



Foods Consumed with Rice that Elicit a Reduction in Glucose Response among Healthy Individuals

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Abstract

Purpose: The purpose of this article is to report and summarise various foods consumed with rice that has shown a positive impact on glucose response. The rationale of this review is that it is useful for public health researchers and nutritionists concerning foods that are beneficial in reducing the glucose response for health monitoring. This review is also useful for individuals interested in improving their daily diet for better health.

Design: This study searched latest PubMed and ScienceDirect international articles from 2015 to 2020. The articles included in the search were those that include mixed rice meal studies, impact on glycaemic response or index. The selected studies were those that involved healthy participants from various regions. An example of word search in PubMed is "Rice glycaemic index", "oryza" [MeSH Terms] OR "oryza" [All Fields] OR "rice" [All Fields] AND "glycaemic" [All Fields]).

Findings: The key findings of this review are any type of rice (white rice, basmati rice, long grain or red rice) has shown to have a beneficial outcome on postprandial glucose response when consumed with the meals tested.

Originality/value: Most of the foods listed in this review are readily available in many parts of the world. This means access to these foods is easy and advocating its consumption is essential. Diversification regarding style or intake of rice across the globe depends on culture and tradition. Understanding glycaemic index and its impact on health particularly diabetes and heart diseases will help reduce the intake of medications. It will also be more cost-effective and improve general well-being and health.



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Introduction

Rice is a staple food among more than half of the world population. In many Asian countries,

rice makes up more than 50% of the daily calorie intake. The intake of rice has been linked to certain metabolic disorders. It has been linked to the

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predisposition of type-2 diabetes particularly among Asians.^{1,2} Within the Asian region, the incidence of diabetes is estimated to increase up to 60% in the year 2025 as compared to 2007.³ A single serving of white rice has been linked to increased risk of diabetes by up to 11%.^{1,3} Therefore, to reduce and control the predisposition of metabolic disorders such as type-2 diabetes, dietary management is one of the best methods of treatment.

The quality and quantity of carbohydrates in foodstuffs such as rice varies and affects the body's glycaemic response (glucose response). The glycaemic index (GI) is a quantitative assessment of foods calculated via glycaemic response.⁴ Foods such as rice can be classified as high GI, medium GI or low GI. High GI foods cause a high and rapid increase in blood sugar levels.⁵ Consumption of low GI foods, on the other hand, causes slow and lower blood sugar levels.⁵ Rapid rise and longer duration of glucose in the blood is known to cause hormonal and metabolic changes which leads to negative health consequences. Therefore, low GI foods are sought for better control of blood glucose levels, thus better health outcome.

Under normal conditions, blood sugar levels increase after a meal. Insulin is released from the β -cells of the pancreas to facilitate the uptake of the blood glucose into tissues and lowers the remaining glucose in the bloodstream.⁶ Under abnormal conditions, after a meal, blood glucose may remain high in the bloodstream (as observed in type-2-diabetes patients), which could be caused by an abnormal insulin activity. The latter was mainly caused by practicing poor diet and lack of physical activity.⁶

However, apart from the quality and quantity of carbohydrates, there are other non-carbohydrate factors of foods that have an impact on GI. One of the factors known to affect the GI in foods is starch quality.⁷ For example, higher amylose contents in foods lead to lower GI. While higher amylopectin contents in food lead to higher GI. Other factors that may also affect the GI of foods includes the contents of organic acids, amylase inhibitors and gel-forming type of dietary fibre, which contributes to lower GI in foods.⁷

The glucose response differs based on the food type. The study of GI in food is a very promising area of research due to food diversity across the world. It is very interesting to observe the varieties and investigations of researchers on different kinds of food and meal combinations on GI. Furthermore, the reduction in glycaemic response has been associated with improvements in health indicators for obesity, diabetes.^{8,9}

Rice is considered a medium or high GI food. Since rice is a main staple food and a favourite among adults and children, it is not easy to exclude rice from our everyday diet. A strategic method is to understand how meal combinations can be manipulated to improve the glycaemic indices of these foods. Furthermore, rice is rarely eaten as a standalone meal and is usually co-ingested with a variety of foods depending on the culture and region. The main goal is to consume foods that can produce reduced glucose responses.

In order to achieve a low GI, various rice meal combinations or diets have been tested. Rice meal combinations such as protein-based, fat-based, vegetable or mixed meals have been tested. Protein-based rice meals refer to when rice is co-ingested with protein-rich foods such as chicken, tofu or eggs. Fat-based rice meals refer to when rice is co-ingested with foodstuffs such as various types of oils, butter or margarine such as Ghee. Vegetable-based rice meals refer to when rice is co-ingested with some kinds of vegetables. However, a review of the various mixed meals with rice on GR has not been done. Therefore, the review aims to update the various foods consumed with rice that has shown a positive impact on GR. The rationale of this review is that it is useful for public health researchers and nutritionists concerning foods that are beneficial in reducing the glucose response for health monitoring. This review is also useful for individuals interested in improving their daily diet for better health.

Methodology

This study searched PubMed and ScienceDirect international articles from 2015 to 2020. The articles included in the search were those that include mixed rice meal studies, impact on glycaemic response

or index. The selected studies were those that involved healthy participants from various regions. An example of word search in PubMed is "Rice glycaemic index", "oryza" [MeSH Terms] OR "oryza" [All Fields] OR "rice" [All Fields]) AND "glycaemic" [All Fields]).

Result and Discussion

Several rice meal combinations have been tested, and most of the studies have shown a positive impact on postprandial GR as summarised in Table 1. Legumes play an important part in everyday diets among many nations. Legumes are known to have many nutritional benefits including a source of energy, proteins, high in fibre, polyphenols, vitamins and minerals.^{10,11} Three articles tested the impact of adding legumes to rice meals on the postprandial glucose response. Black beans and

chickpeas consumed with rice has a lowering effect on the blood glucose response.¹² Ripe bean seeds have positive benefits regarding lowering the blood glucose response.¹³ A similar study also found that ripe plantain has similar beneficial effects.¹³ Another study looked at the combination of rice with lentils and showed a positive effect on the postprandial GR in healthy individuals.¹⁴ Thus, based on these current evidences, co-ingestion of legumes can help to attenuate postprandial GR.¹¹ One of the possible mechanism was that legumes cause slow carbohydrate absorption.¹¹ Interestingly, in recent years, one of the strategies to reduce the GI of bread used flour-based legume as part of the ingredient to make bread.^{11,15} Therefore, the consumption of legumes or lentils has beneficial effects on the postprandial GR.

Table 1: Selected studies on rice mixed meals on Glucose Response 2015 to 2020
Various combinations of varieties of rice and foods were tested. The main categories include protein-based, fat-based and vegetable based meals

Meals Type	Author	Type of food mixed and amount	Type of rice /origin of rice	Cooking/ Preparation	Observation/ Results
Protein-Based/ High-Fibre Diet	12	Legumes: black beans (<i>Phaseolus vulgaris</i> L.) chick peas (<i>Cicer arietinum</i> L.)	Long grain white rice (Great Value, Bentonville, AR, USA).	Rice = rice cooker Beans = cans and heated by microwave	Reduced postprandial glucose
	13	Ripe bean seed (<i>Phaseolus vulgaris</i>) – Okada Town, Nigeria	<i>Oryza sativa</i> (Asian rice)	Bean cooked by pressure cooker	Reduced postprandial glucose – but still in the high GI category
	13	Ripe plantain (<i>Musa paradisiacal</i>) – Okada Town, Nigeria	<i>Oryza sativa</i> (Asian rice)	Fried with groundnut oil	Reduced postprandial glucose – but still in the high GI category
	14	Lentils	White rice (Selections Long Grain White Rice ; Metro Inc., Montreal, Quebec, Canada)	Cooked in rice cooker	Reduced postprandial glucose
Protein-Based Meals	16	Chicken	Pilau rice	Chicken curry (thus, containing fat as well)	Pilau alone = 60 Pilau with chicken = 41
	17	Fresh sea bass (<i>Dicentrarchus labrax</i>)	White rice (Thai Hom Mali Fragrant Rice)	Steam except eggs was boiled	Rice with soya beancurd showed a statistically

		Whole eggs (Seng Choon)			significant reduction glucose response
		Soya beancurd (taukwa)			
		Fresh chicken breast meat			
Fat-Based	18	Liquid oil versus oleo gel type of oil	Instant rice porridge (Knorr chicken and mushroom cup porridge ; Unilever Singapore Pte. Ltd.)		Postprandial capillary glucose was also significantly lower after the liquid oil than after the oleogel
	19	40 g of either saturated fat (SFA, butter), monounsaturated fat (MUFA, olive oil) or polyunsaturated fat (PUFA, grapeseed oil), and 50 g of either low-GI (basmati rice) or high-GI (jasmine rice)	low-GI (basmati rice) or high-GI (jasmine rice)	50 g of available carbohydrate cooked with 40 g of dietary fat in a rice cooker	iAUCs were significantly lower after ingestion of low-GI than high-GI meals, independent of the type of fat.
	20	Beef meatballs (100g) (President's Choice Blue menu lean Italian beef meat-balls, Loblaw Companies Limited, Toronto, ON, Canada)	White Basmati Rice (Uncle Bens white Basmati, Mars, Inc., Houston, TX, USA)		No significant changes to the GR
	21	Ghee	White rice (Thai Hom Mali, Brand: NTUC Fairprice, Singapore)		Reduction in post-prandial blood glucose
		Soybean oil; Brand: NTUC Fairprice, Singapore)	Red rice (<i>O. sativa</i> L) (Thai, Brand: NTUC Fairprice, Singapore)	Stir fried with the oils	Reduction in post-prandial blood glucose especially using Ghee
		Ghee (clarified butter, Brand: QBB, Queensland, Australia).			
Vegetable-Based	22	180g low polyphenol mixed vegetables made up of tomato puree and peeled eggplant (<i>Solanum melongena</i>)	White rice	The seven spices used were turmeric (Everest, India), coriander seeds (Everest, India), cumin seeds (Everest, India),	Significant linear dose-response reductions in the 3-h postprandial incremental AUC (iAUC)
	22	Mixed spices, with			

22	<p>90g curry based vegetables (tomato puree, onions, garlic and ginger) and peeled egg plant Mixed spices with 180 g curry based vegetables (tomato puree, onions, garlic and ginger)</p>		<p>dried Indian goose-berry ('amla', emblica officinalis, Ramdev, India), cayenne pepper (Robertson's, South Africa), cinnamon (McCormick's, USA) and clove (Robertson's, South Africa) and were mixed in ratio of 8:4:4:4:2:1:1, (5:2:1:1) balanced for total vegetables content using 90 g of peeled eggplant</p>	<p>Reductions in the 3-h postprandial incremental AUC (iAUC) for glucose of 19%</p>
23	<p>Indian curry dish – Mixed Vegetable spices</p>	<p>Thai Hom Mali rice</p>	<p>The seven spices used were turmeric (Everest, India), coriander seeds (Everest, India), cumin seeds (Everest, India), dried Indian gooseberry ('amla', emblica officinalis, Ramdev, India), cayenne pepper (Robertson's, South Africa), cinnamon (McCormick's, USA) and clove (Robertson's, South Africa) and were mixed in the ratio of 8:4:4:4:2:1:1</p>	<p>linear dose-response reductions in the 3-h postprandial incremental AUC (iAUC) for CGM glucose of 32%</p>
23	<p>12 g mixed spices plus 180 g curry base vegetables</p>	<p>Thai Hom Mali rice</p>	<p>Curry base vegetables made up of tomato puree, onions, garlic and ginger The seven spices used were turmeric (Everest, India), coriander seeds (Everest, India), cumin seeds (Everest, India), dried Indian gooseberry</p>	<p>linear dose-response reductions in the 3-h postprandial incremental AUC (iAUC) for CGM glucose of 32%</p>

	24	Tested on non-homogenised and homogenised vegetables	Long fragrant white rice	(‘amla’, emblica officinalis, Ramdev, India), cayenne pepper (Robertson’s, South Africa), cinnamon (McCormick’s, USA) and clove (Robertson’s, South Africa) and were mixed in the ratio of 8:4:4:4:2:1:1	Cooked vegetables were prepared by either boiling or steaming.	Non-homogenised low-fat cooked vegetables were shown to reduce the postprandial GR more effectively
Mixed-Meal	25	Consist of pakchoi, cauliflower and egg plant Salmon, carrot and herb sauce combination Norway)	Parboiled long-grain rice (Harlem Foods AS, Oslo,	Raw/cooked vegetables were homogenized using a blender.	Rice was cooked for 20 min in one part rice two parts water. Salmon was minced. Carrots were drained and minced. Salmon and carrots were made paste-like consistency	Lowered glycemic response compared to rice alone

Several studies examined the impact on protein-based meals with rice on GR. One of the studies showed that the intake of chicken with white rice can reduce the postprandial GR compared to consuming white rice alone.¹⁶ In this study, the chicken was prepared in a curry sauce. Another study also tested steamed chicken with rice, which also shows a reduction in GR.¹⁷ A later study compared the various types of proteins such as eggs, bean curd, and steam chicken and fresh sea bass on postprandial GR when consumed with white rice. It showed that a statistically significant reduction in GR was found for the rice meals consumed with bean curd.¹⁷ Thus, irrespective of the way the chicken was prepared, it has a positive impact on lowering the postprandial GR. Regarding a low carbohydrate and high protein type of foods such as egg, a recent study has reported that its consumption during bedtime snacks, resulted in a low fasting blood glucose the next morning.²⁶ This provided more clues in terms

of the beneficial effect of protein-based meals in controlling our blood sugar level.

Several studies have also looked at the impact of postprandial GR consuming rice with fat-based meals. One of the studies has shown that the physical form or type of fats affects the outcome of the GR. In this study, liquid gel works better than oleo gel type of fat in terms of causing the reduction in postprandial GR.²⁷ Sun L., *et al.*, attempted to test the different types of fats quality (saturated fat, monounsaturated fat, or polyunsaturated fat) with either low GI (basmati rice) or high GI (jasmine rice).¹⁹ However, the type of fats did not change the value of the GI of either low or high GI rice as tested.¹⁹ Rice meals with beef had no impact on the GR.²⁰ In a recent study involving Type-1 diabetes adults, has reported that the addition of dietary fat in the form of extra virgin olive oil to low-fat meals did not show any lowering effect to the 3-hour postprandial blood glucose response among

diabetic patients.²⁸ In the same study, reported that the addition of the olive oil to a high energy-dense meal such as pasticcio (creamy, cheesy baked pasta) dish resulted in a sustained increase of the postprandial blood glucose.²⁸ Therefore, the study reports on fat-based meal effects on postprandial GR, so far seem to be inconclusive and still requires more investigation.

Latest reports have shown that vegetable-based meals resulted in an increase in the secretion of blood postprandial hormones, incretin and insulin.²⁹ Which suggests vegetable-based meals can potentially help improve the functionality of beta cells in releasing insulin among Type-2 Diabetes patients.²⁹ Haldar., *et al.*, examined at the impact of vegetable-based meals and various spices consumed together with rice²² and a positive impact of the postprandial GR was observed. Another study by Haldar., *et al.*, also reported that the consumption of polyphenol-rich curry made with various spices and vegetables produced a lowering effect on postprandial GR.²³ The two studies by Haldar., *et al.*, tested mainly vegetable-meal based cooked in curry style. In a recent study, has shown that preparation and type cooking of the vegetables also has an impact on the postprandial GR.²⁴ It has been demonstrated that non-blended low-fat cooked vegetables were shown to reduce the postprandial GR more effectively compared to blended vegetables.²⁴ One of the explanations for this could be because vegetable, in its full form, promotes longer chewing and eating time, which previously has been associated with reduced postprandial GR.²⁴ Apart from that, the presence of polyphenol and dietary fibre in vegetable also plays an important role in affecting the glycemic control as well. Polyphenol for instance, has been associated with improvement in diabetic disease management. However, there was an issue with the low bioavailability of these compounds.³⁰ A recent study suggested the use of encapsulations of the polyphenol in in-vitro studies but has not been tested in humans.³⁰

Therefore, vegetable-based meal helps in terms of controlling the GR, which is beneficial for diabetic patients. Previous reports has shown that, practice of plant-based diet helps to reduce medication needs among diabetic patients.³¹ Currently, the first randomised clinical trial via lifestyle intervention,

i.e. incorporation of vegetable-based diet and active lifestyle is being tested in the Republic of the Marshall Islands.³² The outcome of this clinical trial was hoped to be published after the study completion.

Other Interesting Findings

Several types of foods have positive benefits in controlling the blood glucose levels. Several studies have also reported interesting rice meal combinations and manipulations which have shown to have a positive impact on the blood glucose levels. One study reported an early phase results on the benefit of taking BT1320 tablets before taking rice meals on blood glucose levels.³³ This was the most recent study that reported the use of tablets or food supplements on the control of blood GR. Other studies reported the benefits of the chicken essence when co-ingested with white rice.³⁴ Another interesting finding is the addition of oatmeal to rice porridge meals has a positive impact on the postprandial GR.^{35,36} Regarding the rice porridge preparation, the addition of leaf extracts of *Scoparia dulcis* has helped to improve the fasting blood glucose.³⁷ Current evidence has shown that oat beta glucan (OBG) to carbohydrate-containing meals reduces the postprandial GR.^{36,38} This observation, however, was dose-dependent as well as depending on the molecular weight of the beta glucan.³⁸ A latest report has shown that the way the oats is being processed also have a significant impact on producing the extent of glycaemic response. Mildly processed oats, i.e. steel-cut oats resulted in a much lower glucose iAUC compared to highly processed oats such as Honey Nut Cheerios (HNC).³⁹ The addition of dried fruit taken together with rice meals also has a beneficial effect on reducing the postprandial GR.⁴⁰ The combination of kiwi fruit with rice compared to rice alone were also found to be able to lower postprandial GR⁴¹

Conclusion

Several types of rice meal combinations have been tested, and most of the studies have shown positive impacts on postprandial GR. Protein-based rice meals and vegetable-based rice meals are sought – as shown in some of the selected studies. More work to be done for the fat-based rice meals, as not much evidence are available at the moment. The key findings of this review are any type of rice (white rice, basmati rice, long grain or red rice) has shown to

have a beneficial outcome on postprandial GR when consumed with the meals tested. Most of the foods listed in this review are readily available in many parts of the world. This means access to these foods is easy and advocating its consumption is essential. Diversification regarding style or intake of rice across the globe depends on culture and tradition. The usage of pharmacological tablets such as BT1320 has also recently emerged, but more investigation is needed. On top of meals combinations, a recent study has also shown that meal intake sequence is another possible strategy in achieving a good glycemic control.⁴² Recent studies emerged that certain types of beverage, such as green tea and lemon drinks, have been reported to have a positive impact on controlling the postprandial GR as well.⁴³ Apart from that, there is also a need for tailored individual meals planning due to the variability

in response to various dietary components.⁴⁴ Furthermore, understanding GI and its impact on health, particularly diabetes and heart diseases, will help reduce the needs for medical care costs and thus, the intake of medications. It will also be more cost-effective and improve general well-being and health.

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Conflict of Interest

The author(s) declares no conflict of interest.

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