



Postprandial Glucose and Subjective Satiety Responses to Different Kuwaiti Rice Meals

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Abstract:

Postprandial glucose and subjective satiety responses to four different Kuwaiti rice meals (brown basmati, white basmati mixed with vegetables, and white basmati mixed with lentil) readily available in Kuwait market were compared against white basmati in a randomized, repeated-measure, crossover design trial.

Nine healthy female college students, mean age 21 (standard deviation 1.4) years and mean body mass index 23.1 (standard deviation 4.0) kg/m², were enrolled for the study. On separate occasions, subjects were served different Arabic rice meals (white rice, brown rice, rice with mixed vegetables and lentil rice) each containing 2 cups of cooked rice and 60 g of chicken breast. Subjective appetite information was collected before and after each meal using visual analogue scales (VAS). Blood glucose was measured from finger-prick samples in fasting subjects and at 0, 30, 60, and 120 minutes after the consumption of each test meal. Results showed that adding vegetables and lentil to white rice significantly increased the satiety ($p < 0.05$). Brown rice had the slowest effect on blood glucose level followed by vegetable white rice and lentil white rice, respectively ($p < 0.05$).

It was concluded that the addition of vegetables and lentils to white rice produces a meal with low glycemic response and high satiety level. The results may be useful in helping people lower their blood glucose levels and increase their satiety after consuming rice meals by adding different vegetables and legumes.

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1. Introduction

Rice is the main cereal crop that accounts for 29.2 percent and 26.2 percent of total calories consumed in low-income and developing countries, respectively (Food and Agriculture Organization [FAO] 1993). White aromatic rice 'Basmati Rice' occupies a prime position in Kuwaiti cuisine for its high organoleptic quality. The nutritional features of rice differ according to a number of elements. Rice types, the harvesting location, the transformation conditions, the milling grade, the storage and the cooking techniques are some of the characteristics that govern the nutritional value of the rice. In Kuwait, white rice is the most commonly consumed type of rice. White rice goes through several degrees of polishing. As a result, 8-10 percent of the bran is removed. It is worth mentioning that as the polishing degree increases, the level of proteins, vitamins and minerals in the rice decreases.

Rice is a major source of energy and protein. On the one hand, one hundred grams of white rice deliver 242 kcal, 53.4 grams of carbohydrate and 4.4 grams of protein. It has a number of B vitamins like Niacin (2.8 mg), Thiamin (0.3 mg) and Folate (110 mcg). It also contains some minerals such as iron (2.7 mg), magnesium (14.9 mg), phosphorus (61.4 mg), potassium (48.4 mg) and zinc (0.7 mg). On the other hand, white rice has almost no vitamins A, C, D, E and K. Since rice is a major source of carbohydrate in the diet, consideration has been devoted to knowing its influence on the glycemic response (GR) and the glycemic index (GI) (United States Department of Agriculture [USDA] 2016).

Jenkins et al. introduced the GI in 1981. The GI classifies carbohydrates in terms of their effects on raising blood glucose. Theoretically, it is defined as the area under the two-hour blood glucose curve (AUC) following a 12-hour fast and consumption of a food with a specific quantity of carbohydrates. The area under the curve of the test food is divided by the area under the curve of the standard (glucose, white rice or white bread) to get the GI of the test food (FAO/World Health Organization [WHO] 1998). Several studies have examined the potential health effects of low glycemic index foods. According to Bjorck et al. (1994) and Augustine et al. (2002),

consumption of low glycemic index foods significantly reduces the prevalence and severity of diabetes. Jenkins et al. (1987) and Salmeron et al. (1997) significantly associated consumption of low glycemic index foods with low incidence of hyperlipidemia and cardiovascular diseases, respectively. Furthermore, low glycemic index foods have been associated with enhanced endurance (Thomas et al. 1991), improved colonic fermentation (Wolever et al. 1992), reduced food consumption (Holt et al. 1995) and raised insulin sensitivity (Frost et al. 1996). Since the concept of the GI was first introduced, several foods have been tested for their glycemic index such as potato, rye, corn, wheat, barley and oats (Jenkins et al. 1981; Foster-Powell et al. 2002; Henry et al. 2005; Granfeldt et al. 2006). Several studies have given different glycemic index figures for the same food. This wide variability in the glycemic index figures has been associated with a number of factors such as the amount of amylose, the degree of cooking and gelatinization, the amount of fiber, the post-harvest treatments, the size and shape, and the content of fats and proteins (Thorne et al. 1983; Goddard et al. 1984; Jenkins et al. 1987; Jenkins et al. 1988; Panlasigui et al. 1991; Brand-Miller et al., 1992; Larsen et al. 1996; Hettiarachchi et al. 2001; Foster-Powell et al. 2002; Owen and Wolever 2003; Panlasigui and Thompson 2006; Wolever 2006). Many publications have reported the Glycemic index of rice which reaches as high as 122 (high glycemic index food) (Brand-Miller et al. 1992; Larsen et al. 1996). However, little has been reported on how the addition of vegetables and lentil influence the glycemic index of white basmati rice. Therefore, the objective of this study is to determine the impact of adding vegetables and lentils on the glycemic index and appetite of white basmati rice. The information presented in this paper would enable us to provide support for populations on the most suitable rice mixture in terms of reduced glycemic index and satiety.

2. MATERIALS AND METHODS

Subjects

Nine healthy college students, who responded to posters and flyers, were recruited to take part in the present study at College of Life

Science, Kuwait University. Being diabetic, taking medication or skipping breakfast were the exclusion criteria for this study. Ethical approval for the study was granted from the Humans' Ethics Committee of the Kuwait University. The participants were given comprehensive details of the study procedure and the chance to ask questions. All participants signed the written informed consent prior to participation.

Participant characteristics are shown in Table 1. Data were collected in the fasting state. Height and weight measurements were collected using a stadiometer (Seca Ltd, Birmingham, UK) and Tanita BC-418 MA (Tanita UK Ltd, Yiewsley, Middlesex, UK) with participants standing upright, wearing no shoes and wearing light clothes.

Table (1)
Participants' Characteristics

Characteristic	Mean	Standard deviation
Age (years)	21	1.4
Height (m)	1.58	0.03
Weight (kg)	57.8	11.3
Body mass index (kg/m ²)	23.1	4.0
Fasting blood glucose (mmol/l)	4.5	0.3

Study protocol

The GI was measured using the protocol adapted from the FAO/WHO (1998). Based on the FAO/WHO protocol, six or more subjects should be used to determine the glycemic index of a meal. Therefore, in this study 9 participants were randomly selected and 90g of white rice was the reference food eaten by each subject. The IAUC of the test food was divided by the IAUC of the reference and multiplied by 100 to find the GI for each test meal. Before 24 hours of commencing the test, the participants were asked to limit their caffeine intake and any intense physical activity. Participants were asked to come to the laboratory after a 12 hour fast except for water. They were also recommended to consume a similar size and composition meal the day

before the test since it has been reported to affect the blood glucose measurements (Granfeldt et al. 2006). Prior to testing, all participants provided information of their last meal, physical activity duration and intensity on the previous day and the date of their last period.

Test meals

Four Arabic meals containing basmati rice were tested. All of the meal items were purchased locally from supermarkets and grocery shops in Kuwait city, Kuwait. Compositional and nutritional information for the test foods are shown in Table 2. The white and brown basmati rice was cooked in 850 ml water for 10 and 20 minutes, respectively. The meals were served to the participants within 5 min of preparation. Participants were served the test meals in the afternoon after fasting for 12 hours. All participants were served 200 ml of water with their meals.

Table (2)
Compositional and nutritional information of test foods

Test food	Amount (g)	Energy* (kcal)	Protein* (g)	Fat* (g)	Carbohydrate* (g)
White rice test meal	350 g white rice 60 g chicken breast 5 g corn oil	587	32	11	90
Brown rice test meal	350 g brown rice 60 g chicken breast 5 g corn oil	587	32	11	90
Mix Vegetable rice test meal	263 g white rice 140 g mix green giant mixed vegetables 60 g chicken breast 5 g corn oil	560	32.5	11	82.5
Lentil rice test meal	263 g white rice 100 g lentil 60 g chicken breast 5 g corn oil	587	32	11	90

* United States Department of Agriculture [USDA] 2016.

Blood glucose measurements

Fasting blood samples were taken straight way before consuming the test meals. Additional blood tests were taken at 0, 30, 60, and 120 minutes after consuming the meals. Blood glucose was measured by finger-prick using Accu-Chek Performa Nano glucose meter. Prior to a finger-prick, participants were advised to close-open their hands in order to increase blood flow. It was taken into consideration not to squeeze the finger to extract blood from the fingertip so that plasma dilution would be minimized. Blood glucose response and area under the blood glucose response curves (AUC) were determined by trapezoidal rule using Microsoft Excel 2010.

Subjective appetite

Subjective appetite data was gathered before and after (0, 2, and 4 hours) each meal using visual analogue scales (VAS) adopted from (Flint et al. 2000). In VAS, participants state their level of agreement to a question by indicating a position along a straight line (100 mm) between two end-points. To find out the subjective appetite of the participants using VAS, four questions were asked. The first question was: How strong is your desire to eat? The second question was: How hungry do you feel? The third question was: How full do you feel? And the fourth question was: How much food do you think you could eat? The scale values of these questions were determined by measuring the distance in millimeters from the left end to the position chosen by the participant. Subjective appetite was measured based on the following formula:

Statistical analysis

The analysis was performed using Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA) version 20. One-way analysis of variance (ANOVA) was conducted to examine the effect of the four test meals on blood glucose and the subjective appetite after consuming the meals. Tukey’s post hoc tests were performed to identify significant mean differences among the meals. Statistical significance level was set at $p < 0.05$.

3. RESULTS AND DISCUSSION

The mean IAUC and GI for all test meals are presented in Table 3. There was a significant difference in the IAUC between the 4 types of rice/rice mixtures ($p < 0.05$). The IAUC for white basmati rice differed significantly from that of brown basmati rice ($P = 0.03$), white rice mixed with lentil ($P = 0.02$), and white rice mixed with vegetables ($P = 0.01$). The 4 types of meals exhibited GI values ranging from 36 to 65. Statistical analysis of the GI values show a significant difference between the test meals ($p < 0.05$). Post-hoc Tukey analysis showed that the GI of white basmati rice differed significantly from that of brown basmati rice ($P = 0.02$), white rice mixed with lentil ($P = 0.03$), and white rice mixed with vegetables ($P = 0.03$).

Table (3)
IAUC and GI values for each test food over 120 min

Test food	IAUC		GI	
	Mean	Standard error	Mean	Standard error
White rice	98	15.0	65	7.3
Lentil rice	91	10.4	47	7.5
Mix vegetable rice	88	12.3	42	6.6
Brown rice	75	13.5	36	6.9

The GI values are frequently characterized as either low (55), medium (56 - 69) or high (70) (Brand-Miller et al. 2003a). White basmati rice was high-GI foods. Brown basmati rice, white basmati

mixed with lentil and white basmati rice mixed with vegetables were considered low-GI foods.

The GI value measured for white basmati rice in this study (65) is similar with the one reported by Foster-Powell et al. (2002). The GI of brown basmati rice found in this study is noticeably less (36) than that listed by the same researchers (75).

There are several factors that affect the GI values of rice. Benmoussa et al. (2007) found that amylose structure affects rice digestibility. Some studies have reported an inverse relationship between the amylose content and GI (Goddard et al. 1984; Behall et al. 1988). Finally, processing and preparation methods may affect the rice GI by altering the amylose structure (Panlasigui et al. 1991; Rashmi and Urooj 2003; Brouns et al. 2005). Several studies have classified brown rice as low GI compared with white rice, and it has been generally recommended for diabetic people (Jenkins et al. 1981; Hettiarachchi et al. 2001, Foster-Powell et al. 2005; Panlasigui and Thompson 2006).

The GI values measured for lentil rice and mixed vegetable rice in this study are 47 and 42, respectively. Adding legumes and vegetables to rice seemed to have lowered the rice GI. Fibers in those foods resist digestion by α -amylase in the small intestine (Higgins 2004). Lee and Oh (2004) stated a significant decrease in the GI of fiber containing meals when compared with a white wheat bread. The amount of fibers present in carbohydrate foods was influenced by a number of factors such as pretreatment and storage temperatures (Sajilata et al. 2006). Pre-treated rice and associated foods GIs may fluctuate depending on the amount of processing. Larsen et al. (1996) stated that rigorously pressure parboiled rice exhibited a significant decrease in GI as compared with its non-parboiled ones. Further more, Rashmi and Urooj (2003) proposed that variations in amylose structure through processing might be the reason for the reduction of GIs in pre-treated rice.

Average appetite responses for the four rice meals are shown in Table 4. The average appetite responses dropped from the baseline after the intake of all rice meals up to two hours then steadily increased. The 4 types of meals exhibited average appetite responses values ranging

from 84.8 to 90.9. Brown rice seemed to have promoted satiety the best (84.8), followed by mixed vegetables rice (85.1), lentil rice (88.3) and white rice (90.9). A one-way repeated measures ANOVA followed by Tukey's post hoc analyses showed a significant effect ($P < 0.05$) among the four types of rice meals after 2 and 4 hours of consumption. There was no statistical difference ($P > 0.05$) among all rice meals before and immediately after the consumption of the meals.

Table (4)
Average appetite of each test food

Test food	Time			
	Before eating	0 hr	2 hr	4 hr
White rice	88.4 ± 2.6	4.9 ± 1.9	20.9 ± 3.3	90.9 ± 2.5
Lentil rice	87.9 ± 5.5	4.7 ± 1.3	19.1 ± 1.5	88.3 ± 1.8
Mix vegetable rice	87.7 ± 4.7	3.4 ± 1.7	18.2 ± 1.0	85.1 ± 3.1
Brown rice	89.1 ± 3.0	3.4 ± 1.4	18.1 ± 3.8	84.8 ± 5.0

High fibrous foods such as lentil and vegetables are low in GI and are considered to reduce appetite. These findings support the theory that a reduction in blood glucose spike is linked with reduced appetite. Abou Samra and Harvey (2007) stated that consumption of 33 g of insoluble fiber during a meal reduced appetite and food intake in young men. Anderson and Wood end (2003) support the findings of this experiment. They found that both high and low GI starches have an effect on appetite. However, their effects are triggered at different times. On the one hand, High GI carbohydrates are associated with a decrease in appetite in the short term (one hour or less). On the other hand, low GI carbohydrates promote the satiating effects in the long term (2 to 4 hours).

4. CONCLUSIONS

Addition of lentil and mixed vegetables to white basmati rice significantly reduces the blood glucose response compared to white basmati rice. This addition also suppresses appetite at 2 and 4 hours.

The reduction in appetite could have been caused by the higher dietary fiber and resistant starch contents in those foods.

Therefore, mixing white rice with high fibrous foods such as lentil and vegetables may be a healthier choice when glucose control is essential. Study findings can be used to improve healthy dietary behaviors of individuals as well as the public.

Limitations of the study

One limitation of this research is that all participants in the study were female college students. This was by no means a diverse sample, and it is indistinct whether the same results would relate for males or for old age groups. Another limitation of this study is that the size and composition of the meals consumed by the participants the day before the test are not reported. Different meal compositions may effect blood glucose measurements even after a 12 hour fast (Granfeldt et al. 2006).

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REFERENCES

- AbouSamra, R. and Anderson, G. H. (2007). Insoluble cereal fiber reduces appetite and short-term food intake and glycemc response to food consumed 75 min later by healthy men. *Am J ClinNutr* 86: 972-979.
- Anderson, G.H., Woodend, D. (2003). Effect of Glycemic Carbohydrates on Short-term Satiety and Food Intake. *Nutr Rev* 61:S17-S26.
- Augustine, L.S., Franceschi, S., Jenkins. D.J.A, Kendall, C.W.C., La Vecchia, C. (2002). Glycaemic index in chronic disease: A review. *Eur J ClinNutr* 56: 1049-1071.
- Behall, K. M., Scholfield, D. J. and Canary, J. (1988). Effect of starch structure on glucose and insulin responses in adults. *The American Society for Clinical Nutrition* 47: 428-432.
- Benmoussa, M., Moldenhauer, K.A.K., Hamaker, B.R. (2007). Rice Amylopectin Fine Structure Variability Affects Starch Digestion Properties. *J. Agric. Food Chem.* 55: 1475-1479.
- Bjorck, I., Granfeldt, Y., Liljeberg, H., Tovar, J, Asp, N. (1994). Food properties affecting the digestion and absorption of carbohydrates. *Am J Clin Nutr* 59 (Suppl): 699S-705S.
- Brand-Miller. J.C., Pang, E., Bamall, L. (1992). Rice: A high or low glycaemic index food? *Am J ClinNutr* 56: 1034-1036.
- Brouns, F., Bjorck, I., Frayn, K.N., Gibbs, A.L., Lang, V., Slama, G., Wolever, T.M.S. (2005). Glycaemic index methodology. *Nutrition Research Reviews* 18: 145-171.
- Food and Agriculture Organization. (1993). Rice in human nutrition. Rome: FAO.
- Food and Agriculture Organization/World Health Organization. (1998). Carbohydrates in human nutrition. Report of a joint FAO/WHO expert consultation. Rome: FAO.
- Food Composition Databases Show Foods – WHITE BASMATI RICE, UPC: 65566534 [WWW Document], n.d. URL <<https://>

[ndb.nal.usda.gov/ndb/foods/show/95075?manu = &fgcd = &ds = \(accessed 9.10.17\) > .](http://ndb.nal.usda.gov/ndb/foods/show/95075?manu = &fgcd = &ds = (accessed 9.10.17) > .)

- Foster-Powell, K., Holt, S.H.A, Brand-Miller, J.C. (2002). International table of glycaemic index and glycaemic load values: 2002¹. *Am J Clin Nutr* 76: 5-56.
- Frost, G., Keogh, B., Smith, D., Akinsanya, K., Leeds, A. (1996). The effect of low-glycaemic carbohydrates on insulin and glucose response in vivo and in vitro in patients with coronary heart disease. *Metabolism* 45: 669-672.
- Goddard, M.S., Young, M.S.G., Marcus, R. (1984). The effect of amylose content on insulin and glucose responses to ingested rice. *Am J Clin Nutr* 39: 388-392.
- Granfeldt, Y., Wu, X., Bjorck, I. (2006). Determination of glycaemic index; some methodological aspects related to the analysis of carbohydrate load and characteristics of the previous evening meal. *Eur J Clin Nutr* 60: 104-112.
- Henry, C.J.K, Lightowler, H.J., Strik, C.M., Storey, M. (2005). Glycaemic index values for commercially available potatoes in Great Britain. *Br J Nutr* 94: 917-921.
- Hettiarachchi, P., Jiffry, M.T.M., Wickramasinghe, A.R., Fernando, D.J.S. (2001). Glycaemic indices of different varieties of rice grown in Sri Lanka. *J Ceylon Med Assoc* 46: 11-4.
- Higgins, J.A. (2004). Resistant Starch: Metabolic Effects and Potential Health Benefits. *Journal of AOAC International* 87: 761-768.
- Holt, S.H.A., Miller, J.C.B., Petocz, P., Farmakalidis, E. (1995). A satiety index of common foods. *Eur J Clin Nutr* 49: 675-690.
- Jenkins, D.J.A., Wolever, T.M.S., Taylor, R.H., Barker, H., Hashmeini, Fielden SRD, Baldwin, SRNJM, Bowling, A.C., Newman, H.C., Jenkins, AL, Goff, D.V. (1981). Glycaemic index of foods: A physiological basis for carbohydrate exchange. *Am J Clin Nutr* 34: 362-366.
- Jenkins, D.J.A., Thorne, M.J., Wolever, T.M.S., Jenkins, AL, Rao, A.V., Thompson, L.U. (1987b). The effect of starchprotein

interaction in wheat on glycaemic response and rate of in vitro digestion. *Am J Clin Nutr* 45: 946- 951.

- Jenkins, D.J.A., Wolever, T.M.S., Jenkins, AL. (1988). Starchy foods and glycaemic index. *Diabetes Care* 11: 149-159.
- Larsen, H.N., Christensen, C., Rasmussen, O.W., Tetens, I.H., Choudhury, N.H., Thilsted, S.H., Hermansen, K. (1996). Inof parboiling and physico-chemical characteristics of rice on the glycaemic index in noninsulin dependent diabetic subjects. *Eur J Clin Nutr* 50: 22-27.
- Lee, Y.H., Oh, S.H. 2004. Effect of Resistant Starch on Human Glycemic Response. *Korean Journal of Community Nutrition* 9: 528-535.
- Owen, B., Wolever, T.M. (2003). Effect of fat on glycaemic responses in natural subjects: A doseresponse study. *Nutr Res* 23(10): 1341-1347.
- Panlasigui, L.N., Thompson, L.U., Juliano, B.O., Perez, C.M., Yiu, S.H., Greenberg, G.R. (1991). Rice varieties with similar amylose content differ in starch digestibility and glycaemic response in humans. *Am J Clin Nutr* 54: 871-877.
- Panlasigui, L.N., Thompson, L.U. (2006). Blood glucose lowering effects of brown rice in normal and diabetic subjects. *International Journal of Food Sciences and Nutrition* 57(3/4): 151-158.
- Sajilata, M. g., Singhal, R.S., Kulkarni, P.R. (2006). Resistant Starch-A Review. *Comprehensive Reviews in Food Science and Food Safety* 5: 1-17.
- Rashmi, S., Urooj, A. (2003). Effect of processing on nutritionally important starch fractions in rice varieties. *International Journal of Food Sciences and Nutrition* 54: 27-36.
- Salmeron, J., Manson, J.E., Stampfer, M.J., Colditz, G.A., Wing, AL, Willett, W.C. (1997). Dietary glycaemic load and risk of non-insulin dependent diabetes mellitus in women. *J Am Med Assoc* 277(6): 472-477.
- Thomas, D.E., Brotherhood, J.R., Brand, J.C. (1991). Carbohydrate feeding before exercise: effect of glycemic index. *Int J. Sports Med* 12: 180-186.

- Thorne, M.J., Thompson, L.U., Jenkins, D.J.A. (1983). Factors affecting starch digestibility and the glycaemic response with special reference to legumes. *Am J Clin Nutr* 38: 481-488.
- Wolever, T.M.S., Jenkins, D.J.A., Vuksan, V., Jenkins, AL, Buckley, G.C., Wong, G.S., Josse, R.G. (1992). Beneffect of a low glycaemic index diet in Type 2 diabetes. *Diabetes Med* 9: 451-458.
- Wolever, T.M.S. (2006). *The glycaemic index - a physiological classiof dietary carbohydrate*. Wallingford: CABI Publishers.