DETERMNATION OF GLYCEMIC INDEX (GI) OF SELECTED POPULAR YEMENI FOODS

RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor

in

Department of Therapeutic Nutrition

Submitted by

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INTERNATIONAL MALAYSIAN UNIVERSITY

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2022

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TO

International Malysian University

IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE AWARD OF

Bachelor of Therapeutic Nutrition

YEAR

2022

DECLARATION BY STUDENT

CERTIFICATE

We are hereby certify that we had personally carried out the work depicted in the research project entitled “**Determination of Glycemic Index (GI) of Selected Popular Yemeni Foods"**

No part of the thesis has been submitted for the award of any other degree or diploma prior to this date.

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الخلاصة

الخلفية : يعتبر المؤشر الجلكوزي نظامًا بديلًا لتصنيف الغذاء إعتمادًا على جودة النشويات و سرعة إمتصاصها و مراقبته تعتبر ذات أهمية حيثُ انه يقوم ب علاج السكر و السيطرة عليه . عن طريق إستهلاك النشويات ذات المؤشر الجلكوزي المنخفض .

طريقة العمل : هذه الدراسة وضعت لقياس المؤشر الجلكوزي لبعض الأطعمة التقليدية المُستهلكة بشكل متكرر من قبل المجتمع اليمني . حيث تم اختيار الشوربة، الفتة، الزوم ، السلته، بنت الصحن، الشفوت، العصيدة، و الجلوكوز(كنترول) لقياس المؤشر الجلكوزي.

النتائج: قيم المؤشر الجلكوزي للأطعمة التي تم اختيارها كانت مرتفعة. حيث أن النتائج للمؤشر الجلكوزي لكل من الأغذية لسبعة كانت ما بين 70.68 إلى 84.39 . فالمؤشر الجلكوزي لبنت الصحن كان 84.39 و هو أعلى قيمة بين الأغذية و أقلها كانت الشفوت 70.68.

الخاتمة: من خلال تقييم المؤشر الجلكوزي للأطعمة التقليدية ؛ يُستنتج أن الأطعمة التي تم اختيارها و التي تعتبر من أشهر الأغذية في الشارع اليمنية ، بأنها ذات مؤشر الجلكوزي عالي . و الذي يؤكد بأن العادات الغذائية و استهلاك الأطعمة الشعبية تحتاج إلى ان تكون مرتبطة مع الأسباب الأخرى التي قد تؤدي إلى ارتفاع نسبة السمنة في اليمن وكذلك أنتشار بعض الأمراض المزمنة كالسكر.

الكلمات المفتاحية :

المؤشر الجلكوزي، الأغذية التقليدية ، الأغذية اليمنية ، طلاب جامعيين.

الملخص

مقدمة: يعتبر المؤشر الجلكوزي نظامًا بديلًا لتصنيف الغذاء اعتمادا على جودة النشويات و سرعة امتصاصها. ومراقبته تعتبر ذات أهمية حيثُ انه يقوم بعلاج السكر و السيطرة عليه عن طريق استهلاك النشويات ذات المؤشر الجلكوزي المنخفض.

طريقة العمل : هذه الدراسة وضعت لقياس المؤشر الجلكوزي لبعض الأطعمة التقليدية المُستهلكة بشكل متكرر من قبل المجتمع اليمني. حيث تم اختيار الشوربة، الفتة، الزوم ، السلته، بنت الصحن، الشفوت، العصيدة، و الجلوكوز(كنترول) لقياس المؤشر الجلكوزي .

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الاستنتاجات: من خلال تقييم المؤشر الجلكوزي للأطعمة التقليدية ؛ يُستنتج أن الأطعمة التي تم اختيارها والتي تعتبر من أشهر الاغذية في الشارع اليمنية بأنها ذات مؤشر الجلكوزي عالي . والذي يؤكد بأن العادات الغذائية و استهلاك الأطعمة الشعبية تحتاج إلى ان تكون مرتبطة مع الأسباب الأخرى التي قد تؤدي إلى ارتفاع نسبة السمنة في اليمن وكذلك انتشار بعض الامراض المزمنة كالسكري.

الكلمات المفتاحية :

المؤشر الجلكوزي ، الاغذية التقليدية ، الاغذية اليمنية ، طلاب جامعيين.

Abstract

Background: Glycemic index (GI) is currently considered as an alternative system that classifies food according to the carbohydrate quality (CHO), measuring its absorption speed. Glycemic control is important in the treatment and control of diabetes and consumption of low GI-containing carbohydrates is the main approach.

Methodology: This study was planned to determine in vitro glycemic indices of some traditional foods frequently consumed by Yemeni nation. Glycemic indices of Soup, Fatta, Zoum, Salta, Bint Alsahn, Shaffot, Asidaand, and glucose was taken as reference. . Six healthy subjects aged between 20 and 25 years old participated in this study.

Results: The GI values had high glycemic index among the foods tested. These results showed that the GI values for the seven test foods ranged from 70.68 to 84.39.Test foods (Bint Alsahn) had the highest GI value (84.39) while test foods (Soup) had the lowest GI value (70.68).

Conclusion: In the assessment of the GI value of traditional foods, the present study can conclude that the selected test foods, commonly consumed in Yemen culture, had high GI values. These findings emphasize that the dietary habits and the consumption of traditional foods need to be assessed in connection with other factors with the evidence of the increasing prevalence of obesity in the Yemen.

Key words

Glycemic Index; Glycemic Control; Traditional Foods; Yemeni foods, University students.

Abbreviations

GI	Glycemic Index
GL	Glycemic Load
iAUC	incremental Area Under the Curve
CHO	Carbohydrates
AUC	Area Under the Curve
LGI	Low Glycemic Index
HGI	High Glycemic Index
WHO	The World Health Organization
BMI	Body Mass Index
B-glucose	Blood Glucose
C.B.C	Complete Blood Count
R.B.S	Random Blood Glucose
G	Gram
Ml	Milliliter
m2	Meter Square
Kg	Kilogram
SD	Standard deviation
%	Percentages
et al.	et alia (and associated)
i.e.	(ed est) that is
e.g	For Example
Mins	Minutes
No.	Number
SPSS	Statistical Package for the Social Sciences
>	Is less than
<	Is more than

List of Tables

List of figures

Contents

Chapter-I

Introduction

Chapter-I

Introduction

1.1 Overview

The rising rates of non-communicable diseases (chronic diseases and their associated metabolic disorders) are due to two factors namely: the demographic change and the increasing prevalence of overconsumption and inactivity associated with the Western lifestyle. These have public health and economic implications, and continue to be a matter of great concern. With the world's population aged 60 years or more increasing at more than three times the overall population growth rate and rising to about 1200 million in 2025, the importance of lifelong health promotion and disease prevention activities that can prevent or delay, the onset and severity of non-communicable diseases and promote healthy ageing should be considered (WHO, 2012). This has resulted in continued interest in both diet and lifestyle modifications in prevention and treatment of chronic diseases.

Carbohydrates are the most important nutrient of our diet, in terms of fulfilling energy requirements and other metabolic functions. They represent 45–55% of our daily energy intake, 10–15% being simple carbohydrates or sugars, the remainder being starches and oligosaccharides (Blaak et al., 2016). Carbohydrate intake has been a fairly neglected area until recently, even though carbohydrate accounts for most calories in most diets. There is increasing evidence that both the amount and type of carbohydrate play an important role in weight management and risk of chronic diseases. Classifying carbohydrates according to their post-prandial glycemic effect (ie, the glycemic index of foods) has yielded more useful insights than the historical distinctions of simple versus complex chemical structure. Diets based on carbohydrate foods that are more slowly digested and absorbed (ie, low glycemic index diets) have been independently linked to reduced risk of type 2 diabetes, cardiovascular disease, and some types of cancer (Marsh, 2011).

Glycemic index (GI) is a physiological classification of the available carbohydrate content in foods, first proposed in 1981 (Jenkins et al., 1981). The current findings, together with the fact that there are no demonstrated negative effects of a low glycemic index diet, suggest that the glycemic index should be an important consideration in the dietary management and prevention of obesity and chronic diseases(Liu et al., 2001). By definition, the GI compares equal quantities of carbohydrate and provides a measure of carbohydrate quality but not quantity. In 1997 the concept of Glycemic Load(GL) was introduced by researchers at Harvard University to quantify the overall glycemic effect of a portion of food. Thus, the GL of a typical serving of food is the product of the amount of available carbohydrate in that serving and the GI of the food. The higher the GL, the greater the expected elevation in blood glucose and in the insulinogenic effect of the food.

The longterm consumption of a diet with a relatively high GL (adjusted for total energy) is associated with an increased risk of type 2 diabetes and coronary heart disease (Liu et al., 2001). Rice is the most important staple and a major source of carbohydrate in the Asian diet. Rice is being widely used in human nutrition as a source of energy due to its high starch level (approximately 90% in polished white grains). However, the level of starch can vary among grains of different varieties due to genetic and environmental factors.

The values of total starch can vary and the rate and extension of starch digestion can be influenced by different factors, including variation in the amylose: amylopectin ratio, grain processing, physicochemical properties (particularly gelatinization characteristics), particle size and the presence of lipid–amylose complexes. The main differences in starch composition that influence physicochemical and metabolic properties of rice are caused by variation in the proportions of its two macromolecules, amylose and amylopectin. Amylose is essentially a linear molecule in which D-glucose units are linked by a-1,4 glucosidic bonds, while amylopectin, a branched polymer, contains both a-1,4 and a-1,6 bonds. The amylose: amylopectin ratio is inversely correlated to GI. Rice has given a wide range of results in glycaemic index (GI) studies around the world. The GI of white rice has ranged from as low as 54 to as high as 121 when bread (GI = 100) is used as the reference food (Jenkins et al., 1988; Brand, 2003). This makes it difficult to classify rice as a high- or low-GI food and advice to individuals with diabetes may be incorrect if the product has not been specifically tested first. It is likely that much of the variation in the GI of rice is due to differences in the proportion of starch present as amylose. i.e. amylose: amylopectin ratio. Most rice contains 20% amylose but varieties that contain a higher proportion of amylose (e.g, 28%) have been shown to have a slower rate of digestion and produce lower glycaemic and insulin responses.

The classification of rice as a high- or low-GI food may therefore depend on the amylose content of commercial varieties, but the consumer has no way of determining this from the food label. While it may present challenges for food manufacturers to develop low glycemic index foods, it is well worth to develop these products because of the prevalence of diabetes and pre-diabetes in the region and beyond. It is estimated that by 2030, more than 16 percent of the global population will have a blood sugar problem. "Most of the risk factors are things that can be managed and modified.” "We can reverse pre-diabetes and prevent it from becoming diabetes. Food has become the reason for what's ailing us, but it can actually be a solution in a number of different ways."(IFT, 2012) During the last few years, there has been a large body of data that suggests a diet composed of low GI foods has a role to play in the prevention or treatment of a number of chronic diseases including type 2 diabetes mellitus, cardiovascular disease and cancer. Despite the existence of these supporting data the utility of glycemic index as a tool in the daily diet is still not well utilized due to lack of awareness and educational resources about the concept.

Existing data also support that there is a perceived deficiency in reliable glycemic index education available to the public and the nutrition educators(Grant & Wolever, 2011). The application of the low GI concept in the prevention and management of diet related chronic diseases continues to be a topic of debate due to the following factors:

In-vivo determination of glycemic index (GI) – methodological issues in available carbohydrate analysis and glycemic index testing. There are very few accredited glycemic index laboratories in the world providing credible data on glycemic index values for foods

- Lack of data on the glycemic index of commonly consumed foods.
- In-vivo determination of glycemic index is very expensive and time consuming
- There are no locally manufactured low glycemic index products available to the consumers
- Lack of awareness of glycemic index concept

1.2 Problem Statement

The applied research on the GI is growing in recent years. In Yemen the applied research on GI has growing but yet the established GI database for Yemeni foods is still absence. The research in Gl testing on Yemeni foods is still at its infancy.. This not absolutely be able to represent Yemeni foods as Malaysian culture comprises of multi-ethnical races. Even a food with known GI value is a similar food from Yemen, but food that originated from Yemen is not available. Health professional needs to carefully look into Gl International Table to replace it with the similar food

1.3 Significance of the Study

As the research on GI values of Yemeni food is still at its early stage, thus the findings from this study is believed to contribute to the GI values database of local foods. Along with the establishment of Gl database Yemen, health professionals can use it wisely in dietary guidelines and health recommendation. On the other hand, with the increasing interests of applied research in Gl, the findings of this study and along with the development of local Gl database, is believed to serve as a basis for GI intervention and health recommendations in the future.

1.4 Objectives

1.4.1 General Objective

To investigate and estimate the Glycemic Index values of selected commonly consumed foods in Yemen

1.4.2 Specific Objectives

1. To determine the glycemic response calculated as area under the curve (AUC) of healthy subjects after consuming the reference food and test food groups.
2. To determine GI value of selected commonly consumed foods in Yemen.

Chapter-II

Review of Literature

Chapter-II

Review of Literature

2.1. Overview

This chapter aims to provide evidence of the relevant scientific background of the studies contained in this thesis and to establish the theoretical basis for these studies. First of all, the concept of glycaemic index (GI) and factors influencing the GI of a food and meal are described. Then the energy metabolism and the impact of GI of high carbohydrate (CHO) diets on exercise energy metabolism and performance will be considered in relation to energy substrate availability and utilisation during endurance exercise. Finally, the impact of high CHO diets and the GI on plasma lipids and insulin sensitivity in healthy and disease state individuals will be also discussed.

The concept of glycemic index (GI) was first proposed by Jenkins and colleagues in 1981 to study the impact of the rate of carbohydrate absorption on blood glucose level after a meal (Jenkins et al., 1981). It was initially proposed as a method of ranking carbohydrate-containing foods based on the extent blood glucose level is raised, as learning the glycemic effects of specific food products may allow an in-depth understanding of physiological effects of whole diets (Wolever, Jenkins, Jenkins and Josse, 1991).

The GI of food products is divided into three classifications: high (>70), medium (55-70), and low (<55) (Kalergis, Grandpre and Andersons, 2005). Digestion and absorption of low GI foods occurs slowly, whereas for high GI foods, digestion and absorption occurs rapidly, resulting in varied glycemic responses. For this reason, low GI foods were proposed to induce many health benefits (Kalergis et al., 2005; Granfeldt, Xu and Bjorck, 2006).

Meaning of Glycemic Index The concept of glycemic index (GI) was first proposed by Jenkins and colleagues in 1981 to study the impact of the rate of carbohydrate absorption on blood glucose level after a meal (Jenkins et al., 1981). It was initially proposed as a method of ranking carbohydrate-containing foods based on the extent blood glucose level is raised, as learning the glycemic effects of specific food products may allow an in-depth understanding of physiological effects of whole diets (Wolever, Jenkins, Jenkins and Josse, 1991). The GI of food products is divided into three classifications: high (>70), medium (55-70), and low

2.2. The Concept of glycaemic index and glycaemic load

In the past, CHO was classified as simple sugars and complex CHO based on their chemical composition. Simple sugars include the monosaccharides (glucose, fructose and galactose) and disaccharides (sucrose, maltase and lactose) and complex CHO are long polymers of glucose (starch). It has been assumed that the chemical composition could predict the plasma glucose and insulin responses following ingestion of CHO foods with simple CHO producing a rapid rise and fall in glucose and insulin while complex CHO produce a flatter response. However, it has been observed that CHO foods independent of whether they are based on simple or complex CHO elicit very individual effects on plasma glucose quite separately and unpredictably from its chemical composition due to various factors that influence their rate of digestion and absorption (Millet et al., 1995). Thus, these lead David Jenkins and colleagues (Jenkins et al., 1981) to propose the concept of GI. It was developed to obtain a numeric physiological classification of CHO foods based on the rate of CHO digestion and absorption and to define CHO foods according to their actual postprandial glycaemic impact. Primarily, it was developed to aid individuals with diabetes and hyperlipidemia for better controlling their plasma glucose levels while following a low fat, high CHO diet. The GI is a ranking of foods based on their actual postprandial plasma glucose response compared to a reference food, either glucose or white bread (Jenkins et al. 1981). The GI is calculated by measuring the incremental area under the plasma glucose curve following ingestion of a test food providing 50 g of CHO, compared with the area under the plasma glucose curve following an equal CHO intake from the reference food, which is set to be 100 (Jenkins et al., 1981). Capillary blood samples was taken in the fasted state and at 30 minutes intervals for 2 hours after the ingestion of CHO, with all tests being conducted on the same individual after an overnight fast (FAO, 1998). The capillary blood technique was easier to conduct, produced greater glucose concentration and less variability than venous plasma (Wolever & Bolognesi, 1996). Thus, differences between foods were larger and easier to detect statistically using capillary plasma glucose. Since plasma glucose responses vary considerably from day-to-day within participants, it was recommended that the standard food should be repeated at least three times in each participant to obtain a representative mean response to the standard food (Brouns et al., 2005). Originally the reference food used for calculating the GI was glucose (Jenkins et al., 1981). Now the more commonly used reference food is white bread containing 50g of CHO (Jenkins et al., 1988) than glucose because it is more palatable and avoids the possibility of delayed gastric emptying from the high osmolality of a glucose solution (Jenkins et al., 1984). However, 50 g CHO in white bread is more difficult to determine accurately than is 50 g glucose.

For the GI data, the area under the curve (AUC) is calculated as the incremental area under the plasma glucose response curve (IAUC) (FAO, 1998) and above the fasting plasma glucose concentrations ignoring the area beneath the fasting concentrations (Brouns et al., 2005; Wolever et al., 2003). Therefore, when a plasma glucose value falls below the baseline, only the area above the fasting level is included. This can be calculated geometrically by applying the trapezoid rule as described in Wolever & Jenkins (1986).

The GI of a food depends on the rate at which the CHO is digested in the gastrointestinal tract and the rate of absorption into the bloodstream (Jenkins et al., 1982) which influences the extent and duration of the rise in glucose concentration after a meal. The insulin responses are related to the postprandial glycaemic responses (Wolever & Bolognesi, 1996). In general quickly digested and absorbed CHO will produce a rapid increase in plasma glucose and pancreatic insulin secretion which promotes glucose uptake to counteract the rise in plasma glucose concentrations, sometimes leading to a reactive hypoglycaemia. On the other hand, CHO in a low GI (LGI) food is absorbed at a slower rate than CHO from a high GI (HGI) food, which results in reduced postprandial glycaemia and insulinemia. In essence, the GI reflects the rate of digestion and absorption of a CHO-rich food. It compares equal quantities of CHO and provides a measure of CHO quality but not quantity. Therefore, the GI allows foods to be categorized according to having a low, moderate or high GI. CHO foods evoking the greatest responses are considered to be HGI foods, while those producing a relatively smaller response are categorised as LGI foods. A food is said to be of a high GI if it has a value of more than 70, of moderate GI if it has a value of between 56 and 69, and low GI if lower than 55 (Foster-Powell, 2002). It is important to note that the GI allows only for a relative comparison among foods, as a prerequisite for its measurement is the intake of available CHO, which is the CHO that is absorbed via the small intestine and used in metabolism, preferably in an amount of 50g (Jenkins et al., 1981). The methodological requirement for the GI determination applies solely to the situations where food servings contain only the amount of CHO used. However, CHO foods are seldom eaten alone, but rather as a part of mixed meal. In common day-to-day situations, the amount of CHO content ingested in foods and meals varies greatly. To overcome this problem glycaemic load (GL) was proposed by Salmeron et al. in 1997 as the arithmetic product of GI and CHO amount to quantify the overall glycaemic effect of a portion of food (Salmeron et al., 1997). This can be estimated by multiplying the GI of the food with the amount of CHO (in grams) presents in a specified serving size of that food and dividing by 100. For example, spaghetti has a lower GI than white bread, but normal portion size of spaghetti are commonly larger than portion of a white bread. Therefore GL may or may not differ between these two CHO sources, depending on applicable GI values and portions size.

GL would seem to be a much better predictor than the amount of CHO alone, because similar glycaemic responses were observed among foods differing in available CHO by more than twofold (Brand-Miller et al., 2003). This finding is consistent with Wolever & Bolognesi (1996) who reported that both GI and the amount of CHO are necessary to explain most of the observed variability in glycaemic response.

The GL is important as the higher this is, the greater the glycaemic response and therefore the insulinemic response, as insulin is released in response to glucose entering the bloodstream. A low GL food is considered to have a GL of less than

10, whilst a high GL food is considered to have a GL of 20 or more and of medium GL food when GL is between 10 and 20 (Salmeron et al., 1997).

2.3. The glycemic index (GI) :

The glycemic index has been known as a value assigned to foods based on how quickly and how high those foods cause increases in blood glucose levels.(1) As well it's defind as a system of assigning a number to carbohydrate-containing foods according to how much each food increases blood sugar. The glycemic index itself is not a diet plan but one of various tools — such as calorie counting or carbohydrate counting — for guiding food choices (2) . In other words Glyscemic Index described as the incremental blood glucose area (0-2 h) following ingestion of 50 g of available carbohydrates in the test product as a percentage of the corresponding area following an equivalent amount of carbohydrates.(3)

Furthermore the Glycemic index (GI) is a measure of the glucose response to ingestion of a fixed amount of available carbohydrates; glycemic load (GL) combines the qualitative and quantitative measures of carbohydrates and is the product of the GI and the amount of carbohydrates consumed. High-GI diet has been positively associated with obesity in adult, but epidemiological studies in humans so far have been inconsistent. The glycemic index ranks carbohydrate containing foods on how quickly they elevate blood sugar levels. It is measured by comparing the increase in blood sugar after eating 50 grams of carbohydrate from a single food with the increase in blood sugar after eating the same quantity of carbohydrate from a reference food, which is either pure glucose or white bread. The average change in blood sugar levels over the next two hours, compared to the change in blood sugar levels after consuming the reference food, is the glycemic index value of that particular food. The blood sugar response of the reference food is given a value of 100 and all other foods are compared to this value (Brand-Miller et al., 2003). Foods containing carbohydrates that are quickly digested have the highest glycemic index, since the blood sugar response is fast and high. Slowly digested carbohydrates have a low glycemic index, since they release glucose gradually into the bloodstream (Brand-Miller et al., 2003). In general, most refined carbohydrate-rich foods have a high glycemic index, while non-starchy vegetables, fruits and legumes tend to have a low glycemic index. (4)

While in some books the glycemic index is a scale that ranks the number of carbohydrates in foods from zero to 100, indicating how quickly a food causes a person’s blood sugar to rise.(5)

Also glycemic index is a tool that’s often used to promote better blood sugar management. Several factors influence the glycemic index of a food, including its nutrient composition, cooking method, ripeness, and the amount of processing it has undergone. The glycemic index can not only help increase your awareness of what you’re putting on your plate but also enhance weight loss, decrease your blood sugar levels, and reduce your cholesterol. (6) And some scientists said that Glycemic index is a number. It gives you an idea about how fast your body converts the carbs in a food into glucose. Two foods with the same amount of carbohydrates can have different glycemic index numbers.(7) Amd Glycemic Index in other words can be a measure of the rise in blood sugar after eating a food that contains carbohydrates. (8)

In addition it is a numerical index of how your blood sugar is affected within two to three hours of eating foods that are high in carbohydrates and how they turn into blood glucose.(9)

2.4. Factors influence GI

The rate of digestion and absorption of the CHO-containing foods, and therefore the GI values, are influenced by the nature of the food and the type and extent of food processing. The nature of the food includes the amount and type of dietary fibre, the presence of large amount of fat or protein, nutrient-starch interactions in CHOcontaining foods such as wheat products, the ratio of amylose to amylopectin present in the raw food and antinutrients such as phytic acid, lectins and tannins

Resistant starch and dietary fibre are undigested and not absorbed in the small intestine and therefore contribute little to postprandial glycaemia. However, a lowering glycaemic response has been found when purified extracts of fibre, particularly of the type that forms a viscous gel in water such as guar gum, are added to a test food in a sufficient quantity (Tappy et al., 1996; Wolever et al. 1991).

Findings from several studies investigating the effect of fibre content on the GI of foods are not consistent. Wolever (1990) found that insoluble fibre associated with the GI while Nuttall (1993) suggested that only the soluble fibre has an effect on postprandial glucose concentrations when fibre was added to a CHO. Other studies found no relation between GI and the fibre content of the food (Jenkins et al., 1981) or between the postprandial insulin response to and the fibre content of a food (Holt et al., 1997). In addition, GI cannot be predicted from the fibre content of a CHOcontaining food or from the terms wholemeal and wholegrain for which there are no universal accepted definitions. There were small differences in the GI between brown and white rice, brown and white spaghetti, and whole-wheat and white bread although their fibre contents were quite different. For example, from the GI tables (Foster-Powell et al., 2002), the mean GI of wholemeal bread from 13 studies is 71, while the mean GI of white bread from 6 studies is 70. However, wholegrain when largely intact, have been found to lower GI (Granfeldt et al., 1995).

The addition of protein or fat to CHO-containing foods lowers the overall GI (Miller et al., 2006). Protein that is included in a meal stimulates insulin secretion and reduces postprandial glucose responses (Gannon et al., 1988). Furthermore, protein-rich foods are known to increase insulin secretion without augmenting glucose concentrations (Krezowski et al., 1984; Nuttall et al., 1984). The addition of fat delays gastric emptying which decreases the rate of availability of CHO for digestion and absorption in the small intestine and therefore reduces postprandial glucose responses (Collier et al., 1984; Welch et al., 1987). Adding 5-15 g protein or fat to CHO has been shown to reduce glycaemic responses in normal participants (Owen & Wolever, 2003; Spiller et al., 1987). However, neither fat nor protein in the amounts found in most foods (except for peanuts and most nuts) significantly alters the glycaemic responses (Wolever et al., 1994). Polymers of glucose can occur in a branched form known as amylopectin or linear form known as amylose

(Anisson & Topping, 1994). The GI is affected by the proportion of amylose to amylopectin of the CHO foods. Single strand amylose is digested and absorbed slower than branched-molecule amylopectin, therefore a high amylose: amylopectin ratio decreases the plasma glucose response of starchy foods.

The GI increases when the proportion of amylopectin is higher because amylopectin is more easily hydrolysed in the gut than amylose due to their molecular structures (Vanamelsvoort & Weststrate, 1992).

CHO foods which contain phytic acid produce lower glycaemic response (Thompson et al., 1987). Phytic acid, which is also referred as phytate, is a non-nutrient component of seeds. It is believed to interact with amylase or protein associated with starch, delaying the digestion of starch (Thompson et al. 1987). Other non-nutrients such as lectins and amylase inhibitors may reduce the glycaemic response of foods (Wolever & Jenkins, 1986).

Extrusion, flaking, grinding, canning, storing and cooking of CHO-containing foods can affect the particle size and the integrity of the starch granules (Ocana et al., 1988) and the plant cell walls (Ellis et al., 1991), making the CHO portion more accessible to digestive enzymes (Collings et al., 1981; Wolever, 1990). The method of processing a food can greatly change the GI of the food. Large granules of starch in the CHO foods are broken down by grinding, rolling or pressing so that the amylose or amylopectin become available for hydrolysis. The grinding of food can elicit greater glycaemic responses because ground foods increase the number of food particles and therefore the surface area, making the CHO more accessible for digestion. Ground foods also absorb larger amounts of water during cooking allowing for increased gelatinisation and they may also empty faster from the stomach than ungrounded foods (Collings et al., 1981). Cooking of CHO foods, especially starchy foods can increase the glycaemic response for those foods (Collings et al., 1981). It appears that with cooking, such as boiling, the granules of starch rupture due to swelling, making starch more vulnerable to digestive enzymes.

When the starch is then left to cool or stored for a time, it is gelatinised to which vary in structure depending on the amount of moisture, the amylose to amylopectin ratio and the time and temperature of storage (Annison & Topping, 1994). Retrogradation of starch is a crystallisation of the gel which makes it insoluble thus not amenable to hydrolysis in the small intestine. Repeated cycles of heating and cooling can further the retrogradation (Sievert et al., 1991). The GI of foods is influenced by the heat exposure, the amount of water present, and the time of cooking, (Collings et al., 1981). Thus, the more a starch-containing food is heated, moisturized, ground, or pressed, the more it will be amenable to hydrolysis and digestion, except for the portion that forms insoluble complexes. Processing methods such as extrusion, cooking, explosion, puffing and instantiation make starchy foods more readily digestible (Brand et al., 1985).

The GI values of foods must provide a reliable and consistent measure of relative plasma glucose response, and using the GI to manipulate meals and diets must produce a desired metabolic outcome. The methodology of the determination of the GI has been discussed by numerous authors involving issues such as size of CHO load , 25 or 50 g; reference product, glucose vs. white bread; time of follow-up, 2 or 3 hours and different ways of calculation have been proposed (Wolever, 2004).

Thevariability in the GI values reported by different laboratories for a single food are caused by numerous factors such as the nature of the CHO foods (sugar or starch); the type of sugars (fructose or sucrose); the status of starch (gelatinised or retrograded); the matrix of food (fibres, protein, fat, the amylase : amylopectin ratio, the particle size and food form); the anti-nutrients (enzyme inhibitors, lectins, tannins), differences in processing or cooking techniques (time, temperature, water content, etc), and variation between the particular species of commercial brands of a processed food. In general, published GI values represent the average of the values reported from a number of studies and a number of laboratories (Foster-Powell et al., 2002). Overall, broad agreement has been found between the relative GIs of foods, and the concept is strong enough to cope with inter-individual differences.

2.5. The Relationship between Glycaemic Index and Diabetes Mellitus

The blood glucose is rapidly increased after consumption of high GI foods. In response to this, the body attempts to balance the rise in blood glucose levels by secreting a large amount of insulin. It is considered that repeated overproduction of insulin may lead to insulin resistance in which cells that normally respond to insulin become less sensitive to its effects (Frost et al.,1998). Indeed, excessive intakes of high GI foods over a long period are associated with high insulin levels, insulin resistance, a lower concentration of high density lipoprotein (HDL) and hypertriglyceridaemia (Jenkins et al. 1987). There is a strong positive association between the consumption of high GI of foods and developing risk of T2DM (Sluijs et al. 2010).

High GI foods may alter the risk of T2DM owing to the production of higher blood postprandial glucose concentrations and a greater insulin demand than do low GI foods. It is possible that chronically increased insulin demand may directly increase insulin resistance (Wilkin et al. 2002). Indeed, it is now widely appreciated that insulin resistance precedes the development of T2DM. In contrast, low GI diets have been linked with improvement in metabolic control and decreased risk of development of T2DM due to the fact that they are slowly digested and absorbed, producing a gradual rise in blood glucose and insulin levels (Kalergis et al., 2005). Low GI diet may also improve insulin sensitivity by minimising fluctuation in blood glucose levels and reducing the secretion of insulin over the day [Thomas DE, Elliott EJ 2010)].

Replacing a high GI diet with a . low GI diet might reduce frequent and rapid rise in blood glucose levels and increase the body's sensitivity to insulin. Studies on the postprandial glucose response to CHO-containing foods have demonstrated that the low GI foods decrease the insulin and glucose response compared with high GI foods, suggesting an increase in insulin sensitivity in normal volunteers and in obese insulin resistant subjects [Frost et al., 1996)]. It has been found that a reduction of the fasting plasma glucose concentration in subjects on low GI diets was significantly more pronounced than in those on the high GI diet (Jarvi et al. 1999).

It has also been found that the final values of glycosylated serum proteins (fructosamine) has shown a 7% fall ($p<0.01$) on the low GI diet and a non-significant fall of 2.2% on the high GI diet. Similarly, Frost et al. [1994] have found that a significant fall in fasting blood glucose and fructosamine occurred in type 2 diabetic patients treated only by giving advice to lower the GI of the CHO in their diet for 3 months [Frost et al., 1994)]. These results demonstrated greater improvements in glucose control with a low GI diet as compared to a high GI diet occurred. In addition, the effect of consumption of low GI diet was also shown an improvement in glycated haemoglobin (HbA1c). A study on subjects with diabetes found that significantly better HbA1c levels in subjects consuming a low GI diet compared to the high GI diet group (Heilbronn et al., 2002). In fact, each 1 % decrease in HbA1c was associated with 21% reduction in the risk of diabetic complications (Thomas DE, Elliott EJ 2010).

Indeed, the joint Food and Agriculture Organization (FAO) and World Health Organization (WHO) Expert Consultation Committee advocated the use of low GI diets in the management of individuals at risk of developing diabetes and diabetes-related complications [FAO/WHO, 1998)]. However, the great health benefit of the low GI foods remains to be fully elucidated.

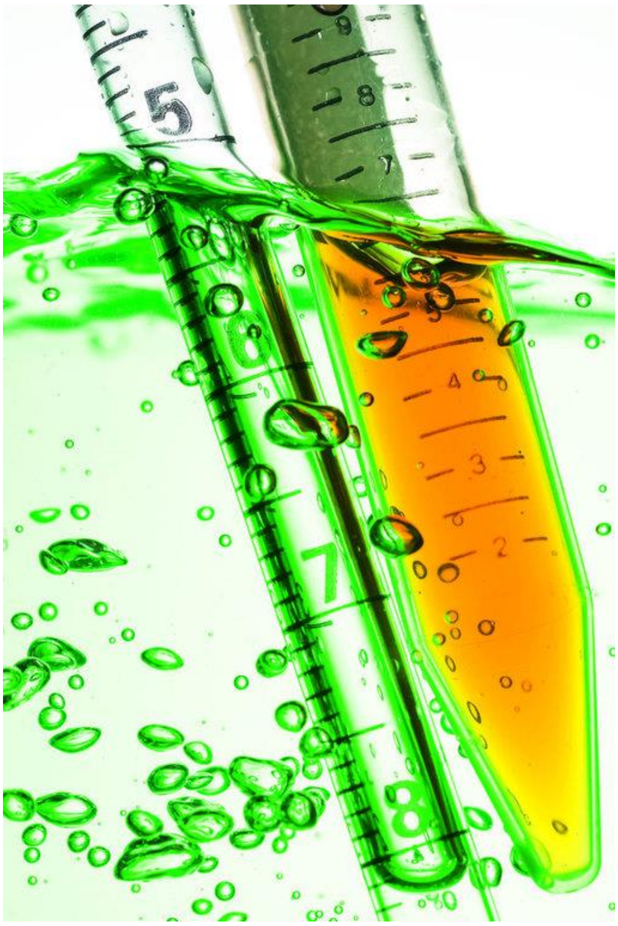
2.6. Definition and Prevalence of Diabetes Mellitus

Diabetes mellitus (DM) is a metabolic disorder characterised by hyperglycaemia and caused primarily by a defect in insulin secretion from the islet cells of the pancreas resulting in an inability of peripheral cells to use glucose (American Diabetes Association, 2014). The number of people with DM in the world is expected to rise from 2.8 % in 2000 to 7.7 % in 2030 due to population growth, aging, effects of modernisation, increase prevalence of obesity and decrease physical activity. It has been estimated that the greatest relative increases in the number of people with diabetes (163 %) will occur in the Middle Eastern region by the year 2030 [Shaw et al., 2009)].

DM is thought to develop for a variety of reasons. Indeed, several pathogenic processes ranging from autoimmune destruction of the β-cells of the pancreas with consequent insulin deficiency to abnormalities that result in the resistance to insulin action (American Diabetes Association, 2014). The majority of cases of diabetes fall into two categories: type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM). T1DM results from β –cell destruction leading to absolute insulin deficiency. Markers of the immune destruction of the β –cell include islet cell autoantibodies, autoantibodies to insulin, autoantibodies to glutamic acid decarboxylase and autoantibodies to tyrosine phosphatises. Some patients with this type of diabetes may present with ketoacidosis as the first manifestation of the disease. This type of diabetes commonly occurs in childhood and adolescence and accounts for only 5-10 % of those with diabetes. People with T1DM present with acute symptoms and markedly elevated blood glucose levels and they need insulin for survival.

T2DM accounts for 90-95 % of those with diabetes and results from progressive insulin secretory defect. The cause of T2DM is thought to be due to a combination of environmental and genetic factors. Most of individuals with T2DM are obese and they do not usually need insulin treatment to survive. The risk of developing this form of diabetes increases with age, lack of physical activity, and obesity. Obesity itself or having an increased percentage of body fat distributed predominantly in the abdominal region causes some degree of insulin resistance. Insulin resistance may improve with weight reduction and/or hypoglycaemic treatment (American Diabetes Association, 2014).

Chapter-III



Materials and Methods

Chapter-III

Research Methodology

3.1. **Getting basic data**

To determine the GI, measured portions of tested food containing 50 g of carbohydrates have been eaten by each of the 6 healthy volunteers after an overnight fast. Fingerprick blood samples has been investigated at 0-20 minute intervals over the next two hours after the meal (at times 0,20,40,60,80,100,120 min; the beginning of the food intake was time 0. (Each volunteer measured his/her B-glucose concentrations by means of a glucometer Optimum).

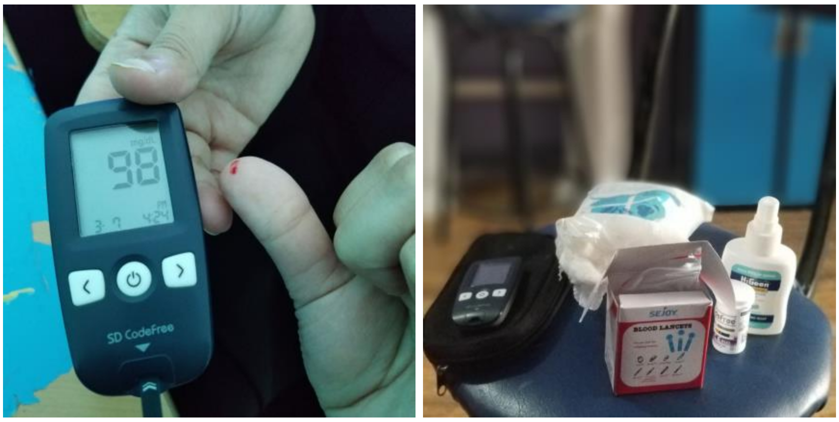


Photo 3:2 Photo of Blood Glucose measurement

3.2. **Construction of B-glucose response curves.**

The averages of the respective B-glucose concentrations after the meal has been used to draw a B-glucose response curve for the two-hour period.

3.3. **Calculations of individual GI values in every volunteer.**

Consistent with the recommended protocol for nondiabetic individuals, the incremental glucose AUC (AUC) was calculated geometrically as the sum of the areas of the triangles and trapezoids over 2 h, excluding the area below the initial fasting glucose concentration. The GI for each individual was calculated by dividing the serum glucose AUC for sample by the mean serum glucose AUC for the reference glucose drink, measured 3 times, and multiplied by 100. These values were then averaged to obtain the mean GI value for each individual.

3.4. **Healthy volunteers**

The participants in this study was healthy persons recruited from the nursing staff, laboratory assistants and students. Thorough clinical and laboratory investigations have been performed to establish that the volunteers were healthy.

3.5. **Tested foods**

The different foods were tested is Shaffot , Saltah, Bint Al-Sahn, Fatta, Asida, Soup, Zoom as showed in Photo (3:1,2,3,4,5,6,7,)

Photo 3:1 Photo of Fahsa

Photo 3:2 Photo of Salta

Photo 3:3 Photo of Bint Al-Sahn

Photo 3:4 Photo of shafota

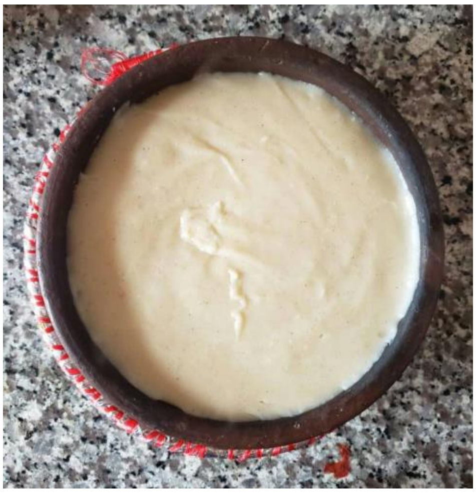


Photo 3:5 Photo of Asida

Photo 3:5 Photo of Soup

Photo 3:7 Photo of Zoom

The food was professionally prepared; the portions have been packed and marked with a set sign. Each serving contain 50 g of samples. Glucose has been dissolved in 300 ml water before drinking.

3.6. **Study design**

1. Each volunteer receive a glucometer Optium and 100 strips (Lot No 51322); everyone was trained in self-monitoring and instruct how to keep to the principles of the study protocol:

- To consume the tested and the standard food daily for breakfast (9:00 h);
- To consume no food from dinner until breakfast; drinking water, mineral water, tea and coffee without sugar was allowed;
- To keep to the same extent of physical exercise during the whole one-week test period;
- Don’t smoke.

2. Each volunteer keep a diary on food intake, exercise and results of B-glucose self-monitoring.

3.7. **Data Analysis and Statistical Methods**

The PC Link has been used to transfer the data from glucometer opium to a PC. MS Excel and statistical program SPSS v. 10.1 were used to analyze the data.

Chapter-IV

Result and Discussion

Chapter-IV

Results and Discussion

4.1. The nutritional assessment of participates

As the study was carried out to estimate the glycemic index of local foods, Six subjects who were willing to participate in the study were selected with normoglycemia (normal blood glucose level). Healthy volunteers between 20-25 years of age having BMI in between the range of 17 and 32 kg/m2 were selected. Physical characteristics of the study population as presented in table (4:1). The laboratory assessment for all participates was carried out and the result presented in table (4:2) the R .B .S was ranged from 83-108 mg/dl, while C .B.C was ranged from 11.2-11.9.

Table 4:1 Physical characteristics of the study population

	Height	**Weight**	**Age**	**BMI**
V1	172	50	23	17
V2	170	65	23	22
V3	163	73	25	32
V3	158	54	23	21
V4	157	45	22	19
V6	165	69	24	25

Table 4:2 Characteristics of subjects participates

Test	V2	V1	V6	V5	V4	V3	Reference values
C .b.c	14.7	14.6	14.8	11.2	11.9	14.8	M 13.5-18.0
R .b .cs	4.70	5.6	5.11	4.8	5.08	4.90	M 4.5--6.5
P .c .v	42.7		43.4	35.1	36.3	36.3	M 42.0-52.0
M .c.v	88.1	84.3	85.0	71.9	71.6	74.9	M 82-98
M .c . h	30.5	29.1	28.9	23.0	23.4	24.4	M 27-32
M .c .h .c	34.7	34.5	34.0	31.9	32.6	33.8	M 30-35
W .b .cs	7.00	4.5	7.12	9.55	9.03	7.00	M 4-11
Neutrophils	63.1	42	30.2	57.7	45.9	48.8	M 40—70
Lymphocytes	25.9	45	64.8	34.2	41.5	39.2	M 20—45
Monocytes	0.6	10	3.6	7.1	8.9	0.6	M 2—10
Esoinophils	0.5	3	0.9	0.6	3.3	0.6	M 1—6
Basophils	00	00	0.5	0.4	0.4	00	M 0—1.0
Platelets count	363	287	328	357	197	343	M 150—450
R .b .s	84	108	88	83	93	88	65—110

4.2. The composition of selected Yemeni traditional foods

The first stage involved in the calculation of the GI value was the proximate composition of the selected foods. Data on the proximate analysis per 100 g of each test food are given in **Table 4:3**.

Table 4:3 Proximate analysis of Yemeni traditional foods (100g)

	Soup	Fatta	Zoum	Salta	Bint Alsahn	Shaffot	Asida
Protein	237.9	564.6	121	116.3	322	137.9	232.8
Fat	0.2	84.4	23.3	13.3	17.2	36.4	42.3
Carbohydrate	18.7	14.2	0.6	33.5	111.5	6.9	5.3
Total calorie	1120.7	2723.2	582.6	819.9	1468.3	759.3	1148.1

4.3. Blood glucose curves

The GI of different varieties of Soup, Fatta, Zoum, Salta, Bint Alsahn, Shaffot, Asidaand, and glucose composite meals were determined and GL was calculated. In total, eight foods were tested for their GI values in an accredited laboratory using the internationally accepted GI testing methodology and the blood glucose concentrations (mg/dl) at time intervals (0, 20, 40, 60,80, 100, 120 min) for traditional Yemeni foods were presented in table (4:4).

Table 4:4 Blood glucose concentrations (mg/dl) at time intervals (0, 20, 40, 60,80, 100, 120 min) for traditional Yemeni foods

	Glucose	Soup	Fatta	Zoum	Salta	BintAlsahn	Shaffot	Asida
0	93.83	96.00	96.17	97.50	98.00	98.33	93.33	91.17
20	196.50	105.50	130.50	102.17	103.67	127.17	96.67	101.83
40	153.33	91.83	111.50	94.50	95.17	120.83	98.00	93.50
60	125.50	89.50	93.67	95.17	98.00	112.00	95.17	98.83
80	118.67	87.67	95.83	93.00	93.50	104.17	93.67	93.67
100	98.17	91.67	94.33	94.00	90.83	104.17	92.17	91.00
120	100.33	87.33	96.50	96.83	91.67	97.17	92.50	90.33

4.4. Glycemic response of food

The mean areas under the glycemic response curves for the standard and test foods are shown in Figure (4:1,2,3,4,5,6,7).

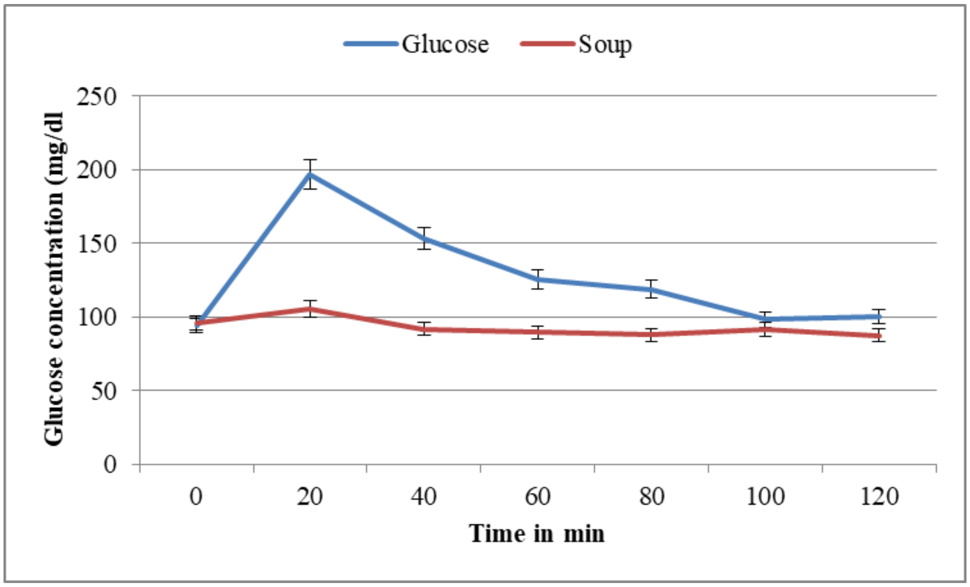


Figure 4.1 The time-averaged area under glucose versus time curve over 120 minutes after consumption glucose and soup diet, n=6.

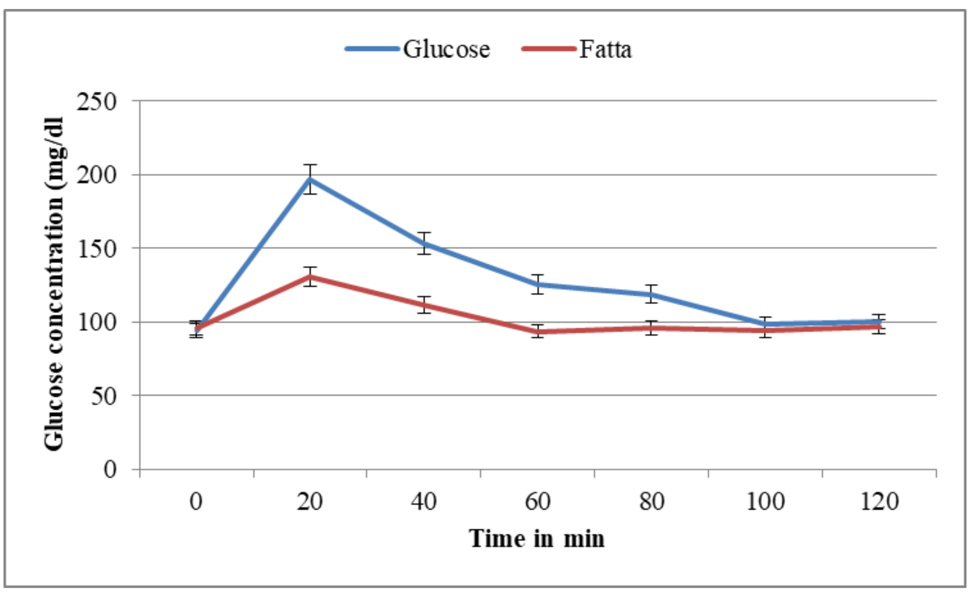


Figure 4.2 The time-averaged area under glucose versus time curve over 120 minutes after consumption glucose and fatta diet, n=6.

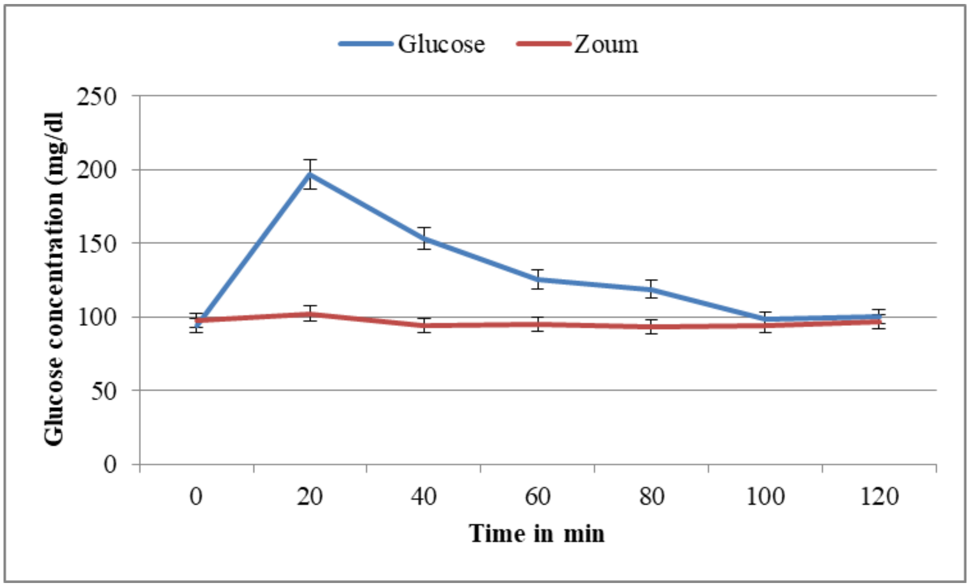


Figure 4.3 The time-averaged area under glucose versus time curve over 120 minutes after consumption glucose and zoum diet n=6.

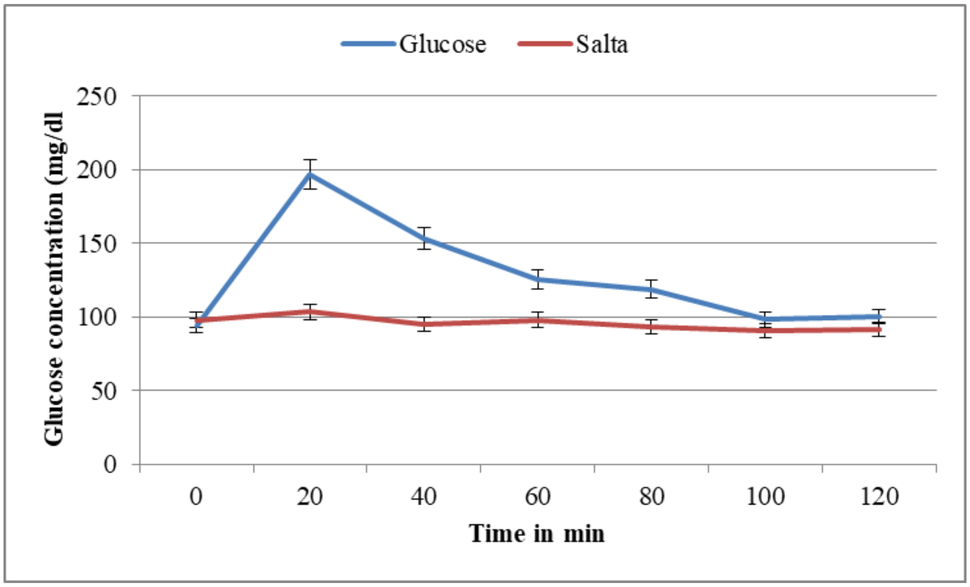


Figure 4.4 The time-averaged area under glucose versus time curve over 120 minutes after consumption glucose and Salta diet n=6.

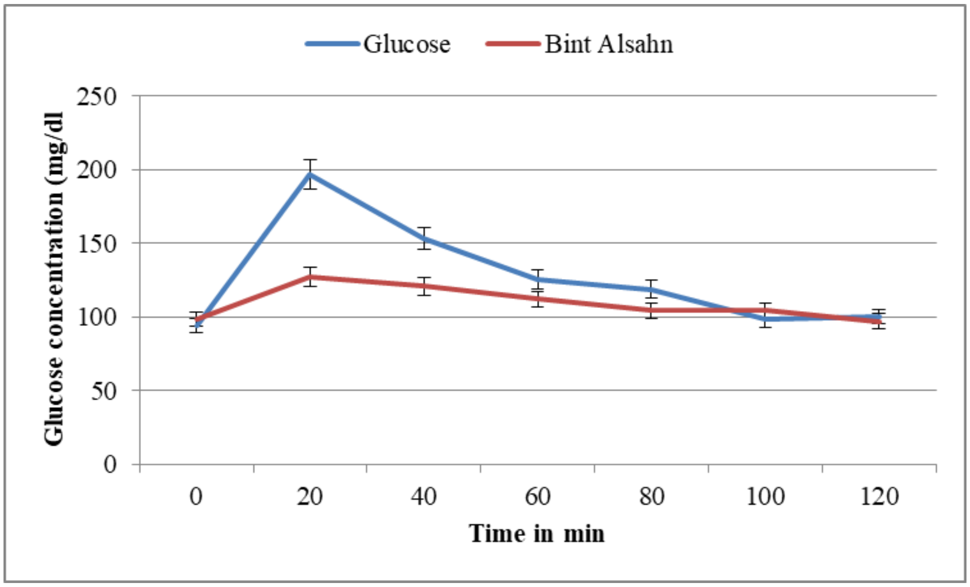


Figure 4.5 The time-averaged incremental area under glucose versus time curve over 120 minutes after consumption glucose and bint alsahn diet n=6.

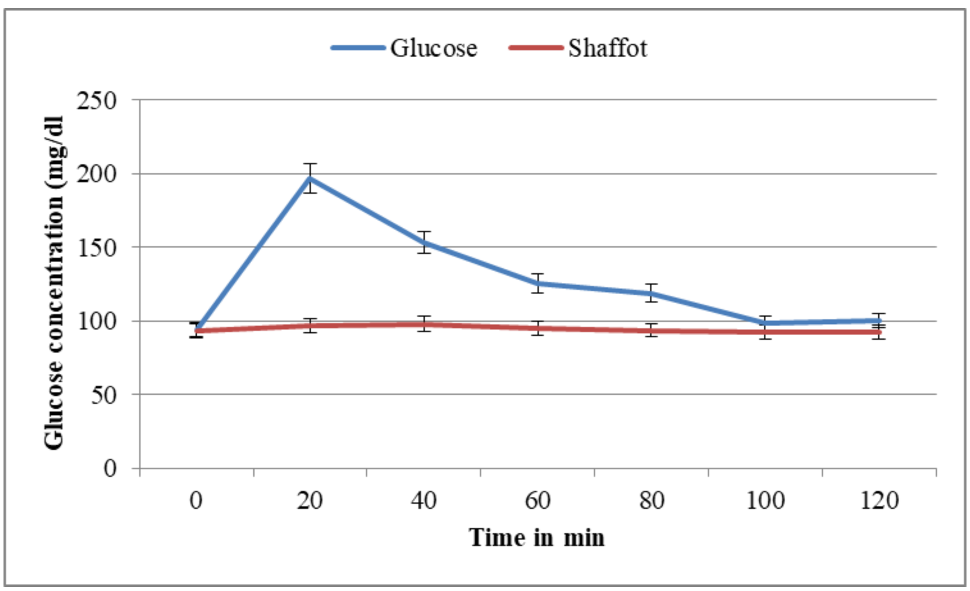


Figure 4.6 The time-averaged area under glucose versus time curve over 120 minutes after consumption glucose and shaffot diet n=6.

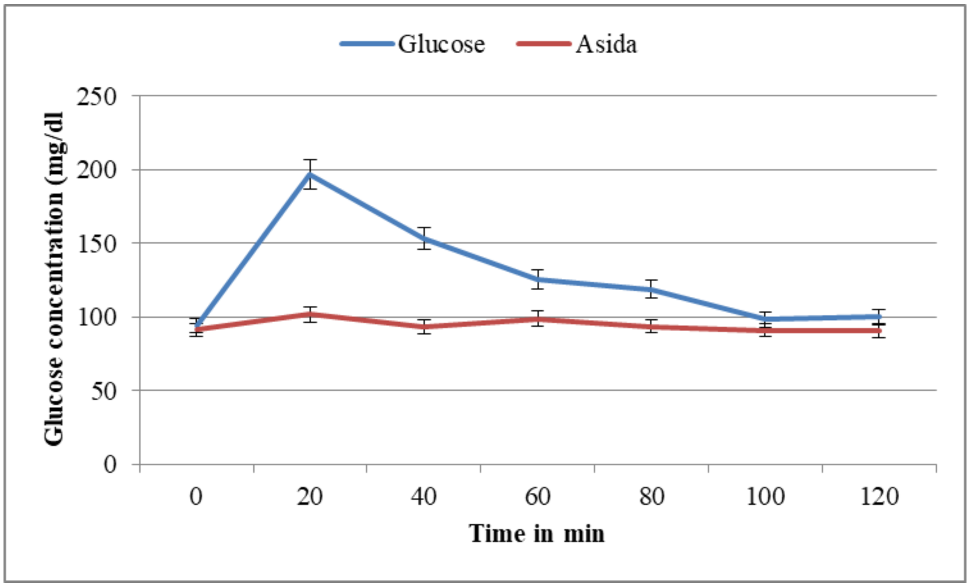


Figure 4.7 The time-averaged area under glucose versus time curve over 120 minutes after consumption glucose and asida diet n=6.

4.5. AUC for the standard and test foods (mean ± SD)

Table 4.5 shows the AUC for the test foods. Significant differences were found in the AUC between the standard and test food.

Table 4:5 Areas under the curve for the test foods

	Tested food	AUC (Mean ± SD)
1	**Glucose**	10523.33 ±3.23
2	**Soup**	7437.78 ±2.92
3	**Fatta**	8295.56 ± 4.24
4	**Zoum**	7680 ± 3.34
5	**Salta**	7680 ±3.54
6	**Bint Alsahn**	8881.11 ± 2.65
7	**Shaffot**	7581.11 ± 3.75
8	**Asida**	7594.44±2.93

4.6. GI values for the test foods

The standard food (glucose) was tested using an equivalent amount of carbohydrate (50 g). The portion sizes of the test foods was 50 g for test food. Table 4.6 also shows the GI values and classification of the seven test foods. These results showed that the GI values for the seven test foods ranged from 70.68 to 84.39, which classified them all as high-GI foods. Test foods 1 (Soup) had the lowest GI value (70.68), whereas test foods 5 (Bint Alsahn) had the highest GI value (84.39).

Table 4:6 GI values for the test foods

	Tested food	GI (Mean ± SD)
1	**Soup**	70.68±1.2
2	**Fatta**	78.83±0.23
3	**Zoum**	72.98±0.89
4	**Salta**	72.98±0.54
5	**Bint Alsahn**	84.39±0.89
6	**Shaffot**	72.04±1.01
7	**Asida**	72.17±1.11

Chapter-VI

Summary & Conclusion

Chapter-V

Summary and Conclusion

The rising rates of non-communicable diseases (chronic diseases and their associated metabolic disorders) is due to two factors namely: the demographic change and the increasing prevalence of overconsumption and inactivity associated. These have public health and economic implications and continue to be a matter of great concern. With the world's population aged 60 years or more increasing at more than three times the overall population growth rate and rising to about 1200 million in 2025, the importance of lifelong health promotion and disease prevention activities that can prevent or delay, the onset and severity of non-communicable diseases and promote healthy ageing should be considered.

This has resulted in continued interest in both diet and lifestyle modifications in prevention and treatment. Carbohydrates are the most important nutrient of our diet, in terms of fulfilling energy requirements and other metabolic functions. Carbohydrate intake has been a fairly neglected area until recently--a surprising fact because carbohydrate accounts for most calories in most diets. Until recently, when the importance of different kinds of carbohydrates, high-fiber, and whole-grain types of carbohydrates, the quality of carbohydrates may need to be considered.

There is increasing evidence that both the amount and type of carbohydrate play an important role in weight management and risk of chronic diseases. Classifying carbohydrates according to their post-prandial glycemic effect (ie, the glycemic index of foods) has yielded more useful insights than the historical distinctions of simple versus complex chemical structure. Diets based on carbohydrate foods that are more slowly digested and absorbed (ie, low glycemic index diets) have been independently linked to reduced risk of type 2 diabetes, cardiovascular disease, and some types of cancer. By definition, the GI compares equal quantities of carbohydrate and provides a measure of carbohydrate quality but not quantity. In 1997 the concept of Glycemic Load(GL) was introduced by researchers at Harvard University to quantify the overall glycemic effect of a portion of food available carbohydrate content in foods, first proposed in 1981.

The methodology for the study was carried out as following.

Seven different varieties of test foods namely were tested. A 50-g gulcose load was used as the reference. All the test food samples were prepared as they are usually prepared for consumption. The portion size of each test food contained 50g Sixty healthy volunteers aged between 21 and 30 inclusive with no known medical condition and otherwise who fulfilled the inclusion and exclusion criteria were recruited for the study and all the subjects signed an informed consent form.

Each of the test food samples were tested during 120 min. The reference food was tested and the test food was tested. The area under the curve for test and reference foods were analysed and the GI values were calculated by expressing each subject's AUC of the test food as a percentage of the same subject's mean reference AUC. The mean of the resulting values was the GI of the test food.

Findings of the study

- A narrow range of GI values from moderate to high glycemic index among the foods tested was noted.
- These results showed that the GI values for the seven test foods ranged from 70.68 to 84.39.
- Test foods (Bint Alsahn) had the highest GI value (84.39).
- Test foods (Soup) had the lowest GI value (70.68).

Conclusions

In the assessment of the GI value of traditional foods, the present study can conclude that the selected test foods, commonly consumed in Yemen culture, had high GI values. These findings emphasize that the dietary habits and the consumption of traditional foods need to be assessed in connection with other factors with the evidence of the increasing prevalence of obesity in the Yemen.

limitation

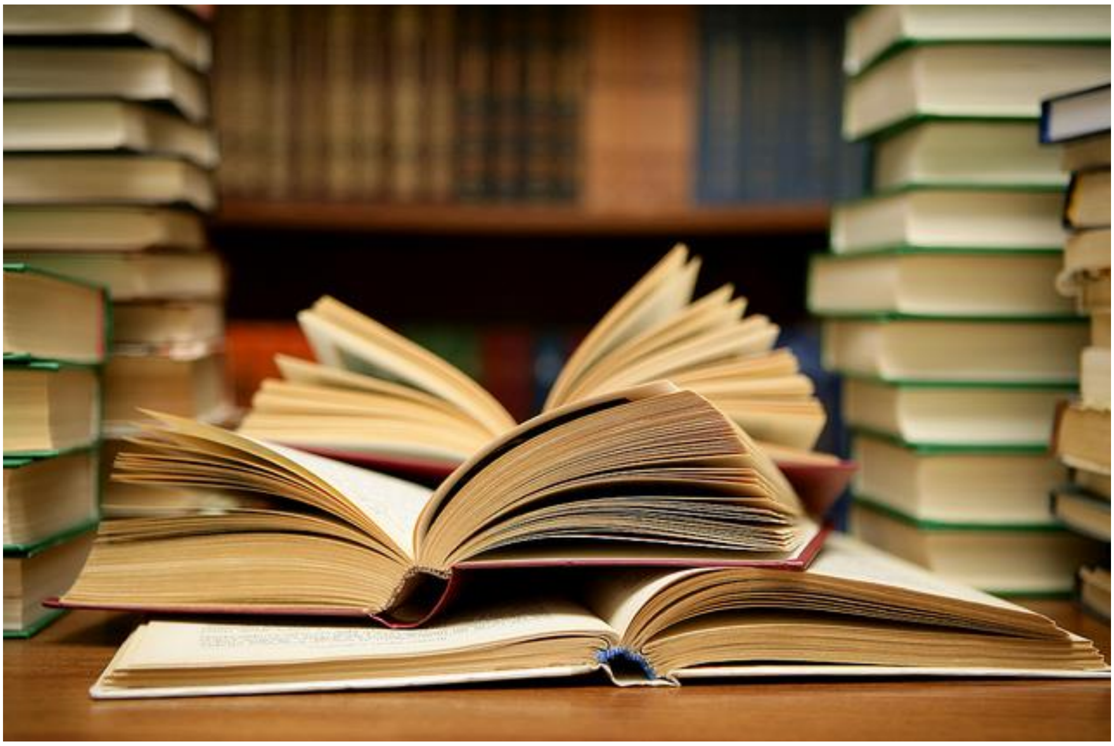
A limitation of this study was the effect of the different cooking methods used by the kitchens, which may have affected the GI values of these foods. Since the traditional foods tested are frequently consumed by the Yemeni, the authors of this study recommend the consumption of smaller portion sizes along with low-GI foods to overcome the high-GI level.

Chapter-VI

Recommendations

Recommendations

To completely address the objectives of this study, additional research should be performed using other traditional Yemeni foods and obese and diabetic individuals as subjects to examine how this links to the increased prevalence of diabetes and obesity in the population. Studies on the chemical analysis and GI of other traditional foods are strongly recommended to be used as preliminary references for setting up a GI and GL database for traditional Yemeni foods. The evaluation of an acceptable portion size for a low-GL diet is also needed. Moreover, preliminary studies to evaluate a low-GI diet using commonly consumed foods and the blood glucose among healthy subjects or diabetic patients are essential.



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