REPUBLIC OF TURKEY
YILDIZ TECHNICAL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

IN VITRO GLYCEMIC INDEX DETERMINATION OF TURKISH SOURDOUGH BREADS AND STRATEGIES TO REDUCE GLYCEMIC INDEX

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İSTANBUL, 2018

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This study was partially supported by Production of Local Starter Culture Having High Techonological Properties to Product Traditional Sourdough Breads Project co-operated with the Scientific and Technological Research Council of Turkey (TUBITAK) and the Istanbul Halk Ekmek (IHE) Grant No: 5150003.

ACKNOWLEDGEMENTS

Firstly, I want to thank to my advisor Associate Professor M. Zeki DURAK for giving me this opportunity and for his direction, trust and encouragement. I thank Assistant Professor Mustafa YAMAN for his guidance and great teaching. It was an honor to work with them.

Besides, thanks to my all friends encouraging me during this time. Especially I want to thank to my dearest friend Büşra Gül BUDAK for listening and encouraging me no matter what happens and my lovely friend Halime UĞUR for her support. I had great moments and made good friends during this time.

Finally, I owe great appreciation to my family members for all things. Especially the most special thanks to my mom Ayten ŞENOL and my dad Hasan ŞENOL, for their permanent support. My dear mom and dad; your little girl grew up and wrote this thesis.

April, 2018

Ezgi ŞENOL

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LIST OF SYMBOLS

℃	Centigrade
G	Gram
HCl	Hydrchloric acid
Mg	Miligram
Ml	Mililiter
M	Molarity
Nm	Nanometer
N	Normality
%	Percentage
NaAc	Sodium acetate
H	Time
U	Unit
Rpm	Revelution per minute

LIST OF ABBREVIATIONS

AUC	Area Under Curve
DF	Dietary Fibre
DM	Diabetes Mellitus
FAO	Food and Agriculture Organization of the United Nations
GI	Glycemic Index
GL	Glycemic Load
HI	Hydrolysis Index
Min.	Minute
RDS	Rapidly Digestible Starch
RS	Resistant Starch
SDS	Slowly Digestible Starch
TS	Total Starch
WHO	World Health Organization
WSB	Wheat Sourdough Bread
WSB-DF	Wheat Sourdough Bread with Dietary Fibres
WYB	Wheat Yeasted Bread

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ABSTRACT

IN VITRO GLYCEMIC INDEX DETERMINATION OF TURKISH SOURDOUGH BREADS AND STRATEGIES TO REDUCE GLYCEMIC INDEX

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MSc. Thesis

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Glycemic Index (GI) is the percentage of glucose response of food. Low GI has positive effect on health. Turkish white bread with its high glycemic index (87) must be reduced for healthy nutrition. Sourdough is considered as a solution. With this study, GI was decreased by using sourdough and changing fermantation conditions. Firstly, 4 different homemade white sourdoughs (Oguzlu (O), Kastamonu (K), Lüleburgaz (L), Afyon/ Bolvadin 2 (B2)) and one whole wheat sourdough, Safranbolu Yıldız Fırını (SYF) were obtained. Traditional sourdough breads fermented at room temperature (25℃) long time (24hrs). O, K, L, B2, SYF had GI of 50.05±0.3, 51.8±1.65, 50±0.5, 51±0.5 and 46.5 ±0.5, respectively. There was no significant difference among the GI of white sourdough breads except SYF containing dietary fiber. %50 whole wheat sourdough breads containing enzyme were prepared at different fermentation times and temperature. Sourdough breads fermented at the low temperature (4℃) different times (15hrs, 18hrs, 20hrs, 24hrs) had lower GI values (58.1±0.1, 55.05±1.5, 54.25±0.25, respectively) than breads fermented at the room temperature (25℃) different times (15hrs, 18hrs, 20hrs, 24hrs) (65.5±0.7, 66±1, 69±1.5, 69±1.5, 74±0.5, respectively). As a result, while GI of cold fermentation breads gradually decreased, other sourdough breads gradually increased.

Key Words: Glycemic index, starch digestion, sourdough

ÖZET

TÜRK EKŞİ HAMUR EKMEKLERİNİN IN VITRO GLİSEMİK İNDEKSİNİN BELİRLENMESİ VE GLİSEMİK İNDEKSİ AZALTACAK STRATEJİLER

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Danışman: Doç. Dr. Muhammed Zeki DURAK

Glisemik indeks (Gİ), gıdanın glukoz yanıtına göre yüzde değeridir. Düşük glisemik indeks sağlık açısından önemlidir. Türk ekmeğinin yüksek glisemik indeksinin (87) sağlıklı beslenme için düşürülmesi gerekmektedir. Bu yüzden ekşi hamur bir çözüm yolu olarak düşünülmektedir. Çalışmamızda Gİ'i düşürmek için ekşi hamur kullanılmış ve ekmeğin fermentasyon koşulları değiştirilmiştir. Öncelikle, 4 tane beyaz ekşi hamur ekmeği (Oğuzlu (O), Kastamonu (K), Lüleburgaz (L), Afyon/ Bolvadin 2 (B2)) ve bir Safranbolu Yıldız Fırını tambuğday ekmeği toplanmıştır. O, K, L, B2, SYF ekmeklerinin Gİ'leri sırasıyla 50.05±0.3, 51.8±1.65, 50±0.5, 51±0.5 ve 46.5±0.5 olarak bulunmuştur. diyet lif içeren SYF kodlu ekmek hariç diğer ekşi hamur ekmekleri arasında önemli bir fark tespit edilmemiştir. Enzim içeren %50 tam buğday ekşi hamur ekmekleri farklı fermentasyon süre ve sıcaklığında hazırlanmıştır. Sırasıyla; oda koşullarında (25°C) ve farklı sürelerde (15s, 18s, 20s, 24s) yapılan ekmeklerin GI'i (65.5±0.7, 66±1, 69±1.5, 69±1.5, 74±0.5); soğuk şartlarda (4°C) ve farklı sürelerde (15s, 18s, 20s, 24s) yapılan ekmeklerin Gİ'nden daha düşük bulunmuştur (62±1, 58.1±0.1, 55.05±1.5, 54.25±0.25). Sonuçta, soğukta fermente edilen ekmeklerin Gİ'nin zamanla azaldığı, diğer ekmeklerin Gİ'nin ise zamanla arttığı görülmüştür.

Anahtar Kelimeler: Glisemik indeks, nişasta sindirimi, ekşi hamur

CHAPTER 1

INTRODUCTION

1.1 Literature Review

The glycemic index is defined by the Food and Agriculture Organization /World Health Organization (FAO/WHO) as the increasing area underneath the blood glucose reply curvature of a 50 g carbohydrate serving of a test food known as a percentage of the reply to the same amount of carbohydrate from a reference food consumed by the identical substance. It is known that high glycemic index is associated with especially diabetes mellitus (DM) and other diseases such as cardiovascular diesease, cancer and obesity. Moreover, lots of studies, including cohort studies as well as randomized controlled trials, shows that especially food having low GI values has positive effects on health [1]. On the one hand, bread is of great importance for diet of people. Especially white bread is one of the most consumed foods with its high glycemic index. In Turkey bread is one of the most popular foods with its high GI compared to other countries. According to the International table of glycemic index, while avarage glycemic index of white bread is 70 in other countries, GI of Turkish white bread is 87 [2]. Because of our being first in line for bread consumption in the world, it has necesitated further research in regard with this issue. However, there is too few research about the topic in Turkey. With this study, we tried to determine and reduce the GI of bread by using sourdough samples collected from different regions of Turkey and by changing fermentation conditions and formulations in order to help people taking care of their healthy nutrition.

1.2 Objective of the Thesis

There is two objective of this study:

1. Determination the effects of sourdough samples collected from different regions of Turkey on Glycemic Index (GI) value of bread,
2. Searching the effect of the different fermentation conditions and different bread formulations on the GI and starch digestibility of bread. (White bread was used as a reference material.)

1.3 Hypothesis

With this study, it can be said that there is a negative correlation between the sourdoughs -GI. In addition to this, sourdough samples containing dietary fiber such as whole wheat flour and fermented under the low temperature (4°C) long time (18h) has the lowest GI value compared to the control bread (White bread) since the enzyme activity added to bread formulation inactivates. Further research is planned on this subject.

CHAPTER 2

NUTRITION

2.1 Nutrition

According to WHO, nutrition is the consumption of food, considered in associated with the human body's dietary needs. Good nutrition – a sufficient, well-adjusted diet combined with regular body activity – is a keystone of good well-being. Insufficient nutrition can cause declined immunity, increased susceptibility to illness, damaged physical and brain development, and decreased productivity.

The foods chosen by human to consume define which nutrients human body will ingest and in what amounts. Nutrients are materials allowing human body to gain energy, restore and protect tissues, and adjust bodily processes. Nutrition being the process of consuming in nutrients from foods at the six classes of nutrients:

- Lipids
- Carbohydrates
- Water
- Proteins
- Vitamin

Carbohydrates, lipids and proteins are stated to as macronutrients since they are needed in big amounts. The macro is to mean large, because this is a simple phrase to remember.

These macronutrients are carbohydrates, lipids and proteins. They are matchless as they are the merely nutrients that offer human body with energy, measured in calories. [3]

All carbohydrates stem from food, but various foods include several kinds of carbohydrates. For instance, when a cookie is consumed, it is eaten frequently sugars, or

simple carbs, while spaghetti dinner includes a lot of starches being complex carbs consisting of many sugars. With eating lot of fruits and veggies, it will be gained in fiber being a kind of carbohydrate not be ingested. This is to mean that it may not be gained energy from fiber, but fiber is good for moving foods via human gastrointestinal tract, because it is wanted several of it in daily diet. [4]

Lipids known as energy sources for human and being generally known as fats, have more even calories per gram than the other macronutrients, because it can be considered of them as energy-intense nutrients being a good resource of maintainable energy for need durability. Like carbs, there are different forms of fats. Saturated fats, like butter, are solid at room temperature (25°C); unsaturated fats, such as vegetable oils, are fluid at room temperature.

As for proteins, they include calories and proteins are very essential for growth and restore, human body benefits from them as a last energy resource. The protein is consumed in a diversity of plant and animal foods, with meats and beans. Human body then transforms these protein to amino acids being the basic building blocks of proteins. The amino ads are then reunited into thousands of several types of body proteins. [4]

2.2 Adequate and Balanced Nutrition

Adequate in other word sufficient and balanced diet is one of the most significant subsidizing issues to succeeding or continuing a good state of health. The human body is a flexible organism, and a varied range of dietary designs and food consumption are able to result in the good health and nutritional welfare. The personal routines and social environment regulate which diet is acceptable. Nonetheless, the enough amount of all crucial nutrients and health-promoting constituents is the origin of a healthy daily diet. Each nutrient has a specific function in the body. Nutrients are stem from foods of plant and animal source. Each food type is a specific source of definite nutrients. As people ingest food rather than nutrients, the profits of the several food groups to a healthy diet are outlined, as well. Diets of the adult healthy people are principal points of this support. The energy and nutrient necessities of people suffering from definite illnesses or of those during specific times in the life cycle such as lactation, pregnancy, childhood or infancy change prominently [5].

2.3 Definition of Terms

2.3.1 Healthy People

Good health for human does not mean only the lack of illness, but requires a situation of physical, mental, and social well-being. Some signs, like a liveliness, good nature, and alertness, good desire for food, natural human body temperature and pulse amount, typical altitude-for-age and weightiness-for height is able to exhibit us how to identify healthy people. A variety of environmental, social, economic factors defines the human health prominence of an individual. [5]

2.3.2 Adequate Diet

A healthy daily diet is to mean diverse things to several people. In children's nutrition, an acceptable diet purposes to support healthy growing and improvement. In adult people nutrition, it emphasizes on achieving or continuing good health and avoiding chronic deteriorating illnesses of multifaceted causativeness. Commonly, good food offers sufficient energy, forms new tissue, restores worn-out muscle, and keeps the body working well. Even though the needs of people are rather alike universal, the personal way of life determines which diet is sufficient. In societies where physical labor is still common, the diversity of foods of plant and animal origin covering the energy requirement, as showed by body mass, will almost unavoidably constitute a sufficient diet. This is mainly real if the food is not extremely processed. In extremely developed societies where foods are generally extremely processed, a nutrient-dense diet with restricted energy content is thought sufficient. Commonly, a well-adjusted diet includes sufficient amounts of carbohydrates, fats, and proteins, along with the suggested daily permissions of all necessary vitamins, minerals, and health-promoting materials. It is suggested that complex carbohydrates of at least 50% of the diet form the main portion of energy consumption; 25% to 30% of energy ought to be stemed from fat, and 10% to 15% from protein. Energy and nutrient needs, but, differ extensively. They are a role of age, body mass, and activity level and health status [5].

Mostly, plant food makes up the basis of sufficient diets. Carbohydrate-rich foods like cereals should be enhanced with foods mainly rich in vitamins A and C, minerals, and protein such as vegetables, legumes and fruits. Foods of animal source, particularly meat

and fish are not crucial for an adequate daily diet, but they are a beneficial complement to most diets. Societies that have adopted vegan daily diets do not display indication of malnutrition when the supply of whole food is acceptable. They rather have a low risk of nutrition-related illnesses such as obesity, diabetes mellitus, certain cancers, hypertension coronary heart diseases [5].

Furthermore, an adequate liquid consumption is significant in terms of an adequate diet. Breastmilk is the most acceptable diet for children up to six months of age. A main problem in all civilizations is the intake of a repetitive diet. A prolonged consumption of an insufficient diet is likely to cause malnutrition, over nutrition or undernutrition, and deteriorating diseases [5].

2.3.3 Healthy Diet

Having a healthy diet via the lifestyle provides to inhibit malnutrition in all its types as well as a variety of non-communicable illnesses and disorders. Nonetheless the enhanced manufacturing of processed food, fast urbanization and changing lifestyles have caused a shift in dietary designs. People are now eating more foods high in energy, fats, free sugars or salt/sodium, and many do not eat sufficient fruit, vegetables and dietary fiber like whole grains. The certain forming of a different, well-adjusted and healthy daily diet will differ dependent on personal requirements, cultural background, available dietary taxes and foods. But elementary rules of what constitute a healthy diet ruin the equal [6].

For adults;

A healthy daily diet includes:

1 Fruits, legumes, vegetables, and whole grains.

2 At least 400 g of fruits and vegetables for each day.

3 Less than 10% of total energy consumption from released sugars being equal to 50 for a person of healthy human body mass consuming around 2000 calories per day

4 Less than 30% of entire energy consumption from fats.

5 Less than 5 g of salt for each day and usage of iodized salt. [6].

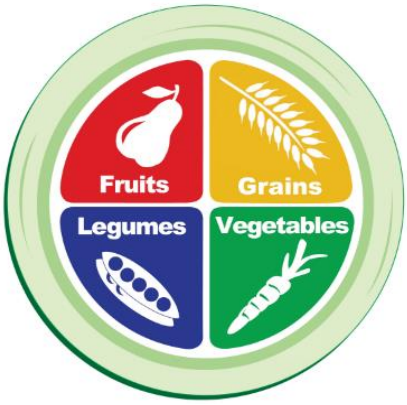


Figure 2.1 Four basic food groups [7]

2.3.4 Achieving Adequate Nutrition

2.3.4.1 Industrialized Countries

The major constituents of a country's daily diet tend to relate to a nation's state of prosperity. The reduction in the intake of starchy foods and the proliferation in animal fat consumption are the most outstanding dietary properties, as civilizations become wealthy.

Simple sugars also make up on normal higher proportion of the whole dietary carbohydrates in developed countries than in poor countries. Presently, the average adult's energy intake in developing countries surpasses by 3000 kilocalories (kcal) the suggested intake, about 30%.

It has been announced that extreme energy intake, definite cholesterol, fats, alcohol, and salt, reduced intake of fibers, fruits and vegetables, together with sedentary life routines subsidize prominently to enlarged occurrence of over nutrition among people populations in industrialized countries.

To keep away from over nutrition and to declining the danger for certain sicknesses it is advised to decline the fat intake by 10% of energy consumption from the current level and retain the saturated fatty acids intake under 10% of total energy intake. The foods intake containing high amount of fat and low amount of crucial nutrients such as meat foodstuffs, fat cheeses, and rubbish food should thus be decreased. An increased eating of crucial main foods like legumes, cereals, vegetables, fruits, and nuts will support to increase the consumption of complex carbohydrates by 10% of total energy, as suggested,

such as an increased consumption of dietary fiber. It is also suitable to lessen the salt consumption, and alcohol ought to be taken merely reasonably [5].

2.3.5 Developing Countries

In poor countries the main nutritional issue is that large pieces of the people cannot have adequate funding or may not grow enough food to provide all their requirements for crucial nutrients.

Deficiency and its related situations are known as the overriding leads to undernutrition. The four most considerable forms of malnutrition in unindustrialized countries: protein-energy malnutrition, monitored by iron-lackness anemia, then vitamin A and iodine insufficiencies.

It is predicted that 1.1 billion people in developed countries live in whole poverty, and that 20% of the total population in developed countries are influenced by chronic dietary energy insufficiency.

Lower energy consumption is nearly associated with decreasing protein intake, vitamins, and minerals. Dietary arrangement plays a significant role in nutritious status. Commonly, adult nutrient requirements are met by most old-fashioned industrialized country's diets when they are consumed in adequate quantity to meet usual energy needs. Old-style diets usually embrace one or two main crops, tubers, and fruits, and are arranged with a minimum of processing. Protein and energy requirements can be met simply by uniting cereal-centered diets with small amounts of other protein foods like pulses or peanuts.

For the adults, protein-energy undernutrition is generally a difficulty merely among families being so poor and they have to give up their old-fashioned diet and begin to depend profoundly on cheap, low-protein foods. But, it is general a problematic for at risk family members such as children, lactating women if either the diet is insufficient or the person is damaged by diseases, which are the two instantaneous reasons of malnutrition. Underlying reasons of malnutrition are current at different stages of the civilization. To advance the nutritional condition in industrialized countries, actions taken must consider the reasons of malnutrition at all stages. These measures embrace nationwide and local policies and activities to progress food processing, marketing and income generation in order to buy food. Extra rules should emphasis on development of the health status,

specially of mothers and children, improvement of nutrition information, care, hygiene, and access to drinkable water [5].

2.3.6 Worldwide

Commonly speaking, the world has sufficient food material. The growing of universal food manufacturing has so far been equivalent to population growing. Yet, many the world's population do not live where lots of the world's food is processed. Industrialized countries produce half of the world's grain, but they have less than one-fourth of the world's inhabitants. Thus, many poor countries and hundreds of millions of non rich people do not share in this great quantity. They struggle with a deficiency of food and nutrition safety resulted in mostly by a deficiency of obtaining power. Lots of countries have an important food supply because of chronic food deficiencies due to disapproving growing or gathering conditions or political turmoil. Merely a few countries are self-sufficient in food stock.

The rest depend on the world market for food importations. Although on all continents except Africa south of the Sahara—the nutritious condition of the population has developed during the last decades, there are still dozens of countries classified as food-insufficiency, poor countries.

Universal, almost one third of whole children less than five years of age have a hard time due to malnourished and much more suffer from progress delay. Up to two billion people have hard time owing to iron insufficiency or anemia, an important proportion of which live in developed countries.

Besides, strategies at the nationwide level to advance the nutritional condition of a country's population, there are many opportunities for common worldwide action. Some of the present procedures and rules of marketable trade put many low-income countries at difficulty. Actual worldwide markets with fair trade relationships and strategies would alleviate or even rise food availability for lots of countries. The worldwide food funding system includes the networks of marketable trade and food help [5].

CHAPTER 3

CARBOHYDRATE

3.1 Carbohydrates

Carbohydrate**s** are possibly the most abundant and widespread organic substances in nature. They are essential substances of all living organisms.

Carbohydrates are made up of by green plants from carbon dioxide and water during photosynthesis. Carbohydrates have role as energy sources and as crucial structural components in organisms. [8]

- There are a widespread arrangement of both healthy and unhealthy foods—bread, beans etc. They also come in various forms. The most usual and plentiful forms are sugars, fibers, and starches. Foods high in carbohydrates are a significant side of a healthy diet. Carbohydrates offer the glucose transformed into energy used to subsidize body functions and physical activity to body. Nevertheless, carbohydrate value is significant; some foods containing high carbohydrate are better than others.

- The healthiest resources of carbohydrates—unmanufactured or insignificantly manufactured whole grains, vegetables and fruits—support healthier life.

- White bread, pastries, sodas, and other extremely processed or refined foods contain Unhealthy resources of carbohydrates [9].

3.1.1 Monosaccharides

Monosaccharides are also known as simple sugars serving as the building blocks for carbohydrates.

Monosaccharides contain polyhydroxy aldehydes or ketones containing carbonyl group and hydroxyl group. The carbonyl group chains in liquid solution with one hydroxyl group to make up a hemi-acetal or hemi-ketal structure. The subsequent monosaccharide is a crystalline soluble solid in water.

Monosaccharides are categorized by many C atoms (carbon) in the molecule such as pentoses, hexoses, tetroses etc. The most-significant pentoses consist of xylose, found joined as xylan in woody tools; arabinose from trees; ribose, a part of ribonucleic acids and many vitamins; and deoxyribose, a part of deoxyribonucleic acid [10].

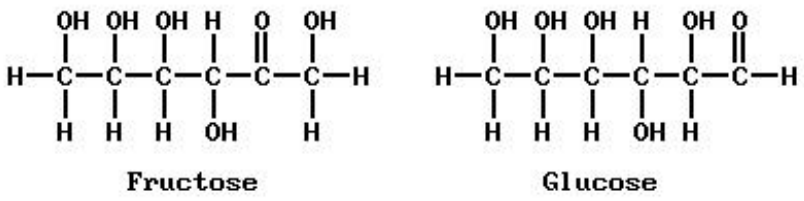


Figure 3.1 Molecule Structure of Fructose and Glucose [10]

3.1.2 Dissacharides

Disaccharide**s** are also called as double sugars, any material composed of two molecules of monosaccharides connected to each other. Disaccharides are crystalline in water. The monosaccharides within disaccharides are connected by glycosidic linkages, the situation of which may be elected α- or β- or their combination. Glycosidic linkages are cutten by enzymes called as glycosidases. The most important disaccharides are maltose, sucrose and lactose.

Sucrose made up after photosynthesis in green leaved plants, is made up of one glucose and one fructose molecule linked through an-, β-bonds.

Milk sugar (lactose) consists of glucose and galactose linked by a β-bond. Maltose being product of the breakdown of starches during ingestion, is made up of two molecules of glucose linked through an α-bond. One more significant disaccharide is trehalose found

in single-celled organisms and in many insects, it also made up of two molecules glucose and an α-bond, yet the bond is different from the bond forming the maltose. [10]

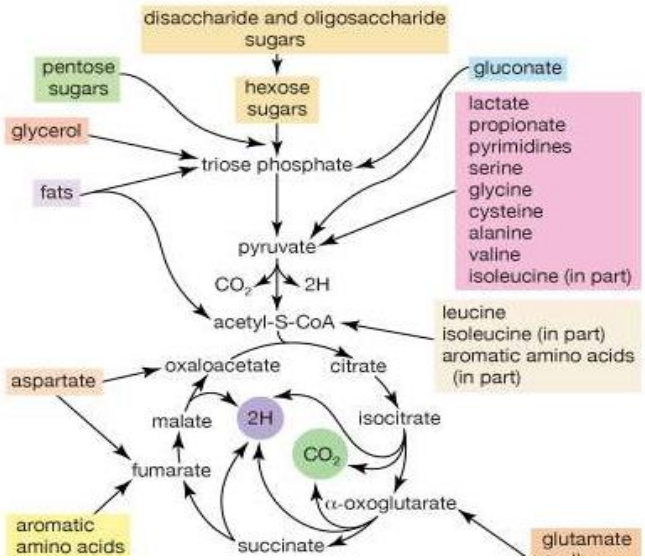


Figure 3.2 Energy is derived from the metabolism of disaccharide and oligosaccharide sugars and other small molecules [10]

3.1.3 Polysaccharides

Polysaccharides are also known as glycan, the type in which lots of natural carbohydrates happen. Polysaccharides can have a molecular construction being either linear or branched. Linear polysaccharides like cellulose generally pack together to make up a firm construction; branched forms (e.g., gum arabic) normally are water-soluble.

Homopolysaccharides are expressed as polysaccharides made up from merely one kind of monosaccharide. Homopolysaccharides can be further divided into linear sequence and branched-sequence, depending on the array of the monosaccharide units. Heteropolysaccharides are expressed as polysaccharides including two or further different kinds of monosaccharides [10].

3.1.3.1 Glycogen

Glycogen is called as a freely organized packing type of glucose. It is big, branched-chain polymer of glucose remains (Figure 3.2) broken down to produce glucose molecules if

the body needs the energy. Lots of the glucose remains in glycogen are connected by α-1, 4-glycosidic linkages.

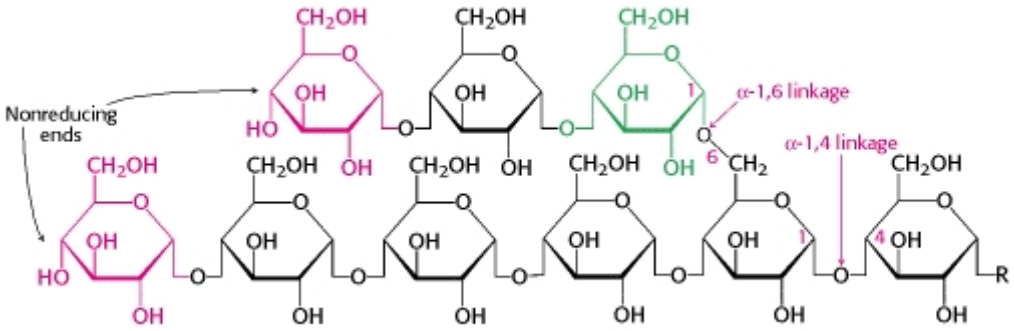


Figure 3.2 Glycogen structure [11]

The two main positions of glycogen packing are in the liver and muscles found at skeleton. The density of glycogen is greater in the liver than in muscle yet extra glycogen is kept in muscle found in skeleton due to its greater mass. Glycogen is found in the cytosol in the kind of granules whose is thickness from 10 to 40 nm (Figure 3.3). In the liver, glycogen production and degradation are controlled to continue blood-glucose as compulsory to provide the needs of the organism. Compared to the muscle, these procedures are controlled to provide the muscle's energy needs itself [12].

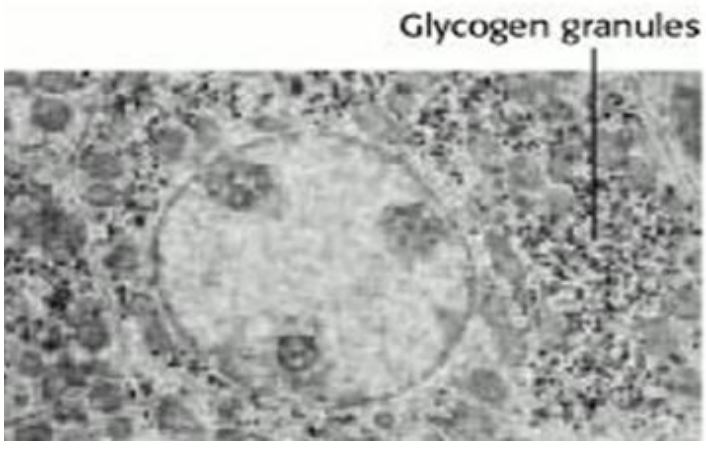


Figure 3.3 Electron Micrograph of a Liver Cell [13]

3.1.3.2 Starch

Starch is a granular, white, organic chemical synthized by all green leaved plants. Starch is a soft, tasteless, white substance not soluble in cold water or alcohol. The simple chemical formulation of the starch is $(C_6H_{10}O_5)_n$. Starch is known as a polysaccharide (*q.v.*) consisting of glucose monomers linked in α 1,4 bonds. The basic type of starch is amylose being the straight polymer; amylopectin is the not-staright type.

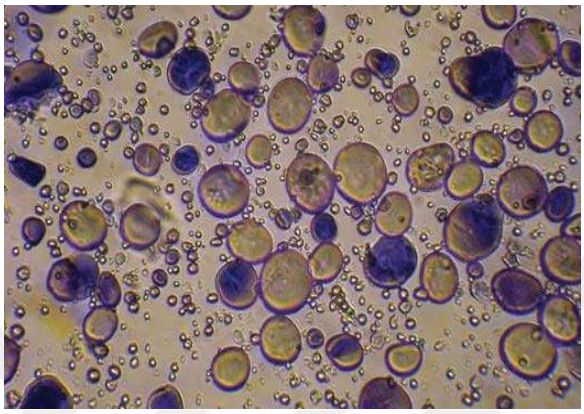


Figure 3.4 Wheat starch granules stained with iodine [10]

Natural starches are made up of about 10%–30% amylose and 70%–90% amylopectin.

Amylose is a not-branched polysaccharide made up of wholely of D-glucose pieces linked by the α-1, 4-glycosidic connections it can be seen it in maltose (part (a) of Figure 3.5).

Investigational indication exhibites that amylose is coiled like a spring, with its six glucose fragments for each turn (part (b) of Figure 3.5). The specific blue-violet color appearing when starch is handled with odine is owing to the form of the complex formed by amylose-iodine. This color test is delicate adaquate to distinguish even minute quantities of starch in solution. [10].

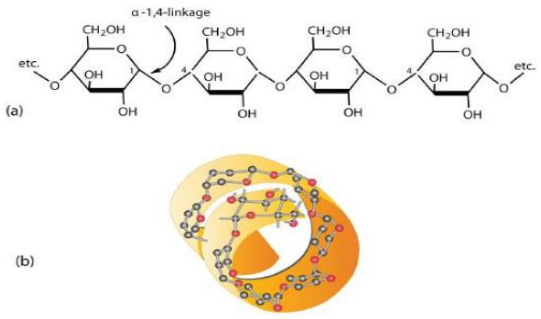


Figure 3.5 Amylose. (a) Amylose is a straight linkage of α-D-glucose units linked by α-1, 4-glycosidic linkages. (b) Due to hydrogen linkage, amylose attains a spiral construction including six glucose units for each turn [14].

Amylopectin is known as a not linear-chain polysaccharide made up of glucose units bonded mostly by α-1, 4-glycosidic linkages yet with random α-1, 6-glycosidic linkages, being accountable for the branching. One molecule of amylopectin can include a variety of glucose fragments (Figure 3.6). The helical construction of amylopectin is interjected by the branching of the linkage and amylopectin forms a less dense reddish brown. [61].

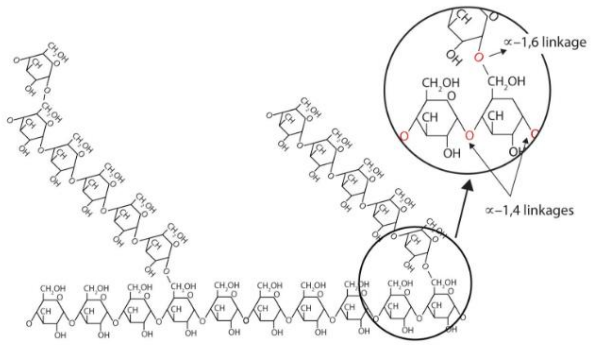


Figure 3.6 Branching in Amylopectin and Glycogen. Both amylopectin and glycogen include branch sides linked via α-1, 6-bonds. These branches happen more general in glycogen [14]

3.2 Digestion and Absorption of Carbohydrates

Oligosaccharides and polysaccharides must be digested to their monosaccharide units before absorbtion.

The starch digestion starts with amylase enzymw found in salivary, yet this activity is a lot less crucial than pancreatic amylase found in the small intestine. Amylase break down the starch to maltotriose, maltose and -dextrins, even though some glucose is also yielded. The α-amylase digestion products are broken down to their monosaccharides units with enzymes such as sucrase, maltase, isomaltase and lactase [15].

At typical Western diets, carbohydrate intake is fast and carbohydrate absorption happens mainly in the small intestine. This is mirrored by the occurrence of finger-like villus in the small intestine mucosa, with villous in the half of the intestine. Nevertheless, carbohydrate ingestion and absorption can happen alongside the entire length of the intestine, and is shifted toward the ileum when the diet includes less readily ingested carbohydrates. In this condition, the upper of small intestine shows large villous constructions with leaf-like arrangements, whereas in the villi become much longer and more finger-like [16].

3.3 Resistant Starch

One of the key progresses in our accepting of the prominence of carbohydrates for human health in the last twenty years has been the detection of resistant starch. Resistant starch is expressed as "starch- starch degradation products not absorbed in the small intestine of healthy humans" [17]. The essential types of resistant starch are surrounded starch, e.g. in whole cell structures (RS_1), some uncooked starch granules (RS_2) and retrograded amylose (RS_3) etc. [18].

While amylopectin is hydrolysed fast, amylose is hydrolysed gradually. Therefore, generally, the resistant starch (RS) starch composition is positively related with the quantity of amylose present. [19].

3.3.1 Resistant Starches and Factors Affecting Starch Digestion

Five forms of Resistant Starch are:

- RS1 – unreachable to digestive enzymes owing to the physical obstacles made up of by cell structure and protein construction. [19].
- RS2 – starches preserved from ingestion owing to their crystalline construction [19].
- RS3 – retrograded starch made up when foods containing starch (*e.g.* potatoes, pasta) are cooked then cooled down. [19].
- RS4 – chemically modified starch made up by cross-linking [19].
- RS5 –The majority of publications describe RS5 as amylose–lipid complexes. [19]. Two different components have been suggested as RS5. The first comprises amylose–lipid complexes being either form during manufacturing and modification after cooking or can be created exaggeratedly and added to foods [20].

3.4 Dietary Fibre

The original explanation of dietary fiber was done by Trowell in 1972 [21]. It was "that portion of food which is stemed from cellular structures of plants ingested so unwell by human ". This is an unclear explanation of somewhat carbohydrate in the diet yet is much more a physiological conception. It was connected by Burkitt and Trowell to the etiology

of a lot of "Western diseases" and on the base of this hypothesis connecting fiber to health was improved. The usage of the phrase has, yet, resulted in many problems over the years owing to controversies about definition. Furthermore, the suggestion that there are lots of dietary fiber insufficiency illnesses is an over-explanation and needs to be changed nowadays in the light of new information of illness anddiet [22].

The leading components of dietary fiber are stemed from the cell structure of plant subject in the diet and include pectin, cellulose and hemicellulose. Lignin, a non-carbohydrate piece of the cell structure is also contained. Dietary fibre is a phrase felt to be worthful for the people looking for this as healthy diet components. Nowadays, there is no agreement as to which carbohydrate components ought to be contained as dietary fibre and various authors have differently contained polysaccharides not containing starch and resistant starch.

More lately it has been advised that oligosaccharides being non digestible also ought to be contained. Dietary fiber has also been recognized by method. Whereas there is common acceptance that the non-starch polysaccharides are the key fragment of dietary fiber there is now no agreement as to if other constituents ought to be contained in this term. It has been advised that the usage of the phrase dietary fiber be slowly phased out [23]. Its prevalent usage and reputation with the person has made this challenging in fact and the phrase has been beneficial in product progress and nutrition teaching.

3.5 Soluble and Insoluble Fiber

These phrases improved out of the primary chemistry of polysaccharides being non-starch exhibited that the small removal of these polysaccharides can be ordered by altering the pH of solutions. They verified very beneficial in the primary accepting of the physiological features of dietary fiber, permitting a simple separation into those which mostly had impressions on glucose and lipid absorption from the small intestine and those gradually and partly fermented and had more marked impressions on bowel practice. Nevertheless, the separation of soluble and insoluble segments is not chemically so different that is reliant on the situations of extraction [24]. In addition, the physiological alterations are not, actually, separate with much unsolvable fiber that is quickly and totally fermented whereas not all soluble fiber has impressions on glucose and lipid absorption.

3.6 Carbohydrates in the Diet

Whereas the carbohydrate amount being mandatory so as to prevent ketosis is so small (around 50 g/day), carbohydrate offers the main of energy for people's diet. There are lots of results in why this is necessary. As well as providing simply available energy for human metabolism, carbohydrate-including nutrients are means for significant micronutrients such as iodine manganese etc.

In conclusion, high carbohydrate consumption when it is compared to food intake containing high fat, decrease the possibility of enhancing obesity and co-morbid situations. The optimal diet should be made up of at least 55% of whole energy becoming from carbohydrate taken with different food resources.

The discussion approved that if carbohydrate intake intensities are at or overhead 75% of whole energy there is be able to be essential contrary properties on nutritious position by the elimination of sufficient amounts of protein, fat and other vital nutrients. In arriving at its approval of a minimum of 55% of total energy intake from carbohydrate, the discussion understood that a substantial percentage of whole energy necessitates to be offered by fat and protein, yet that their support to whole energy intake will differ from a country to the another country on the origin of food intake designs [16].

3.7 Energy Balance

Continuing of energy balance is to importance so as to keep away from obesity and its related co-morbidities like cardiovascular illnesses and diabetes mellitus. Constructive energy equilibrium and obesity happen when entire energy consumption surpassess entire energy spending, irrespective of the extra energy composition. But, the configuration of the diet can impress if and what extent positive energy equilibrium happens. The structure of the diet can also impact the capability to keep up the energy equilibrium. Particularly, diets including at least 55% of energy from different carbohydrate resources, as compared to great-fat diets, decline the probability that human-body fat gathering will happen. Substantial data recommend that diets containing high fat intake tend to subsidize more entire energy intake than diets containing high carbohydrates intake [25].

This impression may be owing to the lower energy concentration of higher carbohydrate diets, as entire volume of food taken seems to offer a crucial satiety cue. There is no information to advise that different kinds of carbohydrates definitely influence whole energy consumption. [26]

As well as impression the casual of having additional energy accessible, the intake of the diet also impresses the amount of additional energy kept as body fat. The human body has a big fat storing size and additional dietary fat stored so proficiently in adipose muscle. Besides, the human body's size to keep the carbohydrate is restricted and excessive carbohydrate is not efficiently kept as body fat [27]. Instead, excessive carbohydrate indicates to be broken down wit oxygen, causing the not direct fat gathering via reducing in fat oxidation [28].

Excessive carbohydrate and fat were formerly believed to be similarly fattening. This was owing to the supposition that lipogenesis was a generally used lane for discarding of excessive carbohydrate.

The available data advise, yet, that this procedure happens seldom in human body materials and merely in cases of significant carbohydrate intake [29]. Mostly, in general situations, gathering of body fat through lipogenesis is very low. Whereas noting the low total support of lipogenesis to human body fat gathering, it should be well-known that lipogenesis is enhanced with insulin resistancy and with enormously excess sucrose or fructose intake [30].

3.8 Physical Activity

Continuing of the energy equilibrium is needy both on energy consumption and energy spending. Continuing of fixed physical body activity importantly decreaes the creating constructive energy equilibrium’s possibility, irrespective of the diet intake. There is arrangement that the combination of an excessive carbohydrate intake and fixed physical activity is the optimum procedure to keep away from positive energy equilibrium and obesity.

The enhanced energy requests of body activity are able to be concluded by carbohydrate or fat. The prominence of carbohydrate for the diet turn into additional serious since the quantity and concentration of body activity progressions.

Lots of high-income countries, the main difficulty is to provide day-to-day energy requirements formed by excessive intensities of day-to-day body activity. In such situations, any mixture of fat and carbohydrate which offers adequate energy being encouraged.

Lots of countries suggest enhancing the leisure time body activity. Whereas enhanced body activity would undoubtedly rises energy requirements, these do not form requests for exact macronutrients. Instead, the optimal diet recognized before is thought ample to offer for such body activity.

There is considerable indication that additional carbohydrate can progress routine for the endurance-educated athlete. A diet containing excess carbohydrate intake during a small number of days preceding a stability event, a excess carbohydrate pre-occurrence mealtime and carbohydrate supplement in the type of carbohydrate-including drinks exhibited to increase the execution throughout extended-distance cycling. There is, but, no indication that such carbohydrate supplement would increase the execution for the conventional of people engaging in amateur body activity of lower concentration and period [31].

3.9 Carbohydrate and Behavior

It has been advised that food consumption could have crucial impressive on manners. Whereas offering breakfast to children not characteristically eating breakfast is able to enhance cognitive process [21]. It is not enough clear that the total the diet consumption can impress be manners. It has been advised that sugar intake induces hyperactivity in children. Yet, a wide evaluation of the writings in this area resolved that there is no sign to subsidize the statement that processed sugar consumption has any essential conclusion on either manners or" mental process in children [32].

As glucose is to importance energy source for the human nervous system, carbohydrate has also been advised to have an important role in brain and mental performance. Whereas

there seems to be a relation between glucose intensities and memory, the experimental prominence of this relation ruins unclear.

3.10 Carbohydrate through the Life Cycle

Nutrient and energy and requests are enhanced in prenatal period, and the primary trial for prenatal women is to see these improved energy requirements so as to guarantee healthy descendants. It has been discovered that where diversity in the food resource is lower and carbohydrate consumption is higher, a low birth mass is general. This growths worries regarding the sufficiency of excess carbohydrate intake to see the nutrient and energy requests of gravidity if food variety is restricted. Nutrient and energy requirements ought to be provided by wide plenty of foods containing carbohydrate intake. There is also some understanding regarding excess fat intake in pregnancy as it may be related to obesity hazard in the mother.

A lot of countries, newborns take 45-55% of energy obtained from fat by means of breastmilk and 35-45% of energy from carbohydrate. Whereas definite decreasings in fat consumption are not suggested under the period of two years, newborns in lots of countries have low fat consumption diets. This is not a problem so long as the energy necessities are carried out. From the period of two and on, the optimal diet cobtaining at least 55% of total energy obtained from different carbohydrate resources should be slowly made known.

Throughout the first four months to six months of lifetime, special breastmilk is advised since this modifies the density of lactose to the growing newborn and newborn gut, generally whereas pancreatic amylase and colonic microflora manufacturing are improving. For newborns fed on formulation, the carbohydrate constituents ought to be generally imitator breast milk to the range probable and in keeping with Codex Alimentarius principles [33].

Carbohydrate intake in the newborn and young baby is substantially affected by both gastrointestinal ripening and the chemical environment of the consumed carbohydrate. The establishing of colon microflora is accountable for colon carbohydrate, altering any carbohydrate ingoing the colon to fatty acids being short chained. Any conflicts or

unsuitable improvement of this microflora causes diarrhea and colon carbohydrate surplusing.

Lactose obtained from dairy products may be a main carbohydrate resource for young children. Furthermore, milk symbolizes a tremendous resource of good protein quality, riboflavin and calcium. In lots of people, much those with lower lactase enzyme activity, milk can be digested in small quantities, especially after meals. Fermented dairy products are be able to be worthful substances in the diet of lots of people regardless of intestinal lactase enzyme status [16].

Often the changeover from youthful to parenthood is relataed with alterations in dietary design. In high-income countries, children commonly ingest very excess carbohydrate stemed from a small number of resources, whereas adults have great diversity. In such situations, the grown-up diet is selected. In high-income countries, instead, surveys show that children have higher carbohydrate consumption from more resources than adults. In those countries, the children diet would appeared like to be more suitable. In all cases, at least 55% of carbohydrate energy obtained from different resources is the optimal [16].

Individuation of carbohydrate consumption is necessitated for advanced year's populations. Senior citizens in a variety of countries are at hazard with regard to both obesity and malnutrition. Food consumption patterns may be changed by alterations in taste sensitivity, chronic illnesses and medication usage. Whereas an excess carbohydrate diet is advised for avoidance of weight gain and obesity, it ought to be believed that some individuals can need diets high in energy concentration so as to keep away from malnutrition. Adjusting carbohydrate consumption to lessen glucose intolerance illness in later life is a contemplation in countries where this intolerance is an issue [16].

CHAPTER 4

CARBOHYDRATES AND HEALTH

4.1 Influence of Carbohydrates on Food Intake

Food consumption is controlled by the difficult relations of physiological procedures related with digestion. Whereas the energy amount of foods has a significant role in detecting the quantity eaten, lots of other belongings of foods also can be significant. These contain delectableness, macronutrients, formula of the solid or liquid food, how it is organized, and energy concentration [16].

Of main concern is if the changing physiological replies to carbohydrates are related to distinguishing impressions on food consumption. Means in which carbohydrates can affect consumption including chewing period, taste, stomach digestion, digestibilitness, absorption amount, hormonal modifications, and metabolic indications arising because of carbohydrate use by different muscles. The roles of these many inspirations and the system that they interrelate to influence food consumption are not known well [16].

It is beneficial to differentiate between "satiety" and "satiation." and Satiation states to the processes that gotten involved in the termination of a meal, while satiety states to the impressions of a food often stated to as a pre-load or a meal [34]. Foods freely overeaten are generally extremely edible and have higher energy concentration. Many studies on carbohydrates have observed the impressions on saturation, that is, how stable quantities of carbohydrate impacts subsequent food consumption [16].

4.1.1 Sugars and food intake

The studies on the influences of sugars on the parameters of food consumption has been lately studied [28]. Some sugars have specific interest due to the sugary taste they offer. Whereas sweetness rises the delectableness of foods, mostly when mixed with fat, and so can rise the possibility that sugary foods will be designated for ingesting [35]. There is no sign that sugar is related with excess food consumption. Consumption of foods or drinks being sweet is restricted by alterations in the hedonic answer to saccharinity throughout intake [36]. Therefore, to a person being hungary a sweetened food will choose as enormously agreeable in taste, yetas ingesting continues this preference of pleasantness deteriorations. Preferences of foods with different tastes, such as, salty foods, will not be influenced by intake of sweet foods. This "sensory-specific satiety" restricts the intake of one type of food and provides to guarantee being a variety of eaten foods [36].

A lot of people have faith in that sugar and other carbohydrates subsidize to overdosing of eating and obesity. Notwithstanding this general belief, there is indirect indication that obese people eat excess amounts of foods being sweet. Certainly, many surveys show a contrary relation between expressed sugar intake and overweight degree [35]. In a recent study of the 10 favorite foods of a big section of women and men being obese, it was shown that obese men recorded mostly protein/fat resources among their favorite foods, while obese women listed mainly carbohydrate/fat sources and foods being sweet. Inclination for carbohydrates was not an ordinary property of obesity. Relatively inclinations for major food resources of fat as opposite to carbohydrate can be a main specific of human obesity patterns [35]. Therefore, though there is little indication that any of the several sugars are related with obesity, sugars are often related to a high-fat composition found in foods and serve to enhance the fat delectableness is related to obesity.

4.1.2 Starch and food intake

Alterations in foods containing starch can impress the quantity eaten or hunger and satiety. For example, the planning method, the food resource, and the amylose/amylopectin amount may all result in diverse glucose/insulin reply and hormonal outlines. Foods including starch differ generally in their glycemic reply (the effect on

blood glucose) from lente, a slower continued glycemic reply, to quick rises in blood glucose [37]. Gradual digestion and absorption of carbohydrates provides to continue steady blood glucose levels which can be useful to diabetics. High intake of lente foods are able to also lessen serum triglycerides and improve lipid [38].

Changing the amylose/amylopectin amount variations physiologic replies impressing the saturation. Starches having the higher-amylose amount are related with a lower glycemic reply than starches having low-amylose rate, and they can be also more gradually digested by the stomach. As would be expected from these physiologic impressions, enhancing the amylose/amylopectin amount has constantly been thought to be related to high saturation [16].

Estimations regarding how resistant starch could impress the satiety are not linear. If alike quantities of resistant and fixed starch are taken, the resistant starch will convey merely around half the energy as the fixed starch and one would guess reduced satiety food consumption. Instead, resistant starch can have role like soluble fibre where it could postpone gastric emptying and extend absorption which in turn can prolong the saturation. When comparing the resistant starch (50g uncooked potato starch) with an equivalent weight of pregelatinized potato starch taken in a drink, the resistant starch was related with a lower glycemic reply and was much less satiating [36].

4.1.3 Dietary fiber and food intake

There are a lots of causes why dietary fiber can decrease food consumption: high-fiber foods last longer to consume; fiber reduces the energy concentration of food; some fibers such as pectin and guar gum slow gastric emptying; fiber may decrease the digestibleness of food; there can be enhanced faucal energy loss on high-fiber intake; and fiber can influence some gastrointestinal hormones that affect the food [24]. The studies on this subject is multipart owing to the different types and doses of fiber that have been experienced, and the extensive diversity of experimental procedures. This is exemplified by the earlier debate of the impressionsof resistant starch being a kind of dietary fiber. Yet, there are lots of studies exhibiting that foods containing high-fiber taken either at breakfast or lunch considerably decrease consumption at the next meal compared to low-fiber foods. Whole everyday energy consumption, but, was not impressed by the amount or kind of fiber in the breakfast [39].

4.1.4 Energy and macronutrient balance

Continuing a constant body mass necessitates achieving energy equilibrium, where the quantity of energy digeste equivalents the quantity of energy consumed. Whereas obesity can only improve when energy consumption surpasses energy spending, labors to subsidize obesity merely to a higher level of energy consumption or to a lower level of energy spending have been ineffective. Obesity can improve gradually from a small, continued positive energy equilibrium produced by some combination of increased energy consumption and declined body activity or could arise from periodic bouts of positive energy equilibrium achieved by short-term rises in consumption or declines in body activity [15].

Attaining body mass instruction necessitates more than attaining energy equilibrium; it also necessitates that macronutrient equilibrium be attained. Macronutrient equilibrium is known that the consumption of each macronutrient is identical to its oxidation. If this is not the situation for a specific macronutrient, human body stores of that macronutrient will alter. For a weight-unchanging person this means that the fuel composition oxidized is alike to taken energy composition. When the state of energy and macronutrient equilibrium is interrupted. The body tries to repair this state of homeostasis. In such situations, the alterations in the quickness with which equilibrium of each macronutrient is reestablished has significant consequences on the role of diet composition in body mass regulation. [16].

4.2 Glycemic Index

Twenty years have lasted since the first relative glycemic index effects of carbohydrate conversations from 51 foods was issued by Jenkins et al [32]. For each gram of carbohydrate, foods having high glycemic index (GI) yield a high peak in postprandial blood glucose and a greate whole blood glucose reply during the first 2 h after intake than do foods having a low GI. In spite of debatable beginnings, the GI is now commonly accepted as a confidental, based on arrangement of foods along with their postprandial glycemic effect. In 1997 a committee of specialists was brought together FAO of the WHO to critic the current research indication about the prominence of carbohydrates for human nutrition and human health [1].

To encourage welfare, the committee supported the intake of a high-carbohydrate diet (≥55% of energy obtained from carbohydrate), with the majority of carbohydrate-including rich in nonstarch polysaccharides foods having a low GI. In Australia, formal dietary procedures for fit progressive year's people specifically suggest the intake of low-GI cereal foods for good [37] and a GI logo documentation program is in place to detect GI values on food packet as a tool of aiding consumers to choose lower-GI foods [40]. Foods tested as commercial GI for the food industry is presently carried out by lots of laboratories all over the the world, such as our own. Lots of latest popular diet books include widespread lists of the GI ideals of personal foods or advocate the intake of low-GI, carbohydrate-rich foods for weight control and good health [41]. Confidental tables of GI gathered from the scientific sources are instrumental in improving the quality of research investigativing the relationship between the health and dietary glycemic effect. The first publication of International Tables of Glycemic Index, issued in this Journal in 1995 with 565 has been mentioned as a reference in lots of scientific articles. Particularly, these tables offered the base for the GI for the usage a dietary epidemiologic means, permissing the novel evaluations of the impression of several carbohydrates on ilness risk factor, distinct from the old-style cataloging of carbohydrates into starches and sugars. Different large-scale, research studies from Harvard University show that the long-term intake of a diet having a high glycemic load is a important free forecaster of the risk factor of progressing cardiovascular disease [32] and type 2 diabetes mellitus [42].

Recently, indication has been gathering that a lower-GI diet might also preserve in contradiction of the improvement of colon and breast cancer [1]. The EURODIAB (Europe and Diabetes) study, getting involved >3000 people having the type 1 diabetes in 31 clinics all around the Europe, exhibited that the GI rating of self-selected diets was independently related to blood levels of glycated hemoglobin in women and men [43].

4.3 Glycemic Load

Both the amount and quality of carbohydrate impress the glycemic reply. By description, the GI matches identical amounts of carbohydrate and offers a degree of carbohydrate superiority but not quantity. In 1997 the conception of GL was presented by scientists at Harvard University to measure the whole glycemic impression of a ration of food [32]. Therefore, the GL of a typical food is the product of the amount of available carbohydrate in that serving and the GI of the food. The higher the GL, the great the predictable

advancement in blood glucose and in the insulinogenic impression of the food. The long-term intake of a diet with a comparatively high GL is related with an increased risk factors of heart disease and type 2 diabetes [42].

Table 4.1 Glycemic Load and Glycemic Index of Some Food Groups [44]

PRODUCTS	**Glycemic index (glucose = 100)**	**Serving size (gram)**	**Glycemic load per serving**
Banana cake, preparedwith sugar	47	60	14
Banana cake, prepared without sugar	55	60	12
Plain Sponge cake	46	63	17
white, frozen Bagel	72	70	25
DRINKS			
Coca Cola® (US formulation)	63	250 mL	16
Fanta®	68	250 mL	23
Lucozade®	95	250 mL	40
REAKFAST CEREALS	**Glycemic index (glucose = 100)**	**Serving size (grams)**	**Glycemic load per serving**
All-Bran®	44	30	9
Coco Pops®	77	30	20
Cornflakes®	81	30	20
Cream of Wheat®	66	250	17
Grape-Nuts®	75	30	16
CRACKERS AND COOKIES			
Graham crackers	74	25	13
Vanilla wafers	77	25	14
Shortbread	64	25	10
Rice cakes	82	25	17
DAIRY PRODUCTS			
Ice cream	62	50	8
Premium, Ice cream (Sara Lee®)	38	50	3
Full-fat Milk	31	250 mL	4
FRUITS			
Apple	36	120	5
Raw Banana	48	120	11
Dried Dates	42	60	18
Grape fruit	25	120	3
Black Grapes	59	120	11

4.4 Factors Affecting Glycemic Index and Glycemic Load of Foods

4.4.1 Carbohydrate contents of foods

Dietary carbohydrates can enhance blood glucose concentration especially in the postprandial period. Consequently, for people having diabetes mellitus, either those with type 1 diabetes or those who have more austere forms of type 2, diet containing a carbohydrate- rich canbe destructive to glycemic index control causing microvascular and macro vascular diseases. In similar with plasma glucose advancement, triacylglycerol intensities and plasma insulin have been expressed to rise with diet containing a high-carbohydrate, in company with other cardiovascular sickness risks [27].

However, not all carbohydrate-rich foods lead to the hyperglycemia when taken. Alterations in postprandial blood glucose replies to several carbohydrate-including foods have also been confirmed in both healthy and diabetic people, even when taken with portions including similar quantities [2]. This exhibits that there can be changes in personal constituents of carbohydrates that are accountable for the informed differences to postprandial blood glucose responses after a number of carbohydrate intake including foods by both healthy and individuals having diabetes.

These alterations in glycemic replies to carbohydrate-rich foods and having also tendency to influence the GL of foods, were concluded to upraise from different constituents of carbohydrates cureency in foods and their features like: Starch composition/features, dietary fiber contents, sugars in addition to other factors including: insulin reply, protein contents, processing methods, diversity, particle dimension, acidity, fat, storage and time of harvest [45].

4.4.2 Starch composition/properties:

Starch subsidizes about 70–80% of the total carbohydrates in normal-diets [46]. For nutritional focuses, starches are categorized on the basis of their rate and extent of digestion into 3 categories, specifically: rapidly digestible starch (RDS), slowly digestible (SDS), and resistant starch (RS).

RDS is the starch segment that is quickly digested and absorbed in the duodenum and proximal regions of the small intestine leading to a fast advancement of blood glucose and generally a successive episode of hypoglycemia [47].

SDS is the starch portion digested gradually yet wholly in the intestine to offer continued glucose issue with a low early glycaemia and successively a slow release of glucose, causing prolonged energy accessibility [47]. It is detected chemically as the starch transformed into glucose after enzymatic digestion. Examples contain: most uncooked cereals and others. The potential health profits of SDS containing constant glucose metabolism, diabetes mellitus organization, etc. [17].

RS is not digested in the upper gastrointestinal tract yet is fermented by the gut microflora, producing short chain fatty acids that offer additional energy to the body. That's why, its definition by Sagilata and colleagues as the fraction of dietary starch that escapes digestion in the small intestine. RS is measured chemically as the variance between total starch (TS) (taken from homogenized and chemically treated sample) and the sum of RDS and SDS, generated from non-homogenized food samples by enzyme digestion [47].

4.4.3 Amylose-amylopectin ratio

Indication exhibits that amylose is slowly digested and have late insulin reply time, providing a lower glycaemia index. Studies carried out by Miller et al exhibited that rice with its high amylose content (Doongara, 28% amylose) provied a substantially low glycemic index (GI) and insulin response than the normal amylose against amylopectin rice diversities (Calrose and Pelde, 20% amylose). Studies concluded by Miller et al exhibited that rice with its high amylose capacity gave a considerably low GI than normal amylose against amylopectin rice diversities [48].

Besides, amylopectin/amylose percentage and amylose buildings with lipids influence the amount of starch hydrolysis. The extent of starch digestibleness commonly reduces as amylose composition rises even though amylose composition is not an only forecaster of digestibleness [49].

Equally, amylose linked with lipid is stronger to be digested by hydrolytic enzymes such as amylase than released carbohydrate [50].

4.4.4 Dietary fiber

The American Association of Cereal Chemists, well-definite dietary fiber as carbohydrate polymer units with much more than a three grade polymerization being neither taken nor absorbed in the intestine [51].

Lately, The British Nutrition Foundation defined dietary fiber as a group of materials in plant foods that are not be able to be totally digested by human digestive enzymes. These contain: lignin, waxes, and polysaccharides like cellulose [52].

In line with the cataloguing of dietary fibre by the American Association of Cereal Chemists as described by James and Mark, dietary fiber is separated into 3 constituents: non starch polysaccharides and oligosaccharides, analogous carbohydrates and lignin materials [53]. Slavin et al exhibited that sticky soluble fibre have an essential role in adjusting postprandial glycemic and insulin replies owing to its impression on gastric emptying and macronutrient intake from the gut [54]. Astonishingly, some potential studies showed that not soluble was contrariwise related with the existence of type 2 diabetes [55].

Numerous studies carried out during the last ten years regarding the impression of dietary fibre on insulin sensitivity on condition that controversial resulsts [56]. In a randomized study, Pereira et. all a showed that consumption of a whole grain diet led to a postprandial enhancement in insulin compassion when compared to a superior grain diet [57].

Equally, Weickert et al., used the same technique to measure insulin sensiviteness in obese and overweight women and showed that this enlarged after 3 days of a diet including bread supplemented with insoluble fibre. The study was conducted a 6 months casual match-timed study comparing a diet including 50 g/d of soluble fibre with a diet containing only 15 g/d of fibre. They found a development in the daily blood glucose profile concentrations and a marked diminishing in the lots of hypoglycemic events [58].

4.4.5 Sugars

GI is influenced by the sugar amount in a food. For instance, sucrose made up of glucose and fructose, has a low GI than glucose owing half to the sucrose molecule consists of fructose, a kind of sugar that subsidizes low blood sugar reply. Furthermore, whereas the

GI of sucrose is 68, glucose GI is 100 [7]. This alteration of GI because of sugar composition can also influence the GL.

4.4.6 Insulin response

Another issue that has been found to have substantial impression on the blood glucose concentration of a personal following carbohydrate intake rich diet is insulin response. The study carried out by Miller et al noted a negative relation between the GI and insulin reply of some foods, a characteristic example having high GI values [35] Calrose brown rice but with a conflicting insulin index of 51. Even though, it is believed that insulin replies to carbohydrate foods is potentiated by calculation of the food containing fat, the reports of Miller et al showed that the fat compositions of the rice was insignificant. Consequently, insulin reply should be an attention reason when defining the optimum foods containing carbohydrate for people suffering from diabetes [48].

4.4.7 Protein content

Foods being protein-rich enhance insulin excretion causing making lower of postprandial blood glucose concentration. Therefore, the natural protein compositions of some foods may be the result in why their starches are not simply digested discussing them with lower GIs. A characteristic example is the situation of pasta gluten and in cereals sluggishing the action of amylase produced by pancreas, thereby causing the lower GIs [59].

4.4.8 Processing techniques

It has been identified that several food manufacturing systems impress the digestibleness of starch having some consequences on the food's GI. Manufacturing systems can impress both the retrogradation-gelatinization procedure, affecting resistant starch formation. For instance, fried and roasted foods were stated to have high GIs than boiled foods [60].

According to the another study, cooking with steam was informed to help the construction of RS17 and starches obtained from different hot-steam-heated legumes were informed to be rich in incomprehensible RS, was not detected in raw beans [61]. Again, Bahado-Singh et al. showed that sweet potatoes process by boiling led to low GI value when we compared to baking, frying, and roasting of sweet potatoes [45].

Another study carried out by the study Deepa et al on relative study about starch digestibleness, glycemic index value and resistant starch of exhibited that the suitable impressions of dietary fiber in delaying the hydrolytic enzymes action are invalidated when whole grains are crushed since they are digested at the identical amount as refined grain flour [59].

A characteristic situation of the impression of manufacturing a food on its effect on blood glucose concentration is shown in the study of Alegbejo et al showed that boiled cocoyam (*C. esculenta*) has a high GI value and so can not be good for diabetics people, a outcome that denied the outdated use of *C. esculenta* in Nigerian ethnomedicine in the management of diabetes while the study of Eleazu et al reported the hypoglycemic action of oven dried *C. esculenta* in experimental diabetic rats and which findings corroborated the outdated use of *C. esculenta* in Nigerian ethnomedicine in the organization of diabetes whereas the research of Eleazu et al showed the hypoglycemic exploit of oven dried *C. esculenta* in investigational rats having diabet and which results helped the outdated use of *C. esculenta* in Nigerian ethnomedicine in the organization of diabetes still conflicting the reports of Alegbejo and his colleagues [62]. These results point to the fact that techniques of processing of food materials frequently influence their GIs. [59].

Especially cold fermantation conditions are highly effective on GI. In 2005, the study carried out Ayerdi et al. showed that people living in the rural areas of Mexico eat corn tortillas and beans as an elementary compounds of their daily diet. Nevertheless, little thing is known regarding the nutritionally related properties of starch present in such united meals. The aim of the current research was to estimate the in vitro starch bioavailability in tortillas−bean mixtures put away at 4 °C for altered times, as related to that of corn tortillas and boiled black beans reserved individually under the same environment. Resistant starch (RS), available starch (AS), and retrograded resistant starch (RRS) compounds were detected. The in vitro starch hydrolysis showes (HI) of cooked freshly and cold-stored food materials were valued using a chewing/dialysis ingestion procedure. HI's were used to estimate glycemic index of the food samples. As in tortillaS and beans reduced between 3 and 6% after 48−72 h, while GI values in the mixture reduced by 3% after 48 h, with no any other alteration by 72 h. Merely negligible rises in RS compositions (1.5−1.6%) were detected for tortillas and beans after 72 h of storage time, and a low enhancement (0.4%) was detected in the mixture. Judging from RRS

values, a significant part of RS is owing to starch retrogradation. The HI and estimated glycemic index values were even higher in tortillas than in bean and the mixture of them.

Hydrolysis amount values reduced in the stored food samples, a design that related with RS and RRS alteations. The gradual food digestion properties of general beans are mainly reserved by the legume−tortilla mixture. Information maintenance the recognized health useful features of starch in outdated cereal−legume food [63].

Lastly, processing of foods using high temperatures could exhibit gelatinization, thus lastingly distracting the amylose-amylopectin construction of the starch compound, making it more easily available by digestive enzymes such as amylase.

4.4.9 Fat

Fat rises the period it takes for food to leave the stomach and arrive the intestine. By slowing the amount where dietary carbohydrates are consumed in the small intestine, fat including foods may impress the increasing in blood sugar and profit a low GI than alike foods not containing fat. For example, the potato chips GI value is 57, in addition to this, baked potato is 85 French fries is 75 and [64].

4.4.10 Acidity

Acid found in food reduces the speed of stomach emptying, thus reducing speed rate where dietary carbohydrates are digested. Thus enhancing the acidity in a meal may reduce GI and blood glucose level. These issues as counted above so incline to influence the reproducibility of GIs and glycemic load of foods. Consequently, in calculating the GIs of foods, all these parameters have to be thought or else, such informations reported can not be a true symbol of the GI of the food substance being examined [7].

4.5 Glycemic Index and Sourdough

4.5.1 Sourdough

Addition of water and grinding of cereals causes the production of a dough turning into a sourdough categorized by acidic taste, flavor and enlarged size of dough owing to gas production. This fermentation ocuurence can have been one of the first microbial progressions being gotten work by man and resulted in the usage of sourdoughs for

bread making process. Leavened bread baking may be drew back to Egypt in 1500 BC, and the researchof the microbiology of sourdough has a history of about 100 years. Not all sourdough samples are exposed to baking. More fluid soured doughs are used in different regions of the world [65].

The main effect of LAB and yeasts in sourdough was thought by the innovators in the research of sourdough microbiology like Holliger (1902) and Beccard (1921). Since sourdough is a middle yet not an end-product, the microbial activities in the dough have to be magistrated on the base of their effect on the superiority of the baked crops produced with its aid. These are characterized by their flavor, nutritional values and their texture, i.e. the size-volumes and distribution of holes and the firmness of the crumb. To some range these properties may be attained without the connection of LAB by submission of yeast, yet the outdated processing and different new alterations are confidential for the metabolic activities of LAB in the sourdough. Upon accumulation of flour and water they keep up to produce acidic products [66].

4.5.2 Sourdough Fermentation and Dietary Fiber for Decreasing the Glycemic Index

Intake of foods having low-glycemic index (GI) and clearly rich in cereal fibers is advisied to avoid different ilnesses like diabetes mellitus, risk factors for heart ilness, also characterized as the metabolic syndrome disease. Indication has been accumulating protecting a low-GI diet in contradiction of progression of obesity colon and breast cancer [67]. The mechanisms of preserving of the low-GI diet can stem from: (1) gradual release of carbohydrates in the upper gastrointestinal system; (2) lowering of the insulin demand and (3) commonly high density of indigestible carbohydrates samples like dietary fiber and resistance starch (RS), increasing the fermentation activity in the colon. This fermentation activity growths the synthesis of fatty acids baing short chain like acetic, butyric and propionic acids [32].

Saturated fatty acids occur energy to colonocytes, and stimulate Na+ and water absorption from the big intestine, even under diarrheic disease conditions. Propionic acid is believed the moderator of the hepatic glucose and lipid metabolism [68]. In addition to this, high DF composition related with lower-GI foods can enhance the metabolic qualities of the lower-GI food diet. In this construction, it is notable that there is a deficiency of commercial low-GI products on the market and that most cereal foods have a low content

in DF. The deficiency of low-GI. Products limits chances to expressively lower dietary GI. In particular, there is a need to progress lower-GI bread products being rich in DF. When DF is added to breads, it is important to make changes in several processing limitations so order to take higher quality being suitable for the mainstream of the people. One option to expand breads quality included DF is the usage of sourdough biotechnology. Moreover, sourdough fermentation process or the direct additional of lactic, acetic and propionic acids during bread making process reduced the postprandial blood glucose level and insulin replies [69].

For the study carried out by Angelis et al. in 2007, selected, sourdough lactobacilli for reducing the GI of wheat bread prepaered with a combination (1:1) of wheat flour and whole meal flour added with oat fiber (5%). Lactobacilli were obtained as starter [70]. However no studies have thought the outdated usage of the sourdough fermentation process as a means for reducing the the white GI value, wheat bread added extra dietary fiber. Reproducible and continuous fermentation activity of the sourdough lactobacilli is indispensable to attain the optimum quality of sourdough bread, also containing the concentration of current carbohydrate amounts [71].

According to another study carried out Angelis et al., in 2007; three Lactobacillus strains were taken and used together as sourdough starter culture. Sourdough enactments were valued for 30 days. Three breads were prepared with: wheat sourdough bread (WSB), WSB added with oat and rye fibres (WSB-DF) and wheat yeasted bread (WYB) fermented with baker's yeast only. WSB-DF and WSB had the higher size and low warmth than WYB. As a result of sensory analysi, it was seen that WSB-DF and WSB were chosen owing to acidic smell, taste and flavor.

When it was compared to WYB and WSB, WSB-DF had high concentration of dietary Fibers (DF). WYB was taken as the control group to predict the hydrolysis index (HI = 100). WSB-DF had values of HI low than WSB (59 vs. 86%). As predicted on 20 helpers, the GI value for WSB-DF was 41%. WSB-DF bread processed at industrial plant joint low-GI with physiologically substantial resource of DF and high standard of structure and sensory properties [71].

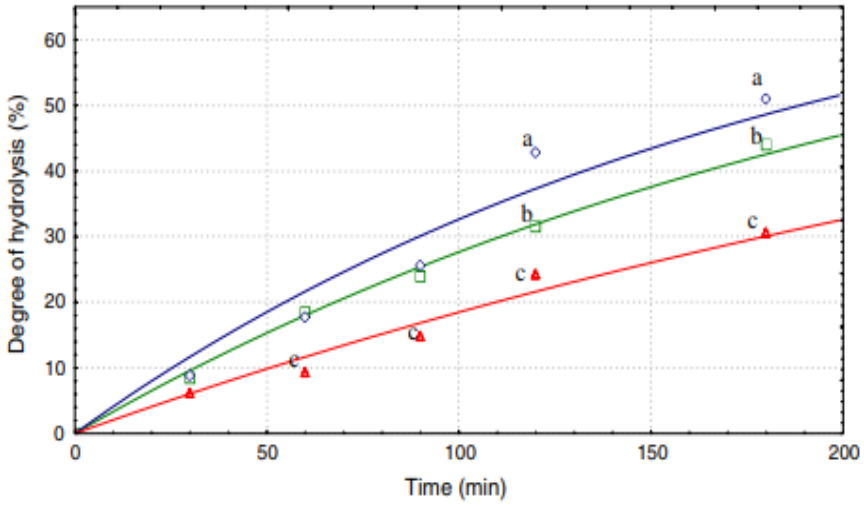


Figure 4.1 Starch hydrolysis rate after chewing, incubation with enzymez such as pepsin, amylase in a dialysis tubing. P < 0.05 [71].

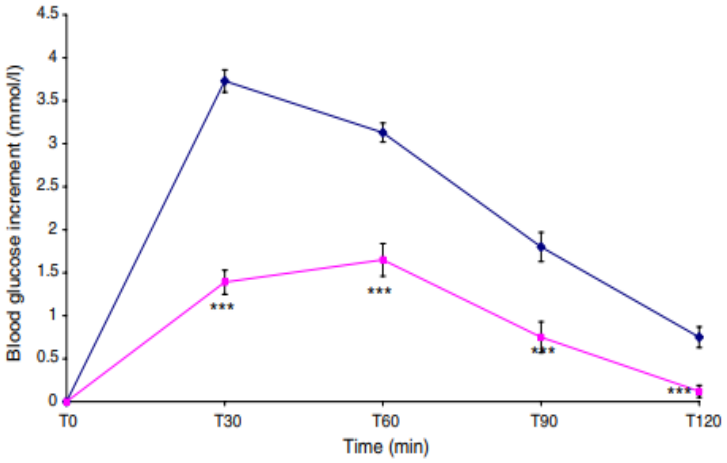


Figure 4.2 Blood glucose increasing (mmol/l) in healthy people after digestion of anhydrous glucose reference material, (P < 0.05) [71].

4.6. Literature Review about Glycemic Index Studies

In the study carried out by Liljeberg et al., in 1996; the possible things of organic acids or an organic salt on the amount of gastric emptying was researched todetect the reasons for reduced post meal replies of blood glucose level and insulin reply to foods containing like sourdough bread samples etc.

Paracetamol was included in bread products with additional lactic acid or sodium propionate and taken as a indicator for the amount of gastric emptying process in healthy people.

Likewise, postprandial glycaemic index values, insulinemia, and satiety were predicted. Thought in rats following they were tube-fed with glucose samples. The bread products prepared with lactic acid both reduced blood glucose level and insulin peply. The bread prepared with sodium propionate also continued its satiety. The cause for the reduced metabolic replies with sodium propionate was perhaps a reduced gastric emptying amount, as it was reduced blood glucose level owing to paracetamol concentrations; there was no such impression detected with bread containing lactic acid. An alike amount of lactic acid in resolution tube-fed to rats did not impress the vanishing of glucose level from the stomach. In contrast to the results in humans, sodium propionate had no impression on the amount of gastric emptying in rats while a solution of propionic acid being equomolar decreased the gastric emptying quantitiy in rats. Perhaps, less of this acid was yielded in the gastric compounds following a bolus loading of a sodium propionate solution than in an eating case. Similarly, the pH and/or the osmolarity can be prominent, and when on condition that in excess quantities, lactic acid decreased the gastric emptying amount in rats. A hydrochloric acid solution of alike pH was evenless operative in this situation [72].

In the study carried out by Novotni et al. in 2012; bread not containing gluten protein commonly has lower nutritious value with its high glycemic index value (GI) and shorter shelf-life. The purpose of this study was to look for the effect of sourdough adding on GI value, firming kinetics and quality parameters of bread not containing gluten prepared by partly baked frozen technology process. Sourdough was prepared with the fermentation process containing the commercial starter culture of *Lactobacillus fermentum* and containing to bread batter at four concentrations (7.5; 15; 22.5 or 30%). It was detected biochemical properties of the sourdough and bread chemical content, glycemic index values as in *vivo*, physical features and firming kinetics properties were determined after final rebaking. All breads were added with inulin and were high in fiber (>6 g/100 g). Control bread group prepared without sourdough sample had modarate GI (68). Sourdough additional reduced bread GI Nevertheless, merely breads prepared with 15 and 22.5% of sourdough samples had lower GI. Furthermore, additional of 15 and 22.5% of sourdough samples had absolutely impressed the quality parameters of incompletely baked frozen bread samples: specific size enhancement, crumb inflexibility reduced and firming was postponned. As a resul, the combining presentation of sourdough samples and incompletely baked frozen technology can reduce the glycemic index value, advance

quality and shelf-life of bread not containing gluten. Such breads can be advised as a part of well well-adjusted diet not containing gluten [73].

In the study carried out by Frei et al., in 2003; Starch degradability was searched in six original Philippine rice samples varrying from amylose composition. An in vitro enzymatic starch digestion technique was used so as to predict the estimated glycemic index value the kinetics of starch hydrolysis as in vitro. Two different usages were searched: first, samples were prepared and searched fast; second, samples were prepared and waited at 4ºC for 24 h so as to show a retrogradation impression. The results showed that substantial alterations in the redicted GI value between rice samples. Values ranged from 68 to109 for cooked rice and from 64 to 87 for stored rice including a type of resistant starch that is the retrograded starch. Starch hydrolysis ratio inclined to be faster and more whole for waxy samples than for high amylose samples. Storing rices in at the 4ºC resulted in a decreasing of the predicted GI value for all samples. The highest reducing in starch hydrolysis ratio after cool storage condition (4ºC) was observed for the waxy samples [74].

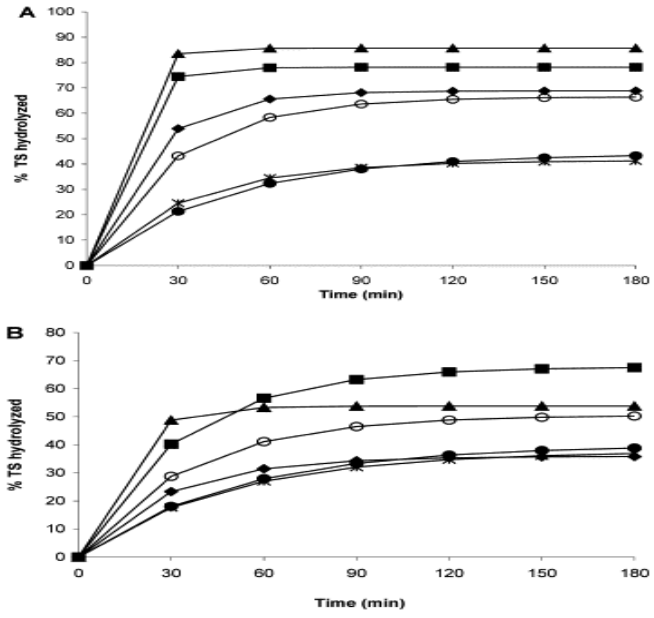


Figure 4.3 In vitro starch hydrolysis ratio of (A) cooked and (B) rice samples containing retrograded: Milagrosa (●), Manumbaeay (○), Kustiyam (∗), Kinaures (■), Bagoean (♦), and Karaya (▲) [74].

In the study carried out by Tamura et al. in 2016; the impression of cooking level on the starch digestibleness of rice being a non-waxy, cooked was searched via a replicated based on gastro intestinal in vitro digestion method. The starch hydrolysis ratio of both non-homogenised and homogenised cooked rices during replicated digestion process was also associated so as to search the effect of grain construction on starch digestibleness. Polished rice grains were prepared with in boiling water for 10 min and 20 min (paritaaly-fully cooked, respectively) to take the rice samples of several cooking degrees. No significant alterations in the balance starch hydrolysis ratio (%) were recorded among the partially and fully cooked rice samples, though important alterations were seen among the uncooked and cooked rice samples. The balance starch hydrolysis ratio (%) of homogenized rice sample was higher GI than non-homogenized matching part. These conclussions exhibited that rice starch digestibleness ought not be impressed by the cooking process degrees related with the starch gelatinization ratio , but was affected by the modification of the grain construction during mechanical manufacturing [75].

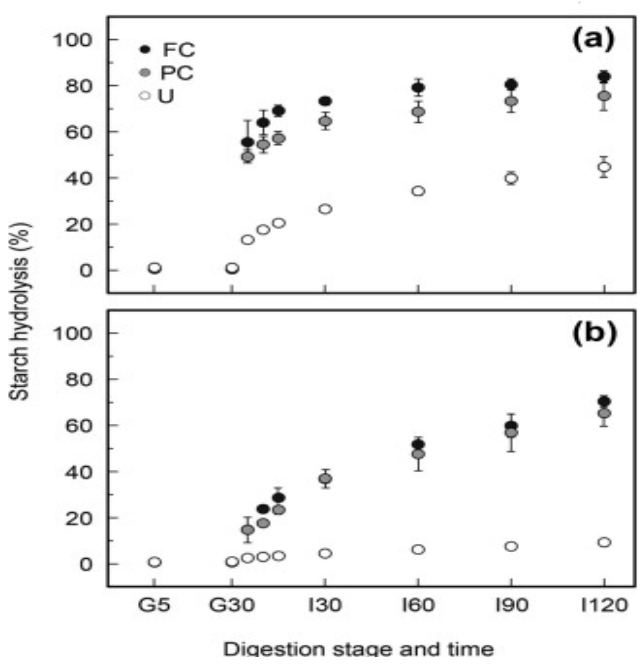


Figure 4.4 Changes in starch hydrolysis ratio (%) of homogenized (a) and non-homogenized (b) uncooked and cooked rice samples during replicated starch digestion process. U (uncooked), PC (partially cooked), FC (fully cooked). Error bars signify standard deviation (n = 3) [75].

CHAPTER 5

MATERIAL METHOD

In this study, after in vitro GI determination of sourdough breads prepared with sourdoughs collected from different regions of Turkey, it was tried to be decreased the GI of breads by changing fermentation conditions and formulations of bread. GI values of breads were evaluated by using an in vitro method based on Goni–assay white bread was used as a standard reference food sample so as to determine glycemic index.

5.1 Devices and Materials

It is seen that devices, materials and additives used during thesis study at Table 5.1, Table 5.2 and Table 5.3.

Table 5.1 Devices used for thesis study

Device	Brand
Refrigerator	Samsung
Shaking Water Bath	Nüve ST30
Grinder	Sinbo
Incubator	Wiseven
Precision Scales	Shimadzu
Automatic pipet(10-100µl)(100-1000µl)n(200µl)	Eppendorf Research
pH Meter	Thermo Scientific
Vortex	Heidolph ax
Water estilation Unite	Human Power
UV Spectrofotometer	Shimadzu(Uvmini-1240)
Centrifugate	EBA 20 (Hettich Zentrifugen)
Heating Magnetic Stirrer	VELP Scientifica-Are
Fermentataion Cabin	Hengel
Industrial Oven	Fimak
Dough Mixer	Öztiryakiler
Colour Measurement Device	CR-400 Konica
Ash Furnace	WiseTherm-Daihan FH-03, Kore

Table 5.2 Materials used for thesis study

Materials	Brand
Pepsin	Sigma
Guar Gum	Sigma
Pancreatin	Sigma
Aminoglucosidase	Sigma
Invertase	Sigma
Glucose Oxidase/Peroxsidase(GOPOD) Glucose Quantification Kit	Megazyme
Sodium Acetate	Merck
Hydrochloric Acid	Merck
Ethanol	Merck

Table 5.3 Additives used for bread making

Additives	Brand
Whole Wheat Flour	İstanbul Halk Ekmek
White Flour	İstanbul Halk Ekmek
Enzyme Mixture(amylase-hemycellulase mixture)	İstanbul Halk Ekmek
Aminoglucosidase	İstanbul Halk Ekmek
Whey Powder	İstanbul Halk Ekmek
Salt	İstanbul Halk Ekmek
Commercial Yeast	PakMaya

5.1.2 Chemicals Used for Thesis Study

5.1.2.1 Hdrochloric Acid (HCl)

0.42 ml HCl is completed to 100 ml with distilled water.

5.1.2.2 Pepsin- Guar Gum

0.5 g pepsin and 0.5 g guar gum is prepared with 100 mL 0.05N HCl. 10 mL is used per 10 g sample.

5.1.2.3 Sodium Acetate (NaAc) (0.05M)

4.10 g NaAc is diluted with 100 mL distilled water

5.1.2.4 Enzyme Mixture

For one sample, 136 mg/mL pancreatin, 13.4U/mL aminoglucosidase ve 25.43 U/mL invertase is prepared. 5mL of this mixture is added to each sample.

5.1.2.5 Glucose Oxidase/Peroxidase Enzyme Kit

It is bought as commercial

5.1.3 Additives Used for Bread Making

5.1.3.1 Whey Powder

Provides desired colour formation and good bread volume.

It is protein source

Gives the elasticity to dough

5.1.3.2 Gluten

It is necessary for good dough shape

Gives the consistency to dough Kıvam artırıcı özelliği vardır.

Increases dough yield

5.1.3.3 Salt

It bonds dough ingredients and Gives desired flavour

It has antimicrobial activity

5.1.3.4 Enzyme Mixture

Enchances colour, quality and freshness of bread

5.2 Methods

5.2.1 Sourdough and Leaven Making Procedure

For the firs objective, sourdough samples collected from different regions of Turkey with theisr own flours but for the second objective sourdoughs were prepared by being used Istanbul Halk Ekmek (IHE) sourdough and and for all breads leaven was done with IHE procedure (Figure 5.1). Each sourdough and leaven were prepared with its own flour (wheat flour or White flour).



Figure 5.1 Regions where sourdough samples were collected (They were showed with stars)

5.2.2 Microfloras Collected from Different Regions of Turkey

After sourdough samples collected from different regions of Turkey some strains found in their microflora were determined by Polymerase Cahin Reaction method (PCR) developed by Kary Mullis in the 1980s [76].

DNA sample includes the target sequences. Firstly, high temperature was used to seperate the original double DNA chains. Secondly, an enzyme called as is *Taq*DNA polymerase obtained from *Thermis aquaticus* synthesizes new strands of DNA chains to the target sequence. To synthesize new DNA Primers and dNTPs or deoxynucleotide triphosphates such as A, T, G ve C were used as building blocks [77].

Table 5.4 Lactic Acid bacterias isolated from sourdough samples

Number	**Isolate Code**	**Type of microorganism**	**Identification (%)**
1	37KB4(Kastamonu)	*Weissella cibaria* strain AU4-800R	100%
2	39LB8 (Lüleburgaz)	*Lactobacillus plantarum* uruma -SU5	100%
3	59SYF1B3 (Safranbolu)	*Lactobacillus rossiae* D03WW01T01-011	100%
4	59O1B5 (Oguzlu)	*Lactobacillus paralimentarius* JCM10	100%
5	032B8 (Bolvadin)	*Lactobacillus sanfranciscensis* TMW 1.1304,	100%
6	59O1B4 (Oguzlu)	*Lactobacillus paracasei* strain LL13	99%
7	0301B5 (Oguzlu)	*Lactobacillus plantarum* strain CIP 103151	99%

Table 5.5 Yeasts isolated from sourdough samples

Number	**İsolate Code**	**Type of microorganism**	**Identification (%)**
1	39LM4 (Lüleburgaz)	Saccharomyces cerevisiaeS288c	100%
2	0301M1 (Oguzlu)	Torulaspora quercuum	100%
3	032BM7 (Bolvadin)	Saccharomyces cerevisiaeS288c	100%
4	37KM6 (Kastamonu)	Saccharomyces cerevisiaeNL32	100%
5	39LM6 (Lüleburgaz)	Saccharomyces cerevisiaeNL32	100%
6	78SYFM3 (Safranbolu)	Saccharomyces cerevisiaeAA2	100%
7	59O1M1 (Oguzlu)	Saccharomyces cerevisiaeAA2	100%

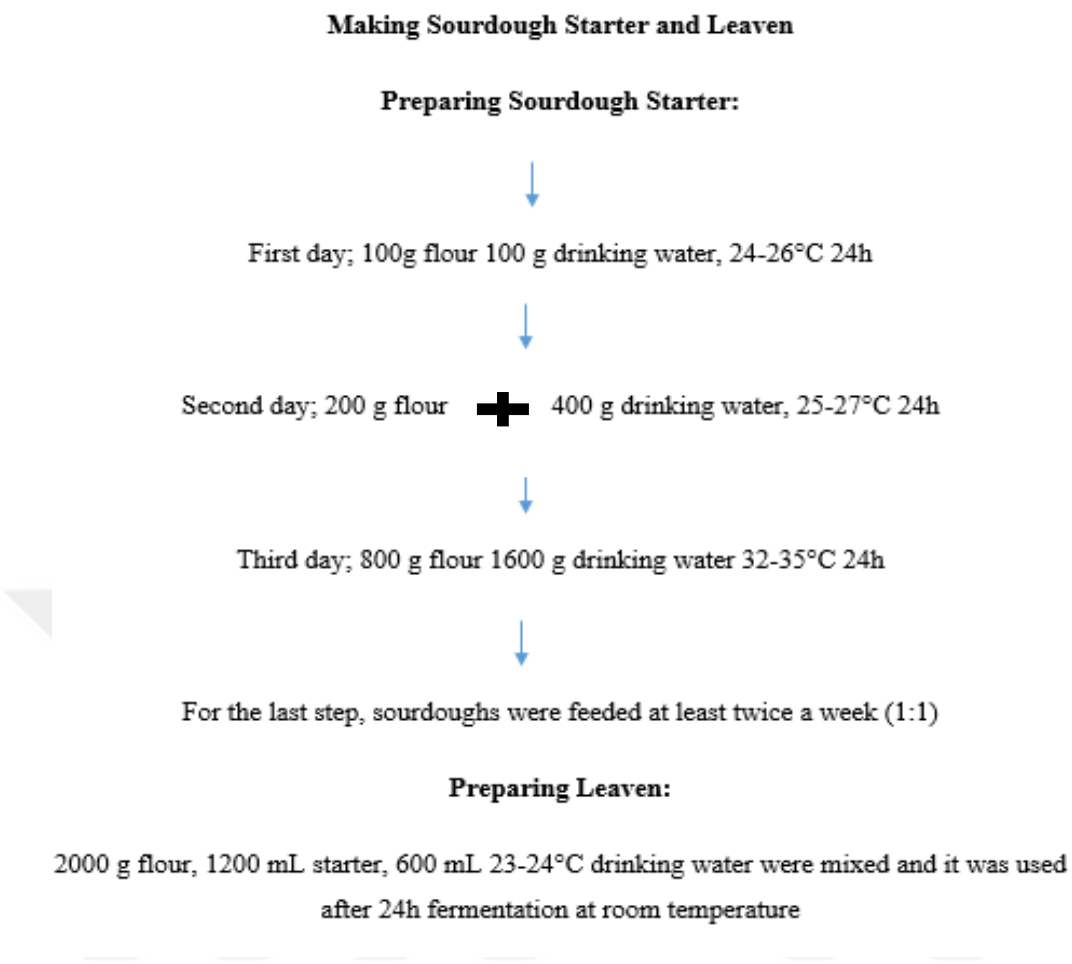


Figure 5.2 Sourdough Starter and Leaven Making Procedure

5.2.3 Bread Making Procedure and Bread Formulations

After breads were prepared by being used Istanbul Halk Ekmek bread making procedure and formulations (Figure 5.2 and Table 5.4). Each bread were done as 150 g with the same procedure then tested. Each bread was prepared with its own flour (whole wheat or white flour). Fermentation temperature was different for breads: (1) %50 whole wheat flour sourdough breads prepared with leaven at different fermentation time at the room temperature (25°C ;15h,18h,20h,24,h), (2)sourdough breads prepared with sourdoughs collected different regions of Turkey at the room temperature with 24 h leaven and (3)%50 whole wheat flour sourdough breads prepared with leaven at different fermentation time under the cold conditions (4°C ;15h,18h,20h,24,h). (First dough fermentation (30-40 min.) was the same all bread formulations). All sourdough breads were prepared with leaven. Besides, traditional sourdough breads did not contain

commercial gluten, yeast and enzyme mixture, only %50 whole wheat sourdough breads contained commercial gluten and the enzyme mixture (hemicellulose- α-amylase) (Table 5.4). White bread used as reference food was provided by Istanbul Halk Ekmek.

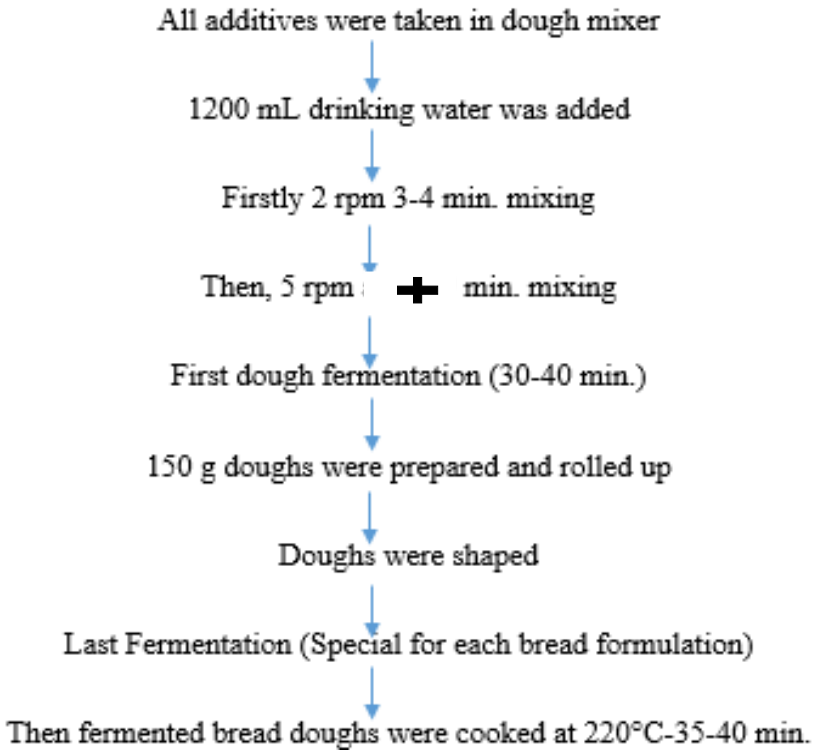


Figure 5.3 Bread Making Procedure

Table 5.6 Formulations used for bread making

	Oguzlu	Kastamonu	Lüleburgaz	Bolvadin 2	Safranbolu	%50 Wheat Flour Breads
Whole Wheat Leaven (g)	-	-	-	-	300	300
Wheat Leaven (g)	300	300	300	300	-	-
Whole Wheat Flour (g)	-	-	-	-	600	300
Wheat Flour (g)	600	600	600	600	-	300
Enzyme mix (g)	-	-	-	-	-	3
Fat or oil (g)	-	-	-	-	-	-
Salt (g)	4,1	4,1	4,1	4,1	4,1	4,1
Water (ml)	180	180	180	180	180	180
Yeast (g)	-	-	-	-	-	-
Ex. Gluten (g)	-	-	-	-	-	15

5.2.4 Total Starch Hydrolyses

Potentially available starch content was assessed following the multienzymatic protocol of Isabel Goni et al., 1997 [78].

Approximately 0.1g bread was taken 50 ml polypropylene tubes. 0.2ml %66 ethanol was added. Samples were vortex mixed. (b) 2 ml KOH was added to each sample. All samples were vortex mixed until particles were dissolved. (c) 0.1 ml α-amylase and 0.1 ml aminoglucosidase (AMG) enzymes were added. (d) Samples were waited for 30 min. in 37°C water bath.(e) Samples taken from water bath were cooled and denaturated with %66 ethanol. (f) Samples were centrifuged at 3000 rpm for 5 min. (g) 0.1ml supernatant was taken and 3 ml GOPOD was added to each sample. (h) These samples were waited 20 min. in 50°C water bath. (ı) Finally, absorbances were measured at 510 nm. Conversion factor from glucose to starch was taken into account as 0.9.

5.2.5 In vitro Digestion Kinetic

The samples were analyzed for in vitro carbohydrate digestion based on Englyst et al. with some modifications. For this purpose, (a) approximately 1 g of ground bread was taken (Figure 5.3), 5 ml pure water and 10 ml pepsin solution were added respectively.

Samples were mixed at 37 °C for 30 min with shaking bath (Nüve ST30). (b) 5ml 0.5 M NaAc buffer and enzyme solution containing α-amylase, pancreatin and invertase enzymes calculated according to sample amount were added. (c) All samples were added 15 ml pure water to dilute the solutions. All of them were put into the water bath at 37 °C. (d)Then, 0.5 ml sample was taken and denatured with 4.5 ml -%66 alcohol. In this way hydrolysed starch was measured every 30 min for a period of 2 hours as similar to in vivo trials.(30, 60, 90,120 and 150 min.(e) 0.1 ml was taken from each denaturated samples and 3 ml GOPOD solution was added to each sample. (f) Samples were waited for 20 min 50° C at shaking bath and absorbance values were determined at 510 nm with Shimadzu Spectrophotometer (Figure 5.4). The glucose concentration-time graphic was obtained by using total starch digestion. With the use of this graphic Area under Curve (AUC) was calculated and compared against a reference (white bread). Then Hydrolyses Index (HI) was calculated for each sample. The hydrolysis index (HI) was calculated as the percentage of total starch digested from the samples as compared to white bread (0–150 min). In this way, predicted Glycemic Index was calculated by applying the following empirical equation expressed by Goni. In this way, glucose concentration released from samples was calculated with the help of starch digestion. On the one hand, starch digestion was determined with the similar way. For this purpose, (a) approximately 0.1 g of ground bread was taken, (b) 0,2 ml %66 ethanol and 2ml KOH (Potassium Hydroxide) were added respectively, (c) 1,2M NaAc (Sodium Acetate Buffer) and 0,1 amylase-0,1ml aminoglucosidase were added to flasks, (d) samples were mixed at 37 °C for 30 min with shaking bath (Nüve ST30) and denaturated with %66 ethanol by 50ml, (e) 0.1 ml was taken from each denaturated samples and 3 ml GOPOD solution was added to each sample, (f) samples were waited for 20 min 50° C at shaking bath and absorbance values were determined at 510 nm with EBA 20 (Hettich Zentrifugen) Spectrophotometer. The amount of digested starch was determined with total starch equation.



Figure 5.4 Ground Bread Samples

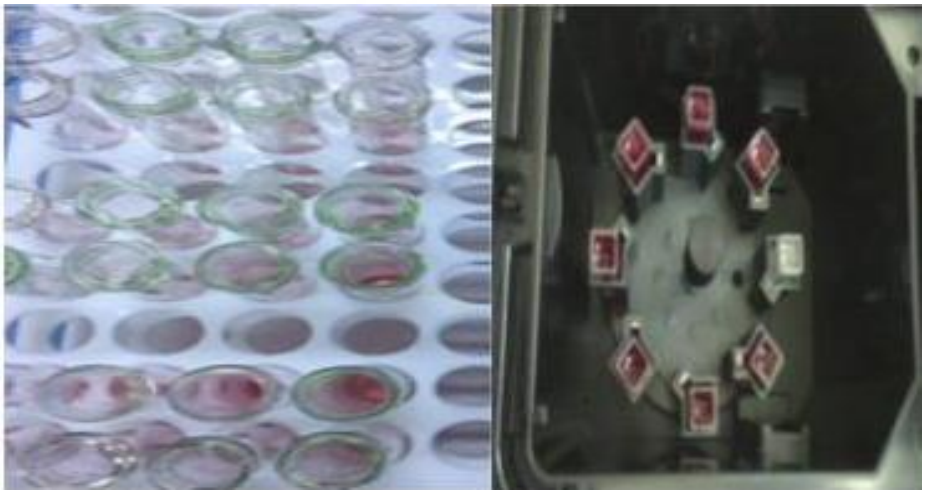


Figure 5.5 Determination of released glucose with spectrofotometer at 510 nm

5.2.6 Data Analysis and Statistical Method

Datas were analysed by using SAS_JMP_6.0 sofware for all parameters. Results were evaluated by using one-way ANOVA, and comparisons were carried out using LSMeans Student's t test. Statistical significance was set $P<0.05$. To calculate the GIs of breads, 3 steps were performed:

Firstly, area under the curve (AUC) was calculated at time 0 to 120 min for each sample. Secondly, hydrolysis index and glycemic index values were calculated. Third, all samples were evaluated with seperately. The analyzes was made with 2 repetition. The following formulation was used for GI calculation:

Total Starch (%): 100/Standard Glucose absorbance/Sample Amount (mg)*Sample absorbance*50*0.9

Hydrolysis Index (%): Sample's AUC*100/White bread's AUC

Glycemic Index (%): 0.549*HI+39.71

5.2.7 Analytical methods to determine physicochemical properties

5.2.7.1 Moisture

It was done according to moisture analysis of Elgün et al., in 2001 [79].

For this purpose, 2-3 g bread was ground. They were waited at 135°C during 2 hours. Then, results were calculated ith following formula:

m1= wight of drying vessel

m2= before drying vessel+sample

m3= after drying vessel+sample

$$\textbf{Moisture}\ (\%) = \frac{m2-m3}{m2-m1} \times 100$$

5.2.7.2 Ash Content

Ash content analysis were done method suggested by Elgün et al. (2001). For this purpose, 3 g sample was ground. They were burned in ash furnace (WiseTherm-Daihan FH-03, Kore) at 900 °C until all samples colour became white. After analysis, % ash content was calculated by being used dry [79].

5.2.7.3 Protein

Protein content of breads was determined according to Kjeldahl Method [79].

Samples were ground as 3 g. Then ground samples were transferred into Kjeldahl flask.25 mL H_2SO_4 ve potassium sulfate (K_2SO_4) catalyzer were added to the flasks and they were burned at 200-250°C for 2hrs, 350-400°C for 8hrs. Samples colour became blue after burning. They ere cooled and 5mL %40 NaOH, 3 mL %3 Boric acid were added then destilation was done.(4 min.) Titration was done with 0.1 N HCI and used HCl amount was registered. Then % raw protein amount was calculated.

5.2.7.4 Colour

Colour parameters were measured with colour measurement device (CR-400 Konica, Minolta, Tokyo, Japan) Colour parameters (L*, a*, b*) (L: brightness, a: redness b: yellowness [80].

5.2.7.5 Sensory Analysis

Table 5.7 Sensorial Analysis Form

Name Surname	
Appreciation	Point
	(1, 2, 3, 4, 5)

1: Very bad

2: Bad

3: Mild

4: Good

5: Vey Good

Evaluations were done with 6 analysts according to sensory analysis form in Table 5.5

CHAPTER 6

RESULTS AND DISCUSSION

As known, GI of food is important in terms of healthy nutrition. That's why, foods are classified in terms of their GI values. (<55 low GI, 55<GI<70 mild, GI>70 high). This classification is according to its potential for raising blood glucose level. Physical structure of food, nutrition content and type of starch, anti-nutrients, cooking and food processing techinique, presence of diet pulp, consumption speed of foods and maturity level of foods are the main factors affecting the GI. It is known that high glycemic index is associated with especially diabetes and other diseases such as cardiovascular diesease, cancer and obesity.

Moreover, some research shows that especially food having low GI has positive effects on health. In Turkey, bread is on top of the list of food with its high GI. In contrast to other countries, bread produced in Turkey has high glycemic index (87) and our being first in line for bread consumption in the world has necesitated further research in regard with this issue.

However, there's too few research about the topic. Determination and reducing of bread GI will help people taking care of their healthy nutrition. For this purpose, using sourdough bread is considered as a solution. It has been proved that sourdough has lowering effect on GI of bead. With this study, after in vitro GI determination of sourdough breads prepared with sourdoughs collected from different regions of Turkey, it was tried to be decreased the GI of breads by changing fermantation conditions and formulations of bread. GI values of breads were evaluated by using an in vitro method based on Goni–assay calculating the GI by measuring rate of total starch digestion. For this purpose, 5 different traditional sourdoughs were obtained: 4 different homemade white sourdoughs (Oğuzlu (O), Kastamonu (K), Lüleburgaz (L), Afyon/ Bolvadin 2 (B2)) and 1 commercial whole wheat sourdough, Safranbolu Yıldız Fırını (SYF). Sourdough breads were prepared with their own flour, extra enzyme was not added to the bread formulation and fermented at low temperature long time. Sourdough breads containing %50 whole wheat flour, extra enzyme (hemicellulase and α-amylase) in bread

formulation were prepared with sourdoughs at different fermentation time and temperature. Breads made from sourdoughs fermented at the low temperature (4℃) long time (15h,18h,20h,24h) had lower GI value compared to breads fermented at the room temperature (25℃) long time.

6.1 Results

6.1.1 Physicochemical Properties of Breads

6.1.1.1 Moisture, Protein and Ash Content

The moisture and ash content of all breads did not differ significantly. The moisture and ash content of all sourdough breads were similar between themselves. However, %50 whole wheat sourdough breads had higher protein content than white sourdough breads as they were added extra gluten during bread making.

Table 6.1 Nutritional Properties of Traditional Sourdough Breads

	Moisture (%)	**Protein (%)**	**Ash (%)**
White Bread	38.2±0.1a	8.1±0.05d	3.5±0.1a
Oguzlu	38.6±0.6a	9±0.15bc	3.6±0.1a
Kastamonu	37.3±0.7a	8.4±0.16cd	3.7±0.1a
Luleburgaz	37.5±0.1a	8.4±0.3cd	3.5±0.2a
Bolvadin 2	36.9±0.1a	8.7±0.15cd	3.6±0.1a
Safranbolu	36.3±1.7a	12.1±0.2a	3.8±0.1a

Table 6.2 Nutritional Properties of %50 Wheat Flour Sourdough Breads

	Moisture (%)	**Protein (%)**	**Ash (%)**
15hrs, 4°C	35.1±0.01a	12.7±0.01a	4.8±0.01a
18hrs, 4°C	37±0.01a	12.5±0.01a	3.9±0.01a
20hrs, 4°C	39.7±0.01a	12.6±0.01a	3.6±0.01a
24hrs, 4°C	40.9±0.01a	12.4±0.01a	3.9±0.01a
15hrs, 25°C	35.1±0.01a	12.7±0.01a	3.8±0.01a
18hrs, 25°C	37±0.01a	12.5±0.01a	2.9±0.01a
20hrs, 25°C	39.7±0.01a	12.6±0.01a	2.6±0.01a
24hrs, 25°C	40.9±0.01a	12.4±0.01a	2.9±0.01a

6.1.1.2 Colour Properties of Breads

There was no significant difference between colours of breads. Colour properties of breads did not show significant difference. All white sourdough and whole wheat breads were similar to each other.

Table 6.3 Colour Properties of Traditional Sourdough Breads

	L	a	b
White Bread	52.64±0.5a	13.14±0.6a	29.33±0.46a
Oguzlu	51.7±0.5a	12.9±0.6a	30.21±0.6a
Bolvadin 2	51.7±0.6a	13.2±0.5a	29.9±0.5a
Kastamonu	52.7±0.5a	13.4±0.5a	29.8±0.7a
Luleburgaz	52.5±0.7a	13.3±0.5a	30.4±0.6a
Safranbolu	47.5±0.6b	11.3±0.5b	16.9±0.5b

Table 6.4 Colour Properties of %50 Whole Wheat Flour Sourdough Breads

	L	a	b
15hrs, 4°C	55±0.8a	15.1±0.1a	21.1±0.1a
18hrs, 4°C	55.74±0.24a	16.775±0.1a	24.21±0.1a
20hrs, 4°C	58.615±1.3a	15.8±0.5a	24.47±0.47
24hrs, 4°C	56.325±0.4a	15.47±0.16	24.5±0.005a
15hrs, 25°C	55±0.8a	15.1±0.1a	21.1±0.165a
18hrs, 25°C	55.74±0.24a	16.775±0.1a	24.21±0.2a
20hrs, 25°C	58.615±1.325a	15.8±0.5a	24.47±0.4a
24hrs, 25°C	56.325±0.425a	15.47±0.16a	24.585±0.005a

6.1.1.3 Total Starch Values of Breads

There was no significant difference among total starch values. On the one hand, it was seen that, cold fermentation a bit gets down the starch hydrolysis when compared to room temperature conditions.

Table 6.5 Total Starch of traditional sourdough breads fermented at room temperature (25 °C)

	Total Starch (%)
Oguzlu	52±0.05
Kastamonu	45±0.05
Luleburgaz	53±0.05
Bolvadin 2	48±0.05
Safranbolu	42±0.05
White Bread	49±0.05

Table 6.6 Total Starch of %50 whole wheat fsourdough breads fermented at 25 °C

	Total Starch (%)
15hrs, 25ºC	58±0.05
18hrs, 25ºC	57±0.05
20hrs, 25ºC	55±0.05
24hrs, 25ºC	55.1±0.05
White Bread	48±0.05

Table 6.7 Total Starch of %50 whole wheat sourdough breads fermented at 4 °C

	Total Starch (%)
15hrs, 4ºC	61±0,05
18hrs, 4ºC	60±0,05
20hrs, 4ºC	60±0,05
24hrs, 4ºC	59±0,05
White Bread	49±0,05

6.1.1.3 Sensory Analysis

Table 6.8 Sensory Analysis Results

	Appreciation
Kastamonu	7±0.05
Luleburgaz	7.2±0.05
Bolvadin 2	7.5±0.05
Safranbolu	7.8±0.05
Oguzlu	8.9±0.05
15hrs, 4°C	7.1±0.05
18hrs, 4°C	7.8±0.05
20hrs, 4°C	7.4±0.05
24hrs, 4°C	7.6±0.05
15hrs, 25°C	6.2±0.05
18hrs, 25°C	6.6±0.05
20hrs, 25°C	6.3±0.05
24hrs, 25°C	6.2±0.06

According to sensory analyses (Evaluations were done with 6 analysts) results, Oguzlu sourdough bread was the most preferred one. On the other hand, cold fermented breads more preferred than breads fermented at room temperature conditions as well as having lowest glycemic index values. Besides, especially breads fermented at 18h under both cold conditions and room temperature conditions preferred mostly in terms of flavor and volume. It was seen that Oğuzlu white sourdough bread and 18h-cold fermented %50 whole wheat sourdough bread had the best pore structure. %50 whole wheat sourdough bread fermented under room conditions-18h had the pore structure that was not homogeneous. When compared the breads fermented at room temperature, all breads fermented at 4°C at different times had the more appreciation.



Figure 6.1 Pore structure of the most preferred Oguzlu white sourdough bread



Figure 6.2 Pore structure of the most preferred %50 whole wheat sourdough bread fermented under cold conditions-18h



Figure 6.3 Pore structure of the most preferred %50 whole wheat sourdough bread fermented under room conditions-18hrs

6.1.2 Determination of GI Value of Breads

GI determination were evaluated according to method explained 5.3.1 and 5.3.2. In vitro digestion of breads were done mouth, stomach and small intestine like being human body,

respectively. Then, released glucose amounts of breads were measured at time 30. min. to 120. min.

Table 6.9 Percentage of released glucose at different times for each traditional sourdough breads (First objective results)

	Time (min.)			
	30	**60**	**90**	**120**
White Bread	0,43	0,48	0,5	0,73
Kastamonu	0,2	0,21	0,29	0,35
Luleburgaz	0,13	0,21	0,22	0,27
Bolvadin 2	0,14	0,19	0,26	0,3
Safranbolu	0,1	0,15	0,2	0,22
Oguzlu	0,15	0,19	0,25	0,31

Table 6.10 Percentage of released glucose at different times for each %50 whole wheat sourdough breads fermented at 4°C (Second objective results)

	Time (min.)			
	30	**60**	**90**	**120**
15hrs, 4°C	0,13	0,16	0,35	0,4
18hrs, 4°C	0,11	0,16	0,32	0,39
20hrs, 4°C	0,1	0,14	0,29	0,36
24hrs, 4°C	0,1	0,14	0,27	0,31
White Bread	0,12	0,26	0,37	0,45

Table 6.11 Percentage of released glucose at different times for each %50 whole wheat sourdough breads fermented at 25°C (Second objective results)

	Time (min.)			
	30	**60**	**90**	**120**
15hrs, 25°C	0,46	0,52	0,56	0,64
18hrs, 25°C	0,46	0,48	0,53	0,7
20hrs, 25°C	0,49	0,55	0,64	0,65
24hrs, 25°C	0.48	0.50	0.6	0.73
White Bread	0,43	0,48	0,5	0,73

It was seen that glucose amount of breads increased from 30. min to 120. min gradually. However, increasing glucose amount of breads prepared with sourdough samples had the lower glycemic index value than white bread. The glycemic index of all white sourdough breads were similar but the sourdough bread prepared with whole wheat flour (Safranbolu sample) had the lowest GI. It was thought that GI value were affected by adding dieatary fiber and using sourdough samples for bread making process. Glycemic Index values were evaluated Goni assay method based on in vitro starch digestion and free glucose amount from 30. Min to 120.min. When it came to HI values, all sourdough breads HI values were lower than white bread.

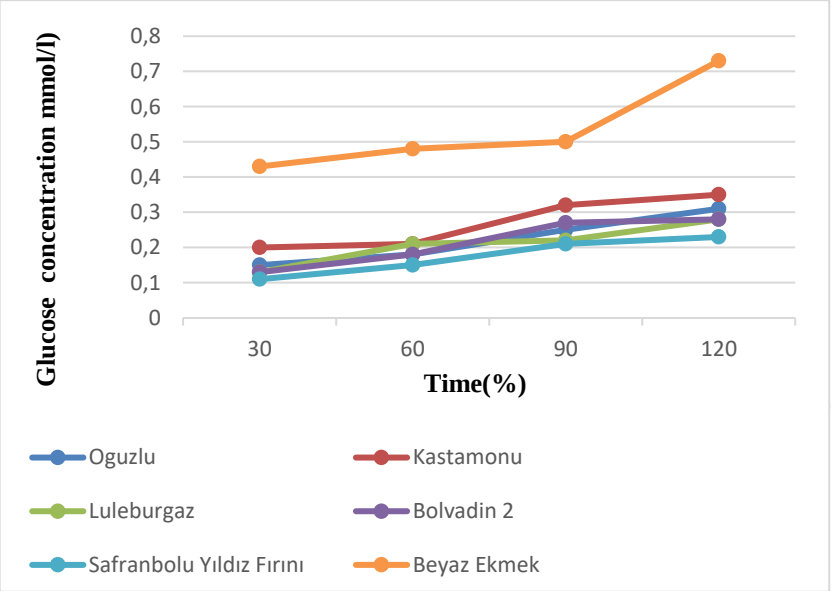


Figure 6.1 Glucose concentration released from carbohydrates during in vitro digestion of white bread and traditional sourdough breads from 0 to 120 min. (First objective results)

Sourdough breads prepared with %50 whole wheat flour fermented under two different conditions: cold fermentation- different times (4ºC-15h, 18h, 20h, 24h), room temperature-different times (25ºC-15h, 18h, 20h, 24h). It was seen that the in vitro starch digestibility increased from 30 min to 120 min. gradually. On the one hand, the results showed that cold fermentation conditions impressed glycemic index value of breads. GI of %50 whole wheat sourdough breads fermented under cold conditions at different times was getting lower from 15h to 24h. On the other hand, GI of %50 whole wheat sourdough breads fermented under room temperature at different times were getting higher from

compared to col fermented sourdough breads. It was thought that the hemicellulose- α-amylase enzyme mix enzyme that was added to bread formulation during bread making process impressed the glycemic index value. Especially, since cold conditions impressed the enzyme activity negatively, GI values were getting lower. There are a few research about this topic. It was mentioned at page 33. When HI values were examined, it was said that cold fermentation breads had the lower values compared to value of breads fermented at room temperature and white bread value.

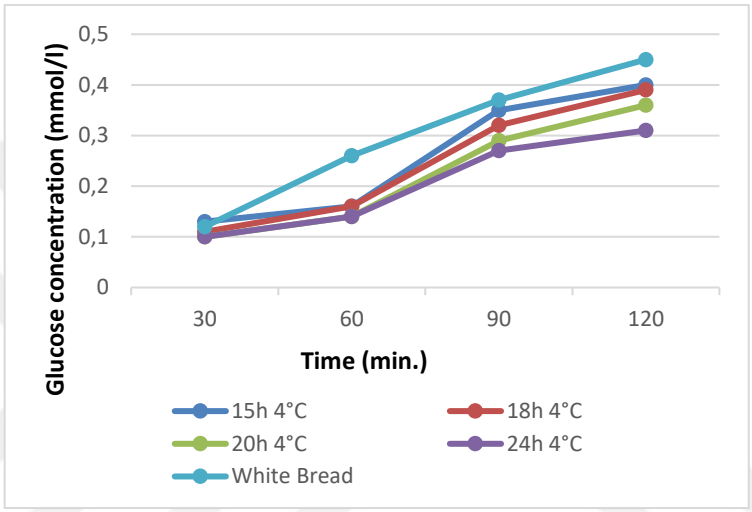


Figure 6.2 Glucose concentration released from carbohydrates during in vitro digestion of white bread and %50 Whole Wheat Sourdough Breads fermented at 4°C from 0 to 120 min. (Second objective results)

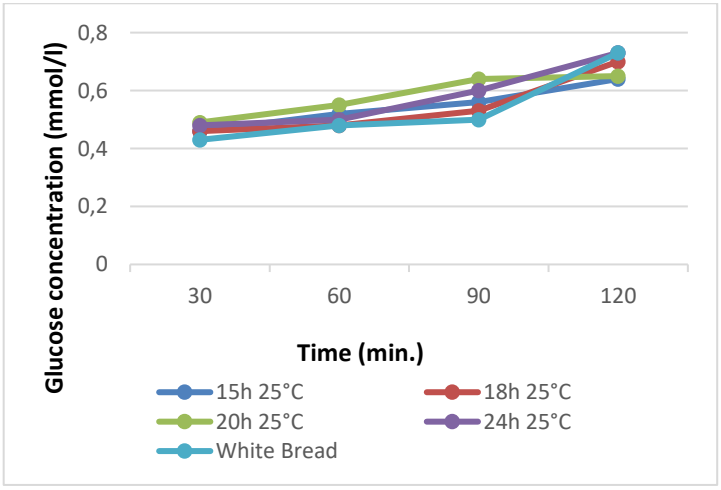


Figure 6.3 Glucose concentration released from carbohydrates during in vitro digestion of white bread and %50 whole wheat sourdough breads fermented at 25°C from 0 to 120 min. (Second objective results)

Table 6.12 Glycemic Index and Hydrolyses Index of Traditional Sourdough Breads (First objective results)

		GI (%)	
	HI 120. min.	**Glucose**	**Bread**
White Bread	100	70±0.05a	100±0.05a
Oguzlu	57.9	50±0.5b	71.5±0.5b
Kastamonu	62	51.8±2.5b	73.5±2.5b
Luleburgaz	57.9	50±0.5b	71.5±0.5b
Bolvadin 2	60	51 ±0.1b	72.8±0.1b
Safranbolu	48	46.5±0.1c	66.4±0.1c

Table 6.13 Glycemic Index and Hydrolyses Index of Breads fermented at 4°C (Second objective results)

		GI (%)	
	HI 120. min.	**Glucose**	**Bread**
White Bread	100	70±0.05a	100±0.05a
15hrs, 4°C	88.8	62±1b	88.5±1b
18hrs, 4°C	79	58.1±0.1b	83±0.1b
20hrs, 4°C	59	55.05±1.5c	71.5±1.5c
24hrs, 4°C	60	54.25±0.25c	71±0.25c

Table 6.14 Glycemic Index and Hydrolyses Index of Breads fermented at 25°C (Second objective results)

		GI (%)	
	HI 120. min.	**Glucose**	**Bread**
White Bread	100	70±0.05a	100±0.05a
15hrs, 25°C	98	65.5±0.7b	93.5±0.7b
18hrs, 25°C	98.9	66±2.1b	94.2±2.1b
20hrs, 25°C	102	69±1.5b	98.5±1.5c
24hrs, 25°C	113	72±1.5c	102±1.5c

6.2 Discussion

The glycemic index is defined by the Food and Agriculture Organization /World Health Organization (FAO/WHO) as the incremental area under the blood glucose response curve of a 50 g carbohydrate portion of a test food expressed as a percentage of the

response to the same amountof carbohydrate from a standart food taken by the same subject. It is known that high glycemic index is associated with especially diabetes and other diseases such as cardiovascular diesease, cancer and obesity. Moreover, a large number of studies, including observational prospective cohort studies as well as randomized controlled trials, shows that especially food having low GI values has positive effects on health [48]. On the one hand, bread is of great importance for diet of people. Especially white bread is one of the most consumed foods with its high glycemic index. In Turkey bread is a popular food with its high GI compared to other countries. In contrast to other countries, bread produced in our country. According to the International table of glycemic index, while avarage glycemic index of white bread is 70 in other countries, GI of Turkish white bread is 87 [2]. Because our being first in line for bread consumption in the world, it has necesitated further research in regard with this issue. However, there's too few research about the topic in Turkey. With this study we tried to determine and reduce the GI of bread by using sourdough samples collected from different regions of Turkey and by changing fermentation conditions and formulations in order to help people taking care of their healthy nutrition. In respect to this, our study is genuine.

In preliminary experiments, O, K, L, B2, SYF had GI of 50.05±0.3, 51.8±1.65, 50±0.5, 51±0.5 and 46.5 ±0.5, respectively. Compared to the control (White bread, GI: 70), the GI of sourdough breads was found low (<55). There was no significant difference among the GI values of white sourdough breads collected from different regions. The difference of SYF was thought to stem from dieatary fiber. When compared to the other studies, Slavin et al showed that viscous soluble fibre plays an important role in controlling postprandial glycemic and insulin responses because of its effect on gastric emptying and macronutrient absorption from the gut.

Compared to the study carried out Angelis et al., in 2007; three Lactobacillus strains were selected and used together as sourdough starter. Sourdough performances were evaluated for 30 days. Three breads were manufactured: wheat sourdough bread (WSB), WSB enriched with oat and rye fibres (WSB-DF) and wheat yeasted bread (WYB) fermented with baker’s yeast alone. WSB-DF and WSB showed higher specific volume and lower firness than WYB. Sensory analysis showed that WSB-DF and WSB were preferred due to acidulous smell, taste and flavor.

Compared to WYB and WSB, WSB-DF had high level of dietary Fibbre (DF). WYB was used as the control to estimate the hydrolysis index (HI = 100). WSB-DF had values of HI lower than WSB (59 vs. 86%). As estimated on 20 volunteers, the value of GI for WSB-DF was ca. 41% [71].

On the other hand, sourdough breads containing %50 whole wheat flour, extra enzyme (hemicellulase and α-amylase) in bread formulation were prepared with sourdoughs at different fermentation time and temperature. Breads made from sourdoughs fermented at the low temperature (4℃) long time (15h,18h,20h,24h) had lower GI value compared to breads fermented at the room temperature (25℃) long time. GI of breads made from sourdoughs fermented at room temperature-different times 65.5±0.7, 66±1, 69±1.5, 69±1.5, 74±0.5; GI of breads made from sourdoughs fermented under cold conditions at different times 62±1, 58.1±0.1, 55.05±1.5, 54.25±0.25, respectively. According to results, while GI value of cold fermentation breads gradually decreased, other breads made from sourdoughs fermented at room temperature long time gradually increased. It was thought that GI values of cold fermentation breads were much lower since enzyme inactivated under cold conditions -long time. Cold fermantation conditions are highly effective on GI. In 2005, the study carried out Ayerdi et al. showed that people living in the rural areas of Mexico eat corn tortillas and beans as an elementary compounds of their daily diet. Nevertheless, little thing is known regarding the nutritionally related properties of starch present in such united meals. The aim of the current research was to estimate the in vitro starch bioavailability in tortillas−bean mixtures put away at 4 °C for altered times, as related to that of corn tortillas and boiled black beans reserved individually under the same environment. Resistant starch (RS), available starch (AS), and retrograded resistant starch (RRS) compounds were detected. The in vitro starch hydrolysis showes (HI) of cooked freshly and cold-stored food materials were valued using a chewing/dialysis ingestion procedure. HI's were used to estimate glycemic index of the food samples. As in tortillaS and beans reduced between 3 and 6% after 48−72 h, while GI values in the mixture reduced by 3% after 48 h, with no any other alteration by 72 h. Merely negligible rises in RS compositions (1.5−1.6%) were detected for tortillas and beans after 72 h of storage time, and a low enhancement (0.4%) was detected in the mixture. Judging from RRS values, a significant part of RS is owing to starch retrogradation. The HI and estimated glycemic index values were even higher in tortillas than in bean and the mixture of them.

Hydrolysis amount values reduced in the stored food samples, a design that related with RS and RRS alteations. The gradual food digestion properties of general beans are mainly reserved by the legume−tortilla mixture. Information maintenance the recognized health useful features of starch in outdated cereal−legume food [63].

According to sensorial analysis results the most prefferd bread was the Oguzlu traditional white sourdough bread was the most preffered when compared to others. On the one hand %50 whole wheat sourdough breads fermented at 4°C were more preffered than %50 whole wheat sourdough breads fermented at 25°C.

All results showed that there was a negative correlation among the GI-sourdough-dietary fiber and long time cold fermentation. In addition, using sourdough increased the quality and flavor properties of bread.

CHAPTER 7

CONCLUSSION

According to this study aimed at decreasing the GI value of bread by using sourdough and changing fermentation conditions of bread:

1. When sensorial and Glycemic Index analyses results were examined, it was seen that the most preffered bread was the Oguzlu traditional white sourdough bread.
2. On the one hand Safranbolu (whole wheat sourdough bread) had the lowest GI value.
3. Among the both cold and room temp. fermented breads, especially breads prepared with 18hrs fermented leaven had the best volume and flavor when compared the other fermentation time breads.
4. In terms of the volume, %50 whole wheat sourdough breads fermented at 25°C were even better than %50 whole wheat sourdough breads fermented at 4°C. But in terms of flavor and lower GI value, cold fermented breads were preffered. (general preferrence was evaluated according to flavor).
5. All results showed that there was a negative correlation among the GI-sourdough-dietary fiber and long time cold fermentation.
6. In addition, using sourdough increased the quality and flavor properties of bread. Further research is needed. Especially a database like Universty of Sydney Database showing our traditional foods GI values is needed.

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