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Characteristics of some wheat-based foods of the Italian diet in relation to their influence on postprandial glucose metabolism in patients with type 2 diabetes

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The present study was aimed at evaluating in patients with type 2 diabetes: (1) the glycaemic response to four starchy foods based on wheat, typical of the Italian diet; (2) the importance of some food characteristics in relation to their effects on postprandial glucose response. Seventeen patients with type 2 diabetes (eleven men and six women) participated in the study. All patients consumed, in random order and on alternate days, 50 g available carbohydrate provided by 90 g white bread and, according to a randomised procedure, an equivalent amount of carbohydrate provided by one (n 8) or two (n 9) of three other different test foods (g): pizza 85, potato dumplings 165, hard toasted bread 60. Foods had a similar nutrient composition. Plasma glucose response, measured for 180 min, was significantly lower after the potato dumplings than after white bread at 90 ($P < 0{\cdot}05$), 120 ($P < 0{\cdot}01$) and 150 ($P < 0{\cdot}05$) min. No difference was observed in postprandial plasma insulin response after the various test foods. The percentage of starch hydrolysed after 5 h *in vitro* hydrolysis with α-amylase was about 30 % lower for potato dumplings than for the other foods. However, no differences in the resistant starch content, the rate of diffusion of simple sugars added to a dialysis tube containing the food, and the viscosity of digesta were observed among the test foods. Scanning electron microscopy of potato dumplings showed a compact structure compatible with impaired accessibility of starch to digestive enzymes. In conclusion, carbohydrate-rich foods typical of the Italian diet which are often consumed as an alternative to pasta dishes are not equivalent in terms of metabolic impact in diabetic patients. Due to their low blood glucose response, potato dumplings represent a valid alternative to other starchy foods in the diabetic diet. Food structure plays an important role in determining starch accessibility to digestion, thus influencing the postprandial blood glucose response.

Non-insulin-dependent diabetes mellitus: Glycaemic index: Food digestibility

In the last few years the so-called 'Mediterranean' diet has often been proposed as a model of healthful eating habits for the prevention of CHD, the major cause of premature death and disability in industrialised countries (Keys, 1970; Keys *et al.* 1986).

The main features of this dietary model are a moderate intake of total fat (with a high intake of monounsaturated fat and low intake of saturated fat and cholesterol) and a high intake of complex carbohydrates (Giacco & Riccardi, 1991). Although this type of diet has beneficial effects on lipid metabolism, its high carbohydrate content might hamper its potentially healthful effects in diabetic patients who are known to be at particularly high risk of CHD. In fact, it is generally recognised that in diabetic patients, particularly those treated with insulin or who present with more severe forms of non-insulin-dependent diabetes mellitus, a diet high in carbohydrate can have detrimental effects on glycaemic control which has an important influence on the development of CHD (Coulston *et al.* 1987; Garg *et al.* 1988) and other chronic complications

Abbreviation: GI, glycaemic index.
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(Rivellese *et al.* 1990; Riccardi & Rivellese, 1991). However, it is known that not all carbohydrate-rich foods are equally hyperglycaemic. Differences in the postprandial blood glucose response to isoglucidic amounts of various foods containing carbohydrate have been demonstrated in both healthy subjects and diabetic patients (Jenkins *et al.* 1981*a*, 1983; Coulston *et al.* 1984). Many factors, such as the nature of carbohydrate, food form, food processing, fibre and anti-nutrient content influence the glycaemic response by modifying starch availability to α-amylase, gastric emptying time, gut hormone profiles, glucose absorption and, finally, by stimulating colonic fermentation which leads to the production of short-chain fatty acids (O'Dea *et al.* 1980; Tappy *et al.* 1986; Jenkins *et al.* 1987; van Amelsvoort & Westrate, 1992).

In recent years information on the glycaemic response to many different foods has become available in the scientific literature (Wolever *et al.* 1994; Foster-Powell & Brand, 1995). However, scanty reports exist on the blood glucose response to carbohydrate-rich foods typically consumed in the Mediterranean area, although this information could be useful to optimise diet planning for diabetic patients. In particular, apart from pasta (Parillo *et al.* 1985; Wolever *et al.* 1986), rice (Casiraghi *et al.* 1993) and a wide variety of legumes (Wolever *et al.* 1994), the data published do not take account of the traditional eating habits of the Italian population, and can only be of marginal help to diabetic patients in the selection of foods with both beneficial effects on lipid metabolism and minimal hyperglycaemic activity. Thus, the aim of the present study was to evaluate the glycaemic response of patients with type 2 diabetes to three wheat-based starchy foods that are typically consumed in Italy as an alternative to bread or pasta. Moreover, since the mechanisms influencing the blood glucose response to foods in diabetic patients are still not completely understood, a second aim of the present study was to elucidate the importance of some food characteristics in relation to their effects on postprandial blood glucose response.

Subjects and methods

Subjects

Seventeen patients (eleven men and six women) with non-insulin-dependent diabetes mellitus, aged 55·0 (SEM 2·1) years with BMI 28·0 (SEM 0·9) kg/m^2, a fasting blood glucose of 8·3 (SEM 0·4) mmol/l and diabetes duration of 4·0 (SEM 0·7) years participated in the study. Nine patients were treated with diet alone and eight patients with diet plus glibenclamide. Drug therapy was held constant throughout the study for all patients. Informed consent was obtained from each patient before beginning the study, and formal approval of the study protocol was given by the Ethics Committee of the 'Federico II' University Medical School.

All diabetic patients were scheduled to attend the Clinical Research Centre three times at 08.00 hours after a 12 h fast; an intravenous catheter was inserted into an antecubital vein for blood sampling and kept patent by saline (9 g NaCl/l) infusion.

Experimental design

All patients (*n* 17) consumed, in random order and on alternate days, 50 g available carbohydrate provided by 90 g white wheat bread (white bread) and, according to a randomised procedure, an equivalent amount of carbohydrate provided by one (*n* 8) or two (*n* 9) of three other test foods (g): pizza (baked plain pizza dough) 85; potato dumplings (made with white wheat flour and white potatoes, and boiled in salt water) 165; commercial hard toasted white bread 60. Three patients consumed (on different days) pizza and commercial hard toasted white bread, three consumed pizza and potato dumplings, three consumed potato dumplings and commercial hard toasted white bread, three patients consumed only pizza, three consumed only commercial hard toasted white bread and two consumed only potato dumplings. Test foods were always dressed with the same amount of olive oil, tomato and cheese; meals were prepared by the staff of the metabolic research kitchen and their composition was evaluated by standard chemical analysis of the foods as consumed (Table 1). Available carbohydrate was determined by difference (100 minus the sum of protein, fat, water, ash, dietary fibre and resistant starch) and expressed in monomeric form. The four meals were similar not only in their nutrient composition and energy, but also in the

Table 1. Composition of the four wheat-based starchy test foods typical of the Italian diet and standard dressing determined by standard chemical analysis*

Test foods	Water (g)	Ash (g)	Available CHO† (g)	Protein (g)	Fat (g)	Energy (kJ)	Total dietary fibre (g)	Resistant starch (g)
White bread (90 g)	29·6	1·0	49·8	8·8	1·8	996	2·5	1·5
Pizza (85 g)	25·8	1·2	50·1	8·7	0·6	954	1·2	2·4
Potato dumplings (165 g)	107	0·3	50·0	6·3	0·7	916	4·1	1·9
Hard toasted bread (60 g)	3·2	1·1	50·1	6·2	0·7	916	1·4	2·3
Standard dressing‡								
Olive oil (10 g)			0·0	0·0	10	377	0·0	0·0
Tomato sauce (100 g)			4·2	1·3	0·1	92	1·5	0·0
Parmesan cheese (10 g)			0·0	3·2	3·1	171	0·0	0·0
Total			4·2	4·5	13·2	640	1·5	0·0

CHO, carbohydrate.
* For details of procedures, see p. 34.
† Determined by difference.
‡ Test foods were always served with the same amount of standard dressing.

amount of fibre (Prosky *et al.* 1992) and resistant starch (Champ, 1992).

All meals were consumed within 20 min. Blood samples for the measurement of glucose and insulin concentrations were obtained 10 min before and immediately before the beginning of the meal and thereafter every 30 min for 180 min. Plasma glucose was measured using a glucose oxidase method (Huggett & Nixon, 1957) and serum insulin by radioimmunoassay (Hales & Randle, 1963).

In vitro studies

Rate of in vitro *starch digestion*. Foods were analysed for their *in vitro* digestibility as described by Brighenti *et al.* (1995). The system employed is based on a multi-enzymic digestion confined within a dialysis tube followed by analysis of the reducing sugars released into the permeate. Although less sophisticated than more recently published procedures aimed at predicting the glycaemic index (GI) of different foods, such as the rapidly available glucose measurement (Englyst *et al.* 1999), it is conceptually similar and provides a good estimate of GI in starchy foods containing small quantities of mono- and disaccharides. In brief, after simulated chewing, aliquots of food containing 2 g starch were placed in a dialysis tube to undergo sequential attacks with salivary α-amylase, pepsin and pancreatic α-amylase to simulate digestion.

Each food underwent three different treatments, the first with active enzymes (digestion), the second with deactivated enzymes (blank), and the third with deactivated enzymes plus a known amount of maltose to allow measurement of sugar diffusibility from the dialysis tube in the presence of food (diffusion). The amount of reducing sugars in the permeate was measured at time 0 and every 30 min for 5 h by colorimetric analysis. For each food tested and for each time, digestion results minus blank were then expressed as a percentage of those obtained for white bread to calculate a digestion index, while diffusion results were related to those obtained for the diffusion of a solution of pure maltose in the absence of food to calculate a sugar diffusion index. Finally, *in vitro* results and compositional analyses were used as the variables to predict the GI of foods by means of the following predictive equation previously calculated in normal volunteers (Brighenti *et al.* 1995):

$$\begin{aligned} GI_{predicted} = {} & 105{\cdot}52 \text{ fibre : carbohydrate} \\ & - 76{\cdot}46 \text{ protein : carbohydrate} \\ & + 1{\cdot}23 \text{ digestion index at } 150\,\text{min} \\ & + 69{\cdot}41 \text{ sugar diffusion index at } 270\,\text{min} \\ & - 83{\cdot}87. \end{aligned}$$

Viscosity of digesta. Viscosity is a physical property of solutions only partly related to the complex flow characteristics of particulate suspensions in the gastrointestinal tract; nevertheless it could be useful in interpreting anomalous glycaemic data due to events related to gastrointestinal transit, such as delayed gastric emptying or reduction of the convective movements in the intestinal lumen.

The viscosity of foods was evaluated for the digesta obtained by *in vitro* hydrolysis with pepsin and neutralised to pH 7·0 with $NaHCO_3$. This procedure was intended as the best compromise between the composition of the acidic gastric chyme and the fully-hydrolysed intestinal digesta, since it represents the situation that occurs *in vivo* at the end of the duodenum where pancreatic digestion begins. Digesta were centrifuged for 5 min at 1000 ***g*** to remove coarse particles. Suspensions were then introduced into a coaxial cylinder viscosimeter (Rotovisco RV 12, MVII cell; Rotovisco, Haake, Germany). Analyses were performed in duplicate at 37°C and at shear rates from 0·009 to 0·576/s.

Scanning electron microscopy. To assess the ultrastructure of potato dumplings and to compare it with that of white bread, hard toasted bread and pizza, samples of foods prepared as eaten were freeze-clamped into liquid N_2, fractured and then metallised with Au on stub and examined at 20 kV using a Cambridge Stereo Scan mod 250 scanning electron microscope.

Statistical methods

One-way ANOVA was used to compare differences in blood glucose and insulin responses between all the test meals. Student's paired *t* test was used to compare differences in blood glucose and insulin responses between bread and each of the test meals. Statistical significance was checked by setting the level of significance at $P = 0{\cdot}05$ (two-tailed; Snedecor & Cochran, 1980). Values are presented as means with the standard errors of the means. Postprandial increments for each variable were calculated by subtracting the mean concentration of the two basal samples from each value. The incremental areas for glucose and insulin were calculated geometrically.

Results

In general, the meals were well accepted.

Characteristics of the patients, in particular fasting blood glucose concentrations (mmol/l; white bread 8·3 (SEM 0·4), potato dumplings 8·4 (SEM 0·4), pizza 8·1 (SEM 0·6), hard toasted bread 8·6 (SEM 0·5)), were all similar before each test meal. Plasma glucose response, evaluated as postprandial increments, were lower after the potato dumplings than after white bread, the difference being statistically significant at 90 ($P < 0{\cdot}05$), 120 ($P < 0{\cdot}01$) and 150 ($P < 0{\cdot}05$) min (Fig. l(a)). However, no significant differences at any time point were observed between hard toasted bread or pizza and white bread. As a consequence, the plasma glucose incremental area under the 180 min curve was significantly lower after the potato dumplings than after white bread (434 (SEM 57) *v.* 659 (SEM 63) mmol/l × min, $P < 0{\cdot}03$), while after pizza (689 (SEM 86) mmol/l × min) and hard toasted bread (768 (SEM 85) mmol/l × min) the incremental areas for glucose were not significantly different from that after white bread (Table 2). The mean peak glucose (the highest increment recorded for each patient) was significantly lower after the potato dumplings than after white bread (4·0 (SEM 0·7) *v.* 6·3 (SEM 0·7) mmol/

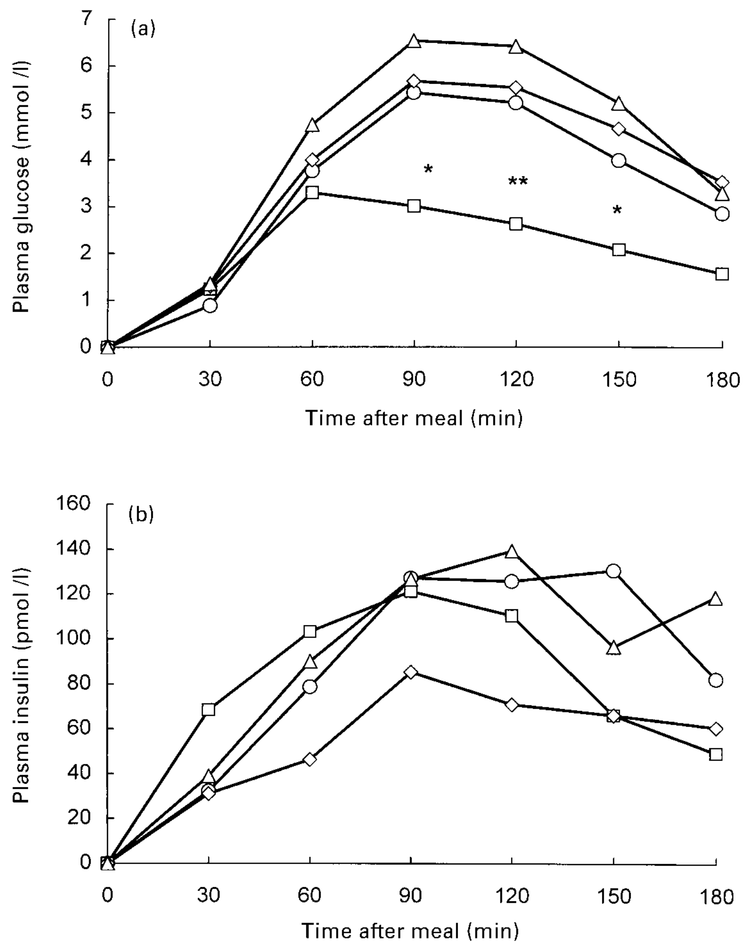

Fig. 1. Mean increase in plasma glucose (a) and insulin (b) above baseline in patients with type 2 diabetes after consumption of the four wheat-based starchy test foods. (○) White bread, (□) potato dumplings, (◇) pizza, (△) hard toasted bread. Mean values were significantly lower after the potato dumplings than after white bread: $*P < 0.05$, $**P < 0.01$. For details of test foods and procedures, see Table 1 and p. 34.

l, $P < 0{\cdot}01$), while after pizza (6·2 (SEM 0·7) mmol/l) or hard toasted bread (7·3 (SEM 0·6) mmol/l) it was not significantly different from that for white bread (Table 2). The mean time of maximal glycaemic increment (time needed to reach the highest concentration) was not significantly different between the different test foods. The GI, calculated as a percentage of the incremental area under the 180 min curve of the test food with regard to white bread (Wolever *et al.* 1990), was significantly lower ($P < 0{\cdot}05$) with potato dumplings (74 (SEM 12) %) than

Table 2. Fasting blood glucose and blood glucose responses after consumption of the four wheat-based starchy test foods for patients with type 2 diabetes

(Values are means with the standard errors of the means)

Test foods…	White bread		Potato dumplings		Pizza		Hard toasted bread	
	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Fasting blood glucose (mmol/l)	8·3	0·4	8·4	0·4	8·1	0·6	8·6	0·5
Peak time (min)†	107	7	82	11	107	10	107	7
Peak glucose rise (mmol/l)	6·3	0·7	4·0***	0·7	6·2	0·7	7·3	0·6
Glucose IAUC (mmol/l × min)	659	63	434**	57	689	86	768	85
Glycaemic index (%)	100		74*	12	114	14	104	5

IAUC, incremental area under the 180 min curve.
* For details of test foods and procedures, see Table 1 and p. 34 respectively.
Mean values were significantly different from those for white bread (Student's paired *t* test): $*P < 0.05$, $**P < 0.03$, $***P < 0.01$.
† Time taken to reach highest glucose concentration.

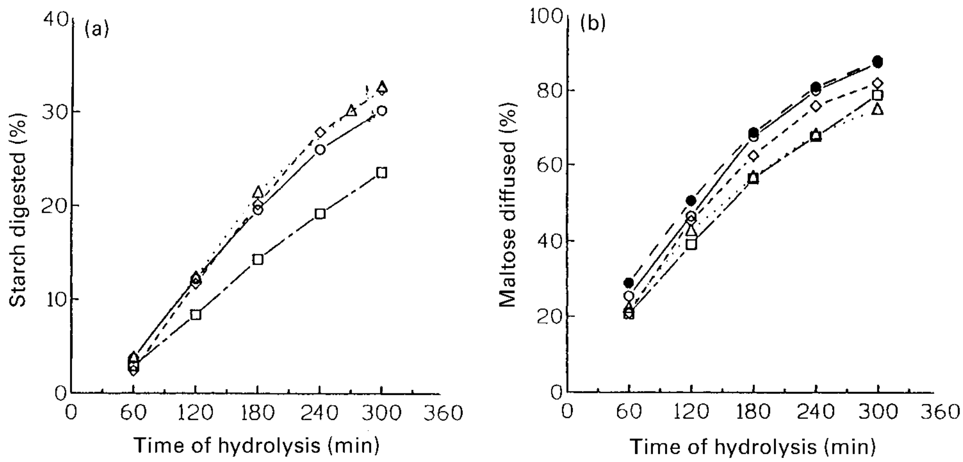

Fig. 2. (a) Time-course of *in vitro* starch hydrolysis of the four wheat-based starchy test foods. (b) Time-course of *in vitro* maltose diffusion from dialysis tube in presence of test foods or a solution of pure maltose in the absence of food. (○) White bread, (□) potato dumplings, (◇) pizza, (△) hard toasted bread, (●) pure maltose. For details of test foods and procedures, see Table 1 and p. 34.

with white bread, while it was not significantly different with pizza (114 (SEM 14) %) or hard toasted bread (104 (SEM 5) %; Table 2).

No significant differences were observed in postprandial insulin response after the various test foods (Fig. 1(b)).

The *in vitro* analyses showed uniformity in the characteristics of foods, apart from starch digestibility of potato dumplings. The percentage of starch hydrolysed after *in vitro* hydrolysis for 5 h was about 30 % lower for potato dumplings compared with the other foods (Fig. 2(a)). However, no difference in the percentage of maltose diffusion between the various test foods was observed at any given time (Fig. 2(b)). As a consequence, the calculated digestion index and sugar diffusion index showed a difference only for the digestion index of potato dumplings, which at 270 min was 61·8 % compared with 99·5 % for pizza and 91·9 % for hard toasted bread (white bread 100 %).

The resistant starch content of potato dumplings was similar to that of white bread (1·9 g *v.* 1·5 g, respectively), while pizza and hard toasted bread had a slightly higher content (2·4 g and 2·3 g respectively; Table 1). The viscosity of digesta measured after *in vitro* digestion of potato dumplings, white bread and pizza was in the same low range (from 41·7 to 73·0 Pa.s, measured at a shear rate of 0·036/s). A slightly higher value was obtained for hard toasted bread (406 Pa.s), although it was still far from values with physiological significance in terms of reduction of gastric emptying or impairment in the rate or extent of enzyme–substrate mixing.

There was very close agreement between the GI measured *in vivo* and the predicted GI, which was calculated using the formula given earlier (p. 35) which takes into account *in vitro* results and compositional analyses. Estimated GI values based on a value of 100 % for white bread were (%): potato dumplings 71; pizza 104; hard toasted bread 102.

The scanning electron microscopy of potato dumplings showed a compact structure composed of starch granules surrounded by a matrix of heat-denatured wheat protein and dispersed starch (Fig. 3(b)). The resulting structure resembles that of pasta, another unleavened wheat food (Monge *et al.* 1990) with a low GI, and is compatible with an impaired accessibility of starch to digestive enzymes. In comparison, the structures of leavened products (i.e. hard toasted and common white breads, and pizza) are much less compact, presenting high porosity and smaller and more dispersed granules (Fig. 3(a, c and d)).

Discussion

The present study shows that pizza and hard toasted bread, traditional Italian foods based on leavened white wheat flour, elicit a blood glucose response in diabetic patients similar to that of white bread. However, potato dumplings, a typical potato–wheat food, often used as a substitute for pasta in first-course dishes, is able to reduce glycaemia during the whole postprandial period.

Bread has been widely studied in both normal (Mourot *et al.* 1988; Holm & Bjorck, 1992; Liljeberg & Bjorck, 1994) and diabetic subjects (Parillo *et al.* 1985; Wolever *et al.* 1990; Rasmussen *et al.* 1991) and has been considered as one of the most consistent foods in relation to its glycaemic response, to such an extent as to be recommended as the standard food for GI calculations. Neither the presence of dietary fibre (Jenkins *et al.* 1981*b*) nor the use of flours from other cereals than wheat (Foster-Powell & Brand, 1995) have been shown to modify its blood glucose response. The only practical way to reduce the glycaemic response to bread is to add a high percentage of intact (or partly milled) grain to the flour (Jenkins *et al.* 1988; Liljeberg *et al.* 1992). These data have been used to demonstrate the importance of a reduced rate of amylolysis as the key mechanism regulating postprandial blood glucose response to foods based on leavened flours. Wheat dough undergoes many chemical–physical modifications during baking that could, at least theoretically, affect the structure of starch to such an extent as to affect its

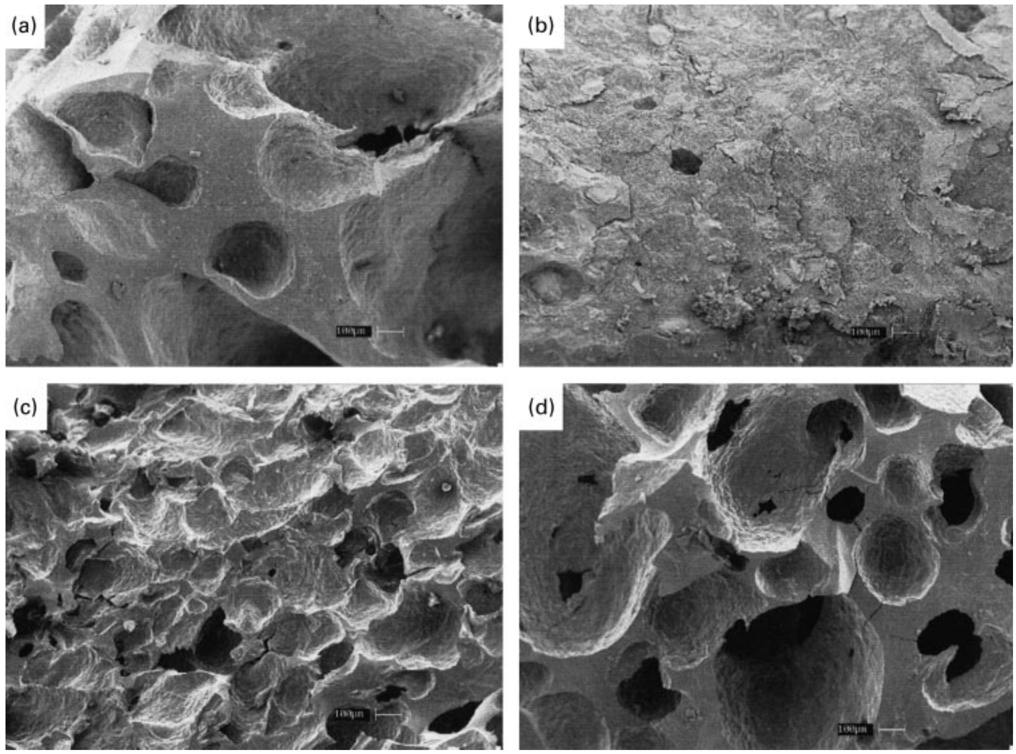

Fig. 3. Ultrastructure of the four wheat-based starchy test foods assessed by scanning electron microscopy. (a) White bread, (b) potato dumplings, (c) pizza and (d) hard toasted bread. The potato dumplings showed a more compact structure than the other foods. For details of test foods and procedures, see Table 1 and p. 34.

digestibility. Liljeberg *et al.* (1995) have shown that the presence of organic acids or baking for a long period at low temperature can reduce amylolysis and increase the content of resistant starch in breads made with mixtures of barley and wheat flours, which might be modulated by processing conditions. Pizza and hard toasted bread are two leavened products based on white wheat flour which are often consumed as substitutes for bread and pasta in Italy, particularly in the southern regions. These two products are subject to very different cooking processes, pizza is cooked rapidly at very high temperatures and consumed immediately after baking, while hard toasted bread undergoes two thermal treatments (one for baking the bread and a second one for drying it, at <200°C until the product is completely toasted and its structure becomes very hard and brittle). Our results suggest that these treatments are unable to modify either digestibility or glycaemic response, and thus that the consumption of pizza or hard toasted bread instead of bread has no significant influence on postprandial blood glucose concentrations. A similar conclusion was reached when using a more ‘international’ type of pizza in patients with type 1 diabetes (Ahern *et al.* 1993).

A different and unexpected finding is that potato dumplings elicit a significantly reduced plasma glucose response compared with the other foods tested. Our observation of a GI of about 70 is much lower than the value previously reported by us for freshly boiled potatoes of the same cultivar (Parillo *et al.* 1985) and also lower than the GI of gnocchi reported by another group (Brand-Miller *et al.* 1999), although the latter value probably refers to gnocchi prepared only with wheat flour (without potatoes). This finding suggests that the low rate of carbohydrate digestion observed for this food is due to the particular way it is prepared, i.e. mixing potato and wheat starch. In order to explain the different effects of the test foods on postprandial glucose metabolism, food characteristics which influence glucose response were evaluated. The mechanisms already proposed to explain such effects range from reduction in α-amylase accessibility (O’Dea *et al.* 1981; Jenkins *et al.* 1982; Bornet *et al.* 1989), modifications of intestinal events such as gastric emptying (Holt *et al.* 1979; Mourot *et al.* 1988) and intestinal absorption (Edwards *et al.* 1987), to the nature of the starch, and in particular the relative amounts of rapidly digestible, slowly digestible and resistant starch (Englyst *et al.* 1996, 1999).

In our *in vitro* system we found a lower digestion index for potato dumplings compared with all the other foods, with no differences in the sugar diffusion index. Taken together, these two terms express the rate to which products of starch hydrolysis are released, giving allowance for sugars entrapped within the dialysis system used to simulate intestinal absorption (Jenkins *et al.* 1982; Brand *et al.* 1985; Casiraghi *et al.* 1992). In this way it becomes apparent that the lower digestion index of potato dumplings is independent of its effect in retarding the diffusion of small molecules across the dialysis membrane indicating that the mechanism is linked to the rate of starch hydrolysis more than to viscosity of digesta. Moreover, the lower blood glucose response after consuming potato dumplings cannot be accounted for by variations in plasma insulin levels, since insulin concentrations were similar after both potato dumplings and the other foods tested. Discrepancies in plasma glucose and insulin responses to carbohydrate-rich foods (as observed in the present study) are often observed in patients with type 2 diabetes with impaired insulin secretory ability in whom a compensatory variation of insulin secretion in relation to the glycaemic load of the meal does not occur. In these patients moderate changes in the glycaemic load of the meal result in marked changes in postprandial plasma glucose levels in the absence of major variations of insulin concentrations (Parillo *et al.* 1996). Taken together these observations suggest that the reduced glucose response observed *in vivo* for potato dumplings is due to a reduction in starch susceptibility to α-amylase rather than to the mechanisms linked to gastric emptying, sugar absorption or insulin release. The presence of starch fractions resistant to digestion (i.e. resistant starch) has been suggested to be associated with a reduction in glycaemic impact of starchy foods, possibly as an index of high amylose content (Raben *et al.* 1994). Potatoes are particularly prone to resistant starch formation during repeated cooking–cooling cycles (Englyst & Cummings, 1987). However, the amount of resistant starch present in potato dumplings was not much different from that present in other foods tested in the present study, which rules out the possibility that the low *in vitro* and *in vivo* response observed for potato dumplings could be due to a lower load of available carbohydrates.

Since neither viscosity, nor hyperinsulinism, nor variations in any of the food constituents known to influence blood glucose metabolism, such as resistant starch, simple sugars, or dietary fibre, can justify the reduced glycaemic influence of potato dumplings, it is very likely that the effect observed has to be looked for in their structure.

Starch accessibility to digestive enzymes has a strong influence on its digestibility, thus modulating the post-prandial blood glucose response (Brighenti *et al.* 1995). In the case of potato dumplings, scanning electron microscopy showed a compact structure similar to that observed in other low GI starchy foods (Monge *et al.* 1990; Fig. 3(b)) which is consistent with a reduction in the rate of starch accessibility due to a combination of a compact form and a need for protein digestion to free trapped starch granules. However, for leavened foods the high porosity due to the entrapment of gas bubbles that expand during cooking greatly increases the surface exposed to enzyme activity.

Independently of the mechanism by which potato dumplings elicit a reduced blood glucose response in diabetic subjects, our results can have practical implications for the management of diabetes. In particular, potato dumplings could represent a valid alternative to pasta for the diabetic diet because of its low blood glucose response. Since there are not many carbohydrate-rich foods eliciting a low postprandial glycaemic response, the knowledge that potato dumplings (for recipe, see Appendix) can also be included in this category is good news for diabetic patients, who can therefore increase their food choices, thus improving their compliance with the diet.

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Appendix

Potato dumplings recipe (to serve four):

Potatoes (old raw) 400 g Salt 15 g

White flour 220 g Boiling water 2 litres

Boil potatoes, peel and put through a ricer. Gradually add flour, kneading until smooth. Shape into long rolls about 10 mm in diameter, cut into 10 mm pieces and roll these in flour. Cook for 5 min in rapidly boiling salted water, drain and serve with a tomato sauce.