Postprandial Blood Glucose Response to Spaghetti Meal in Diabetic and Healthy Subjects

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Spaghetti is a form of pasta that is recommended to diabetic subjects in our setting and therefore the study of post prandial response of this food was carried out. Ten (10) type-2 diabetics and five (5) non- diabetics (control) were used for the study. Diabetic and control volunteers took test meal (spaghetti) consisting of 50 g of available carbohydrate portion. This was compared to their response on a separate occasion to the standard reference food (glucose) containing an identical amount of available carbohydrate (50 g). The glycaemic index (GI) was calculated using the method of Jenkins *et al*. (1981). The glycaemic index of spaghetti in type-2 diabetic subjects was 64 while that of control subjects was 60. The calculated GL of this meal equal 32 in diabetic subjects and 30 in control subjects.

Key words: Type 2 diabetes, Glycaemic index, Glycaemic load, Spaghetti.

Type 2 diabetes, is form of diabetes, which accounts for 90–95% of those with diabetes, previously referred to as non-insulin dependent diabetes, type 2 diabetes, or adult-onset diabetes, encompasses individuals who have insulin resistance and usually have relative (rather than absolute) insulin deficiency. At least initially, and often throughout their lifetime, these individuals do not need insulin treatment to survive. In this type of diabetes, the beta cell mass may be reduced (Donath and Halban, 2004; Butler *et al.*, 2003) but more importantly, there is an impaired ability to make and secrete insulin in response to a rise in glucose concentration.

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The composition and physicochemical properties of foods affect satiation and post-prandial metabolic responses. For people with diabetes, the consumption of smaller meals may be beneficial since the consumption of smaller, more frequent meals have associated with improvements in blood glucose management (Jenkins *et al*, 1989).

Many characteristics of pasta products have been studied with respect to the glycaemic response they produce. Such characteristics include the type of flour (durum compared with non-durum wheat) used for making pasta (Brand *et al*., 1990) and the amount and type of fiber (Bourdon *et al*., 1999; Holt *et al*., 1997) and protein (Wolever *et al*., 1986) in the final product.

The bioavailability of starch is affected dramatically through processing, regarding both rate and extent of small-intestinal digestibility. This permits optimizing the digestion of starch by choice of raw materials and processing conditions.

Pasta is an example of a product that has a low GI because of the physical entrapment of ungelatinized starch granules in a sponge-like network of protein (gluten) molecules in the pasta dough. Pasta is unique in this regard. As a result, pastas of any shape and size have a fairly low GI (30-60). If we put pasta (low GI) or bread (high GI) in a glass of water, the bread dissolves much faster with easier access for enzymes and thus faster breakdown of the starch. This was elegantly showed in a study on ten type 2 diabetic patients receiving pasta or bread baked from the same durum wheat, where lower postprandial glucose and insulin levels were found after a pasta meal than after a comparable bread meal (Jarvi *et al*., 1995). Pasta cooked al dente showed lower GI than following prolonged cooking; possibly due to incomplete gelatinization and/or maintained physical structure (Ludwig, 2003a) and simple preparation, such as mashing of potato increase the GI by 25% (Pi-Sunyer, 2002).

Spaghetti is form of pasta that is been recommended to the diabetic subjects in our setting and therefore the study of post prandial response of this food was carried out.

MATERIAL AND METHODS

Ten (10) type-2 diabetics and five (5) non-diabetics (control) were used for the study. The diabetics were those who regularly attend the Diabetic clinic of the Ahmadu Bello University Teaching Hospital Shika, Zaria, Kaduna State, Nigeria. The scientific and ethical committee of Ahmadu Bello University Teaching Hospital, Shika- Zaria, Nigeria approved the procedure and protocol. A written consent was obtained from each subject before the commencement of the study. Instructions were given to type – 2 diabetic and control subjects before commencement of the study and verbal confirmation of adherence to the instructions was obtained from each subject before starting the research. Each volunteer was instructed to have an overnight fast of 8- 10 hours proceeding the time of the study. Diabetic and control volunteers took test meal (spaghetti) consisting of 50 g of available carbohydrate portion of one food as estimated from food tables (Paul and Southgate, 1978). This was compared to their response on a separate occasion to the standard reference food (glucose) containing an identical amount of available carbohydrate (50 g). The glycaemic index (GI) was calculated using the method of Jenkins *et al*. (1981).

The meal and glucose were consumed within 10-15 minutes as instructed. Apart from the diabetes the subjects were in good condition. On the day of study, 2 mls of venous blood samples was withdrawn from each subject at fasting state by venepunture and after 30, 60, 90,120 and 150 mins of consumption of glucose or spaghetti meal. The 30 mins intervals was to allow the calculation of the incremental blood glucose area over the following two half and hours. The blood samples were allowed to clot for 10-15 min, immediately centrifuged at 1500 revolutions per minute and glucose analysis was done using glucose oxidase method (Trinder, 1969).

Glycaemic index and load

Glucose was considered to correspond to a glycaemic index (GI) of 100, and the GI of spaghetti meal in both subjects were calculated based on their incremental blood glucose area expressed relative to the reference incremental blood glucose area of the glucose. The GI for each food was taken as the average of all 10 individuals' values for diabetic subjects and average of all 6 individuals' value for control subjects. The glycaemic load (GL) was calculated using the carbohydrate content of the serving portion of the meal as percentage multiplied by the GI.

Statistical analysis

Data was presented as mean plus or minus standard deviation of the mean. Pair student t test was used to compare the effects of glucose versus spaghetti meal in diabetics, glucose versus spaghetti meal in healthy subjects. Unpaired student t test was used to find the differences between the healthy and diabetic subjects. SPSS 12.0 (SPS Inc, Chicago IL) Software package was used for statistical computations. The significance level was set at $p<0.05$.

RESULTS

The average age for type-2 diabetic subject was 51.40±2.41years while the control groups mean age was 54.14±2.52years and was similar (p>0.05). The body mass index of the diabetics and the control groups were 29.88±2.36 kg/m^2 and 28.47±1.63kg/m^2 respectively it was also similar. The average duration of diabetes mellitus in the type-2 diabetes study group was 3.30±0.39years (Table 1).

All the type-2 diabetics were on one or combinations of hypoglycaemic drugs plus diet except one who was on diet only. Information obtained from the subjects revealed that the major regularly consumed foods before the study were beans, acha, and wheat; other carbohydrate foods are eaten sparingly. The quantity consumed depends on how much they can eat and be satisfied.

The spaghetti meal was significantly lower at 120 and 150 minutes when mean blood glucose responses to glucose and spaghetti meal in the diabetic subjects were compared while it was not significantly lower at any time period in that of control subjects (Table 2). The two hours postprandial blood glucose in diabetics was 17.39±2.12mmol/L after standard food and 13.46±1.87mmol/L after spaghetti meal; it was significantly lower after consumption of spaghetti. In control subjects two hours postprandial blood glucose was 7.81±1.44mmol/L after glucose while it was 5.16±0.38mmol/L when spaghetti was consumed and was similar $p>0.05$.

The spaghetti meal produced significantly lower mean incremental value between glucose and spaghetti meal in diabetic subjects from 60-150 minutes but there was no significant difference in the control subjects ($p>0.05$) (Table 2). The mean incremental value between diabetic and control subjects was significantly higher in diabetic subjects at 60-150 minutes than the control subjects ($p<0.05$) (Table 4.10). The maximum increase in diabetic subjects was 9.36±0.89mmol/L and 6.17±2.08mmol for glucose and spaghetti food respectively and it was significantly higher for glucose than the spaghetti food. In control subjects it was 3.91±0.73mmol/L and 2.80±0.81mmol/L for glucose and spaghetti respectively but it was similar statistically.

Type-2 subjects reached peak serum concentrations of glucose at 90 minutes after reference food consumption but when the test meal was consumed the peaked serum concentration was at 60 minutes. The peak serum concentration in control was reached at 60 minutes after consumption of reference food and 30 minutes after test foods.

The glycaemic index of spaghetti in type-2 diabetic subjects was 64 while that of control subjects was 60. The calculated GL of this meal equal 32 in diabetic subjects and 30 in control subjects.

DISCUSSION

The glycaemic index of medium range was seen in the diabetic and control subjects after the consumption of spaghetti in this study. This is in support of Jarvi *et al*. (1995) work where lower postprandial glucose level was found after pasta meal than after a comparable bread meal. Pasta cooked al dente showed lower GI than following prolonged cooking, possibly due to incomplete gelatinization and/or maintained physical structure (Ludwig, 2003) and simple preparation, such as mashing of potato increased the GI by 25% (Pi-Sunyer, 2002). In this study spaghetti was cooked for 15 minutes which may be responsible for the medium GI response seen in this work but cooking time showed no influence on glycaemic responses in either healthy subjects (Bornet *et al*., 1990) or diabetic patients (Wolever *et al*., 1986) or on insulin responses in healthy subjects (Bornet *et al*., 1990).

Pasta has been shown as an example of a product that has a low GI because of the physical entrapment of ungelatinized starch granules in a sponge like network of protein molecules in the pasta dough. Pasta is said to have a unique property in this regard, as a result, pastas of any

Table 1. Parameters of diabetic and control subjects' fed with spaghetti

	Age(years)*	BMI(Kg/m^2)*	Duration*	Glycaemic* Index	Glycaemic# Load
Diabetic subjects	51.40±2.41	29.88±2.36	3.30±0.39	64.34±7.66	32.0
Control subjects	54.14±2.52	28.47±1.63	N/A	59.48±10.22	30

*Means ± SD. #Calculated rounded up value of the means. N/A= Not Applicable

Table 2. Blood glucose responses and increments to glucose and spaghetti meal in diabetic and healthy subjects

	Diabetic Subjects				Control Subjects			
	Glucose Solution		Spaghetti Meal		Glucose Solution		Spaghetti Meal	
Time (Min)	Blood glucose (mmol/L)	Incremental glucose (mmol/L)	Blood glucose (mmol/L)	Incremental glucose (mmol/L)	Blood glucose (mmol/L)	Incremental glucose (mmol/L)	Blood glucose (mmol/L)	Incremental glucose (mmol/L)
0	8.81±1.47		9.15±1.59		4.83±0.54		3.92±0.35	
30	13.46±1.36	4.65±0.61	12.91±1.69	3.76±2.46	8.04±0.78	3.24±0.78	6.73±0.75	2.80±0.81
60	17.41±1.40	8.60±0.79[a]	15.32±1.68	6.17±2.08[a]	8.74±0.73	3.91±0.73	5.97±0.70	2.04±0.71
90	18.17±1.77	9.36±0.89[b]	14.16±1.70	5.01±2.74[b]	7.19±1.40	3.36±0.95	5.86±0.69	1.93±0.59
120	17.39±2.12[c]	8.58±1.15[d]	13.46±1.87[c]	4.31±3.05[d]	7.81±1.44	3.99±1.00	5.16±0.38	1.23±0.29
150	17.18±1.91[e]	8.37±1.06[f]	13.03±1.85[e]	3.88±2.83[f]	5.69±0.85	0.86±0.48	4.61±0.28	0.69±0.21

Values in mmol/L are means ± SD. Values in the same row with same superscripts are significantly different ($p<0.5$). Blood glucose concentration at time 0 min corresponds to Fasting blood sugar (FBS). Incremental glucose means increment in blood glucose concentration over fasting blood glucose.

shape and size have a fairly low GI (30-60) (Jarvi *et al*., 1995). This was elegantly shown in a study on ten type 2 diabetic patients receiving pasta or bread baked from the same durum wheat, where lower postprandial glucose and insulin levels were found after a pasta meal than after a comparable bread meal (Jarvi *et al*., 1995). In pasta products, gluten forms a visco-elastic network that surrounds the starch granules, which restricts swelling and leaching during boiling. Pasta extrusion is known to result in products where the starch is slowly digested and absorbed (Buller and Grand, 1990; Gudmand-Hoyer, 1994). Available data on spaghetti also suggest that this product group is a comparatively rich source of resistant starch (Dills, 1993). The slow-release features of starch in pasta probably relates to the continuous glutinous phase. This not only restricts swelling, but possibly also results in a more gradual release of the starch substrate for enzymatic digestion. Pasta is now generally acknowledged as a low glycaemic index food suitable in the diabetic diet. However, it should be noted that canning of pasta importantly increases the enzymic availability of starch, and hence the glycaemic response (MacDonald, 1995).

Processing of foods can optimize nutritional properties or diminish them severely, and it can either decrease or increase the GI of a given food. The GI reported in this meal may be due to cooking and chewing of the meal which was done in the usual way that people used to cook spaghetti and the subjects chewed the spaghetti properly before swallowing. The maintenance of high-starch crystalline is an important factor in low-GI food. Many factors such as food form; particle size, cooking, processing, and starch structure affect the GI (Bjo¨rck *et al*, 1994). Digestible solids empty from the stomach only when they have been changed to particles of < 2 mm (*Meyer et al*., 1981). The size of the particles contained in the mashed potatoes meal was reduced before ingestion, whereas considerable stomach motor activity was required to reduce the spaghetti to such small particles before they passed through the pylorus. The importance of food structure (thickness, particle size, and shape) and processing in relation to postprandial responses is further elucidated by studies that compared the al dente properties of spaghetti with macaroni (Granfeldt, 1991, Wolever *et al*., 1986) and of extruded with home made non-extruded pasta (Bourdon *et al*., 1999).

The compact structure of pasta achieved during processing appears to contribute more substantially to starch hydrolysis and glucose response than do cereals of a similar chemical composition and type, as indicated by the finding that bread made from durum wheat gives a higher glucose response than does pastas made from durum wheat (Granfeldt *et al*., 1991). They found that consumption of a diet with a low glycaemic index and a preserved food structure improved glucose and insulin responses. It is noted that chewing and cooking time may be responsible to the GI that is reported in this work.

The glycaemic load of 50 grams of spaghetti was large but outside the research hardly will you find someone who eats just 50 grams of spaghetti and be satisfied. In as much as knowing glycaemic index of food is good, when planning a meal, the glycaemic load is also paramount. The quantity of spaghetti to be consumed by an individual with diabetes must be less than fifty grams of available carbohydrate.

The lack of difference in glycaemic responses, despite different insulin concentrations, suggests that this difference in response to the high- and low-fiber pastas may have been due to the relatively low glycaemic response to pasta, as reported by several investigators. The glycaemic response to various processing conditions of pasta was lower after consumption of spaghetti and linguine than it was after consumption of bread made with the same ingredients, but differed only slightly between the pasta types (Granfeldt *et al*., 1991). Järvi *et al* (1995) reported similar results when comparing the glycaemic response to a pasta meal with that to a meal containing bread made with pasta ingredients.

CONCLUSION

Pasta should be cooked al dente (firm to the bite). It should be slightly firm and offer some resistance when chewing it. Overcooking boosts the GI. Although most manufacturers specify a cooking time on the packet but start testing about 5-7 minutes before the indicated cooking time is up. While al dente pasta is a low GI choice in some researches, eating too much would have a marked effect on blood glucose. Is necessary to watch the portion size (glycaemic load). A cup of al dente pasta combined with plenty of mixed vegetables can turn into three cups of a pasta-based meal and fits easily into any adult's daily diet.

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