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The Use of the Glycemic Index and Lipimic Response to Modify and Improve the Health Value of Fast Meals.

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ABSTRACT

This study aims to modify some fast meals purchased in the Egyptian market to make them be of higher nutritional value and less hazardous to health. The meals are two of plant origin namely koshary and Tamia and two of animal origin namely pizza and Hawawshi. Assessment of the health value was made by following the Glycemic index (GI), Glycemic load (GL) and lipimic response (LR). In addition a feeding experiment was done to evaluate the health impact of two of these modified meals on alloxan diabetic rats. Results showed that modification of these meals brought about reduction of the GI, GL and LR. Feeding experiment showed that rats fed on the modified koshary and pizza have lower values of the lipid parameters as compared to control diabetic rats. In conclusion, GI, GL and LR of 4 fast meals are given. The modification of meals was effective as proved by the feeding experiment which showed that animals fed on the modified meals have better blood glucose tolerance and lipid profile.
Keywords: glycemic index; lipimic response; fast meals; Diabetes; rats.

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INTRODUCTION

Fast food is preferred by a lot of people either old or young. This is because it has several advantages, although may be false, however attractive. It's delicious, filling, affordable, and readily available just any time of the day, being only a drive through phone call away. The most serious disadvantage of fast food is that it is usually nutritionally unbalanced and, therefore, unhealthy in the long run,if consumed on a regular basis. It is also very high in sodium, coming from common salt and other additives. On top of all this, fast food is high in fat but deficient in dietary fiber and essential micro-nutrients like vitamins and minerals. Recent scientific studies have shown that high-calorie foods rich in fats, refined sugar and salt could reconfigure the hormones in the body in such a way that they make you crave for such foods and always leave you asking for more. That may result in obesity and the associated health complications [1].

Bringing about changes in this eating habit is not easy. Nutrition education and health claims in different mass media brought about limited success in this respect. The alternate to this or complementary to it, is to modify this fast food on scientific based roots to turn them healthy, thus may be consumed without any adverse effect on health. Jenkins et al. [2] and Carrie et al. [3] proposed the glycemic index as a system for classifying carbohydrate containing foods according to glycemic response. The classification of food according to the glycemic index has been used as a tool to assess the potential prevention and treatment strategies for diseases, where glycemic control is of importance such as in case of diabetes. Low glycemic index diets have also been reported to improve serum lipid profile, reduce C-reactive protein concentration and aid in weight control [4].

Postprandial hyperglycemia has been recognized as an important risk factor for cardiovascular diseases, not only among persons with diabetes, but also among general population [5, 6]. Postprandial hyperglycemia appears to increase cardiovascular diseases risk by producing oxidative stress [6-8]. In vitro studies have shown that glucose causes oxidation of membrane lipids, proteins, lipoproteins and DNA and activate inflammation [7]. Due to strong interrelation between carbohydrate and lipid metabolism, lipimic response is also equally important in ranking the food items or meals with regard to its effect on lipid homeostasis.

The aim of the present study is to determine the glycemic index and lipimic response of a number of fast food meals common in the Egyptian market and frequently consumed by the population. A trial was made to use the glycemic index as a parameter to assess the improvement of the health value of these meals by modification of the quantity or type of food ingredient used for their preparation.

MATERIALS AND METHODS

The plant based meals (koshary and tamia), and the animal based ones (pizza and Hawawshi) were purchased from the local market.Koshary is a popular meal formed of rice, lentils, chickpea, pasta, fried onion and ketchup. Tamia is formed of beans and a mixture of vegetables mixed together, ground then made in the form of small cakes and fried in oil. Hawawshi is formed of bread filled with hacked meat mixed with some vegetables and spices. This is heated in an oven till the meat is ripened.Pizza is formed of Desk; Souses; Tomato slices; Black olive; Ketchup; Green peper; Motzarila cheese; Mushroom; tomato souse.

- Sprague Dawley albino rats, (2 Month age), weighting between 120-150g were obtained from the animal house, National Research Center, Cairo, Egypt.
- Kits used for the estimation of Glucose, triacylglycerols, total cholesterol, total lipids; LDL-C and HDL-C were purchased From El Amana company – Giza (Egypt). All kits were produced by the Bio-diagnostic Company.
- Serum glucose was determined as described by Trinder [9]. Total cholesterol according to Richmond [10]. LDL-C as described by Wieland and Sieidel [11]. HDL-C was determined according to Burstein *et al*. [12]. Total lipids as described by Zollner and Kirsch [13]. Triacylglycerol was determined as described by Fassati and Prencipe [14].

Nutrient Composition

The nutrient content of each meal was analyzed before and after modification using the standard AOAC [15]. These nutrients were moisture, Protein, fat, ash, and crude fiber.

Glycemic Index

The glycemic index of the meals was calculated according to the method described by Jenkins *et al*. [2].

$$GI = \frac{\text{Area under the curve for meal}}{\text{Area under the curve for glucose}} X100$$

Glycemic Load

The glycemic Load of the meals were calculated according to the method described by Willett *et al*. [16].

GL = GI / 100 × Net carbohydrates.

(Net carbohydrates are equal to the total carbohydrates minus dietary fiber).

Lipimic response

The triacylglycerols tolerance of the tested meals was expressed by measuring the rise in plasma triacylglycerols of rats at fasting, 2, 4 and 6 hours after meal consumption. The highest value of plasma triacylglycerols attained after food consumption was reached after 4 hours. The Lipimic response of the meal was calculated by dividing the difference between the 4 hours triacylglycerol value and the fasting divided by the fasting level. Sunflower oil was taken as a standard. The fat intake of each test meal was fixed at 1 g/kg body weight [17].

Modificaion of meals

Meals of Tamia, Koshary, Hawawshi and pizza were modified by changing the types and quantities of the ingredients used for their preparation. The glycemic index, glycemic load and lipimic response of these meals were estimated before and after modification.

Biological evaluation

Koshary and pizza were subjected to biological evaluation on experimental diabetic animals.The rats were treated with alloxan to induce diabetes by intravenous injection of 5% solution of 70 mg alloxan /kg body weight in the tail vein under ether anesthesia [18]. Fasting blood samples were collected from the orbital vein using heparinized capillary tubes before and after 72 hours of alloxan injection. This was done in order to determine the concentrations of glucose in plasma. Rats resistant to alloxan were excluded.

Rats were then classified according to their weight and blood glucose levels to 6 groups (each of 6) as follows:

Control group 1, normal rats (n=6) were fed on basal diet prepared according to Reeves *et al*. [19].
Control group 2, diabetic rats (n=6) were fed on basal diet.
Group 3: Diabetic rats fed on koshary before modification.
Group 4: Diabetic rats fed on Koshary after modification.
Group 5: Diabetic rats fed on pizza before modification.
Group 6: Diabetic rats fed on pizza after modification.

The feeding experiment lasted for 4 weeks. At the end of this period, the animals were fasted for 16 hours. Rats were then given the tested diets to determine the GI as mentioned before.The second day, rats were fasted overnight, and then sacrificed under slight ether anesthesia. Blood samples were collected into heparinized centrifuge tubes. Plasma was separated by centrifugation at 3000 r.p.m for 15 minutes. Plasma samples were frozen at – 20°C until the determination of biochemical parameters. Animal procedures were performed in accordance with the Ethics Committee of the National Research Centre, Cairo, Egypt.

RESULTS

Composition of Meals

The composition of the meals before and after modification is shown in table (1,2, 3, 4).Meals were modified by either changing the quantities of the different ingredients or by adding new ingredients. The modified Koshary contain more lentil, the quantity was more than doubled (102 g in the modified relative to 42 g). Chickpea was also about 4 times (43g /Kg relative to 11g/Kg). The other constituents were also relatively changed.The modified tamia contains chickpea, a new ingredient added. The amount of salad served with the meal was increased for nearly double (308 g relative to 175 g/kg). Bread was slightly reduced. Hawawshi meal was modified by adding new ingredients such as soybean 112 g/kg, garlic 17.0 g/kg andBroccoli 56.0 g/kg.The amount of the other ingredients used was slightly changed.Pizza was modified by replacing Mozzarella cheese with Mackerel fish and exclusion of Mushroom and addition of carrot.

Glycemic index and Load

The values of the glycemic index and load of the modified meals are given in table (6). As shown in the table, modification of meals caused a reduction in the values obtained for both the GI and GL. The GI of koshary changed from 72.8 to 22.96, that of Tamia from 35.3 to 18.5, for pizza from 70.3 to 25.01 and for hawawshi from 56.13 to 32.45. The GL for koshary dropped from 16.5 to 5.36, for Tamia from 7.7 to 2.4, for Pizza from 15.68 to 6.2 and for hawawshi from 11.64 to 8.26.

Lipimic response

The triacylglycerols tolerance of the tested meals was expressed by measuring the rise in plasma triacylglycerols of rats at fasting, 2, 4 and 6 hours after meal consumption. The highest value of plasma triacylglycerols attained after food consumption was reached after 4 hours. The values obtained are shown in table (7). Sunflower oil was taken as a standard. The value obtained for Koshary meal was (22.65) and that for tamia meal (38.96). The value for pizza meal was (44.75) and for hawawshi meal (19.09).

Feeding experiment

A feeding experiment was done on rats lasted for 4 weeks. The included groups were a normal control group and 5 alloxan induced diabetic groups. The control and diabetic control groups were fed on the standard diet.Group 3 was fed on koshary and Group 4 was fed on modified koshary, Group 5 was fed on pizza and group 6was fed on modified pizza. The food intake, feed efficiency ratio and body weight of rats included in all groups are shown in table (8). The gain in body weight was maximum in case of normal control rats (137.61±2.87g). The gain in body weight of control diabetic rats was 118.39± 8.58g. The gain in body weight of rats fed on koshary (108.4± 2.38g) was not much different from that of rats fed on modified koshary (106.57±7.9g). The same observation was noticed for pizza, the values were 105.4±2.42g before and 103.93±1.02g after modification. The food intake of rats varied, diabetic control rats consumed more food than normal control. Rats fed on modified koshary or pizza consumed less food than their partners fed on these 2 items before modification. In spite of this low food consumption, the feed efficiency ratio of the modified meals either koshary or pizza were higher. In case of koshary, the value was 0.5±0.04 and reached to 0.55±0.04 after modification. For pizza, it was 0.49+0.01 and became 0.57±0.02.

The glucose tolerance was testedfor rats after the end of the feeding period, and compared with that before feeding.The results obtained are tabulated in table (9). The glucose tolerance in this case was restricted to 2 values, fasting blood glucoseand after 2 hours from dosing.

As shown in the table the fasting blood glucose level of diabetic rats was higher (92.09 ± 5.23 mg/dl) than that of normal control (68.24 ± 2.76 mg/dl). After feeding, the value obtained was lower (78.06 ± 3.17 mg/dl) and changed to (92.35 ± 2.1 mg/dl) after 2 hours from dosing.

As mentioned, the diabetic control rats had a relatively higher fasting blood glucose level and also higher values after 2hours from dosing. These same values after the feeding period was not much different (see table 9).

The results show that the rise in blood sugar after dosing in case of rats fed on the modified koshary is higher(182.82 ± 6.65 mg/dl) than before modification, (173.43 ± 6.77 mg/dl). In case of pizza the values were lower in modified pizza (175.66 ±6.31 mg/dl) than before modification (184.5 ±6.31mg/dl). When this parameter wasanalyzed after the feeding period, the values obtained for the blood glucose level 2 hours after dosing were always lower than corresponding values obtained before the feeding period. This was for both modified and non-modified meals (see table 9).

The plasma lipid parameters of rats included in the different groups either the control or diabetic fed on the studied meals before and after modification are shown in table (10).

As shown in the table, alloxan injection caused a marked increase in the values obtained for the lipid parameters. The values obtained were 422.86±3.77, 127.51±2.72, and 113.0±2.83and 52.24±2.59mg/dl for total lipid, triacylglycerols, total cholesterol and low density lipoprotein cholesterol. Corresponding values for normal control in the same sequence were 355.0±5.6, 103.73±1.34, 82.77±7.99 and 19.45±2.87mg/dl. The high density lipoprotein-cholesterol was decreased in diabetic rats.

It can be noticed that rats fed on the modified koshary and pizza have lowervalues of the lipid parameters as compared to control diabetic rats. However these values are still higher than that of normal controls. The plasma total lipids of diabetic rats fed on koshary were 433.75±4.19 and decreased to 407.5±3.41 mg/dl after feeding with modified koshary. Triacylglycerols were 122.16±1.98 and changed to 115.5±2.83, total-cholesterol was 106.28±2.93 and changed to 102.02±2.43; low density lipoprotein-cholesterol dropped from 45.57±2.57 to 40.71±2.55 mg/dl. The high density lipoprotein-cholesterol was slightly increased. In case of rats fed on pizza, the values obtained for plasma total lipids, triacylglycerols, total cholesterol and low density lipoprotein-cholesterol were 421.25±2.79, 121.83±3.15, 101.68±2.43 and 40.21±1.99 mg/dl, respectively. Corresponding values for rats fed on pizza after modification was400.63±3.05, 112.77±2.34, 92.94±1.44 and 32.46±1.63 mg/dl.

The ratio of total cholesterol/ high density lipoprotein-cholesterol was increased in diabetic rats then decreased when rats were fed on the studied meals and were further decreased when these meals were modified.

Table 1: Composition of koshary meal before and after modification

Ingredients	Koshary(g)	Modified koshary(g)
Pasta	463	369
Rice	136	111
Lentil	42	102
Onion	21	41
Chick pea	11	43
Tomato souse	272	258
Souse (garlic- vinegar)	55	76
Total weight	1000	1000

Table 2: Composition of Tamia meal before and after modification

Ingredients	Tamia (g)	Modified tamia (g)
Bread	298	230
Salad (tomato- carrot)	175	308
Broad bean	527	154
Chickpea	-	308
Total weight	1000	1000

Table 3: Composition of Pizza meal before and after modification

Ingredients	Pizza(g)	Modified pizza(g)
Desk	457	437
Souses	110	-
Tomato slices	77	131
Black olive	22	32
Ketchup	44	-
Green peper	44	64
Motzarila cheese	132	-
Mushroom	68	-
tomato souse	46	45
Carrot	-	120
Onion	-	64
Mackerel fish	-	107
Total weight	1000	1000

Table 4: Composition of Hawawshi meal before and after modification

Ingredients	Hawawshi(g)	Modified Hawawshi(g)
Bread (balady)	434	354
Meat	461	281
Onion	79	112
Greenpepper	26	68
Soy bean	-	112
Garlic	-	17
Broccoli	-	56
Total weight	1000	1000

Table 5: Nutrient composition of meals before and after modification (g/100g dry sample)

	Protein	Fat	Ash	Fiber	Carbohydrate
Koshary	15.3	9.8	4.2	10.0	60.7
Modified koshary	23.2	9.7	3.2	11.9	52.6
Tamia with bread and salad	18.0	20.1	4.8	12.3	44.6
Modified Tamia with bread and salad	22.2	12.8	2.00	34.3	28.7
Pizza	32.6	17.1	4.0	5.1	41.1
Modified Pizza	18.1	2.8	0.3	8.6	70.2
Hawawshi	28.2	25.2	2.9	5.5	38.0
Modified Hawawshi	30.7	18.2	3.8	3.2	44.1

Table 6: Comparison of Glycemic Index and Glycemic load of meals before and after Modification.

Meals	GI		GL	
	Before	After	Before	After
Koshary	72.80	22.96	16.50	5.36
Tamia	35.30	18.50	7.70	2.40
Pizza	70.30	25.01	15.68	6.20
Hawawshi	56.45	32.45	11.64	8.26

Table 7: Triacylglycerols tolerance of tested plant based meals (mg/100 ml)

Meal Groups	Fasting	2 hours	4 hours	6 hours	%of change
Sunflower	150.07±3.31	174.68±7.91	191.64±11.62	160.65±6.37	27.70
Koshary	105.46±2.26[d]	121.16±3.02[d]	129.35±4.28[d]	101.71±2.48[d]	22.65
Tamia	98.98±5.08[d]	119.79±3.58[d]	137.54±5.90[d]	103.75±2.54[d]	38.96
Hawawshi	119.79±1.51[d]	128.67±2.8[d]	142.66±3.25[d]	114.67±4.31[d]	19.09
Pizza	106.62±2.21[d]	137.75±5.5[c]	154.33±3.97[b]	116.45±6.75[d]	44.75

Table 8: Food intake; feed efficiency ratio and body weight of rats fed on experimental meals for 4 week.

Groups	Initial Body Weight(g)	Final Body Weight (g)	Body Weight Gain (g)	Total food Intake (g)	Feed Efficiency Ratio
Normal–control	178.60±5.93	316.21±6.54	137.61±2.87	345.6±7.86	0.38±0.14
Diabetic-control	183.62±11.04	302.01±7.97	118.39±8.58	379.73±11.19[a]	0.31±0.02
Koshary	185.15±5.67	293.55±5.37	108.40± 2.38[a]	215.64±4.67[d]	0.50±0.04[d]
Modified Koshary	170.33±6.92	276.90±5.90[a]	106.57±7.90	195.49±3.17[d]	0.55±0.04
Pizza	175.40±5.60	280.79±4.65[a]	105.40±2.42	216.72±4.10[d]	0.49±0.01[d]
Modified Pizza	172.27±2.91	276.20±2.95[b]	103.90±1.02	184.39±4.65[d]	0.57±0.02[d]

Table 9: Plasma Glucose (mg/dl) of rats before and after feeding (4weeks) with modified meals.

Groups	At the beginning of the experiment		At the end of the experiment	
	Fasting	2 hrs	Fasting	2 hrs
Normal –control	68.24±2.76[d]	78.24±1.59[d]	78.06±3.17[d]	92.35±2.10[d]
Diabetic-control	92.09±5.23	157.89±5.75	127.94±4.72	151.03±3.52
Koshary	96.28±5.90	173.43±6.77	119.18±4.38	148.43±5.18
Modified Koshary	92.83±4.38	182.82±6.65[b]	117.83±3.17	143.5±3.10
Pizza	98.10±4.76	184.51±6.72[b]	120.67±4.99	147.69±4.01
Modified Pizza	87.63±3.44	175.66±6.31[a]	112.76±3.44[a]	133.30±5.25[b]

Table 10: Plasma Lipid profile ofthe studied groups fed on meals before and after modification (mean ± S.E.)

Groups	Total Lipid (mg/dl)	Triacylglycerol (mg/dl)	Cholesterol (mg/dl)	HDL-C (mg/ dl)	LDL –C (mg/dl)	T. Chol / HDL
Normal-control	355.0±5.6[d]	103.7± 1.3[c]	82.8±7.9[d]	42.6±1.2[d]	19.5±2.9[d]	1.9±0.1[d]
Diabitic-control	422.8±3.8	127.5±2.7	113.0±2.8	35.3±0.7	52.2± 2.6	3.2± 0.1
Koshary	433.8±4.2	122.2±1.9	106.3±2.9	36.3±0.5	45.6± 2.6	2.9±0.1[a]
Modified Koshary	407.5±3.4[b]	115.5±2.8[a]	102.0±2.4[c]	38.2±0.8[b]	40.7±2.6[c]	2.7±0.1[d]
Pizza	421.3±2.8	121.8±3.2[b]	101.7±2.4	37.1±0.9	40.2±1.9[d]	2.7±0.1[d]
Modified Pizza	400.6±3.1[d]	112.8±2.3 [d]	92.9±1.4 [d]	37.9±0.6[b]	32.5±1.6[d]	2.5±0.1[d]

DISCUSSION

This is a trial to modify the diet by changing the composition so as to reduce health hazards using glycemic index as well as the lipimic response as indicators for assessment. Two fast meals one from plant (koshary) and the other (pizza) from animal origin were analyzed and nutritionally evaluated through determination of their glycemic index and lipimic response. Based on this analysis they were modified by changing the composition simultaneously with evaluation through measurement of the glycemic index. Furthermore, their impact upon health was evaluated through a feeding experiment on animals.

As shown in (table 4) the main ingredients composing the plant based meal are rice and lentils and in pizza meal, these are meat, chicken or motzorila cheese. The other ingredients include wheat, tomato or

souse, onion, green pepper, mushroom. It is clear that the protein and fat content of pizza meal (table 5) are relatively higher than that of the plant based meal koshary.
Koshary meal was modified by reducing the amount of rice and increasing the amount of lentils (table1). Rice was reduced from 136 to 111 g while lentils were increased from 42 to 102g. Chickpea was also increased from 11- 43g

Lentils (***Lens Culinaris***) is known for its nutritional quality. It is a rich source of protein, dietary fiber, vitamins, and minerals [20]. The fat content of lentils does not exceed 10 g/ kg. Such an amount of fat is remarkably low and does not cause any health complication on consumers.Pulses in general were reported to lower glycemic index for people with diabetes [21]; in cancer prevention [22] and in protection against cardiovascular diseases due to its dietary fiber content [23]. As a result of these modifications, the protein content of koshari increased from 15.3 to 23.2g%, and the carbohydrates was reduced from 60.7 to 52.6g%.

Remarkable changes occurred in the values obtained after measurement of the glycemic index and glycemic load of the modified meals. GI of koshary changed from 72.8 ranked as high category to 22.96 ranked as low category and the glycemic load from 16.5 to 5.4.Tamia was prepared from bean and chickpea instead of beans alone in the ratio of 1: 2. The amount of other ingredients combined with tamia meal was changed. Bread was decreased from 231 to 198g, salad was increased from 175 to 308g; the amount of tamia itself was reduced from 527 to 461g. Considerable changes in chemical composition occurred. The protein content increased from 18 - 22.2g%, fat content was markedly decreased from 20.1- 12.8g%, fiber was increased from 12.0 - 34.3g% and carbohydrates was reduced from 44.6 - 28.7g%. As shown, these modifications succeeded to reduce the carbohydrate content of these 2 meals in turn decrease the glycemic load and minimize the rise in glucose concentration in blood. As a result of these modifications the GI of koshary changed from 72.8 to 22.96 and the glycemic load from 16.5 to 5.4. In case of tamia the GI changed from 35.3 to 18.5 and GL from 7.7 to 2.4. It is clear that the modification could achieve its goal by lowering both the GI and GL of the meals.

It has been reported by Chung and Taylor [24] that compared with a low-GI meal, a high-GI meal is characterized with hyperglycemia during the early postprandial stage (0–2 h) and a compensatory hyperlipidemia associated with counter-regulatory hormone responses during late postprandial stage (4–6 h). It is thus expected that the modified meals can participate in protection of consumers from hyperglycemia and or hyperlipedemia and their consequences.

It was found that, elevated intracellular glucose level induces tricarboxylic acid cycle electron donor overproduction and mitochondrial proton gradient increase, leading to an increase in electron transporter lifetime. Subsequently, the electrons leaked combine with respiratory oxygen (O_2) resulting in superoxide anion ($^{\bullet}O_2^-$) production. Advanced glycation end products derive ROS via interaction with their receptors. Elevated diacylglycerol and ROS activate the protein kinase C pathway which, in turn, activates NADPH oxidases. A vicious circle of pathway derived ROS installs. Pathologic pathways induced ROS are activated and persistent though glycemia returns to normal due to hyperglycemiamemory [25]. The modification done in these meals that reduced their glycemic index is expected to avoid the occurrence of this metabolic sequence thus save the consumers from such health hazards.

Animal based meals were also modified. In case of hawawshi, soybean was added (112g/kg) on the expense of meat, besides; broccoli was added (56g/kg) to the meal. This modification caused a slight increase in protein content of hawawshi from 28.2to30.7g % and a drop in fat content from 25.2 to 18.2g%. There was a moderate increase in carbohydrate content. In case of pizza, mackerel fish was added (107g/kg) and souses was removed from the meal. As a result of this modification the protein content of pizza dropped from 32.6g% to 18.1g%, (table5). The fat content also dropped from 17.1 to 2.8g%, while the carbohydrate was increased from 41.1 to 70.2g%. Although the increased amount of carbohydrates in the modified meal is against the concept to decrease the glycemic index and load of either hawawshi or pizza meal, yet the change of the ingredients agree quite well with health aspects. Soybean was selected due to their functional properties [26] as well as biological and health benefits [27]. Mackerel fish has been reported to posses several health benefits such as lowering triacylglycerols, reducing the risk of heart disease, help with blood circulation and lower blood pressure, reduce risk of depression, suicide, schizophrenia and Alzheimer's disease and strengthen the immune system [28].

In spite of the relative increase of the carbohydrate content of the modified meals, yet the determined glycemic index and the calculated glycemic load of both meals were markedly decreased relative to the case before modification. As shown in table (6), the GI of pizza dropped from 70.30 to 25.01 and that of hawawshi from 56.45 to 32.45, the GL changed from 15.68 to 6.20 in case of pizza and from 11.64 to 8.26 in case of hawawshi. This means that a true change occurred in the modified meals, they are no more causing the same elevation of blood sugar as they did before modification. This is of benefits to those who suffer from diabetes. Most studies have reported an increased risk of chronic diseases in people who followed a high GI/GL diet [29, 30]. The findings of those authors are supportive to our conclusion that the modification of these 2 mealswith low glycemic index (GI) could specifically reduce some of the health risks caused by these types of food before modification particularly for diabetics.

Animal experiment was done to assess the effect of modification of the 2 meals namely koshary and pizza on glucose level and lipid pattern. Animals were rendered diabetic by injection with alloxan. The choice of diabetic rats as models in this study was based upon the fact that the main target of meal modification is to minimize the rise of blood sugar concentration following consumption of the meal which protect against exhaustion of the pancreas, in addition to avoid disturbance of lipid pattern.
In a study to examine whether high (GI) and (GL) diets are associated with increased risk of developing coronary heart disease in Whites and African Americans with and without type 2 diabetes; Dale *et al*. [31] concluded that reduction of the GI and GL in diets of African Americans and Whites subjects (without diabetes) may play a role in reducing CHD risk,. In another cross-over pilot study [32], it was found that participants who received low glycemic index meals demonstrated significantly lower mean daytime blood glucose and a trend toward lower variability, suggesting a clinically relevant impact of reducing glycemic index.

As shown in table (8) the food intake of diabetic rats (379.73±11.19g), was more than that for non-diabetic ones (345.6±7.86g). This was reflected on both the gain in body weight and the feed efficiency ratio for animals fed on the standard laboratory diet. Diabetic rats fed on koshary consumed relatively less amount of food (215.64±4.67g), gained less weight 108.4±2.38, however showed higher feed efficiency ratio (0.5± 0.04). Those who were fed on the modified koshary also consumed less amount (195.49±3.17g), gained less body weight (106.57±7.9g) but still of higher feed efficiency ratio (0.55±0.04). More or less the same observations were noted in case of pizza. This shows that in spite of the reduced food intake by diabetic rats yet the feed efficiency ratio is relatively high indicating that these meals are more efficient to promote growth. This observation applies for the meals either before or after modification.

As shown in table (9), the blood sugar of diabetic rats before the start of the feeding experiment, measured 2 hours after meal was significantly higher (157.89± 5.75mg/100ml) than that of control rats (78.24±1.59). Rats fed on koshary meal showed relatively high values similar to that of control diabetic rats.When these measurements were done after feeding, significantly lower values were obtained particularly in case of non-diabetic rats. Modification of koshary caused a change of glycemic index from 72.6 to 22.96 after modification and for pizza from 70.3 - 25.01.

This is believed to be due to the improvement of the health state of the animals due to consumption of the modified meal. The insufficiency of insulin secretion in diabetic rats is the limiting factor behind the limited effect of dietary modification on glucose tolerance under such condition. Perhaps this observation is the first to be reported in the literature since it was not possible to trace any similar one in the available reviews. It is believed that consumption of these modified meals with low GI by patients suffering from type 2 diabetes who do not suffer from insulin insufficiency but resistance can help to improve the condition and participate in reducing blood sugar level. This goes in parallel with the findings from the study by Lauren *et al*. [32] suggesting that reducing dietary GI may be an important component of lifestyle interventions for prevention or management of Glucose tolerance andtype 2 diabetes. They added that their findings are of particular importance given that children who develop disorders of glucose metabolism are likely to be a particularly high-risk group. Thus the ability to demonstrate substantial differences in blood glucose with a dietary change lasting a single day suggests that a low GI diet is a promising approach for achieving improved health outcomes.

The lipid profile of rats fed on the modified meals either koshary or pizza showed considerable improvement. Plasma total lipid, triacylglycerols, total cholesterol and LDL-cholesterol were markedly reduced. Such finding agree with that of Arturo *et al*. [33], who found that a low GI diet with more than 23g fiber per day, containing Mexican style foods may help to improve dyslipidemia in individuals with type 2 diabetes. In the same time, there was an improvement in the value of HDL- cholesterol as a result of consumption of the modified meals. Studies indicate that GI is related to patho-physiological responses after meals. Compared with a low-GI meal, a high-GI meal is characterized with hyperglycemia during the early postprandial stage (0–2 h) and a compensatory hyperlipidemia associated with counter-regulatory hormone responses during late postprandial stage (4–6 h) [24]. Thus it can be stated that, the modified meals succeeded to minimize hyperglycemia following consumption of the meal and in turn decreasing the counter regulatory hormone action, thus lead to partial correction of hyperlipidemia.

In brief it can be stated that the present study succeeded to give values perhaps for the first time to the glycemic index and load, in addition to the lipimic response to a number of popular meals usually and may be oftenly consumed by Egyptians. The glycemic index was used to modify some of these meals in a trial to reduce the value of their glycemic index and lipimic response. This was to minimize their health hazards and make them safe to the consumers. The modification was effective proved by the feeding experiment which showed that animals fed on the modified meals have better blood glucose tolerance and lipid profile.

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