



Trabajo Original

Evaluation of the acceptability of low glycaemic index preparations, formulated by replicating traditional Chilean culinary preparations with a high glycaemic index

Evaluación de la aceptabilidad de preparaciones de bajo índice glicémico, formuladas como réplicas de preparaciones típicas chilenas de alto índice glicémico

Claudia Vega, Kathleen Priken, Elizabeth Venegas, Paola Vera, Daniela Pincheira and Marcela Alviña

School of Nutrition and Dietetics. Facultad de Farmacia. Universidad de Valparaíso. Valparaíso, Chile

Abstract

The aim of this study was to determine the acceptability of low glycaemic index (GI) preparations, equivalent to the traditional high GI ones in Chile, elaborated with minimal changes in the ingredients and culinary techniques that significantly diminish the GI and maintain acceptability level. Twelve high-GI traditional lunches and their low GI counterparts were prepared. For 12 days, 20 apparently healthy women randomly tasted 2 paired preparations per day (low and high GI). The attributes of appearance, taste, smell, and texture of salads, main course, and desserts, as well as those of the full lunch, were evaluated using a hedonic scale of 7 and 9 points. Lunches with a high GI ($90 \pm 20.5\%$) were modified by changing types of food ingredients, and/or by using culinary techniques to provide a low-GI counterpart with $47 \pm 5.9\%$ GI ($p < 0.001$). All the preparations were classified as optimal, exceeding the established cut-off point. The "Legume with CHO" lunch had a higher acceptability level in its low GI version ($p = 0.006$), while the "Chicken with corn" lunch had it in its high GI version ($p = 0.004$). There was a preference for low-GI salad appearance ($p = 0.003$) and dessert flavour ($p = 0.024$), while high-GI main dishes were better praised for flavour ($p = 0.034$) and texture ($p = 0.012$). It is therefore possible to prepare low-GI menus equivalent to their traditional counterparts that are received as generally acceptable, with components and sensory attributes equal to, or even better than typical Chilean cuisine dishes.

Keywords:

Glycaemic index.
Acceptability. Sensory
evaluation. Typical
meals. Ingredients.

Resumen

El objetivo de este estudio fue determinar la aceptabilidad de preparaciones de bajo índice glicémico (IG) diseñadas a partir de aquellas de alto IG de consumo habitual en Chile, elaboradas con mínimos cambios en sus ingredientes y basándose en técnicas culinarias que disminuyen el IG. Doce preparaciones tradicionales de alto IG se eligieron para preparar sus homólogos de bajo IG. Durante 12 días, 20 mujeres en buen estado de salud probaron, de forma aleatoria, 2 preparaciones equivalentes por día (de bajo y alto IG), y evaluaron la aceptabilidad promedio de las ensaladas, los platos principales y los postres, así como el almuerzo completo, a través de una escala hedónica de 7 puntos y una de 9 puntos para evaluar aceptabilidad de los atributos: apariencia, sabor, olor y textura. Los almuerzos de alto IG ($90 \pm 20,5\%$) se modificaron cambiando los tipos de ingredientes y/o las técnicas culinarias, formulando preparaciones homólogas de bajo IG ($47 \pm 5,9\%$, $p < 0,001$). Todas las nuevas preparaciones se calificaron de óptimas, excediendo el punto de corte establecido. La preparación "legumbres con cereales" obtuvo la más alta aceptabilidad en su versión de bajo IG ($p = 0,006$), mientras que la preparación "Pollo con choclo" lo hizo en su versión de alto IG ($p = 0,004$). Hubo mayores preferencias por la apariencia de las ensaladas ($p = 0,003$) y el sabor de los postres de bajo IG ($p = 0,024$), mientras que los platos principales fueron mejor valorados en cuanto a sabor ($p = 0,034$) y textura ($p = 0,012$) en su versión de alto IG. Por lo tanto, es posible preparar menús de bajo IG equivalentes a sus homólogos tradicionales que son considerados generalmente como aceptables, con componentes y atributos iguales o mejores que las preparaciones tradicionales chilenas.

Palabras clave:

Índice glicémico.
Aceptabilidad.
Análisis sensorial.
Preparaciones típicas.
Ingredientes.

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Correspondence:

Marcela Alviña. Facultad de Farmacia. Universidad de Valparaíso. Avda. Gran Bretaña N° 1093. Playa Ancha, Valparaíso, Chile
e-mail: marcela.alvina@uv.cl

INTRODUCTION

Carbohydrates (CHO) are the main nutrients in diets across the world. Their primary function is to act as energy fuel, and according to their structure vary in their palatability, digestion, absorption, release of hormones, and oxidation (1,2). Glycaemic index (GI) is an indicator of the healthy quality of CHO present in food, and is defined as the increase in the area under the blood glucose curve that is produced by the intake of a fixed amount of available CHO from a given food, usually 50 g, in relation to the same amount of CHO from a standard food (glucose or white bread) (3). Therefore, foods that occupy more than 70 % of the area under the blood glucose curve of the standard food are considered high-GI, and those with a small glycaemic increase, less than 55 %, are referred to as low-GI (4).

There are certain factors that affect the GI of food and therefore influence glycaemic response, such as type of sugar ingested, starch nature, cooking method and elaboration of foods that modify gelatinization, gelling, and retrogradation degree of starch (5).

Other factors that affect GI are the preliminary culinary techniques or mechanical procedures that increase contact surface, thus increasing the area exposed for enzymatic hydrolysis (6-9). On the other hand, the addition of ingredients with high amounts of dietary fibre, proteins, or fats can decrease the GI of food, reducing its glycaemic response (10-13).

The traditional food prepared in Chile is based on tubers (potatoes) and refined cereals, mainly derived from wheat and rice, which, when applying typical culinary techniques, present high GI values. A local study found that although the food preparations preferred by the Chilean population with type-2 diabetes mellitus (DM2) presented a daily average of CHO within the recommended range ($219.8 \text{ g/day} \pm 27.0$), average GI was high ($74.9\% \pm 11.3$), which in turn showed a strong positive correlation with the metabolic control parameters of DM2 (14). These preparations are also often consumed by the general population in Chile, which could imply an increased risk of developing DM2 among healthy subjects, and could also induce complications in subjects with DM2.

The purpose of this study was to assess the acceptability of low-GI preparations equivalent to traditional high-GI ones in Chile, elaborated with minimal changes in the ingredients and culinary techniques to significantly diminish GI while maintaining acceptability levels.

MATERIALS AND METHODS

SUBJECTS

The sample consisted of 20 female subjects aged 30 to 65 years, with a body mass index $\geq 18.5 \text{ kg/m}^2$. Exclusion criteria included people receiving sulfonylureas or insulin treatment, or people with diabetic complications (nephropathy, retinopathy, renal failure, cardiovascular disease, cerebrovascular accident). Previously, all subjects signed a written consent form. The study was

approved by the Bioethics Institutional Committee for Research in Human Beings, Universidad de Valparaíso (approval certificate number 32).

LUNCH STANDARDIZATION

Two types of traditional Chilean lunches were prepared, high-GI and low-GI, which included salad, main dish, and dessert. High-GI lunches were designed based on a previous study that detailed the usual total daily intake of 108 DM2 subjects with metformin treatment, yielding a total consumption of $2000 \pm 350 \text{ kcal/day}$, $220 \pm 27 \text{ g CHO/day}$, with a GI of $74.9 \pm 11.3\%$ (14).

Lunches from the high-GI diet were used to obtain low-GI ones with changes in the types of food, ingredients, and/or culinary techniques (to generate a significant decrease in GI). Finally, 12 typical Chilean preparations were selected and underwent a pilot study, where the recipes were standardized in terms of products or raw materials, culinary techniques, weight of each ingredient, and flow diagrams of the preparations, to experimentally verify whether the theoretical planning to obtain low-GI counterparts was accurate in terms of organoleptic parameters.

The nutritional contribution of the lunches was established using a chemical composition food table (15), and the GI values were taken from the University of Sydney's GI database (16). As a requirement for all lunches (high and low GI), a contribution of 50-60 g of available CHO and a value of GI over 70 % for high-GI lunches, and less than 55 % for low-GI, was established.

ACCEPTABILITY STUDY

The subjects were summoned to the Faculty of Pharmacy's food science laboratory at 11:00 hours for 12 days, and were required to consume their usual breakfast two hours before arrival, without consuming food between breakfast and the intervention. Each subject was offered a tray with 30 g of salad, 50 g of a main dish, and 30 g of a dessert. It was ensured that the presentation and distribution of each component of the high- and low-GI lunch were similar in order to minimize distractions and avoid preferences prior to tasting.

The acceptability study of the lunches was carried out in a random order. Each subject tasted two lunches per day, one low-GI and one high-GI, for which they evaluated the overall acceptability of the salad, main dish, dessert and full lunch with a 7-point hedonic scale, where 7 was "I like it a lot" and 1 was "I greatly dislike it". A score of ≥ 5.5 was considered optimal, a score between 5.4 and 4.1 medium, and one ≤ 4.0 unsatisfactory. In addition, the acceptability of the appearance, flavour, and texture was measured in each of the lunch components using a 9-point scale, with 9 being "extremely preferred" and 1 being "extremely rejected". Scores ≥ 7.0 were considered optimum, between 6.9 and 4.4 were considered medium, and those ≤ 4.5 were deemed deficient.

STATISTICAL ANALYSIS

Given that all quantitative variables in the scale had a normal distribution, the results are expressed as average \pm standard deviation. For the comparison of the GI of both equivalent preparations, Student's t-test was used for independent samples, and for the analysis of the comparison between the two meals regarding the sensory evaluation variables, Student's t-test was used for paired samples. For all the above-mentioned analyses, a p -value < 0.05 was considered significant. Data were analysed with the SPSS 20.0 statistical software program for Windows (SPSS Inc., Chicago, USA).

RESULTS

MAIN INGREDIENTS AND THEORETICAL GLYCAEMIC INDEX OF LUNCHES

Twelve high-GI preparations with their respective low-GI counterparts were produced. The contribution of available CHO from the high-GI group was on average 53.4 ± 3.6 g, while in the low-GI group it was 48.8 ± 3.6 g, which showed no statistical significance.

Table I shows the preparations with their glycaemic index values and the complete menus, which were comprised of a salad,

Table I. Preparations included in the meals and determinant GI main ingredients

#	Preparations	Ingredients for high GI	High GI (%)	Ingredients for low GI	Low GI (%)
1	Salad	Boiled beet and carrot	93	Tomato with peel, raw celery, hard-boiled egg	51
	Meat soup (Boiled meat, potatoes, pumpkins, corn and rice)	White rice		Brown rice	
	Dessert	Raw orange, skim milk, cornstarch		Raw raspberry, fat yogurt	
2	Salad	Raw celery, boiled corn	121	Raw celery and carrot	51
	Meatball soup (meatball, vegetables and CHO)	Small-size pasta, breadcrumbs		Brown rice	
	Dessert	Raw pineapple, orange juice		Orange, egg white	
3	Salad	Boiled corn and fava bean	69	Steamed cauliflower and broccoli, raw bell pepper	42
	Steamed baked fish with CHO	Peeled boiled potato and peeled baked tomato		Brown rice with vegetables, baked tomato with peel	
	Dessert	Raw banana, yogurt		Raw apple and pear with peel, orange	
4	Salad	Boiled fava bean, carrot and beet	100	Steamed green beans	52
	Meat with rice	Cooked white rice and corn		Cooked brown rice	
	Dessert	Sugar-free jelly		Yogur	
5	Salad	Boiled corn and carrot	82	Raw cabbage and carrots	45
	Zucchini pudding	Breadcrumbs		Chopped meat	
	Dessert	Raw kiwi, orange juice		Raw apple with peel, yogurt, oat	
6	Salad	Boiled beet, peeled raw tomato	79	Raw carrot, steamed corn	36
	Legume with CHO	Boiled chickpeas, white rice		Boiled beans, peeled wheat	
	Dessert	Grated peeled raw apple, sugar-free jelly		Evaporated milk, sugar-free jelly	
7	Salad	Raw cabbage	100	Raw carrot and cabbage	53
	"Niño envuelto" ^(a) with mashed potatoes	Instant mashed potatoes		Mashed potatoes with peel	
	Dessert	Raw kiwi		Raw apple and pear with peel, almonds	
8	Salad	Boiled carrot, peeled raw tomato	68	Raw cucumber, raw tomato with peel	46
	Bolognese spaghetti	Boiled white spaghetti		Boiled whole wheat spaghetti	
	Dessert	Boiled pear, diet jam		Apple with peel, yogurt	

(Continuation in the next page)

Tabla I (Cont.). Preparations included in the meals and determinant GI main ingredients

#	Preparations	Ingredients for high GI	High GI (%)	Ingredients for low GI	Low GI (%)
9	Salad	Cooked beet, raw celery	97	Raw tomato with peel, raw celery	53
	Chicken with corn	Boiled peas, cooked corn paste		Vegetable mix with boiled corn	
	Dessert	Raw orange		Oat, skim milk	
10	Salad	Boiled corn, croutons, peeled raw tomato	65	Raw tomato with peel, raw onion	39
	Lentils	Breadcrumbs, boiled peeled potatoes and pumpkins		Brown rice, cooked chard	
	Dessert	Sugar-free jelly, grated peeled raw apple		Egg white, grated raw apple, cinnamon	
11	Salad	Boiled fava beans and boiled peeled potatoes	73	Steamed broccoli, boiled potatoes with peel	45
	Fish pudding	Breadcrumbs		Breadcrumbs	
	Dessert	Skim milk, boiled white rice		Yogurt, raw apple with peel, almonds	
12	Salad	Raw grated carrot, raw purple cabbage	127	Tomato with peel, raw purple cabbage	53
	Meat with mashed potatoes	Instant mashed potatoes		Mashed potatoes with peel, skim milk	
	Dessert	Raspberry pulp, skim milk, cornstarch		Raw raspberry, raw apple with peel, yogurt	
Mean ± SD		90 ± 20.5 *		47 ± 5.9 *	

The lunch's name is given according to the main dish. ^(a) "Niño envuelto" refers to a thin slice of meat wrapping vegetables in sticks. CHO: carbohydrate; GI: glycaemic index. * Statistically significant difference between the glycaemic indices of both groups as measured by Student's t-test for independent samples ($p < 0.001$).

a main dish, and a dessert, with detailed modifications made with the aim of obtaining low-GI preparations from the initial high-GI recipes. Desserts had modifications involving the selection of ingredients with a lower GI, quantity of protein incorporated, processing of raw materials, and quantity of fibre contributed. In salads and main dishes refined foods were replaced by whole-meals, tubers by vegetables, cooked vegetables by raw vegetables, peeled vegetables by vegetables with peel, and grated foods by whole foods.

ACCEPTABILITY OF FOOD PREPARATIONS

All the preparations in figure 1 were classified as optimal, exceeding the established cut-off point.

Only two lunches had significant differences in their acceptability levels: the low-GI "legume with CHO" lunch had a higher acceptability against its high-GI version, while the high-GI "chicken with corn" lunch got a higher acceptability value when compared to its low-GI equivalent. The courses that had greater scores included the dessert in the low-GI "legume with CHO" lunch, while in the high-GI "chicken with corn" lunch both the main dish and dessert obtained a better score than their low-GI version (data not shown in the figure).

SENSORY ATTRIBUTES OF FOOD PREPARATIONS

In figure 2 there was a preference for the low-GI salad and dessert dishes, while the main dishes were slightly better praised regarding flavour and texture in the high-GI preparations.

ACCEPTABILITY RANKING FOR LOW GLYCAEMIC INDEX LUNCHES

Table II compares the ranking that was compiled based on both score scales. Some preparations were placed in the same position in both rankings, such as "Meat soup" (1st place), while the lowest-ranking positions were held by the same three preparations.

DISCUSSION

It is essential to be able to offer the population healthy food preparations with a low GI that may be widely accepted, so that such options will become the preference over traditional diets, which usually present high GI levels based on their cereals and processed derivatives (17).

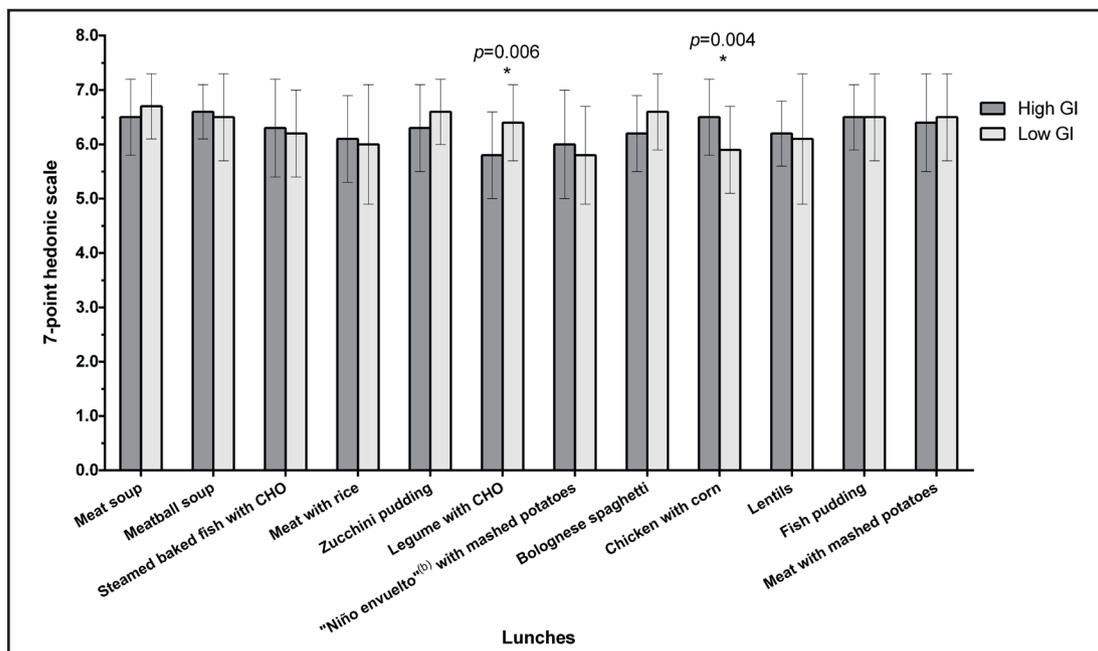


Figure 1.

General acceptability of high and low GI lunches according to a 7-point hedonic scale. Values are expressed as mean ± SD. ■: High glycaemic index; □: Low glycaemic index. ^(a) Lunches are represented with the name of the main dish in each one, and include salad, main dish, and dessert. ^(b) "Niño envuelto" refers to a thin slice of meat wrapping vegetables in sticks. *Statistically significant difference.

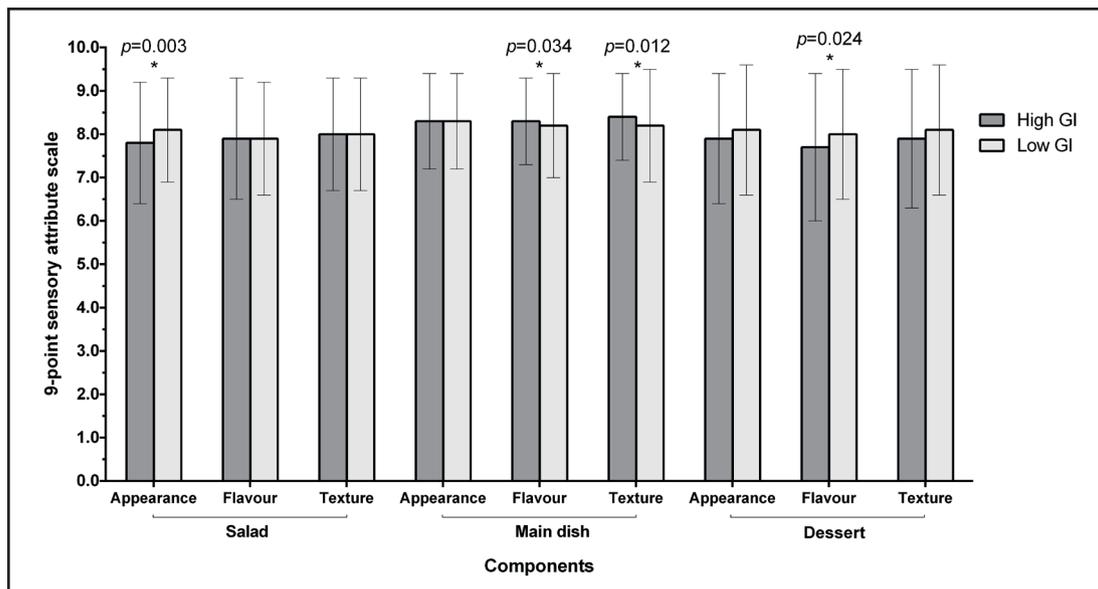


Figure 2.

Acceptability evaluation of sensory parameters on a 9-point scale for the components of the high and low-GI lunches. Values are represented as mean ± SD. ■: High glycaemic index; □: Low glycaemic index. *Statistically significant difference when comparing the attributes of each GI group, as measured by Student's t-test for paired samples.

In the present study, 12 preparations that are typically consumed in Chile were used as determined by Pincheira's study (14) with a high GI, and from them it was possible to obtain 12 low-GI counterpart dishes, with a significant difference when comparing

the average GI obtained between both preparations. In order to remove the interference of GL (glycaemic load) from the preparations, and isolate the GI as the main variable, all the menus were prepared with a total of 50 to 60 g of CHO.

Table II. Acceptability ranking for low glycaemic index lunches according both scales

Ranking	7-point hedonic scale ^(b)	9-point sensory attribute scale ^(b)
1	Meat soup	Meat soup
2	Zucchini pudding	Meatball soup
	Bolognese spaghetti	
3	Meatball soup	Fish pudding
	Fish pudding	Meat with mashed potatoes
	Meat with mashed potatoes	
4	Legumes with CHO	Zucchini pudding
5	Steamed baked fish with CHO	Legumes with CHO
		Bolognese spaghetti
6	Lentils	Lentils
		Steamed baked fish with CHO
7	Meat with rice	"Niño envuelto" ^(a) with mashed potatoes
8	Chicken with corn	Meat with rice
9	"Niño envuelto" ^(a) with mashed potatoes	Chicken with corn

CHO: carbohydrates. ^(a) "Niño envuelto" refers to a thin slice of meat wrapping vegetables in sticks. ^(b) Two or three preparations in the same level represent a tie in that ranking position.

In order to modify and convert high-GI lunches into low-GI preparations, the extrinsic and intrinsic factors that modify the speed of digestion for food CHO, and therefore their GI, was used. The mechanical process was considered a variable to modify from the typical preparations habitually used, which by reducing the size of food particles allow a greater surface/volume ratio and thus make them more susceptible to salivary and intestinal amylases, increasing in this way the GI (18). In this sense, a study showed that a one-inch potato cube increases its GI by 25 % if crushed, depending also on factors such as type of starch, physical form, and gelatinization ability (19).

For some preparations (legumes with cereals, pastries, mashed potatoes, rice, etc.), starch gelatinization was considered a determinant factor of GI, with granules absorbing water, thus considerably increasing their volume and viscosity. This structural change increases physical accessibility and facilitates the function of intestinal enzymes during the digestive process, thus increasing the GI of food (20). For example, raw potato is less digestible than cooked potato, where the hydrolysis of starch is favoured by the capacity to become gelatinized at high temperatures (55-66 °C) in the presence of water. In this situation, the endogenous amylases are activated during the cooking process, and before being denatured by the effect of temperature they manage to degrade the starch to dextrins (19).

In the present study, the use of dry heat was encouraged in the preparations of low GI, instead of humid heat (21). The insoluble fibre content of each food was also considered, as this could act as a barrier to amylase function, and therefore further reduce glucose absorption, which decreases the GI of the preparations (22).

On the other hand, the soluble dietary fibre, both at the gastric and intestinal level, as a result of its viscosity, slows gastric emptying and transit time, respectively, in addition to the small intestine, which increases the thickness of the layer of water that should pass the solutes to reach the membrane of the enterocyte, generating a reduction in glucose absorption and thus resulting in a flattened glycaemia curve with an insulin response according to the demand of glycaemia. To achieve the described properties, it was necessary to consider the amount of dietary fibre contained in each food, with or without peel, raw or cooked food, and the consumption of pulp or juice squeezed from fruit (23,24).

In some of the preparations, the addition of foods rich in proteins and fats played an important role. The proteins to be consumed with CHO generate a delayed increase in insulinemic response, which is on average 3-4 hours postprandial. The phenomenon is especially evident with pasta, where the presence of gluten slowed the action of digestive amylases, which limits the absorption of glucose. In the case of fats, it has been seen that, when consumed in conjunction with CHO, the area under the curve of the glycaemic response diminishes within the first 2-3 hours, which may be due to delay in gastric emptying (10). It should also be noted that a decrease in GI occurs through the intestinal hormones known as incretins, where the glucagon-like peptide-1 (GLP-1) stimulates the production of insulin, and is secreted in the L-cells of the ileum after ingestion of fats. This peptide promotes a reduction of the stomach's acid secretion and intestinal motility, which decreases the rate of absorption of nutrients, and in turn increases the sensitivity of peripheral tissues to insulin (11,12). A clear example can be seen by placing a potato into the oven without fat, which has a higher GI (95 %) than a potato chip to which fat has been added during cooking (75 %) (19).

Another factor to consider is the production process and manufacturing of the products. Indeed, certain industrial processes lead to an increase in gelatinization, as is the case with the manufacturing of instant mashed potatoes, which increases by about 30 % their GI when compared with natural mashed potatoes (4,25). On the other hand, the process of pasta binding decreases its GI due to the extrusion of the dough, which leads to a heating effect that results in the formation of a protective layer that will help slow down starch gelatinization during cooking. This is applicable for long pasta such as spaghetti and noodles; however, research has shown that short pasta made from the same flour may have higher, even 2-fold values due to an increase in contact surface with digestive enzymes and their increased propensity to gelatinize, just as happens with soup noodles (82 %) as compared with spaghetti (40 %) (16).

The challenge of this study was making culinary changes that would convert a high-GI preparation into a low-GI one, while maintaining a good level of acceptability. Regarding the results

of general acceptability for each menu in both groups, a high level of approval was successfully achieved. This result was similar to that shown in a clinical trial in subjects with obesity (26). The averages obtained in most of the high- and low-GI lunches were higher than 6 points ("I moderately like it"); only 3 obtained average scores below 6 points, presenting the most noticeable differences with their counterparts; however they did exceed the established optimal cut-off point. When evaluating the average acceptability of the salads, main dishes, and desserts consumed in the low- and high-GI lunches, it was observed that, while there were no significant differences between both lunches in each group, all of them exceeded 6 points on average, with the main dishes having a higher average than the others.

When comparing the specific acceptability values of the salads, main dishes, and desserts that made up each high- and low-GI lunch, it was observed that the best evaluations applied to main dishes, either high- or low GI. In another hand, the most noticeable differences between high- and low-GI meals were found in desserts, which can be attributed to menu variability, personal preferences in taste, complexity of preparations, and/or the high prevalence of fruits, considering that usual consumption of fruits in Chile has decreased (27).

The "legumes with CHO" menu showed greater acceptability in its low-GI version, possibly due to a significant difference specifically in its dessert (Bavarois), which could probably be attributed to the addition of evaporated milk generating changes in consistency and flavour. On the contrary, the "chicken with corn" high-GI main dish and dessert showed significantly greater acceptability than their low-GI counterparts, possibly because the subjects preferred the preparation containing a whole piece of chicken separated from the stew to small pieces of chicken amongst a mixture of vegetables, which is commonly a preference related to the visual size of the portion of food on each plate (28,29). In relation to the dessert, the high-GI version had a higher score than the low-GI "oats with milk", most likely because texture and appearance were not well received, this being a dish that is seldom eaten. Evidence showed that this pattern of behaviour repeated itself, with high-GI food obtaining greater acceptability scores than low-GI food when the latter version had ingredients not commonly used on a daily basis (30,31).

It should be noted that two methods of sensory evaluation were used, one that assessed general acceptability and one that assessed attributes separately, achieving a consensus in the final ranking of the best and worst menus. These findings confirm the reliability of the results obtained.

CONCLUSION

Given that the population has a strong preference for high-GI food and preparations, the introduction of low-GI diets could be quite challenging, as it would be necessary to implement changes to promote a decrease in GI, something that would be unusual for the population and their eating habits. This study was able to show that it is possible to produce low-GI menus equivalent

to traditional ones that are perceived as generally acceptable, and that have some components (salad, main dish or dessert) with high acceptability scores, equal to or even better than typical Chilean culinary preparations, as well as components that could not achieve a greater acceptability.

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