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Glycemic Index of Commonly Consumed Lebanese Mixed Meals and Desserts

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Abstract: The determination of the Glycemic Index (GI) and Load (GL) for mixed meals serves as a dietetic tool in meal planning to reinforce the benefits of low GI meals and decrease the physiological effects of high GI meals. In this study, the glycemic indexes of ten Lebanese mixed meals and desserts were assessed; Bourgoul A Banadoura (BB), Fattit Hommos (FH), Loubieh Bzet (LB), Mehshe Malfouf (MM), Sfouf (SF), Siyadieh (SI), Riz bi Halib (RH), Meghleh (ME), Pizza (PI) and Riz A Dgeg (RD). Twelve female volunteers consumed a standard glucose solution containing 50 g of dextrose and 350 mL of water as reference meal and samples of the ten mixed meals and desserts containing each 50 g of carbohydrates as test meals on separate days. Their blood glucose levels were measured every 15 min over 2 h following the test food consumption. The mean values of the GI (GL) of the mixed meals were found to be BB = 50.09 (38.35), FH = 37.21 (18.78), LB = 12.76 (2.15), MM = 67.93 (56.24), SF = 48.59 (20.70), SI = 14.62 (9.74), RH = 56.83 (20.21), ME = 49.50 (44.10), PI = 56.04 (12.10) and RD = 57.34 (33.03). The results of this study, serve as valuable data for health professionals in proper menu planning for diabetes mellitus and hyperlipidemia.

Key words: Glycemic index, mixed meals, Lebanese dishes, dessert

INTRODUCTION

The Glycemic Index (GI) is based on the measurement of blood glucose within 2 h from the consumption of a test food containing 50 g of available carbohydrates and comparing it to the blood glucose response to a similar amount of a standard food, either glucose or white bread (Jenkins *et al*., 1981). The Glycemic Load (GL) is calculated by multiplying the GI of a consumed food by its carbohydrate content and dividing by 100 (Salmeron *et al*., 1997). An increase in blood glucose level is proportionally produced in response to an increase in GL (Venn *et al*., 2006). There exist a number of factors that affect the reproducibility of the GI of a food (Pi-Sunyer, 2002). The GI of the same fruit tends to decrease with fruit ripeness (Pi-Sunyer, 2002; Englyst and Cummings, 1986). The higher the amylose/amylopectin ratio in a food, the lower the GI (Bjorck *et al*., 2000). The whole form of a food has a lower GI than its mashed or pureed form, which in turn has a lower GI than its juice form (Pi-Sunyer, 2002). Grains that are finely ground have a higher GI because they are easier to digest than those roughly ground (Heaton *et al*., 1988). Increasing the acidity of a food significantly lowers its GI (Bjorck *et al*., 2000; Sugiyama *et al*., 2003; Maioli *et al*., 2008).

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Chemically modifying a food during processing modifies its GI (Pi-Sunyer, 2002; Raben *et al*., 2007; Liljeberg and Bjorck, 2005; Rashmi and Urooj, 2003). Combining macronutrients influences GI that is positively associated with its dietary carbohydrate content and is negatively associated with the food's protein and fat content (Sahyoun *et al*., 2008; Nuttall *et al*., 1985; Gannon *et al*., 1993; Frid *et al*., 2005; Gentilcore *et al*., 2005; Wolever *et al*., 1994; Sheard *et al*., 2004). The extent to which the GI could be affected by the dietary fiber content of the food is debatable (Pi-Sunyer, 2002). Wolever (1990) found a positive association between insoluble (r = 0.584), but not soluble fibers and GI. However, soluble fibers have an effect of postprandial glycaemia (Nuttall, 1993). In terms of fiber viscosity, the more viscous the fiber is, the higher is its effect on decreasing the GI of a food (Würsch and Pi-Sunyer, 1997).

In recent years, the GI has been transformed as a tool in planning diets for diabetic patients and the prevention of diabetes, cardiovascular disease, obesity and even certain cancers. It has been shown that low insulin levels (Miyashita *et al*., 2006), as a result of low GI foods, help in burning fat by increasing satiety and fullness after eating (Heaton *et al*., 1988). This has been associated with reducing the risk of developing obesity (Brand-Miller *et al*., 2002). However, inconsistent effect of high GI on hunger and satiety has been reported (Pi-Sunyer, 2002).

Experimental and observational studies in animals and humans have provided good evidence to support the direct effect or association of low GI or GL diets in both the management and the prevention of diabetes (Brand-Miller *et al*., 2003a; Salmeron *et al*., 1997), while others rejected these hypotheses (Ratner *et al*., 2005). Consumption of a low GI diet may improve glycemic control by reducing glucose excursion in youths with type 1 diabetes using continuous monitoring (Nansel *et al*., 2008). Whereas, according to the American Diabetes Association's 2006 position statement, there is no sufficient evidence that the GI is helpful clinically to prevent type 1 diabetes (Ratner *et al*., 2005). As for type 2 diabetes, in many studies conducted, glycemic control was significantly improved when subjects consumed diets with a low GI (Frost *et al*., 1994; Fontvieille *et al*., 1992). Two other group studies did not find any association between GI or GL and type 2 diabetes incidence (Meyer *et al*., 2000; Stevens *et al*., 2002). Thus, at present it is not comprehensive whether there is an association between GI or GL diet and the development of type 2 diabetes (Pi-Sunyer, 2002).

The GI can alter risk factors for heart disease (Liu *et al*., 2000). A high GI diet induces elevated glycaemia and insulinemia, which can lead to a group of metabolic abnormalities including high blood pressure and high blood triglycerides that increase the risk of heart disease via syndrome X (Liu *et al*., 2000). High GI was associated with low HDL cholesterol levels, a risk factor for heart disease, in the Third National Health and Nutrition Examination Study (Ford and Liu, 2001).

The issue of whether the glycemic index of an individual food is valid when incorporated in a meal is controversial (Mehio *et al*., 1997). Jenkins *et al*. (1981) suggested that the GI of a meal can be calculated by adding the percent carbohydrate contributions of each food contained in the meal multiplied by each food's published GI. Sud *et al*. (1988) argue that a food is more than the sum of its nutrients due to physical and chemical interactions between nutrients and non-nutrients. In their study, natural intact foods yielded a higher postprandial glycemia than their equivalent food extracts containing the same nutrients composition.

A Lebanese meal, chickpeas sandwich, had the highest GI (GI = 86) among western, Chinese, Indian, Italian and Greek meals (Chew *et al*., 1988). The highest glycemic and insulemic response, among studied Lebanese composite meals, was reported for stuffed grape leaves, lowest for chickpea dip salad and moderate for kibbeh saynieh (Mehio *et al*., 1997).

The purpose of this study was to determine the GI of ten commonly consumed Lebanese mixed meals as a step in developing a database setting the way for future accumulation of such data. The results are important means for menu planning to improve blood glucose control, improve blood lipids and reduce the risk of heart disease and assist in overweight and obesity management.

MATERIALS AND METHODS

Subjects and Blood Analysis

A total of 12 female volunteers participated in this study following a signed letter of consent. Their ages ranged between 20-22 years and their mean body mass index was 21.25 (18.50-25.20) (Table 1). Exclusion criteria included regular use of prescription drugs, allergies to food items tested in the study and obesity classification (BMI greater than 30). Prior to testing, blood was withdrawn for biochemical analysis after 12 h of fasting. Blood samples collected for HbA_1C analysis were collected in K_3 EDTA tubes. Blood samples for glycemia determination were collected in serum clot activator tubes. None of the subjects had impaired glucose tolerance. The Biochemical assessment results are summarized in Table 1.

Meals and Methodology

The reference food consisted of a 50 g glucose anhydrous solution dissolved in 350 mL of water. Ten different Lebanese meals and desserts were analyzed for their nutrient contents using Nutrition Pro software (Nutritionist Pro, v. 4, Axxya Systems, Stafford, TX) (Table 2).

Table 1: Subjects' age, BMI and biochemical assessment

Subject	Age (year)	BMI (kg m^{-2})	Glucose (mg dL^{-1})	HBA1C (%)	Insulin (µU mL^{-1})
1	20	25.20	80	5.0	16.5
2	22	22.30	73	4.9	6.2
3	22	21.40	79	4.8	6.3
4	20	20.07	73	4.8	5.9
5	22	21.25	78	5.0	6.2
6	20	18.73	82	5.1	6.6
7	20	18.90	84	4.9	6.0
8	21	18.50	93	4.8	14.0
9	22	23.69	87	5.4	12.0
10	21	20.86	79	5.0	6.1
11	21	21.95	87	5.0	5.8
12	22	23.69	86	5.2	8.0

Table 2: Mixed meals nutrient composition in 100 g food samples

Mixed meal	Carbohydrate	Proteins	Fat	Water	Energy (cal)
Bourgoul A banadoura (BB)	18.23	3.02	1.98	73.73	96.15
Fattit hommos (FH)	22.43	7.33	4.39	64.85	154.99
Loubieh bzet (LB)	7.03	1.99	1.62	31.79	49.38
Meghleh (ME)	22.84	0.31	0.09	76.65	90.80
Mehshe malfouf (MM)	15.77	2.84	1.14	68.32	100.93
Pizza (PI)	22.49	8.57	8.57	63.68	157.47
Riz A dgeg (RD)	9.60	13.60	4.38	70.09	134.15
Riz Bi halib (RH)	21.55	24.33	1.31	59.90	95.49
Sfouf (SF)	60.86	4.01	11.63	29.11	361.46
Siyadieh (SI)	15.50	8.40	9.22	68.74	100.00

Table 3: Recipes of the tested meals and their methods of preparation

Meal	Ingredients	Preparation method
Bourghoul a Banadoura	5 cups dry bulgur; 2 chopped onions; 1.5 kg red tomato; 0.25 cup vegetable oil; 7 tsp salt; 1 tsp black pepper; 3.5 cups water	Stir fry the onions with the vegetable oil. Chop the tomatoes into small pieces and add them to the onions, once they become slightly red. Meanwhile, wash/clean the bulgur with water several times. When a paste-like mixture starts to form, add the bulgur, water, salt and pepper. Let the mixture simmer for 45-50 min.
Meghleh	6 cups tap water; 2 cups white sugar; 1 tbsp caraway seeds; 1 tsp anise seeds 0.5 tsp of ginger; 1 cup powdered rice	Put all the ingredients together then turn on the stove. Stir well for 20 min. When it thickens and reaches the desired pudding-like consistency, turn of the stove and pour in bowls.
Fattit Hommos	500 g boiled chickpeas; loaf white bread; 1 tbsp crushed garlic 8 cups yogurt; 3 tbsp vegetable oil; 1 cup dried pine nuts; 1.25 tsp salt	Soak the chickpeas overnight in water. Put the chickpeas in a pan and add water until it covers the peas. Boil the chickpeas and then drain any additional remaining water. In a separate pan, fry the pine nuts in vegetable oil. In a bowl, mix the yogurt with crushed garlic. Toast the white bread. To serve, put the bread crumbs in the bottom of a serving plate. Add chickpeas, then the yogurt. Garnish with the fried pine nuts.
Mihshe Malfouf	2 kg raw cabbage; 6 cups short grain rice; 600 g ground beef meat; 1 clove garlic; 4 tbsp vegetable oil; 28 tbsp lemon juice; 5 tbsp salt; 1 tbsp black pepper; 1 tbsp dried mint; 8.5 cups water	Add the oil to the meat and stir fry in a pan with black pepper and 3 tbsp salt. Peel and crush the garlic clove. Add to the cooked meat. Add the cabbage and 2 cups of water to the meat. Cook until the cabbages become very tender. Add the rice, 2 tbsp salt and 4 cups of water. After 40 min or when the rice is cooked, add the dried mint and lemon juice. Turn of the stove after 10 min.
Loubieh Bzet	1 kg French beans; 1.5 cup chopped red tomato; 7 pieces garlic; 3 tbsp chopped onions; 2 tbsp crushed garlic; 2 tbsp tomato paste; 2 tsp salt; 1 cup water; 4 tbsp olive oil;	Stir fry the chopped onions and crushed garlic in 2 tbsp olive oil. Add the French beans, garlic pieces and 1 cup water. Close the pan to tenderize the beans for 15 min. Add the chopped tomatoes and tomato paste. Cook for 25 min. Turn off the stove and then add 2 tbsp of oil of the cooked meal.
Riz A Dgeg	2 cups basmati rice; 10 cups tap water; 1.5 kg chicken; 200g ground meat; 2 tsp salt; 0.5 tsp black pepper; 0.5 tsp ground cinnamon	Boil the chicken with cinnamon, salt and black pepper. Fry the meat, then add to it the sauce of the chicken and the rice. Boil the rice for 20 min. Then add the chicken to the rice.
Riz Bi Halib	2 cups short grain rice 20 tbsp; skimmed powdered milk; 20 tbsp sugar; 5 g corn flour; 7 cups water	Boil the rice with 4 cups of water. Dissolve the milk with 3 cups of water and add to the rice mix. Add the sugar and corn flour. Stir the mixture while it gently heats. When it thickens and reaches the desired pudding-like consistency, turn of the stove and pour in bowls.
Sfouf	3 cups (1 cup = 240 mL) white flour; 1.5 cup sugar; 0.5 cup vegetable oil; 3 tsp baking powder; 2 tsp Saffron; 1 cup water	In a bowl, mix the sugar, water and oil. Add the flour, saffron and baking powder to the bowl. Mix gently until a dough forms with no granulated flour in. Pour the dough to an oil lubricated tray. Bake at 350°C for 35 min.
Siyadiyeh	900 g of fish filet 150 g of onions 210 g of olive oil 1300 g of basmati rice 4 g of black pepper 74 g of nuts 1200 g of tap water 50 g of salt 55 g of vegetable oil	Fry the fish filet, then the nuts. Cut the onions into small cubes and fry them, with the same oil used for the filet, until brown. Then add the tap water to the oil and onions and put the rice, the salt and the black pepper. Boil them 20 min. In a plate put the rice, then the fish filet and decorate with the nuts
Pizza	66.7 g all purpose wheat flour; 1.7 g salt; 0.200 g baker's Yeast; 33 g water; 67 g red tomato; 27 g chopped onions; 0.07 g ground oregano; 40 g Mozzarella cheese; 20 g ham	Mix the dough, evenly distribute the topping and bake.

The meals were tested following traditional processing and accustomed consumption; the recipes and methods of preparation are presented in Table 3. The reference solution and test meals were consumed by the 12 subjects and capillary blood glucose was obtained through finger prick using a glucometer (Accu-Check Go®, Roche Diagnostics Limited, Beirut, Lebanon) at fasting and at 15, 30, 45, 60, 75, 90, 105 and 120 min after ingestion. The GI of each meal was calculated as the incremental blood glucose area of the test meal divided by the incremental area of the glucose solution multiplied by 100 (Wolever *et al*., 1991). The GL was calculated using GI multiplied by the available carbohydrate per the serving commonly adopted for each tested meal.

The experimental work was conducted at the Notre Dame University Facilities between November 2008 and April 2009. Blood tests were conducted in the Health Center and the meals analysis and cooking were conducted in the Nutrition Lab. and kitchen.

RESULTS AND DISCUSSION

The GI, serving sizes and GL of the tested meals were presented in Table 4. The GI classification of BB (GI = 50.09±8.72; GL = 38.35±6.68) is in accordance with that of plain bulgur (Jenkins *et al*., 1986). Several factors may have contributed to its low GI, although it is a wheat product. Gelatinization is more likely to occur because the endosperm coating of the bulgur is left intact during processing. Gelatinized starch acts as a physical barrier in the digestion process, thus reducing the glycemic index (Jenkins *et al*., 1988). The high fiber content, phytate content, as well as high amylose to amylopectin ratio in bulgur may have also contributed to this low GI (Mehio *et al*., 1997). Additional hypoglycaemic physical properties of bulgur particles are their large size and rough grinding as compared to other wheat products (Heaton *et al*., 1988).

Chickpea is the major contributor of carbohydrate in FH (GI = 37.21±3.73; GL = 18.781±1.88). Thorne *et al*. (1983) reported that legumes, including chickpeas, comprise a food group of low starch digestibility, thus producing relatively small blood glucose rises after consumption by both normal and diabetic people. Mehio *et al*. (1997) studied the GI of chickpea salad dip and reported a flattening in blood glucose levels 2 h from consumption. The discrepancy between the GI of the two meals, FH and chickpea salad dip (GI = 5.90), is possibly due to the white bread ingredient in FH. Sometimes used as a reference test meal, white bread elicits a glycemic response almost similar to that of glucose solution. The use of whole yogurt as an ingredient in FH increases the fat content of the meal. Fat reduces the glycemic index by delaying gastric emptying (Gentilcore *et al*., 2005). Thus, a higher glycemic index is expected if skimmed yogurt is used instead.

Similar in its low digestibility to chickpeas, LB (GI = 12.76±4.90; GL = 2.15±0.83) had the lowest GI among the studied meals. French beans are the major source of carbohydrate and are high in dietary fiber (Khanum *et al*., 2000). The higher the fiber content in a meal, the lower is its glycemic index, due to the role of fiber in reducing glucose absorption and slowing the rate of enzymatic contact with starch (Würsch and Pi-Sunyer, 1997). Addition of crystalline cellulose increased the viscosity of the chyme and reduced glucose absorption (Takahashi *et al*., 2005).

Short grain rice is the main source of carbohydrate in MM (GI = 67.93±7.89; GL = 56.24±6.53). The GI of short grain rice varies between 43 (Le Floch *et al*., 1992) and 112

Table 4: Glycemic index (GI) and load (GL) of the test meals based on serving sizes commonly adopted in Lebanon

Meal	GI (Mean±SEM)	Serving size (g)	Available CHO (g)	GL (Mean±SEM)
BB	50.09±8.72	420	76.57	38.35±6.68
FH	37.21±3.73	225	50.47	18.781±1.88
LB	12.76±4.90	240	16.87	2.15±0.83
ME	49.50±7.69	390	89.08	44.09±6.85
MM	67.93±7.89	525	82.79	56.24±6.53
PI	56.04±6.71	96	21.59	12.10±1.45
RD	57.34±6.67	600	57.60	33.03±3.84
RH	56.83±7.35	165	35.56	20.21±2.61
SF	48.59±4.94	70	42.60	20.70±2.11
SI	14.62±3.24	430	66.65	9.74±2.16

LB: Loubieh Bzet; SI: Siyadieh; FH: Fattit Hommos; BB: Bourgoul A Banadoura; RD: Riz A Dgeg; RH: Riz bi Halib; SF: Sfouf; PI: Pizza; ME: Meghleh; MM: Mehshe Malfouf; Available CHO: Available carbohydrates per serving size; SEM: Standard error of the mean

(Ayuo and Ettyang, 1996), according to different brands and processing procedures (Ito *et al*., 2005; Matsuo *et al*., 1999). The GI of MM is close to that reported for short grain rice (Ito *et al*., 2005). It was expected to have a lower GI considering the cabbage component of the meal. It was also postulated that the addition of lemon juice to MM would reduce its GI due to the alteration of the gastrointestinal medium pH, necessary for optimal functioning of enzymes (Bjorck *et al*., 2000). However, the available carbohydrates in rice have been reported to be highly variable due to intrinsic botanical variations (Foster-Powell *et al*., 2002).

Sfouf (GI = 48.59±4.94; GL = 20.70±2.11) is a Lebanese dessert prepared with saffron. Wheat flour and table sugar constitute the main sources of carbohydrate in SF. Few spices were tested for their effects on GI. Hlebowicz *et al.* (2007) reported that an intake of 6 g of cinnamon with rice pudding reduces postprandial glucose, possibly through reducing the rate of gastric empting. Results from the supplementation of meals with curry leaves powder, in non-insulin dependent patients, indicated a transient decrease in postprandial glycemia after 15 days of experimentation (Mani and Iyer, 1990). Cooked nutmeg and mustard paste reduced GI among subjects although, no statistical significance was found (Masayo *et al*., 2005). The effect of saffron on postprandial glycemia has not been previously studied. Saffron in SF does not seem to have any effect on GI.

Basmati rice constituted the major carbohydrate source in SI (GI = 14.62±3.24; GL = 9.74±2.16). The low GI for SI may be due to several factors. For basmati rice, studies showed variations in its GI, but all categorized it as a medium GI food (Aston *et al*., 2008). Fat was added to bake the fish and fry the mixed nuts and onions. The resulting fat and water mixture, resulting from fish baking, was used to cook the rice. Fat is likely to have contributed to the low GI, due to its role in delaying gastric emptying (Gannon *et al*., 1993). Although, almond is only added as a garnish in SI, it may play a hypoglycemic role as it was identified to reduce postprandial glycemia in a dose-dependent manner (Josse *et al*., 2007). Protein content in meals negatively correlates with GI (Nuttall *et al*., 1985). In SI, fish fillet is the major source of proteins, contributing to decreased postprandial glycemia.

Riz Bi Halib (GI = 56.83±7.35; GL = 20.21±2.61) and Meghle (GI = 49.50±7.69; GL = 44.09±6.85) are Lebanese dessert with rice and sugar as the main sources of carbohydrate. Sydney University's Glycemic Index Research Service reported that rice pudding has a GI of 59. Both Western and oriental versions of rice pudding had very close GI. The RH and ME are served as cold deserts. The cooling process results in gelatinization and the formation of resistance starch type II. Resistant starch is indigestible and its formation in RH causes a medium GI (Liljeberg and Bjorck, 2005). It is expected that the GI would be higher if RH and ME are served hot, due to high simple sugar content and low gelatinized starch, fat and fiber content. The constituents of these two deserts were expected to induce some differences; RH is made of whole rice with milk while ME with ground rice and caraway, anise and ginger spices (Table 3).

Although, not of Lebanese origin, PI (GI = 56.04±6.71; GL = 12.10±1.45) has become one of the most popular meals in Lebanon. Wheat flour in the dough is the main source of carbohydrate in PI. The GI of pizza, in this study, is very close to that reported by Wolever *et al.* (1994). The result as medium GI meal was expected, due to the contribution of high fat content in ham, medium fat content in mozzarella cheese and added vegetable oil in the dough. These factors delay gastric emptying thus, reducing postprandial glycemia, compared to plain dough. The effect of fiber in the tomato sauce is also hypoglycemic.

Riz A Dgeg (GI = 57.34±6.67; GL = 33.03±3.84), prepared according to the oriental way (Table 3), resulted in a GI close to that of convenience meals of Tandoori chicken and rice and similar GI for Chicken Korma and rice meal (Henry *et al*., 2007). Long grain rice comprised

the major source of carbohydrate in RD and is reported to have among the highest GI of different rice types (Ito *et al*., 2005; Aston *et al*., 2008, Wolever *et al*., 2003). The decrease in GI from high to medium is expected, due to the increase of protein content in the meal as boiled chicken. Protein content and GI negatively correlate in a mixed meal (Nuttall *et al*., 1985). Mixed nuts may have contributed to the same hypoglycemic effect, as in the case of SI.

CONCLUSION

The glycemic indexes of ten Lebanese mixed meals were analyzed, as part of developing a glycemic index database for popular Lebanese meals. Based on the standard classification of meals for the GI (Brand-Miller *et al*., 2003b), the study shows that FH, BB, LB, ME, SF and SI are low GI meals. The GI of PI, RD, RH and MM is intermediate. This study, is part of a series of studies aiming at developing a glycemic index database for Lebanese mixed meals. The Results serve as valuable data for health professionals, including dieticians, in the prevention and treatment of diseases.

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