higher total SCFA in cecal and colonic digesta compared with those fed with polished rice and

refined wheat diets. They concluded that unpolished rice and whole wheat could modulate gut microbiota composition and increase the SCFA concentration with wheat being superior to rice in this regard. It is likely that several factors are involved, i.e., micronutrient content, fiber content, and/or glycemic index [23].

3. Glycemic Response to Brown Rice Consumption

Rice starch is composed of two glucose polymers, a linear one, amylose and a branched one, amylopectin. There are different types of rice which differ in the amount of the two polymers [24] and in the postprandial blood glucose response they produce. Glycemic index studies of rice report values ranging from 64 to 93 [25], however, most rice varieties are of high glycemic index [26]. Rice starches with a higher amount of amylose are more resistant to human digestion [27]. In addition to the amylose content of paddy rice, post-harvest processing such as milling, parboiling, and quick-cooking, and home cooking and cooling processes can influence starch digestibility.

Considering the impact of postprandial glycemia on health and in disease prevention and the fact that low glycemic indices are preferable over high ones, Boers et al. [28] performed a systematic search of the literature characterizing the range of postprandial glucose responses to rice and the primary intrinsic and processing factors known to affect such responses. They reported that the milling process shows a clear effect when compared at identical cooking times, with brown rice always producing a lower postprandial glucose and postprandial insulin response than white rice. However, they concluded that at the longer cooking times, normally used for the preparation of brown rice, smaller and inconsistent differences are observed between brown and white rice.

Musa-Veloso et al. [29] conducted a systematic review and meta-analysis of randomized controlled trials comparing the effects of wholegrain wheat, rice, and rye with those of each grain's refined counterpart on postprandial blood glucose area under the curve (AUC). The consumption of intact (wholegrain) rice, compared with white rice was associated with a significant reduction in blood glucose AUC so they concluded that wholegrain rice significantly attenuates the postprandial blood glucose response.

Recently, RamyaBai et al. [30] studied the glycemic index in association with the microstructure of four cereal grain foods determined by scanning electron microscopy and concluded that wholegrain or wholemeal flour may not necessarily be low in glycemic index. Intact wholegrain foods are a healthier alternative to milled wholegrains. They also noted that instant quick-cooking brown rice exhibited a high glycemic index, due to the processing method. Regular brown rice may be a healthier option.

4. Pigmented Rice

The issue of wholegrain rice consumption is particularly relevant for pigmented rice where a substantial proportion of nutritionally valuable components is located in the bran layers and in the germ.

The potential health benefits of this kind of rice have been primarily attributed to the presence of polyphenols which have been demonstrated to have antioxidant [31], anti-inflammatory [32], and anti-adipogenic potential [33] in in vitro and in vivo experiments with murine models. Moreover, human dietary intervention studies have shown wholegrain pigmented rice consumption to reduce serum low density lipoprotein, total cholesterol, and total triglyceride levels [34].

Consumption of the purple rice pericarp as a supplement was reported to inhibit atherosclerotic plaque formation in mice more strongly than the same product from non-pigmented rice due to the reduction of cholesterol accumulation, oxidative stress, and inflammation [35].

Aalim and Luo [36] recently investigated the effects of roasting and frying on brown and red wholegrain rice. Red rice was characterized by superior phenolic content and the presence of proanthocyanidins which were enhanced by roasting. However, brown rice showed greater phenolic stability compared with red rice. Chromatographic separation showed that red rice was dominated by protocatechuic acid and (-)-epicatechin, whereas brown rice showed high contents of p-hydroxybenzoic acid, (-)-epicatechin, and syringaldehyde.

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