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Uncooked rice of relatively low gelatinization degree resulted in lower metabolic glucose and insulin responses compared with cooked rice in female college students

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Abstract

Cooking processes that gelatinize granules or disrupt structure might increase the glucose and insulin responses because a disruption of the structure of starch by gelatinization increases its availability for digestion and absorption in the small intestine. We hypothesized that the uncooked form of rice, which has a relatively low degree of gelatinization even though in powder form, would result in lower metabolic glucose and insulin responses compared with cooked rice (CR). To assess the effects of the gelatinization of rice on metabolic response of glucose and insulin, we investigated the glucose and insulin responses to 3 rice meals of different gelatinization degree in female college students (n = 12): CR (76.9% gelatinized), uncooked rice powder (UP; 3.5% gelatinized), and uncooked freeze-dried rice powder (UFP; 5.4% gelatinized). Uncooked rice powders (UP and UFP) induced lower glucose and insulin responses compared with CR. The relatively low gelatinization degree of UPs resulted in low metabolic responses in terms of the glycemic index (CR: 72.4% vs UP: 49.7%, UFP: 59.8%) and insulin index (CR: 94.8% vs UP: 74.4%, UFP: 68.0%). In summary, UPs that were less gelatinized than CR induced low postprandial glucose and insulin responses.

Keywords: Glycemic index; Insulin index; Blood glucose; Rice; Gelatinization; Women
Abbreviations: ANOVA, analysis of variance; CR, cooked rice; GI, glycemic index; II, insulin index; UFP, uncooked freeze-dried rice powder; UP, uncooked rice powder.

1. Introduction

The glycemic index (GI) ranks carbohydrate-containing foods according to how they affect postprandial blood glucose concentrations. Insulin index (II), on the other hand, describes the effect of absorbed carbohydrates on postprandial insulin levels [1]. Although it is generally accepted that there is a good correlation between GI and II of foods [2], this is not always the case [3]. High-GI foods raise blood glucose levels quickly and stimulate insulin secretion. The continued intake of high-GI foods is associated with an increased risk of chronic diseases such as obesity, cardiovascular diseases, and diabetes. Thus, low-GI foods are suggested to be beneficial in reducing the incidences of these diseases [4-6]. For these reasons, many starchy foods including rice, which is the stable food in many countries, have been studied for its effect on the blood glucose response.

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Table 1
Nutrient composition and degree of gelatinization of the experimental meals

Nutrient composition	CR	UP	UFP
Portion size (g)	148	65	59
Carbohydrate (g)	50	50	50
Protein (g)	4.2	4.3	4.4
Fat (g)	0.7	0.7	0.6
Fiber (g)	0.2	0.2	0.3
Energy (kJ)	933.5	935.1	933.0
Degree of gelatinization (%)	76.9 ± 1.8	3.5 ± 1.4	5.4 ± 2.2

Values are means, and for gelatinization, the values are means ± SD.

Rice has given a wide range of results in GI studies, with the GI of rice ranging from as low as 54% to as high as 121% [7,8]. This makes it difficult to classify rice as a high- or low-GI food. In some studies, rice was classified as a low-GI food, whereas others assigned it to the high-GI category. Studies on the GI of rice may be affected by many factors, such as composition of the grain (particle size, amount and type of fiber, viscosity, availability of starch, and amylopectin and amylose content), and cooking methods [9].

Rice is cooked for consumption purposes in a variety of methods including boiling, pressure-cooking, and steaming [10]. Cooking processes that gelatinize granules or disrupt structure might increase the glucose and insulin responses. A disruption of the structure of starch by gelatinization increases its availability for digestion and absorption in the small intestine [11]. A much greater blood glucose response occurs after the consumption of cooked starch compared with raw starch, and pureed compared with whole foods [11,12].

Uncooked foods are gaining popularity as the focus on health points toward fresh, whole, without heat treatment, vitamin- and enzyme-rich foods. Moreover, uncooked starchy foods might have relatively low GI because the cooking process may increase the GI. In view of the increased attention to uncooked starchy foods and the nutritional advantages of carbohydrates that are slowly digested and absorbed, uncooked rice is of particular interest. In addition, the intact form of uncooked rice is difficult to consume because of swallowing; however, the rice powder and freeze-dried rice powder are more easily consumed and are the dominant forms of healthy uncooked foods in the market. Therefore, it is important to study the effects of the powder forms of uncooked rice because this form of rice greatly increases the surface area and results in much more rapid digestion and absorption of the rice which may increase the glucose and insulin responses [9].

Therefore, 2 important aspects of rice should be examined on health. The uncooked form and powder form of rice will influence the postprandial glucose and insulin levels in the human. We hypothesized that the uncooked form of rice, which has a relatively low degree of gelatinization even though in powder form, would result in lower metabolic glucose and insulin responses compared with cooked rice (CR). Hence, the present study was undertaken to investigate the in vivo glucose and insulin responses of rice cooked by one of the most popular ways of consuming rice and compared with uncooked rice (raw and freeze-dried powder form) in women to assess the effects of the gelatinization of rice on glucose and insulin metabolic responses.

2. Methods and materials

2.1. Test meals

Rice was harvested in the Pungtak of Korea, bought in bulk, cleaned, and then subjected to each processing treatment. Test rice meals were the 2 types (raw or freeze-dried form) of uncooked rice powder (UP; 80-mm mesh) and CR, in which 50 g rice was cooked by boiling for 15 minutes in the presence of 100 mL water; CR, UP, and uncooked freeze-dried rice powder (UFP). Rice powder was filled into glass vials, and the vials were frozen at −70°C for 24 hours. After which, it was immediately placed into a Christ model Alpha freeze dryer (type 1050; Van Der Heyden, Brussels, Belgium); UFP was performed at a shelf temperature of −50°C with a pressure below 1 mbar for 24 hours. All tested meals contained 50 g of available carbohydrates. The degree of gelatinization in test meals was measured based on the starch-iodine complexing reaction [13]

2.2. Subjects and study protocol

Subjects were excluded if they were smokers, were taking prescription medications, were dieting, or had irregular eating habits. In total, 12 healthy female college students participated in the present study. The subjects were served 4 different test meals at random order on separate days within 4 weeks. The subjects were served the test meals at 8 AM after overnight fasting. The meals were consumed within 15 minutes along with 200 mL water. The CR was served within 15 minutes after the end of the cooking process. An intravenous cannula was inserted into a superficial vein in the forearm, and blood samples were collected immediately before serving the test meals and 30, 60, 90, and 120 minutes after. Each subject signed a written informed consent of acceptance, which was previously approved by the Ethical Committee for Human Experimentation of Dongduk Women's University and conducted in accordance with its rules and regulations.

Table 2
Characteristics of the subject

Characteristics	Subjects (n = 12)
Age (y)	21.8 ± 2.7
Height (cm)	160.5 ± 5.0
Weight (kg)	55.5 ± 7.4
Lean body mass (kg)	36.2 ± 3.3
Fat mass (kg)	17.0 ± 4.9
% body fat	30.9 ± 5.1

Values are means ± SD for 12 subjects.