

# The Postprandial Glycemic and Insulinemic Effects of Three Cooked Vegetables: *Corchorus Olitorius*, *Spinacia Oleracea*, and *Daucus Carota* on Steamed White Rice

Ahmad Faqih\*<sup>1</sup> and Buthaina Al-Khatib<sup>2</sup>

## Abstract

**Background:** Eating cooked vegetables with rice is quite common in Jordan and worldwide. Dietary fibers of vegetables are expected to play a role in the glycemic control of meals.

**Aim:** To study the postprandial glycemic and insulinemic effect of three cooked vegetables: mulukhiyah leaves (*Corchorus olitorius*), spinach (*Spinacia oleracea*) and carrots (*Daucus carota*).

**Methods:** The postprandial glycemic and insulinemic effect of the three cooked vegetables on steamed rice were studied by running the oral glucose tolerance tests on apparently healthy young adults, each of who served as his own control, using white bread as the reference. Insulin sensitivity was measured by calculating the composite insulin sensitivity index.

**Results:** The glycemic index (GI) of rice ( $84.2 \pm 10.5\%$ ) ingested with chicken broth was significantly lowered only by eating 120 g of mulukhiyah leaves (ML) and not by either carrots or spinach. The insulinemic index (II) of steamed white rice eaten with broth was significantly lowered by 120 g of ML ( $61.7 \pm 9.2\%$ ) and 150 g of spinach ( $42.9 \pm 9.0\%$ ). Insulin sensitivity was only improved by spinach. All results are expressed as means  $\pm$  SEM and are considered statistically significant at  $P < 0.05$ .

The results also suggested that there was no significant difference between the calculated relative GI and relative II responses of the three cooked vegetables at the two assigned levels, each eaten with rice and broth compared to the corresponding GI or the II values of the individual foods from which they were composed of.

**Conclusions:** Eating a relatively high portion of mulukhiyah leaves improves the glycemic response to white rice whereas only higher levels of carrots tended to improve the glycemic response of white rice, and spinach at either level had no apparent effect. While insulin level was lowered by the three tested vegetables, its sensitivity was improved by eating spinach only.

**Keywords:** Glycemic index, insulinemic index, mulukhiyah leaves, spinach, carrots, insulin sensitivity.

(J Med J 2013; Vol. 47 (2):161- 175)

Received

Accepted

February 2, 2012

December 16, 2011

1. Faculty of Agriculture, The University of Jordan.
2. Msc in Dietetics and Human Nutrition, Faculty of Agriculture, The University of Jordan.

\* Correspondence should be addressed to:

Prof. Ahmad Faqih

E-mail: Faqiham@ju.edu.jo

© 2013 DAR Publishers/ University of Jordan. All Rights Reserved.

## **Introduction**

Dietary fibers which by definition cannot be digested by humans play an important role in improving the glycemic control. Water-soluble dietary fibers are more effective than insoluble fibers.<sup>1, 2</sup> Part of this control can be ascribed to glucagon-like peptide-1 (GLP-1) which is secreted by intestinal L-cells and to ghrelin which is secreted by the stomach. It is well established that GLP-1 slows the gastric emptying rate and consequently slows down the rate of glucose absorption into the blood stream which plays an important role in glucose control and diabetes treatment<sup>3</sup>. It also stimulates glucose-dependent insulin secretion in addition to decreasing the production of glucagon. Furthermore, insulin sensitivity can be increased by some fibers.<sup>4, 5</sup> Ghrelin, an appetite-stimulating hormone is down regulated by soluble fibers by delaying gastric emptying.<sup>6</sup> Glucose-dependent insulintropic polypeptide (GIP) is secreted by K-cells of the intestine and as the name indicates its function is to stimulate insulin secretion. GIP and GLP-1 are called incretins and thus both have the incretin effect, meaning that a higher amount of insulin is secreted when an equivalent amount of glucose is administered orally than intravenously.<sup>5</sup> Tahrani and colleagues summarize the difference between GIP and GLP-1 as follows, “unlike GLP-1, GIP has no effect on  $\alpha$ -cells that secrete glucagon and has no impact on food intake, satiety, gastric emptying, or body weight.”<sup>5</sup>

The postprandial glycemic and insulinemic effect of foods can be studied in terms of their effect on the glycemic index (GI) and insulinemic index (II) on cooked rice as in our study. The GI refers to the incremental area

under the glucose response curve after an amount of carbohydrate from a test food relative to that of a control food that is consumed.<sup>7</sup> The area under the curve for glucose (AUCg) is calculated to reflect the total rise in blood glucose level after the test food. The glycemic index is calculated by dividing the AUCg resulting from eating a fixed amount of carbohydrates (50 g) of the test food by the AUCg resulting from eating a similar amount of carbohydrates from the reference food and multiplying the answer by 100.<sup>7</sup> The use of a reference food is essential for reducing the confounding influence of differences in the physical characteristics of the subject.<sup>8</sup> Jenkins and his co-workers<sup>8</sup> first introduced the concept of the glycemic index (GI) in 1981.

Recent studies show a positive impact of low-GI diets on hunger ratings,<sup>9</sup> resting energy expenditure, nitrogen balance, fat loss,<sup>10</sup> and weight loss.<sup>6, 11, 12</sup> In 2007, the World Health Organization (WHO) and Food and Agriculture Organization (FAO)<sup>13</sup> updated the 1998 recommendations about carbohydrates in human nutrition by recommending to people from industrialized countries to base their diets on foods with low GI (< 55%), in order to prevent the most common diseases of affluence, notably obesity, coronary heart disease, and diabetes.

The development of insulinemic indices (IIs) for foods has also been reported as necessary to supplement the GI tables used in the dietary management of diabetes mellitus.<sup>14</sup> It has been widely assumed that the insulin response is proportional to the glucose response, and therefore the glycemic response is an accurate predictor of the insulin response.<sup>15</sup> The II of foods can also be determined from the

corresponding incremental blood insulin areas.<sup>16</sup>

Traditionally, many Middle Eastern dishes are prepared from cooked rice along with vegetables in different amounts and various methods. For this report, carrots, spinach, and mulukhiyah leaves were selected. The GI and II have been widely determined from single food items, which may not necessarily predict their GI and II in mixed dishes.<sup>17</sup> Besides, people do not usually eat single food items.<sup>16</sup> Thus, additional research is needed to determine the glycemic index of mixed dishes rather than the single foods that comprise them. The glycemic and insulinemic response elicited by a meal is termed the relative glycemic response (RGR) and the relative insulinemic response (RIR), respectively. Wolever and Bolognesi<sup>18</sup> developed an equation to estimate the RGR and RIR of a meal from the individual GI, II, and the amount of carbohydrate content of the meal components. The equation was found to explain 90% of the variation in mean glucose responses conducted by mixed meals in normal subjects.<sup>18</sup>

The objective of the present study was to determine the glycemic and insulinemic indices of mulukhiyah leaves (*Corchorus olitorius*), spinach (*Spinacia oleracea*), or carrots (*Daucus carota*) when eaten at two different levels with steamed white rice and chicken broth.

## **Materials and Methods**

**Preparation of Test Foods:** White rice, chicken, mulukhiyah leaves, spinach, and carrots were purchased from a local market in Amman, Jordan. All vegetables were washed with water. Spinach (medium size leaves) was

chopped into small square pieces (about 3 cm<sup>2</sup>), mulukhiyah leaves were chopped into small pieces, and carrots of medium length (about 80 g for each) were peeled and chopped to round slices (about 5mm). All vegetables were weighed, put into polyethylene bags, and kept frozen until used within three weeks.

Chicken broth (B) was prepared separately by using young chickens (age 42 days, about 2 kg) without skin and bones, using two liters of water and 30 grams of salt per one kilogram of chicken and were boiled for a period of 20 minutes. Chicken broth was served in 200 mL disposable plastic cups along with steamed white rice and with each vegetable dish at two different levels.

Rice (R; American white rice, medium-grain; trade mark: Sun White) was weighted by an electronic balance, put in a household steam cooker, covered with aluminum foil, and left for a period of four hours until it became tender but firm. Sunflower oil (5 g) and table salt (5 g) were added to each serving of white rice, the average weight of which before steaming (and after steaming) was as follows: 60g (150g), 55g (138g), 50g (125g), and 40g (100g).

Each vegetable dish was prepared either at a low level equivalent to one cup of raw vegetables or half a cup of cooked vegetables or at a high level to about twice or three times the low level per serving. The average amount of one serving and the method of preparation of each dish were determined by a pilot study of five neighboring housewives.

Each serving of frozen vegetables was prepared by adding 40 mL of filtered water and 5g of salt and boiled for 20 min. for the low

level. For the high level, the amount of water and salt were doubled for carrots and tripled for spinach and mulukhiyah leaves and then cooked for 20 min.

**Subjects:** Fifteen apparently healthy adults (3 men and 12 women) with a mean ( $\pm$ SEM) age of 25.4 ( $\pm$ 1.82) and a normal BMI of 21.6 ( $\pm$ 0.97) volunteered to participate in the study. Thus, the inclusion criteria stipulated that all subjects should be apparently healthy and young, with a normal BMI in addition to having a normal oral glucose tolerance test (OGTT) based on the results of the (OGTT) that was conducted on the control (white bread) as explained in the experimental design section. All participants were informed about the experimental protocol and the purpose of the study before they signed a written consent form. The protocol of the study was approved by the scientific committees of the Nutrition and Food Science Department at the Faculty of Agriculture and the Faculty of Graduate Studies at the University of Jordan.

**Experimental Design:** Oral glucose tolerance tests (OGTT) were applied following 10–12 hours of overnight fasting. To clarify the experimental design referring to tables 2, 3, and 4, we notice that there are 4 food dishes that comprise every set of test vegetables, namely bread (the reference) and 3 other dishes, all of which need a conduction of a total of 4 glucose tolerance tests. For each OGTT to be conducted for each food dish, each subject serves as his/her own control by completing the four OGTTs required for the 4 food dishes that comprise every set of test vegetable tables. The reference is assigned a glycemic index of 100 and an insulinemic index of 100. The reference is considered “the control”. For a certain study subject called

“x”, “x” is subjected to the first OGTT for the reference food. The area under the curve for glucose (AUC<sub>g</sub>) is assigned the value of 100 and similarly giving the area under the curve for insulin (AUC<sub>i</sub>) the value of 100. Then after a rest of 2 to 3 days, a second glucose tolerance test for rice and broth is conducted for person “x” to be followed after the rest period by the third and the fourth oral glucose tolerance tests for the two different levels (portions) of each vegetable, respectively. This makes person “x” a control for himself since he was first subjected to the oral glucose tolerance test using bread as a control with which we compare the postprandial glycemic and insulinemic response of the other test foods for every set of the test vegetables. This protocol was repeated (replicated) five times for every food (bread, rice and broth with each vegetable at two different levels) for every set of vegetables. This means that 5 different persons (replicates) are needed for any one of the foods for any particular set of vegetable. Less than 5 persons are needed in the few cases whereby a certain person who was subjected to OGTT for the reference bread chose to sit for the food dishes that comprise a different vegetable set, without repeating OGTT for bread which he was already subjected to.

The first OGTT test was applied on the reference, local Arabic white bread (85g, free from sugar and any other additives) containing 50 grams of carbohydrates and prepared from straight grade flour with an extraction rate of about 77%. It was consumed thoroughly using a cup of plain water (200 mL) to wash down any food residue in the mouth. All foods, other than bread, were served warm. The second OGTT was run on a portion of steamed American white rice (R; 60 g) containing 50 g

of carbohydrates and was eaten along with a cup (200 mL) of warm chicken broth (B) which was beneficial to wash down any residue in the mouth similar to that of water used with the reference. The third and fourth OGTTs were run on the cooked vegetables each eaten at two different levels with steamed R+B. The four OGTTs for every vegetable were replicated (repeated) for each of the corresponding five subjects, having Arabic white bread as the control for each of the 3 vegetables as shown in table 3 and table 4. Thus, each of the five subjects served as his own control by being subjected to 3 OGTTs for every vegetable and a fourth OGTT for the reference (Arabic white bread). Subjects were tested at the same time in the morning but on four non-successive days.

The portion size of white bread (85g), rice (60g), and the combined portions of rice and vegetables in each test dish were based on the proximate analysis that we determined according to AOAC methods as shown in table 1.<sup>19</sup> The portions of rice and raw vegetables were combined to give a total of 50 g carbohydrates (table 1b). The initial venous blood sample (0 time) was taken at the fasting state and at 30, 60, 90, and 120 min thereafter. The test food was completely ingested within 10 to 15 minutes using plain water for bread and chicken broth for rice alone or for rice eaten with vegetables; plain water and chicken broth helped in ingesting any food residue from the oral cavity. Serum glucose was determined in duplicate by the enzymatic colorimetric method using a hexokinase reagent kit (Roche Diagnostics, GmbH, D-68298 Mannheim, Germany). Serum insulin was determined by an electrochemiluminescence immunoassay

(ECLIA), using an atomic analyzer (Modular Analytics E170, Roche) with commercial analysis kits (Cobas; Roche Diagnostics, Diagnostic GmbH, SandhoferStrasse 116, D-68305Mannheim, Germany). All instruments were calibrated accordingly to ensure the accuracy of the results. Areas under the curve for glucose (AUC<sub>G</sub>) and insulin (AUC<sub>I</sub>) were calculated excluding the areas below the fasting levels.<sup>8</sup> The observed glycemic index (GI), insulinemic index (II), relative glycemic response (RGR), and relative insulinemic response (RIR) were calculated.<sup>20</sup>

Based on OGTT, the following formula was used to calculate the composite insulin sensitivity index (CISI):<sup>21</sup>

$$\text{CISI} = 10,000/\sqrt{[(\text{fasting G} \times \text{fasting I}) \times (\text{mean G (0-120 min)} \times \text{mean I (0-120 min)})]}$$

where G = Glucose and I = Insulin.

**Statistical Analysis:** AUC, GI, II, and CISI were calculated using Microsoft Office Excel 2003. Statistical analysis was performed using Statistical Package for Social Sciences software (SPSS, version 9.0, 2004).<sup>22</sup> All results were expressed as means  $\pm$  standard error of the mean (SEM) and were considered statistically significant at the 5% level ( $P < 0.05$ ). A separate analysis for each dish was performed. Differences in GI, II, AUC, CISI, and peaks of glucose and insulin concentrations between the test dishes were subjected to a one-way analysis of variance (ANOVA). Results which exceeded 2 SEM of the total mean were considered out-layers and were excluded, leaving the number of replicates (n) for certain OGTT data of each of the tested vegetable equal to 4 and not 5 and for the combined rice and bread equal to 13 and not 15 (table 3 and table 4).

**Table (1): Proximate Composition of 100 g of Tested Food Items**

Food item	Moisture (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Crude fibers (%)	Carbohydrates (N.F.E.) <sup>1</sup> (%)	Energy Kcal/100g
White Arabic bread	30.0	8.2	1.2	1.6	0.4	58.6	278.0
White rice (medium grain)	10.0	4.7	0.6	0.6	0.8	83.3	357.4
Carrots	90.5	0.9	0.2	0.8	1.0	6.6	31.8
Mulukhiyah leaves	83.0	4.9	0.8	2.5	1.3	7.5	56.8
Spinach	91.3	2.9	0.3	1.4	0.9	3.2	27.1

1. Carbohydrates are calculated by difference as nitrogen free extract (N.F.E)
2. Values are based on fresh weight basis. 3. Mulukhiyah is *Corchorus olitorius*.

**Table (1b): The Combined Amounts of Raw White Rice and Tested Vegetables in Different Portion Sizes that Give a Total of 50 Grams of Carbohydrates.\***

Test Vegetable	The Lower Vegetable Level (Rice + Vegetable, g)		The higher Vegetable Level (Rice + Vegetable, g)	
	Rice, g	Vegetable, g	Rice, g	Vegetable, g
Carrots	50	130	40	260
Mulkhiyah leaves	55	40	50	120
Spinach	58	50	55	150

\* Based on Table 1 for carbohydrate content.

## Results and Discussion

The mean values for fasting serum glucose level for bread in normal fasting subjects expressed during the 120 minutes period of OGTT in addition to AUCg, GI, and RGR are presented in tables 2 and 4. All subjects exhibited normal glucose and insulin responses to ingested bread as based on the OGTT data obtained. The mean values for serum insulin response in normal fasting subjects for bread and for all test foods are presented in tables 3 and 4 which also show the serum insulin response, the calculated AUCi, the II, and the RIR. Results are further discussed in the following paragraphs.

**The Glycemic and Insulinemic Responses to Rice (R) Ingested with Broth (B):** The

glycemic and insulinemic responses (GI and II) to R+B were tested for each test vegetable group (tables 2 and 3) and then they were calculated for all subjects combined, in which case the GI value of R+ B ( $93.4 \pm 1.3\%$ ) tended to be lower but not significantly different from that of bread. In contrast, the corresponding II for all subjects combined ( $86.6 \pm 2.5\%$ ) was significantly lower than that of bread. The results of GI and II cannot be compared directly with the results obtained from other studies because of a number of reasons, including variation in varieties of rice used,<sup>23</sup> processing conditions,<sup>24, 25</sup> food structure such as particle size and shape,<sup>26</sup> and the proportion of starch type between amylose and amylopectin.<sup>27,28</sup>

**Table (2): Serum Glucose Response and AUC during OGTT for the Various Test Foods (means  $\pm$  SEM).**

Test dishes	n*	Serum glucose (mg/dL) levels within two hours					AUCg (mg.min/dL)
		0 min. (Fasting)	30 min.	60 min.	90 min.	120 min.	
<b>1. Carrots Set:</b>							
Bread	5	90.2 $\pm$ 2.0 <sup>a</sup>	103.6 $\pm$ 4.4 <sup>a</sup>	93.4 $\pm$ 5.5 <sup>a</sup>	90 $\pm$ 3.4 <sup>a</sup>	87.2 $\pm$ 3.8 <sup>a</sup>	8052 $\pm$ 910 <sup>a</sup>
Rice (R,60g) +chicken broth (B, 200mL)	4	91.3 $\pm$ 2.3 <sup>a</sup>	112.8 $\pm$ 5.1 <sup>a</sup>	88.0 $\pm$ 6.4 <sup>a</sup>	84.3 $\pm$ 4.0 <sup>ab</sup>	87.5 $\pm$ 4.4 <sup>a</sup>	7170 $\pm$ 1053 <sup>a</sup>
Rice (R,50g) +B with carrots (130g)	4	91.1 $\pm$ 2.3 <sup>a</sup>	119.4 $\pm$ 5.1 <sup>ab</sup>	92.5 $\pm$ 6.4 <sup>a</sup>	81.9 $\pm$ 4.0 <sup>b</sup>	85.5 $\pm$ 4.4 <sup>a</sup>	8170 $\pm$ 1053 <sup>a</sup>
Rice (R,40g) +B with carrots (260g)	4	91.8 $\pm$ 2.3 <sup>a</sup>	127.9 $\pm$ 5.1 <sup>b</sup>	98.6 $\pm$ 6.4 <sup>a</sup>	72.7 $\pm$ 4.0 <sup>c</sup>	79.6 $\pm$ 4.4 <sup>a</sup>	6430 $\pm$ 1053 <sup>a</sup>
<b>2. Mulukhiyah leaves (ML) Set:</b>							
Bread	5	85.2 $\pm$ 2.0 <sup>a</sup>	95.8 $\pm$ 4.3 <sup>a</sup>	100.8 $\pm$ 5.5 <sup>a</sup>	88.2 $\pm$ 3.4 <sup>a</sup>	84.6 $\pm$ 3.8 <sup>a</sup>	9357 $\pm$ 910 <sup>a</sup>
Rice (R,60g) +chicken broth (B, 200mL)	5	88.4 $\pm$ 2.0 <sup>a</sup>	107.6 $\pm$ 4.3 <sup>b</sup>	89.8 $\pm$ 5.5 <sup>ab</sup>	86.4 $\pm$ 3.4 <sup>a</sup>	83.6 $\pm$ 3.8 <sup>a</sup>	7848 $\pm$ 910 <sup>a</sup>
Rice (R,55g) +B with ML (40g)	4	84.5 $\pm$ 2.3 <sup>a</sup>	91.3 $\pm$ 5.1 <sup>a</sup>	89.2 $\pm$ 6.4 <sup>ab</sup>	81.8 $\pm$ 4.0 <sup>a</sup>	86.3 $\pm$ 4.4 <sup>a</sup>	8144 $\pm$ 1051 <sup>a</sup>
Rice (R,50g) +B with ML (120g)	4	91.8 $\pm$ 2.3 <sup>a</sup>	98.1 $\pm$ 5.1 <sup>ab</sup>	82.0 $\pm$ 6.4 <sup>b</sup>	80.2 $\pm$ 4.0 <sup>a</sup>	81.7 $\pm$ 4.4 <sup>a</sup>	3350 $\pm$ 1051 <sup>b</sup>
<b>3. Spinach Set:</b>							
Bread	5	90.0 $\pm$ 2.0 <sup>a</sup>	108.4 $\pm$ 4.4 <sup>a</sup>	104.2 $\pm$ 5.5 <sup>a</sup>	90.6 $\pm$ 3.4 <sup>a</sup>	79.0 $\pm$ 3.8 <sup>b</sup>	8754 $\pm$ 910 <sup>a</sup>
Rice (R,60g) + chicken broth (B, 200mL)	4	93.0 $\pm$ 2.4 <sup>a</sup>	106.6 $\pm$ 5.4 <sup>a</sup>	96.2 $\pm$ 6.8 <sup>ab</sup>	94.6 $\pm$ 4.2 <sup>a</sup>	90.0 $\pm$ 4.6 <sup>a</sup>	8750 $\pm$ 1114 <sup>a</sup>
Rice (R,58g) +B with spinach (50g)	4	86.5 $\pm$ 2.4 <sup>a</sup>	106.4 $\pm$ 5.4 <sup>a</sup>	90.7 $\pm$ 6.8 <sup>b</sup>	80.8 $\pm$ 4.2 <sup>b</sup>	91.0 $\pm$ 4.6 <sup>a</sup>	7584 $\pm$ 1114 <sup>a</sup>
Rice (R,55g) +B with spinach (150g)	4	85.5 $\pm$ 2.4 <sup>a</sup>	105.4 $\pm$ 5.4 <sup>a</sup>	101.9 $\pm$ 6.8 <sup>ab</sup>	86.1 $\pm$ 4.2 <sup>ab</sup>	84.0 $\pm$ 4.6 <sup>ab</sup>	8304 $\pm$ 1114 <sup>a</sup>
<b>4. R+ B, combined subjects</b>							
Bread (reference)	15	88.5 $\pm$ 0.3 <sup>a</sup>	102.6 $\pm$ 0.8 <sup>a</sup>	99.5 $\pm$ 0.9 <sup>a</sup>	89.6 $\pm$ 0.6 <sup>a</sup>	83.6 $\pm$ 0.7 <sup>a</sup>	8721 $\pm$ 208.6 <sup>a</sup>
Rice+ Chicken broth (R+B)	13	90. $\pm$ 0.5 <sup>a</sup>	110.0 $\pm$ 0.6 <sup>a</sup>	91.3 $\pm$ 0.8 <sup>a</sup>	87.2 $\pm$ 0.8 <sup>a</sup>	86.2 $\pm$ 0.7 <sup>a</sup>	8048 $\pm$ 209.9 <sup>a</sup>

1. n: initial number of subjects was five and ended with excluding the out-layer values from each tested vegetable dish.
2. One way ANOVA adjusted for multiple pair-wise comparisons by least significant test was performed for every treatment.
3. Means in the same column for each group of vegetable test meals with different superscript are significantly different at (P<0.05).
4. White bread is the reference food ingested with plain water; cooked vegetables are used in the study.
5. AUCg: area under the curve of glucose.
6. For rice + chicken broth, all subjects for the bread and R+B in the three groups were combined together.

**Table (2): Serum Glucose Response and AUC during OGTT for the Various Test Foods (means ± SEM).**

Test dishes	n*	Serum glucose (mg/dL) levels within two hours					AUCg (mg.min/dL)
		0 min. (Fasting)	30 min.	60 min.	90 min.	120 min.	
<b>1. Carrots Set:</b>							
Bread	5	90.2 ± 2.0 <sup>a</sup>	103.6 ± 4.4 <sup>a</sup>	93.4 ± 5.5 <sup>a</sup>	90 ± 3.4 <sup>a</sup>	87.2 ± 3.8 <sup>a</sup>	8052 ± 910 <sup>a</sup>
Rice (R,60g) +chicken broth (B, 200mL)	4	91.3 ± 2.3 <sup>a</sup>	112.8 ± 5.1 <sup>a</sup>	88.0 ± 6.4 <sup>a</sup>	84.3 ± 4.0 <sup>ab</sup>	87.5 ± 4.4 <sup>a</sup>	7170 ± 1053 <sup>a</sup>
Rice (R,50g) +B with carrots (130g)	4	91.1 ± 2.3 <sup>a</sup>	119.4 ± 5.1 <sup>ab</sup>	92.5 ± 6.4 <sup>a</sup>	81.9 ± 4.0 <sup>b</sup>	85.5 ± 4.4 <sup>a</sup>	8170 ± 1053 <sup>a</sup>
Rice (R,40g) +B with carrots (260g)	4	91.8 ± 2.3 <sup>a</sup>	127.9 ± 5.1 <sup>b</sup>	98.6 ± 6.4 <sup>a</sup>	72.7 ± 4.0 <sup>c</sup>	79.6 ± 4.4 <sup>a</sup>	6430 ± 1053 <sup>a</sup>
<b>2. Mulukhiyah leaves (ML) Set:</b>							
Bread	5	85.2 ± 2.0 <sup>a</sup>	95.8 ± 4.3 <sup>a</sup>	100.8 ± 5.5 <sup>a</sup>	88.2 ± 3.4 <sup>a</sup>	84.6 ± 3.8 <sup>a</sup>	9357 ± 910 <sup>a</sup>
Rice (R,60g) +chicken broth (B, 200mL)	5	88.4 ± 2.0 <sup>a</sup>	107.6 ± 4.3 <sup>b</sup>	89.8 ± 5.5 <sup>ab</sup>	86.4 ± 3.4 <sup>a</sup>	83.6 ± 3.8 <sup>a</sup>	7848 ± 910 <sup>a</sup>
Rice (R,55g) +B with ML (40g)	4	84.5 ± 2.3 <sup>a</sup>	91.3 ± 5.1 <sup>a</sup>	89.2 ± 6.4 <sup>ab</sup>	81.8 ± 4.0 <sup>a</sup>	86.3 ± 4.4 <sup>a</sup>	8144 ± 1051 <sup>a</sup>
Rice (R,50g) +B with ML (120g)	4	91.8 ± 2.3 <sup>a</sup>	98.1 ± 5.1 <sup>ab</sup>	82.0 ± 6.4 <sup>b</sup>	80.2 ± 4.0 <sup>a</sup>	81.7 ± 4.4 <sup>a</sup>	3350 ± 1051 <sup>b</sup>
<b>3. Spinach Set:</b>							
Bread	5	90.0 ± 2.0 <sup>a</sup>	108.4 ± 4.4 <sup>a</sup>	104.2 ± 5.5 <sup>a</sup>	90.6 ± 3.4 <sup>a</sup>	79.0 ± 3.8 <sup>b</sup>	8754 ± 910 <sup>a</sup>
Rice (R,60g) + chicken broth (B, 200mL)	4	93.0 ± 2.4 <sup>a</sup>	106.6 ± 5.4 <sup>a</sup>	96.2 ± 6.8 <sup>ab</sup>	94.6 ± 4.2 <sup>a</sup>	90.0 ± 4.6 <sup>a</sup>	8750 ± 1114 <sup>a</sup>
Rice (R,58g) +B with spinach (50g)	4	86.5 ± 2.4 <sup>a</sup>	106.4 ± 5.4 <sup>a</sup>	90.7 ± 6.8 <sup>b</sup>	80.8 ± 4.2 <sup>b</sup>	91.0 ± 4.6 <sup>a</sup>	7584 ± 1114 <sup>a</sup>
Rice (R,55g) +B with spinach (150g)	4	85.5 ± 2.4 <sup>a</sup>	105.4 ± 5.4 <sup>a</sup>	101.9 ± 6.8 <sup>ab</sup>	86.1 ± 4.2 <sup>ab</sup>	84.0 ± 4.6 <sup>ab</sup>	8304 ± 1114 <sup>a</sup>
<b>4. R+ B, combined subjects</b>							
Bread (reference)	15	88.5 ± 0.3 <sup>a</sup>	102.6 ± 0.8 <sup>a</sup>	99.5 ± 0.9 <sup>a</sup>	89.6 ± 0.6 <sup>a</sup>	83.6 ± 0.7 <sup>a</sup>	8721 ± 208.6 <sup>a</sup>
Rice+ Chicken broth (R+B)	13	90. ± 0.5 <sup>a</sup>	110.0 ± 0.6 <sup>a</sup>	91.3 ± 0.8 <sup>a</sup>	87.2 ± 0.8 <sup>a</sup>	86.2 ± 0.7 <sup>a</sup>	8048 ± 209.9 <sup>a</sup>

1. n: initial number of subjects was five and ended with excluding the out-layer values from each tested vegetable dish.

2. One way ANOVA adjusted for multiple pair-wise comparisons by least significant test was performed for every treatment.

3. Means in the same column for each group of vegetable test meals with different superscript are significantly different at (P<0.05).

4. White bread is the reference food ingested with plain water; cooked vegetables are used in the study.

5. AUCg: area under the curve of glucose.

6. For rice + chicken broth, all subjects for the bread and R+B in the three groups were combined together.

**Table (4): Glycemic Index, Relative Glycemic Response, Insulinemic Index, Relative Insulinemic Response, and Composite Insulin Sensitivity Index for OGTT as Affected by the Tested Vegetables (Means ± SEM).**

Test dishes	GI (%)	RGR (%)	II (%)	RIR (%)	CISI
<b>1. Carrots:</b>					
Bread	100 <sup>a</sup>		100 <sup>a</sup>	7.9 ± 1.1 <sup>a</sup>	7.9 ± 1.1 <sup>a</sup>
Rice (R,60g) +chicken broth (B, 200mL)	92.7 ± 12.1 <sup>a</sup>	95.1 ± 10.8 <sup>a</sup>	92.0 ± 8.9 <sup>a</sup>	9.6 ± 3.3 <sup>a</sup>	9.6 ± 3.3 <sup>a</sup>
Rice (R,50g) +B with carrots (130g)	101.3 ± 12.1 <sup>a</sup>	102.8 ± 10.1 <sup>a</sup>	67.5 ± 7.7 <sup>b</sup>	12.2 ± 5.2 <sup>a</sup>	12.2 ± 5.2 <sup>a</sup>
Rice (R,40g) +B with carrots (260g)	83.3 ± 12.1 <sup>a</sup>	84.2 ± 10.8 <sup>a</sup>	84.2 ± 8.9 <sup>ab</sup>	10.8 ± 4.6 <sup>a</sup>	10.8 ± 4.6 <sup>a</sup>
<b>2. Mulukhiyah leaves (ML):</b>					
Bread	100 <sup>a</sup>		100 <sup>a</sup>	10.5 ± 5.2 <sup>a</sup>	10.5 ± 5.2 <sup>a</sup>
Rice (R,60g) +chicken broth (B, 200mL)	84.2 ± 10.5 <sup>a</sup>	87.9 ± 9.3 <sup>a</sup>	81.0 ± 9.0 <sup>b</sup>	9.1 ± 2.3 <sup>a</sup>	9.1 ± 2.3 <sup>a</sup>
Rice (R,55g) +B with ML (40g)	88.1 ± 12.1 <sup>a</sup>	91.9 ± 10.8 <sup>a</sup>	73.7 ± 7.7 <sup>cb</sup>	9.9 ± 2.3 <sup>a</sup>	9.9 ± 2.3 <sup>a</sup>
Rice (R,50g) +B with The ML (120g)	34.1 ± 12.1 <sup>b</sup>	43.4 ± 10.8 <sup>b</sup>	61.7 ± 9.2 <sup>c</sup>	9.0 ± 2.3 <sup>a</sup>	9.0 ± 2.3 <sup>a</sup>
<b>3. Spinach :</b>					
Bread	100 <sup>a</sup>		100 <sup>a</sup>	7.5 ± 2.6 <sup>a</sup>	7.5 ± 2.6 <sup>a</sup>
Rice (R,60g) + chicken broth (B, 200mL)	100.1 ± 12.8 <sup>a</sup>	100.6 ± 11.4 <sup>a</sup>	76.1 ± 7.7 <sup>ab</sup>	8.8 ± 4.2 <sup>a</sup>	8.8 ± 4.2 <sup>a</sup>
Rice (R,58g) +B with spinach (50g)	89.8 ± 12.8 <sup>a</sup>	93.0 ± 11.4 <sup>a</sup>	76.5 ± 7.7 <sup>ab</sup>	11.2 ± 6.4 <sup>ab</sup>	11.2 ± 6.4 <sup>ab</sup>
Rice (R,55g) +B with spinach (150g)	95.6 ± 12.8 <sup>a</sup>	98.1 ± 11.4 <sup>a</sup>	42.9 ± 9.0 <sup>c</sup>	17.8 ± 5.1 <sup>b</sup>	17.8 ± 5.1 <sup>b</sup>
<b>4. R + B, combined subjects</b>					
Bread (reference)	100 <sup>a</sup>		100 <sup>a</sup>		
Rice+ Chicken broth (R+B)	93.4 ± 1.3 <sup>a</sup>		86.6 ± 2.5 <sup>b</sup>		

1. One way ANOVA adjusted for multiple pair-wise comparisons by least significant test was performed for every treatment.
2. Means in the same column for each group of test dishes with different superscripts are significantly different ( $P < 0.05$ ).
3. GI: Glycemic index, RGR: Relative glycemic response, II: Insulinemic index, RIR: Relative insulinemic response, CISI: Composite insulin sensitivity index.
4. For rice + chicken broth, all subjects for the bread and R+B in the three groups were combined together.

The small amount of fat (5g of sunflower oil) that was added to steamed rice in addition to the small amount of fat that arises from chicken broth are partially responsible for the lower value of GI and II obtained in this study. Fats and oils slow the rate of gastric emptying of food (here rice) carbohydrates and their absorption,<sup>29</sup> leading to lowered blood glucose

level, lowered GI%, and lowered II%.

**The Glycemic and Insulinemic Responses of Carrots (Cr) Ingested with R and B:** The glycemic indices produced by eating carrots with rice and chicken broth at two different levels were not significantly different from one another or from the GI of the reference white

bread (table 4). However, due to the increased sample size, the difference became significant as was discussed above. The observed GI values were 101.3% and 83.3% for the higher (260g) and the lower (130g) levels of carrots, respectively, with a tendency of the higher level to lower blood glucose ( $P=0.08$ ). In contrast to the GI, the postprandial II of the lower level of Cr+R+B (67.5%) was significantly lower than that of bread, R+B, and the higher level of Cr+R+B (table 4). The tendency to decrease blood glucose because it was affected by the increase of the ingested amount of carrots is consistent with what was reported by Gustafsson, *et al*<sup>30</sup> who found that the larger the carrot portion, the lower the glucose and insulin responses and the higher the satiety scores that were obtained. This lowering effect was related to the increase in the amount of dietary fiber resulting from increasing carrots in the dish.<sup>30</sup> During the cooking of the carrots, physicochemical properties of dietary fiber may be modified and, as a consequence, certain physiological effects may also change. For example, glycosidic linkages in the dietary fiber can be broken, resulting in the solubilization of dietary fiber or its loss.<sup>31</sup>

Carrots (*Daucus carota*) are an important root vegetable and are usually used for juice production. Carrots get their characteristic and bright orange color from  $\beta$ -carotene which is metabolized to vitamin A by humans when bile salts are present in the intestine. Carrots are rich in dietary fibers, antioxidants, and minerals.<sup>32</sup> To evaluate the effect of the dosage on the metabolic response to vegetables added to a mixed lunch meal, Gustafsson and his colleagues<sup>30</sup> chose carrots as an example. They found that the larger the carrot portion, the lower the glucose and insulin responses

and the higher the satiety scores. In the revised GI tables (2008),<sup>33</sup> the mean GI value for peeled and boiled carrots was 32 when using glucose as a reference and 70 when using white bread as a reference.

Results in table 4 show that whereas the larger portion of carrots tended ( $p > 0.05$ ) to lower the insulinemic index of R+B to  $84.2 \pm 7.7\%$ , the smaller portion significantly lowered ( $p > 0.05$ ) it II to  $67.5 \pm 7.7\%$ . Insulin response seems to be a complex system as was explained before. Incretin hormones play an important role in insulin regulation; the hormone glucose-dependent insulinotropic polypeptide (GIP) and glucagon-like-peptide 1 (GLP-1) are potent determinants of the postprandial insulin release that occurs when blood glucose increases.<sup>34</sup> The incretin hormones are essential in the regulation of postprandial glycemia.<sup>35</sup> Orskov and associates<sup>36</sup> noticed that plasma insulin responses correlate significantly with GIP and GLP-1 responses in healthy volunteers. Further research work is required to clarify the glycemic and insulinemic effect of carrots.

***The Glycemic and Insulinemic Responses to Mulukhiyah Leaves Ingested with R and B (MLRB):*** Whereas the higher portion of ML (120g) significantly lowered the GI % of R+B from 84.2% to 34.1%, the lower level had no effect (table 4). The corresponding II (table 4) of R+B when eaten with ML both the lower and higher levels were 73.7% and 61.7%, respectively.

Insulin sensitivity as measured by CISI was not affected by ML (table 4). This finding is in agreement with the general conclusion arrived at in 2005 by Innam and colleagues.<sup>37</sup> They found that the viscous soluble dietary fibers

that were extracted from ML had significantly suppressed the blood glucose level in arat due largely to the delayed absorption of glucose from the intestinal membrane in the upper digestive tract caused by the  $\alpha$ -glucosidase inhibitor present in the viscous soluble dietary fibers of ML. This mechanism was further confirmed in 2009 by Phuwapraisirisan and colleagues<sup>38</sup> who were able to isolate from ML new flavonol glycosides, corchorusides A and B, which acted as  $\alpha$ -glucosidase inhibitors.<sup>38</sup>

Mulukhiyah (*Corchorus olitorius*) is commonly cultivated locally as a popular seasonal vegetable. It is native to Egypt and the Middle East. The stem of the plant is an important source of fiber.<sup>39</sup> Recently, it has been found that the strong antioxidant activity of the leaves of mulukhiyah is attributed to some of its antioxidative phenolic compounds.<sup>40</sup> Whereas a large amount of water-soluble polysaccharides are present in mulukhiyah leaves,<sup>39</sup> dietary fibers obtained from their leaves have a high water-holding capacity.<sup>41</sup> The leaves are usually cooked as fresh, frozen, or dried.

***The Glycemic and Insulinemic Responses of Spinach (S) Ingested with R +B (SRB):*** The observed mean postprandial GI produced by the two levels of spinach, 50g and 150 g, ingested with R+B were 89.8% and 95.6%, respectively (table 4). In contrast, it can be observed that the higher level of spinach lowered significantly the insulinemic response of R+B to  $42.9 \pm 9.0\%$ , and the lower level had no effect (table 4).

The findings from this study demonstrate that spinach eaten with rice and chicken broth does not apparently improve the postprandial glycemic response in healthy subjects at the

two different levels used. This can be explained by the observation that spinach improved insulin sensitivity: CISI value was increased significantly from  $8.8 \pm 4.2$  for R+B alone to  $17.8 \pm 5.1$  for R=B eaten with the higher portion of spinach (table 4), but at the same time it decreased the amount of insulin produced as exemplified in the AUCi, with a net result of no change in its glycemic effect. In other words, the apparent decrease in blood glucose level that might have resulted due to the **improved insulin sensitivity** obtained was abolished by the **lower insulin amount** that was produced by the higher portion of spinach.

Another possible explanation can be ascribed to the smaller amount of spinach we used. It is a coincident that Gustafsson and colleagues<sup>42</sup> used a large spinach portion (250 g) containing 7.2 g of fibers which resulted in a low postprandial glycemic effect and not their 150g portion. They did not calculate insulin sensitivity which should have shed some light on the physiological mechanism of the lowering glycemic effect of spinach. Thus, further studies are needed to have some depth to explain this finding.

Spinach (*Spinacia oleracea*) is an edible flowering plant of the family amaranthaceae. It is native to central and southwestern Asia.<sup>43</sup> It is a rich source of vitamin A, vitamin C, vitamin E, and vitamin K, and it is especially high in lutein. Gustafsson and his colleagues<sup>42</sup> evaluated the satiety effect of spinach in mixed meals, using a control meal without spinach and a test meal with spinach, both meals were balanced regarding their energy (2000 kJ), digestible carbohydrates (59 g) and similar protein and fat content. They found that the largest spinach portions (250 g in a 2000 KJ meal) reduced the post-prandial glucose

response in adult subjects.<sup>42</sup>

**Relative Glycemic and Insulinemic Response:**

Relative glycemic and relative insulinemic response (RGR) values of the means for all the vegetable-based dishes revealed the same pattern of significance parallel to the GI and II values of the individual foods from which they were prepared (table 4). These results are in line with what Wolever and colleagues<sup>17</sup> found that GI is a significant determinant of the glycemic responses of mixed meals.

In conclusion, the glycemic and insulin micresponses of rice and chicken broth are improved when eaten with cooked leaves of mulukhiyah. Whereas higher levels of cooked carrots tended to improve the glycemic response of rice and chicken broth, spinach had no apparent effect on the blood glucose level in spite of the fact it apparently improved insulin sensitivity. It was further noticed that there was no difference between the calculated relative glycemic response for all the vegetable-based dishes and the GI values of the individual foods from which they were prepared, suggesting that the GI is a significant determinant of the glycemic response of mixed meals.

**References**

1. Jenkins DJA, Kendal CWC, Axelson M, Augustin LSA, Vuksan V. Viscous and non-viscous fibers, non-absorbable and low glycaemic index carbohydrates, blood lipids and coronary heart disease. *Curr Opin Lipidol* 2000; 11:49–56.
2. Panahi S, Exatagha A, Temelli F, Vasanthan T, Vuksan V. Glucan from two sources of oat concentrates affect postprandial glycemia in relation to the level of viscosity. *J Am Coll Nutr* 2007; 26:639–44.

3. Kim W, Egan JM. The role of incretins in glucose homeostasis and diabetes treatment. *Pharmacol Rev* 2008;60:470–412.
4. Grover GJ, et al. Effects of the soluble fiber complex PolyGlycoplex® (PGX®) on glycemic control, insulin secretion, and GLP-1 levels in Zucker diabetic rats. *Life Sciences* 2011; 88:392.
5. Tahrani AA, Pia MK, Barnett, AH Management of type 2 diabetes: The GLP-1 pathway. *Future Prescriber* 2009, 9(3): 18-24 (DOI: 10.1002/fps.39)
6. Wang ZQ, Zuberi AR, Zhang XH, Macgowan J, Qin J, Ye X, et al. Effects of dietary fibers on weight gain, carbohydrate metabolism and gastric ghrelin gene expression in mice fed a high fat diet. *Metab Clin Exp* 2007;56:1635–42.
7. Food and Agriculture Organization\ World health organization. Carbohydrates in human nutrition: report of a joint FAO\WHO expert consultation. *FAO Food and nutrition paper* 1998; 66: 1-140.
8. Jenkins DJ, Wolever TS, Taylor RH, Barker H, Hashmeim SD, Baldwin SM. Glycemic index of foods: a physiological basis for carbohydrate exchange. *American Journal of Clinical Nutrition* 1981; 34: 362–6.
9. Ludwig DS, Majzoub JA, Al-Zahrani A, Dallal GE, Blanco I, Roberts SB. High glycemic index foods, overeating, and obesity. *Pediatrics* 1999; 103: 261E–266E.
10. Carels RA, Darby LA, Douglass OM, Cacciapagli HM, Rydin S. Education on the glycemic index of foods fails to improve treatment outcomes in a behavioral weight loss program. *Eating Behaviors* 2005; 6: 145–150.
11. Pawlak PB, Ebbeling CB, Ludwig DS. Should obese patients be counseled to follow a low-glycemic diet? Yes. *Obesity Reviews* 2002; 3, 235–243.
12. Raben A. Should obese patients be counseled to follow a low-glycemic index diet? No. *Obesity Reviews* 2002; 3: 245–256.
13. Nishida C, Nocito M. FAO/WHO Scientific Update on carbohydrates in human nutrition: introduction. *European Journal of Clinical*

- Nutrition 2007; 61, S1–S4.
14. Bornet FRJ, Billaux MS, Messing B. Glycemic index concept and metabolic diseases. *International Journal of Biology and Macromolecules* 1997; 21: 207- 219.
  15. Pi-Sunyer FX. Glycemic index and disease. *American Journal of Clinical Nutrition* 2002; 76: 290S–8S.
  16. Lin MHA, Wu MC, Shin LS and Lin J. Glycemic index, glycemic load and insulinemic index of Chinese starchy foods. *World Journal of Gastroenterology* 2010; 16: 39-49.
  17. Wolever TM, Yang M, Zeng XY, Atkinson F, Brand-Miller JC. Food glycemic index, as given in Glycemic Index tables, is a significant determinant of glycemic responses elicited by composite breakfast meals. *American Journal of Clinical Nutrition* 2006; 83: 1306–12.
  18. Wolever TM, Bolognesi C. Source and amount of carbohydrate effect postprandial glucose and insulin in normal subjects. *Journal of Nutrition* 1996; 126: 2798–806.
  19. Horwitz W, George W, Latimer J. *Official Methods of Analysis of AOAC International*, 2005; 18th edition. Gaithersburg, MD.
  20. Wolever TM. Carbohydrate and the regulation of blood glucose and metabolism. *Nutrition Reviews* 2003; 61: S 40-8.
  21. Ceriello A, Johns D, Widel M, Eckland JD, Gilmore KJ, Tan MH. Comparison of effect of pioglitazone with metformin or sulfonylurea (mono-therapy and combination therapy) on post-load glycemia and composite insulin sensitivity index during an oral glucose tolerance test in patients with type 2 diabetes. *Diabetes Care* 2005; 28:266–272.
  22. Statistical analysis system (SAS). *SAS/STAT User's Guide*, Release 6.03 edition. SAS Institute Inc. Cary, NC, USA, 1988.
  23. Brand-Miller JC, Pang E, Bramal L. Rice: a high or low glycemic index food? *American Journal of Clinical Nutrition* 1992; 56:1034–6.
  24. Brand JC, Nicholson PL, Thorburn AW, Truswell AS. Food processing and the glycemic index. *American Journal of Clinical Nutrition* 1985; 42: 1192– 1196.
  25. Traianedes K, O'Dea K. Commercial canning increases the digestibility of beans in vitro and postprandial metabolic responses to them in vivo. *American Journal of Clinical Nutrition* 1986; 44: 390–397.
  26. Jarvi A, Karlstrom B, Granfeldt Y, Bjorck I, Vessby B, Asp NG. The influence of food structure on postprandial metabolism in patients with non-insulin-dependent diabetes mellitus. *American Journal of Clinical Nutrition* 1994; 59: 794S.
  27. Behall KM, Scholfield DJ, Yuhaniak I, Canary J. Diets containing high amylose vs amylopectin starch: effects on metabolic variables in human subjects. *American Journal of Clinical Nutrition* 1989; 49: 337–344.
  28. Panlasigui LN, Thompson LU, Juliano BO, Perez CM, Yiu SH, Greenberg GI. Rice varieties with similar amylose content differ in starch digestibility and glycemic response in humans. *American Journal of Clinical Nutrition* 1991; 54: 871–877.
  29. Collier G, O'Dea K. The effect of co-ingestion of fat on the glucose, insulin, and gastric inhibitory polypeptide responses to carbohydrate and protein. *American Journal of Clinical Nutrition* 1983; 37: 941–944.
  30. Gustafsson K, Asp NG, Hagander B, Nyman M. Dose-response effects of boiled carrots and effects of carrots in lactic acid in mixed meals on glycemic response and satiety. *European Journal of Clinical Nutrition* 1994; 48(6): 386-96.
  31. Nyman M, Maria SJ, Svanberg J. Modification of physicochemical properties of dietary fiber in carrots by mono- and divalent cations. *Food Chemistry* 2002; 76: 273–280.
  32. Mikkelsen B, David P. Carrots. *Urban Legends Reference* 2005; p. 19. Cited by: [www.Snope.com](http://www.Snope.com).
  33. Foster-Powell K, Holt SH, Brand-Miller JC. *International table of glycemic index and glycemic load values: 2002*. *American Journal of Clinical Nutrition* 2002; 76: 5–56.

34. Fehmann HC, Göke R, Göke B. Cell and molecular biology of the incretin hormones glucagon-like peptide-1 and glucose-dependent insulin releasing polypeptide. *Endocr Rev* 1995; 16: 390–410.
35. Gatenby SJ, Ellis PR, Morgan LM, Judd PA. Effect of partially depolymerized guar gum on acute metabolic variables in patients with non-insulin-dependent diabetes. *Diabetes Med* 1996; 13: 358–64.
36. Orskov C, Wettergren A, Holst JJ. Secretion of the incretin hormones glucagon-like peptide-1 and gastric inhibitory polypeptide correlates with insulin secretion in normal man throughout the day. *Scand J Gastroenterol* 1996;31:665–70.
37. Innamì S, Ishida H, Nakamura K, Kondo M, Tabata K, Koguchi T, Shimizu J, Furusho T. Jew's mellow leaves (*Corchorus olitorius*) suppress elevation of postprandial blood glucose levels in rats and humans. *International Journal of Vitamins and Nutrition Researches* 2005; 75(1): 39-46. (Abstract)
38. Phuwapraisirisan P, Puksasook T, Kokpol U, Suwanborirux K. Corchorusides A and B, new flavonol glycosides as  $\alpha$ -glucosidase inhibitors from the leaves of *Corchorus olitorius*. *Tetrahedron Letters* 2009; 50:5864–5867.
39. Azuma K, Nakayama M, Koshioka M, Ippoushi K, Yamaguchi Y, Kohata Y, Yamauchi K, Ito H, Higashio H. Phenolic antioxidants from the leaves of *Corchorus olitorius*. *Food Chemistry* 1999; 47: 3963–3966.
40. Ohtani K, Okai K, Yamashita U, Yuasa I, Misaki A. Characterization of an acidic polysaccharide isolated from the leaves of *Corchorus olitorius* (Moroheiya). *Bioscience, Biotechnology, and Biochemistry* 1995; 59: 378–381.
41. Yamazaki E, Murakami K, Kurita O. Easy preparation of dietary fiber with the high water-holding capacity from food sources. *Plant Foods for Human Nutrition* 2005; 60: 17–23.
42. Gustafsson K, Asp NG, Hagander B, Nyman N. Satiety effects of spinach in mixed meals: Comparison with other vegetables. *European Journal of Clinical Nutrition* 1995; 46: 327- 334. (Abstract)
43. Ball GFM. Vitamins in foods: analysis, bioavailability, and stability. CRC Press; 2006; pp. 236.

## تأثير تناول الجزر والملوخية والسبانخ المطهوه على غلوكوز وإنسولين الدم للأرز المطهو بالبخار

أحمد الفقيه<sup>1</sup> وبثينة الخطيب<sup>2</sup>

1- استاذ، كلية الزراعة، الجامعة الأردنية؛ 2- ماجستير تغذية، كلية الزراعة، الجامعة الأردنية

### الملخص

**الخلفية:** يشيع تناول الخضراوات مع الأرز في الأردن وغيره من بلدان العالم. وتلعب الألياف الغذائية دورا في تنظيم غلوكوز وإنسولين الدم لدى الأصحاء ومرضى السكري خاصة.

**الهدف:** هدفت الدراسة إلى معرفة التأثير المباشر لتناول كل من الملوخية والسبانخ والجزر المطهوه على مؤشر سكر وإنسولين الدم الناجم عن تناول هذه الخضراوات مع الأرز المطهو بالبخار والمتناول مع مرق الدجاج.

**الطريقة:** أجري اختبار تحمل غلوكوز الدم لدراسة تأثير الجزر والملوخية والسبانخ على مؤشر سكر وإنسولين الدم الناجم عن تناول هذه الخضراوات المطهوه مع الأرز الابيض المطهو بالبخار المتناول مع مرق الدجاج. تطوع لهذه الدراسة أشخاص أصحاء بالغون، بلغ متوسط أعمارهم 25.4 سنة ( $\pm 1.28$  معدل خطأ القياس)، كما بلغ متوسط نسبة كتلة أجسامهم 21.6 كغم/م ( $\pm 1.0$ )، وتمتع جميعهم بنتائج طبيعية لاختبار تحمل الغلوكوز.

**النتائج:** انخفض مؤشر كتلة سكر الدم للأرز مع المرق بتناول 120 غم من الملوخية، ومال هذا المؤشر إلى الانخفاض بتناول 260 غم من الجزر المطهو، ولكنه لم يتأثر ظاهريا بتناول السبانخ المطهو. أما مؤشر إنسولين الدم، فقد انخفض بشكل ملموس بتناول 120 غم من الملوخية أو 130 غم من الجزر أو 150 غم من السبانخ وقد تحسنت حساسية الإنسولين بشكل جوهري بتناول السبانخ فقط.

**الاستنتاجات:** حدث تحسن ذو دلالة معنوية لمؤشر سكر الدم للأرز المطبوخ حين تناوله مع كمية عالية نسبيا من الملوخية، ولكن هذا المؤشر مال إلى التحسن بتناوله مع الكمية الأعلى من الجزر، ولكنه لم يتأثر ظاهريا بتناوله مع السبانخ. انخفض مستوى مؤشر إنسولين الدم للأرز بدلالة معنوية حين تناوله مع أي من هذه الخضراوات، أما حساسية الإنسولين الناجمة عن تناول الأرز فلم تتحسن إلا بتناول السبانخ.

**الكلمات الدالة:** مؤشر كتلة سكر الدم، مؤشر إنسولين الدم، الملوخية، سبانخ، جزر، حساسية الأنسولين.