

Are Rice and Spicy Diet Good for Functional Gastrointestinal Disorders?

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Rice- and chili-containing foods are common in Asia. Studies suggest that rice is completely absorbed in the small bowel, produces little intestinal gas and has a low allergenicity. Several clinical studies have demonstrated that rice-based meals are well tolerated and may improve gastrointestinal symptoms in functional gastrointestinal disorders (FGID). Chili is a spicy ingredient commonly used throughout Asia. The active component of chili is capsaicin. Capsaicin can mediate a painful, burning sensation in the human gut via the transient receptor potential vanilloid-1 (TRPV1). Recently, the TRPV1 expressing sensory fibers have been reported to increase in the gastrointestinal tract of patients with FGID and visceral hypersensitivity. Acute exposure to capsaicin or chili can aggravate abdominal pain and burning in dyspepsia and IBS patients. Whereas, chronic ingestion of natural capsaicin agonist or chili has been shown to decrease dyspeptic and gastroesophageal reflux disease (GERD) symptoms. The high prevalence of spicy food in Asia may modify gastrointestinal burning symptoms in patients with FGID. Studies in Asia demonstrated a low prevalence of heartburn symptoms in GERD patients in several Asian countries. In conclusion rice is well tolerated and should be advocated as the carbohydrate source of choice for patients with FGID. Although, acute chili ingestion can aggravate abdominal pain and burning symptoms in FGID, chronic ingestion of chili was found to improve functional dyspepsia and GERD symptoms in small randomized, controlled studies.

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Key Words

Chili pepper, Rice, Functional gastrointestinal disorder, Capsaicin, TRPV1 receptor

Introduction

Complaints of gastrointestinal symptoms after food ingestion are common in patients with functional gastrointestinal disorders (FGID) and are reported in 25-64% of irritable bowel syndrome (IBS) patients.^{1,2} IBS patients often complain of food-related gastrointestinal symptoms secondary to more than one specific food.

A recent population-based study in the USA demonstrated that 16.5% and 28.3% of IBS patients had intolerance to 1-2 food items and > 2 items, respectively.² These statistics suggest that hyper-sensitivity to the ingestion of foods is common in IBS. Research studies also demonstrate that certain foods, such as chili, fructose or fructan containing foods and fatty foods, can affect gastrointestinal motility and sensation^{3,4} and induce gastrointestinal symptoms more than other foods.⁴⁻⁶ This suggests that

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certain foods, and not just the process of eating foods, can aggravate symptoms in patients with FGID. Therefore, modification of either eating habits (reducing meal size and/or the time of meals) or the composition of meals (avoiding specific food items) may benefit patients with FGID, and studies on the effects of food on gastrointestinal functions and symptoms are important.

The effects of food ingestion on gastrointestinal symptoms in patients with FGID have been extensively studied, mainly in Western countries and with Western diets. Moreover, information regarding the effects of typical Asian foods on gastrointestinal symptoms of FGID is quite limited. This review will focus on the effects of specific but widely used Asian diets/ingredients, "rice and chili or spicy foods," on gastrointestinal functions and their roles on the symptoms of FGID.

Characteristics of the Asian Diet

The Asian diet is characterized by a high-carbohydrate, high-fiber, low-fat, and low-meat protein composition.⁷ Typical Asian food generally consists of rice and vegetables as the major source of carbohydrate and fiber. Vegetable oil is a common source of fat, whereas fish, eggs, poultry, and pork are the main sources of protein. This is in contrast to Western diets, which are rich in animal fat and beef protein but lower in carbohydrate and fiber contents. In addition, Asian foods often consist of several ingredients, such as chili, to make the foods tastier.

1. Role of rice and high-carbohydrate diet in FGID

In general, food can aggravate gastrointestinal symptoms by several mechanisms including: exaggerated physiologic responses of the gastrointestinal tract, food intolerance, allergy, increased intestinal gas,⁸ and modification of gut motility and sensation.

Food with high-carbohydrate content may cause symptoms of functional bowel disorders by both allergic and non-allergic mechanisms. As for the latter, carbohydrate may cause gastrointestinal symptoms because of incomplete absorption in the small bowel, such as lactose mal-absorption.⁹ In the allergic mechanism, the protein contents in the carbohydrate sources may cause allergic reactions to the gastrointestinal tract, such as gluten in wheat.¹⁰

Major types of carbohydrate in the human diet are: starches, sucrose, and lactose. They have to be digested into monosaccharide before being absorbed through the gut mucosa. If the

complex-carbohydrate and monosaccharide are not completely absorbed into the small bowel, then these substances will enter the colon and will be fermented by colonic bacteria to produce gas and short-chain fatty acids, which may contribute to the symptoms reported in patients with FGID¹¹ such as diarrhea, gas, bloating, and abdominal discomfort and pain. The non-absorbable carbohydrates and their metabolites may induce gastrointestinal symptoms by their effects on gut sensation¹² and gut motility, such as decreased gastric tone, decreased lower esophageal sphincter pressure and accelerated small bowel transit.¹³⁻¹⁵ A recent study in Asia (India) demonstrated that there is a similar prevalence of lactose intolerance in IBS patients and healthy controls.¹⁶ The authors performed lactose hydrogen breath tests in 124 IBS patients and 53 age- and gender-matched healthy controls. They found a similar prevalence of abnormal lactose hydrogen breath tests in IBS patients and healthy volunteers (72% vs. 60%). However, IBS patients developed gastrointestinal symptoms more often than healthy volunteers after ingestion of lactose (56% vs. 34%).¹⁶ This higher rate of gastrointestinal symptoms suggests that there is a role of visceral hypersensitivity in the expression of carbohydrate mal-absorption symptoms and that the completeness of small intestinal absorption of carbohydrate is important in patients with IBS and can associate with their IBS symptoms.

2. Rice is completely absorbed in the small intestine, producing little gas

Major sources of complex carbohydrate or starch in the human diet are wheat, rice, oat, potato, and corn. The effects of each complex carbohydrate or starch on gastrointestinal symptoms depend on its fiber content, its allergenicity, and the completeness of the small bowel digestion and absorption. In Western countries, wheat is the major source of carbohydrate. It may cause gastrointestinal symptoms by allergic reaction to gluten, the major protein component of wheat.^{17,18} In a recent meta-analysis of 14 studies, patients who fulfill the criteria of IBS ($n = 2,278$) have a higher prevalence of celiac disease than controls ($n = 1,926$).¹⁹ The pooled prevalence of positive IgA-class antigliadin antibody, either positive endomysial antibody or tissue transglutaminase, and biopsy-proved celiac disease in IBS were 4.0%, 1.63%, and 4.1%, respectively. Pooled odds ratios (95% confidence interval) for positive IgA-class antigliadin antibody, either positive endomysial antibody or tissue transglutaminase, and biopsy-proved celiac disease in IBS patients compared with controls were 3.40 (1.62-7.13), 2.94 (1.36-6.35), and 4.34 (1.78-10.6), respec-

tively.¹⁹ This implies that, in a subgroup of IBS patients, ingestion of a gluten-containing diet may aggravate and avoidance of the diet may improve gastrointestinal symptoms.²⁰ Furthermore, wheat ingestion produces the highest peak of breath hydrogen compared to other sources of carbohydrate such as corn, oats, potatoes, beans, and rice in healthy humans.²¹ This suggests that wheat carbohydrate is not completely absorbed in the small bowel and that it may produce gastrointestinal symptoms, independent of gluten hypersensitivity.²²

Rice is the major source of carbohydrate in Asian populations. In contrast to wheat and other sources of carbohydrate, rice is completely absorbed in the small bowel and produces very little intestinal gas after ingestion.²¹ A previous study demonstrated that the amount of hydrogen, a maker of carbohydrate metabolism by intestinal bacteria,²³ in breath samples after rice ingestion is minimally increased and not significantly different from the fasting period.²¹ Furthermore, rice has been shown to have a low allergenicity. Previous studies demonstrated that serum IgG levels produced in reaction to several kinds of food such as wheat, beef, pork, lamb, soybean, shrimp, egg, and crab were increased in IBS patients compared to healthy humans,^{24,25} but the serum IgG levels produced to rice in IBS patients is mild²⁶ or not increased.^{25,26} A study from China in 37 IBS, 28 functional dyspepsia, and 20 healthy controls demonstrated that serum IgG antibody titers to rice was similar in IBS (28.7 ± 0.5 U/mL) and functional dyspepsia patients (29.5 ± 0.7 U/mL) compared to healthy controls (28.4 ± 0.5 U/mL). In contrast, the serum IgG antibody titer to wheat was increased in IBS patients (60.6 ± 3.4 U/mL) compared to functional dyspepsia patients (49.4 ± 2.0 U/mL) and healthy controls (48.1 ± 2.0 U/mL).²⁵ This low production of IgG suggests that rice has a low allergenicity compared to other common foods.

3. Rice has lowest fiber content compared to other common sources of carbohydrate

It has been reported that fiber speeds up human gut transit²⁷ and can improve constipation symptoms.²⁸ However, its benefit in FGID is limited. Recent meta-analysis studies on the effect of fiber on global symptoms of IBS patients demonstrated conflicting results.^{28,29} In addition, it may worsen abdominal pain and bloating symptoms.^{28,29} In healthy humans, ingestion of fiber (psyllium) can delay intestinal gas transit and cause more gas retention after intestinal gas perfusion.³⁰ Thus, a high-fiber diet may worsen abdominal bloating and pain by delaying intestinal gas transit and increasing gas production in the colon secondary

to bacterial fermentation. In certain parts of Asia, such as in India, healthy controls and patients with IBS have more dietary fiber (51.7 and 52.3 g/day, respectively) than the recommended amount for the general population (20-40 g/day).³¹ Therefore, increasing the dietary fiber consumption of functional gastrointestinal disorder patients in certain parts of Asia may not provide any benefit but may worsen the bloating and abdominal pain symptoms.

Although the Asian diet is rich in fiber, rice - the widely used complex carbohydrate - has the lowest fiber content compared to other kinds of cereal. A previous study demonstrated that the total fiber content (insoluble + soluble fiber) of different kinds of cereal is lowest in rice and highest in wheat (4.1% in rice vs. 12.5% in wheat).³² As high-fiber may worsen abdominal pain and bloating symptoms, rice may be the most preferable carbohydrate source for functional gastrointestinal disorder patients with predominant symptoms of bloating and abdominal pain.

4. Clinical studies suggest benefits of rice-based meal in IBS

Rice has been the major source of carbohydrate in exclusion diets in several clinical studies.³³⁻³⁷ These studies demonstrated that the exclusion diet is well tolerated and can improve IBS symptoms in both open and controlled studies.³³⁻³⁷ A recent study by King et al.³⁸ suggests that the rice-based exclusion diet may improve symptoms in IBS by reducing intestinal gas production. The study was performed in 6 female IBS patients and 6 female controls by measuring 24-hour hydrogen and methane production after ingestion of rice-based exclusion diet or standard diet, in a crossover controlled trial, using a whole-body calorimeter. The authors found that after standard diet the gas excretion rate and hydrogen production was higher in IBS patients (2.4 mL/min and 332 mL/24 hr, respectively) than in controls (0.6 mL/min and 162 mL/24 hr). The rice-based exclusion diet reduced hydrogen production compared to standard diet in both IBS (79 vs. 332 mL/24 hr) and controls (95 vs. 162 mL/24 hr). In addition, in IBS patients, the exclusion diet reduced symptoms [symptom score = 8 (5.25-10) vs. 4 (3-7)] and reduced the maximum gas excretion rate compared to the standard diet (0.5 vs. 2.4 mL/min).

Recently, the very-low-carbohydrate strategy has been shown to improve IBS-D symptoms in a small open study.³⁹ The authors found that 13 of the 17 patients who were enrolled completed the study. Ten (77%) of the patients who completed the study reported adequate relief of IBS symptoms. Furthermore,

the stool frequency, stool consistency, pain scores, and quality of life were significantly improved.

Because there have been reports of inadequate dietary intake because of food avoidance in IBS patients, the avoidance of poorly-absorbed carbohydrates combined with the consumption of well-absorbed carbohydrates or rice may be more appropriate than the use of very-low-carbohydrate diets in the dietary treatment strategy for IBS patients.

All together, rice may be the best source of carbohydrate for patients with functional bowel disorder because of its low allergenicity, its nearly complete absorption in the small bowel, and its low fiber content. In addition, a small crossover controlled study supports its benefit in IBS.³⁸

5. Effect of chili on FGID

Chili and spicy food are common in most Asian countries. The average daily chili consumption in Asian people is 2.5-8 g/person. It is much higher than that of 0.05-0.5 g/person in European and American peoples.⁴⁰ Recent studies suggest that acute and chronic ingestion of chili can modify gastrointestinal symptoms in FGID.^{6,41} Whether or not a high prevalence of spicy food modifies gastrointestinal symptoms at the population level is not known. In addition, data on the effect of chili or spicy foods on FGID in Asian countries with a high prevalence of spicy food have been limited.

6. Capsaicin mediated visceral nociception in FGID

The active ingredient of chili is capsaicin. Capsaicin can modulate gastrointestinal sensation via capsaicin or TRPV1 receptors. These receptors have been found at different levels throughout the gastrointestinal tract.⁴²⁻⁵⁰ Capsaicin, acid, and heat can stimulate the TRPV1 receptors and mediate a sensation of burning and pain.⁵¹ Several studies suggested that TRPV1 receptors can mediate sensations of warmth, pressure, cramping, and pain in the human gut.⁵² Increases in the number of TRPV1 receptors have been found in the gut mucosa of patients with conditions associated with visceral hypersensitivity, including in the esophagus of patients with non-erosive reflux disease (NERD),⁴² in the colon of patients with irritable bowel syndrome⁵³ and in the rectum of patients with rectal hypersensitivity.⁴³ Recent studies demonstrated that patients with FGID, including functional dyspepsia and irritable bowel syndrome, exhibit gut hypersensitivity to capsaicin or capsaicin containing chili.^{6,54} Hammer et al.⁵⁴ studied the effect of 0.75 mg capsaicin powder ingestion on gastrointestinal symptoms in 54 functional dyspepsia patients and 61

healthy controls. They found that after capsaicin ingestion, nausea, a flutter-like sensation, warmth and abdominal pain scores were higher in functional dyspepsia patients than in healthy volunteers. A recent study in 20 IBS-D patients demonstrated that ingestion of chili-containing meals produces higher abdominal pain and abdominal burning symptom scores than standard meals and when compared to the symptoms reported by healthy volunteers in response to ingestion of chili-containing meals.⁶ Studies suggest that abdominal pain and burning symptoms seem to be the typical gastrointestinal symptoms of capsaicin hypersensitivity,^{6,54} whereas abdominal bloating symptoms seems to be independent of the capsaicin pathways.

Low-grade inflammation in the gastrointestinal tract has been proposed as a major pathogenesis of FGID, especially in irritable bowel syndrome.⁵⁵ Up-regulation of TRPV1 pathways resulting in visceral hypersensitivity to mechanical and chemical stimulations has been reported following an induction of colonic inflammation in an animal model.⁵⁶ In humans, gut inflammation has been reported to be associated with an increased number of TRPV1-expressing nerve fibers.^{50,57} Thus, hypersensitivity of the TRPV1 pathways in patients with FGID is likely a result of low-grade inflammation and may be an important pathogenesis of gut hypersensitivity, abdominal pain, and abdominal burning symptoms in FGID.

7. Desensitization of capsaicin receptors, its role on patients' symptom profiles and treatment of FGID

It has been reported that prior exposure of esophageal mucosa to capsaicin solution do not affect esophageal sensation in response to acid perfusion or to balloon distention.⁵⁸ However, the study evaluated the effect of single stimulation of esophageal mucosa by perfusion of capsaicin solution into the esophagus and could not exclude the desensitization effects of capsaicin receptors in the gut mucosa after repeated exposure to capsaicin agonists.

It has been demonstrated that TRPV1 receptors can be desensitized by repeated exposure to capsaicin.⁴⁸ Recent small studies suggested that chronic ingestion of capsaicin containing chili can modify dyspepsia symptoms in functional dyspepsia patients⁴¹ and GERD symptoms in NERD⁵⁹ by decreasing dyspeptic and GERD symptoms, respectively. Bortolotti et al.⁴¹ randomized 30 functional dyspepsia patients to receive 2.5 g/day of red pepper powder or placebo in a double-blind manner for 5 weeks. They found that red pepper significantly improved overall symptom scores, epigastric pain, fullness, and nausea scores rela-

tive to placebo. The overall symptom scores decreased from 3.3 ± 0.6 at baseline to 1.7 ± 0.2 at the end of week 5 for red chili treatment compared to from 3.4 ± 0.7 to 2.5 ± 0.3 for placebo treatment. In a preliminary study in 8 patients with NERD, red chili ingestion for 6 weeks significantly improved total GERD, heartburn, and regurgitation symptom scores compared to placebo.⁵⁹ The authors found that, at baseline, total GERD scores, heartburn, and regurgitation scores were similar comparing between chili and placebo capsules (chili vs. placebo: 7.6 ± 3.7 vs. 4.7 ± 2.8 , 4.6 ± 2.3 vs. 3.2 ± 2.1 , and 2.9 ± 2.4 vs. 1.5 ± 1.6 , respectively). At the end of week 6, red chili significantly decreased GERD symptom scores (chili vs. placebo: 0.9 ± 1.2 vs. 4.9 ± 2.4), heartburn symptom scores (0.4 ± 0.6 vs. 3.7 ± 1.6), and food regurgitation symptom scores (0.5 ± 0.8 vs. 1.3 ± 1.6) compared to placebo. The effects of chili ingestion on functional dyspepsia and GERD symptoms were observed after the 2nd week of treatment in both studies. The similar effects of chronic ingestion of red chili in functional dyspepsia and NERD patients suggests that capsaicin receptors play role on the development of both functional dyspepsia and NERD symptoms and is consistent with previous reports of visceral hypersensitivity to capsaicin in functional dyspepsia⁵⁴ and increase TRPV1 receptors in NERD.⁴² In contrast, a previous study in 12 healthy volunteers reported that chronic chili ingestion induce more gastroesophageal refluxes.⁶⁰ However, the duration of chili ingestions was too short (≤ 1 week) in relative to the other studies, which showed the desensitization effect of chili (5-6 weeks). These limited data suggest that the natural capsaicin agonist (chili) may have a therapeutic role for pain and burning symp-

toms in FGID and more research studies are needed to confirm this hypothesis.

The effect of spicy food, which is frequently eaten in Asia, on the gastrointestinal symptom profiles in FGID at population level is not clearly known. Studies of GERD symptoms in Asian patients have reported a lower prevalence of heartburn compared to Western patients. A study of GERD symptoms in German patients who underwent 24-hour esophageal pH monitoring showed that both heartburn and acid regurgitation are the main typical GERD symptoms,⁶¹ whereas a similar study in an Asian country (Thailand) with a high prevalence of spicy food reported only acid regurgitation, but not heartburn, as the main GERD symptom (Fig. 1).⁶² Furthermore, epidemiologic studies in Asian countries, including China, Iran, and Thailand, demonstrated lower heartburn/regurgitation symptom prevalence ratios⁶³⁻⁶⁶ compared to Western or developed countries with a low prevalence of spicy food.⁶⁷⁻⁶⁹ However, the low heartburn/regurgitation symptom prevalence ratio was not observed in Korea.⁷⁰ In Turkey, an European country with a high prevalence of spicy food, the prevalence of heartburn in the population is much lower than the prevalence of acid regurgitation (weekly heartburn vs. acid regurgitation: 10% vs. 15.6%, respectively).⁷¹ When the studies that reported the prevalence of annual regurgitation and heartburn symptoms were included, studies of the American population reported a heartburn/regurgitation prevalence ratio of 0.91-0.94,^{68,69} whereas studies in China reported a lower ratio of 0.34.⁶⁴ There has been no study that directly compares GERD symptom profiles between Asian and Western peoples or patients in the area of high and low prevalence of chili in the diet.

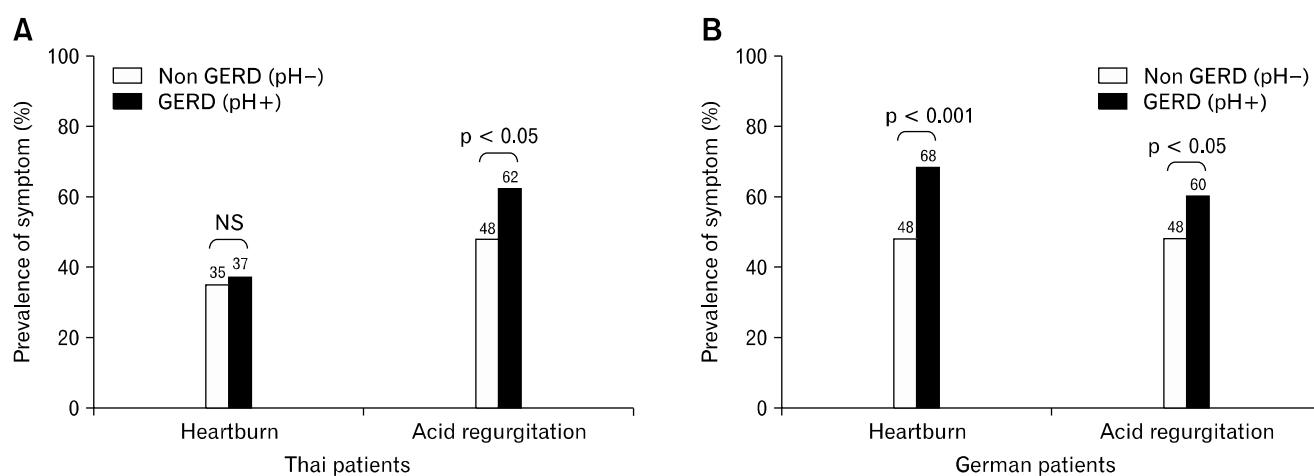


Figure 1. The prevalence of heartburn and acid regurgitation symptoms in patients with positive and negative 24-hour pH monitoring: a comparison of the 2 studies from Asia (A, Thailand)⁶² and Europe (B, German).⁶¹

However, the collective results of the available studies imply that acid or gastric content regurgitation into the esophagus in people in certain regions of Asia is not perceived as heartburn symptoms by the esophagus in the same way that heartburn symptoms are perceived by Western people. The high prevalence of spicy food may play a role in this finding, but this hypothesis has not been proven. The low prevalence of heartburn symptoms is not likely to be a misinterpretation of acid reflux symptoms in Thai people because acid perfusion tests produce no symptoms in most Thai GERD patients (GI Motility Research Unit, Chulalongkorn University, Thailand, un-published data). However, the heartburn/regurgitation symptom prevalence ratio is not lower in Mexico, where the prevalence of spicy food is high. This inconsistency suggests that not only spicy food, but also other factors, may influence the sensitivity of esophagus to gastro-esophageal reflux contents at the population level.

In summary, capsaicin or TRPV1 receptors are involved in the pathogenesis of burning and pain symptoms of the gastrointestinal tract. Recent small studies suggest that the chronic use of capsaicin-containing chili can decrease heartburn and abdominal pain in GERD and dyspepsia, respectively. In addition, the ratio of the prevalence of heartburn/regurgitation symptoms in the population is lower in several parts of Asia; this lower rate may be related to the high prevalence of chili or spicy food.

Conclusion

Rice seems to be the most preferable source of carbohydrate in patients with FGID. It has a low allergenicity and fiber content; it is also completely absorbed in the small bowel and produces little gas after ingestion. Therefore, it should be advocated as a major source of carbohydrate for patients with IBS and those with other functional GI disorders.

There has been increasing evidence to support the role of capsaicin receptors in the pathogenesis of symptoms of FGID. Preliminary studies support the role of desensitization of capsaicin receptors by chili, a natural capsaicin receptor agonist, for the treatment of functional dyspepsia and NERD. However, more research studies are needed to confirm this hypothesis.

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