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WHOLE GRAINS CONSUMPTION IN LEBANON: THE MISSING LINK FOR FOOD AND NUTRITION SECURITY – A FOOD SYSTEMS APPROACH.

by
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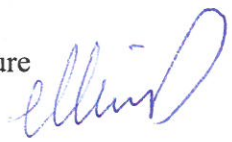
Signature  Date 02/08/2019

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AN ABSTRACT OF THE THESIS OF

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Major: Food Security

Title: Whole grains consumption in Lebanon: the missing link for food and nutrition security –A food systems approach.

Background: Non-communicable diseases (NCDs) are becoming a huge health concern, and their rates are dramatically increasing worldwide, more specifically in the MENA region and Lebanon. Unhealthy food consumption patterns are their main risk factor, and are mainly driven by our current food systems. Hence, food purchasing decisions are not only limited to personal choices. Whole grains are proven to be protective foods against NCDs, and bread being one of the most consumed staple foods in Lebanon is therefore a very suitable target product for nutritional interventions. Substituting refined bread with whole wheat bread can be a great attempt to curb NCDs. Providing suggestions to increase brown bread consumption requires an analysis of the main actors in Lebanese bread's food system: the millers, bakers, and consumers.

Objectives: This study aims to determine the drivers and barriers to whole wheat bread consumption in Lebanon. The secondary objective is to explore the perceptions and experiences of consumers, bakers, and millers with respect to whole wheat bread production and consumption. The outcomes, or the third objective, will be to identify intervention entry points within the food system to promote and enhance whole wheat products consumption.

Methods: Data from this study was derived from consumer surveys in addition to open ended interviews with bakers and millers. They were conducted from June until September 2018. Consumer surveys included sociodemographic questions (sex, highest attained educational level), their preferred bread type, whole wheat bread knowledge section as well as the reasons for consuming or not consuming whole wheat bread. Bakers and millers' interviews revolved around bread and flour production machineries and practices, sales, regulations and market prices and demand. Participants could also provide

their own suggestions in order to increase whole wheat bread consumption among the Lebanese population and curb NCDs.

Results: Data from 150 consumers were included in the study, as well as data from four mills and five bakeries. 58% of the interviewed sample favored white bread over brown bread (42%). The most misidentified terms defining whole wheat bread were bread with fibers (65.3%), multicereal bread (56.7%) and bran bread (42%). Regarding the barriers to whole wheat bread consumption, the most reported reasons for not consuming brown bread were its unfavorable taste (78.4%) and texture (34.1%), its high price (10.2%) and low availability (8%). As for the reasons drivers to brown bread consumption, the major reasons reported were its health benefits (71%), fiber content (53.2%), its good taste (38.7) and its perceived lower caloric load (37.1%). The logit model's results showed that females are twice likelier to correctly/almost correctly define brown bread compared to a male's odds. The main themes discussed with the interviewed millers showed that Lebanese bread cannot be produced from locally grown wheat. Also, most of them only own machineries for white flour production, and either sell whole flour through premixes or through imports. however, whole wheat products have a lower shelf life. Bakers produce white bread by machineries contrary to brown bread which is manufactured by hand, which increases its price. Brown products are priced 20% higher than white products but sell 70-80% less. Results from all data collection processes unlocked intervention entry points within the Lebanese bread's food system, concerning improving the taste and texture, raising awareness, increasing whole wheat product's availability and accessibility, marketing and governmental subsidies

Conclusion: Findings from this study highlighted the Lebanese adults' preference to white bread over whole wheat bread and the reasons behind it, as well as suggestions at the national level in order to increase whole wheat bread consumption and decrease NCDs.

CONTENTS

ILLUSTRATIONS

TABLES

CHAPTER I

INTRODUCTION

Non-communicable diseases (NCDs) are becoming a huge health concern (Allen, 2017). Their rates are rising over time, leading to an increase of morbidity and mortality around the world, in the Middle East and North Africa (MENA) region and more specifically in Lebanon (WHO, 2016). Unhealthy dietary practices are listed as one of their main risk factors, which renders NCDs a major nutritional challenge (Lim, 2013). Whole grains are proven to be protective foods, and the current heavy substitution of whole grains with refined grains is contributing to the rise of chronic diseases. Bread is one of the most consumed staple grains worldwide (Awika, 2011) and especially in Lebanon (Nasreddine, 2011). Therefore, it is a very suitable target product for health interventions. This thesis analyzes whole wheat bread consumption among adults in Lebanon, their drivers and barriers in order to provide suggestions for increasing its consumption in an attempt to curb NCDs. However, individuals' dietary practices are influenced by numerous factors including personal preferences and habits as well as social, economic, and environmental factors such as food availability and accessibility (Vabø, 2014). Therefore, food consumption is not only dictated by their own personal choices. They tend to be influenced by various biases and cues in the food system, as it possesses the ability to affect and shift food consumption patterns and health outcomes. Today's current food system is promoting unhealthy dietary choices such as calorie dense nutrient poor choices; which are contributing to the increase of NCDs. Therefore, interventions at the consumer level should

be applied synergistically with strategies addressing other parts of the food system. Hence, this thesis also analyzes and investigates the food system in Lebanon specific to bread and its main actors to identify intervention points not only targeting Lebanese consumers, but the whole food system around them.

The analytical framework deployed by this study is a food systems analysis. Surveys and interviews addressing the main actors in the food system specific to bread – millers, bakers and consumers – have been used to reveal their perceptions, drivers, and barriers to whole wheat bread consumption. They also reveal intervention entry points for increasing whole wheat bread consumption in Lebanon to reduce NCDs and direct our food system and dietary choices towards healthier practices.

CHAPTER II

LITERATURE REVIEW

A. Non-communicable diseases: definition, rates and risk factors:

Definition and rates: A non-communicable disease (NCD) is a medical condition or disease that is by definition non-infectious and non-transmissible among people (Kim, 2013). Currently, the world is facing an epidemic of diet-related NCDs, along with widely prevalent undernutrition resulting in substantial socio-economic burdens. This epidemic is mostly caused by the emergence of modern food consumption patterns marked by a high intake of heavily processed products, refined grains and animal proteins. Those patterns are leading to higher levels of NCDs worldwide and more specifically in the MENA region. NCDs include cardiovascular diseases (CVDs), hypertension, dyslipidemia, diabetes, cancer and obesity (Allen, 2017). Together, they have become the world's leading causes of death, accounting for 70% of deaths globally and 74% in the MENA region in 2015, claiming the lives of 1.6m people (WHO, 2016). In 2008, almost 1.2 million individuals died from NCDs in the Arab region with more than 34% being younger than 60 years (Musaiger, 2012). CVDs and Type 2 diabetes are the main causes of deaths in this region, being responsible for almost one million deaths annually (Lozano, 2012). MENA countries have some of the world's highest diabetes rates, and CVDs are already the single largest killer in the region (IDF, 2017). Also, this region has 6 out of the top 10 countries worldwide with the highest prevalence of diabetes (WHO, 2011). As for Lebanon, NCDs

are estimated to be responsible for 85% of deaths with CVDs being the leading cause (WHO, 2018). Sibai, Hwalla et al (2010) mentioned in their review that 47% of the MENA region's burden of diseases is due to NCDs, and that figure was forecast to reach 60% by 2020 (Khatib, 2004). Globally, nearly half of NCD deaths affect people in their productive years, so they reduce the ability of individuals and hence, endangering economic development and competitiveness in the nation and across borders (WHO 2011).

The growing importance of NCDs is shown by their alarming, increasing trends and their associated burdens and mortalities, as well as by their incorporation into the Sustainable Development Goals (SDGs) and the proposed targets paying more attention to them. The Millennium Development Goals (MDGs) ignored NCDs, as they were not a problem previously targeted with all the emphasis instead placed on infectious diseases. But currently, due to the NCDs' alarming rates, the SDGs included a specific target to reduce the premature mortality from NCDs by one third (SDG 3) (Hawkes & Popkin, 2015). Additionally, a review done by Naja, Hwalla et al (2017) examining published papers addressing nutrition and NCDs in Arab countries from 2006 till 2015 found a steady increase in the number of articles about the nutrition-NCD association, with the publications between 2014 and 2015 being five times higher compared to 2005-2006. The figures below (1-12) display the total NCD deaths in the total population of some MENA countries from 2000-2016. An upward trend is clearly visible in all the listed countries, highlighting their alarming rates and that urgent prevention and treatment actions are needed. The data was extracted from the Global Health Observatory data repository of the WHO, in total NCD mortality by country (WHO website, visited in November 2018).

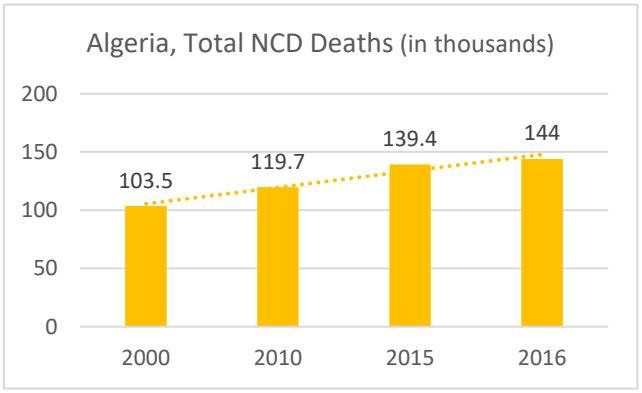

Figure 1: Algeria, Total NCD Deaths in thousands, from 2000-2016

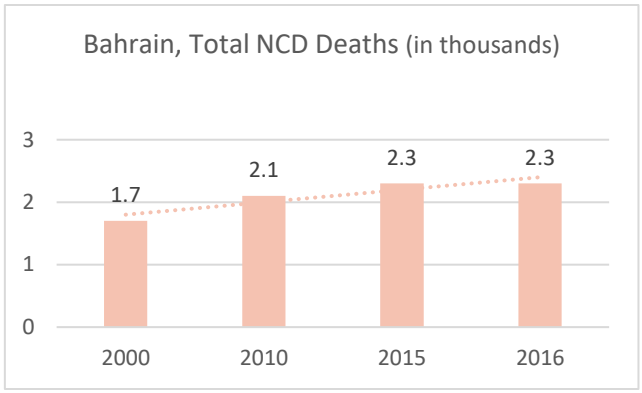

Figure 2: Bahrain, Total NCD Deaths in thousands, from 2000-2016

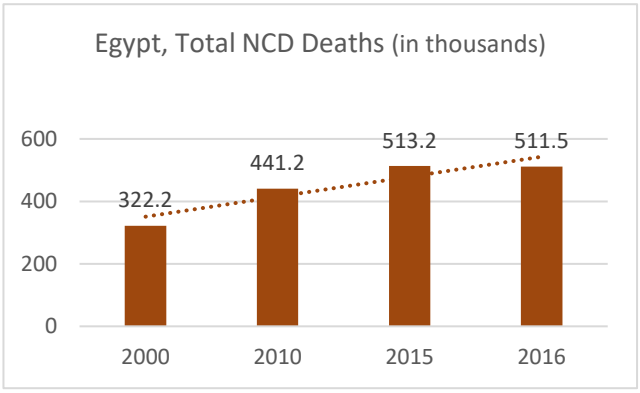

Figure 3: Egypt, Total NCD Deaths in thousands, from 2000-2016

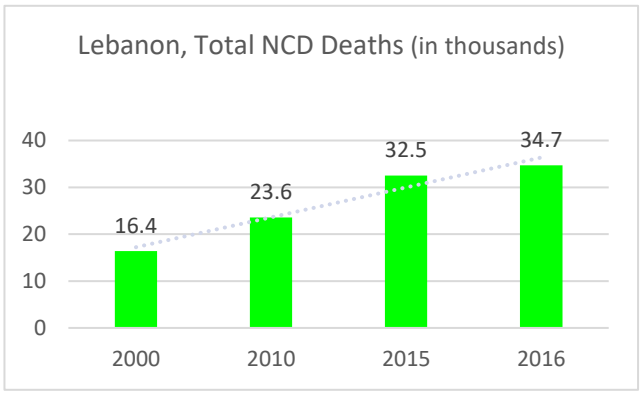

Figure 4: Lebanon, Total NCD Deaths in thousands, from 2000-2016

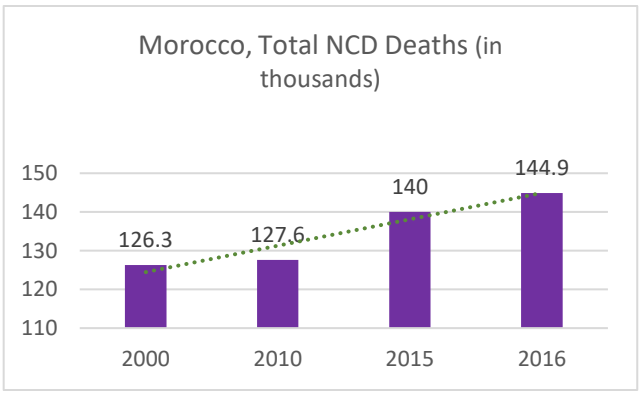

Figure 5: Morocco, Total NCD Deaths in thousands, from 2000-2016

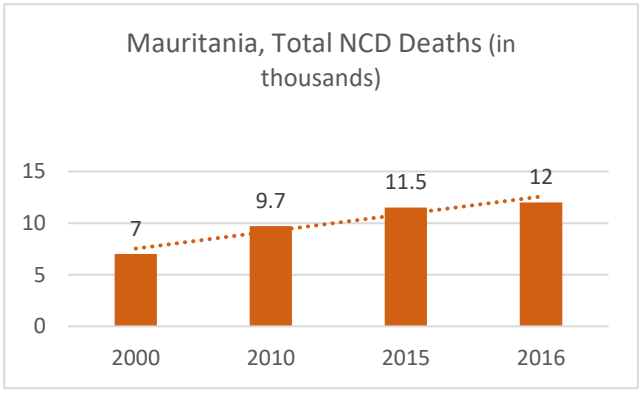

Figure 6: Mauritania, Total NCD Deaths in thousands, from 2000-2016

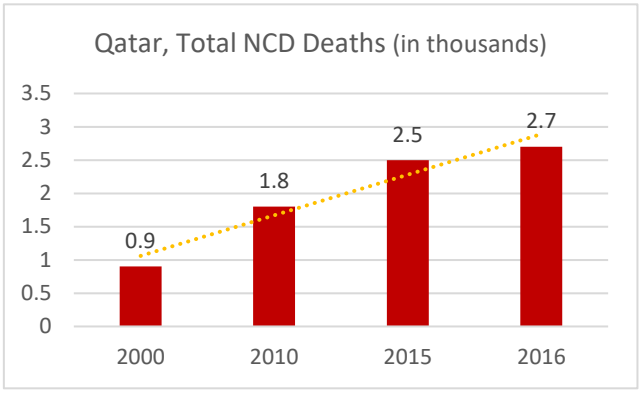

Figure 7: Qatar, Total NCD Deaths in thousands, from 2000-2016

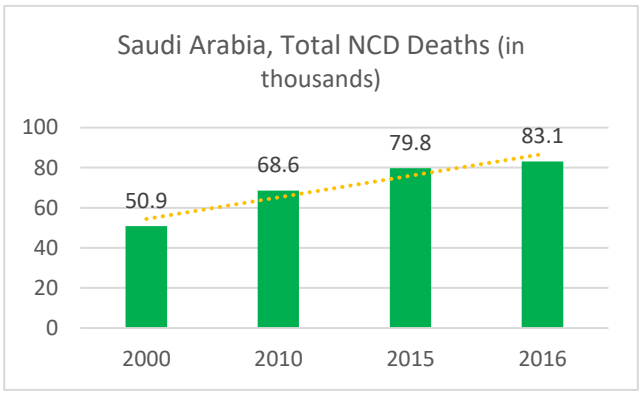

Figure 8: Saudi Arabia, Total NCD Deaths in thousands, from 2000-2016

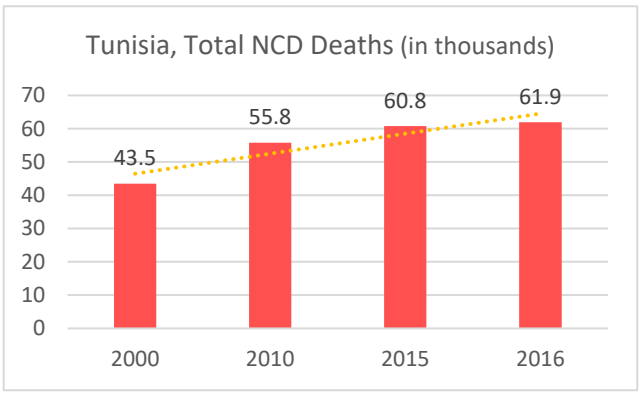

Figure 9: Tunisia, Total NCD Deaths in thousands, from 2000-2016

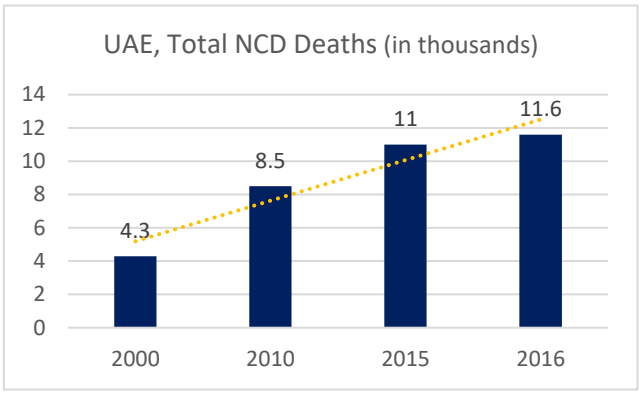

Figure 10: UAE, Total NCD Deaths in thousands, from 2000-2016

Arab countries have been overall increasingly productive in NCD research (Singh, 2017). As for Lebanon, the NCD Prevention and Control Plan (NCD-PCP) for 2016-2020 of the Ministry of Public Health (MoPH) briefly listed hyper caloric diets as a behavioral risk factor for NCDs. Unhealthy diet was included as a target in the strategic objectives for 2016-2020 to decrease and control NCDs, and reduced junk foods, trans-fat and salt intake as outcomes. However, those could be considered as very general outcomes and recommendations, therefore, more detailed and targeted food systems and nutritional directives are needed in order to encourage and increase implementation and compliance on both governmental and population level. Hence, this thesis can be considered to offer

narrow, specific suggestions to reduce NCDs by targeting the most consumed staple food, and to contribute to the work against NCDs in Lebanon. Its methodology can also be easily applied in other MENA countries.

Risk factors: In order to control NCDs, it is mandatory to reduce the risk factors associated with them. These include modifiable risk factors such as high blood pressure, obesity, hyperglycemia (high blood glucose) and hyperlipidemia (high blood lipids). Risk factors also include behavioral risk factors such as tobacco use, excessive consumption of alcohol, lack of physical activity and unhealthy eating patterns (WHO, 2013). Studies have shown that 60-75% of coronary and 36% of cancer incidents can be explained by lifestyle factors such as overweight and obesity; which are in turn the consequences of unhealthy diets (Esmailnasab, 2012). In fact, suboptimal diet is now the leading risk factor of NCDs affecting both metabolic and modifiable risk factors (Lim, 2012). Diet and high Body Mass Index (BMI) are the risk factors with the highest disability adjusted life years (DALYs), a measure of a risk factor's contribution to premature disability and death, for NCDs (Rahim, Hwalla et al, 2014).

A recent report from the University of Washington's Institute for Health Metrics (2013) showed that the first of the top 10 risk factors for losing good health was the dietary risk factor, which accounted for the highest number of years of healthy life lost. The same report showed that a diet low in whole grains contributes significantly to a high percentage of DALYs, highlighting their importance in fighting NCDs.

Additionally, women have a special role in the health and nutrition of the population, and this role is important for both the family and society as a whole (WHO, 2000). Women

have traditionally been responsible for buying food and preparing meals, so their competence in matters of healthy nutrition will largely determine the health of families and, accordingly, of society (WHO, 2000). Hence, they can play a key role in amending inappropriate dietary habits and decreasing NCD rates worldwide.

B. Whole grains: definition and benefits in decreasing NCDs:

1. What are whole grains?

Definitions of whole grains have been published by the food industry, grain organizations and governments and generally fall into two categories: whole grains and whole grain foods. The main difference between the two is that definitions of whole grains focus on the components of the grain and their proportions, whereas definitions of whole grain foods describe the quantity of whole grains included in the food.

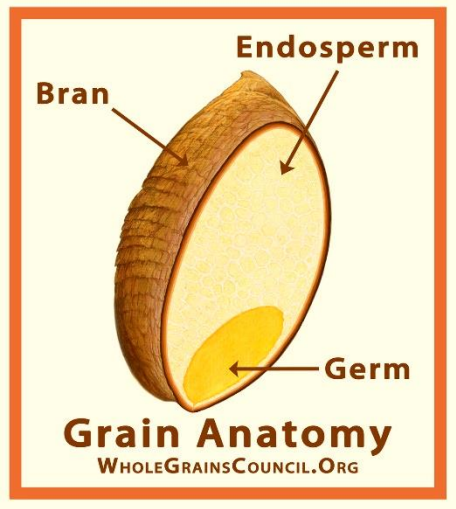

Figure 11: The three main parts of the kernel.

The American Association of Cereal Chemists International (AACCI) was the first to define whole grains in 1999 (AACCI, 1999). This definition as adopted in 2006 by the U.S. Food and Drug Administration (FDA) and issued in their draft guidance on whole grains

label statement (Korczak, 2016). The definition was as follows: “Whole grains shall consist of the intact, ground, cracked, or flaked caryopsis of the grain whose principal components, the starchy endosperm, germ, and bran, are present in the same relative proportions as they exist in the intact grain” (Korczak, 2016).

As for the Whole Grains Council, they endorsed the following definition in 2004: “Whole grains or foods made from them contain all the essential parts and naturally-occurring nutrients of the entire grain seed in their original proportions. If the grain, which is also called the kernel, has been processed, the food product should deliver the same rich balance of nutrients that are found in the original grain seed” (Korczak, 2016).

Outside the United States, the HEALTHGRAIN Forum’s definition is different, because it takes into consideration the losses due to processing; such as losses should be less than 2% of the grain and less than 10% of the bran (Van der Kamp, 2014). However, there is no consensus on this (Van der Kamp, 2014).

Given the range of definitions as presented above, a universally accepted definition for whole grain foods unfortunately still does not exist. For example, the AACCI characterized whole grain foods as a product that must contain 8g or more of whole grains per 30g. The USDA added that 51% or more of the product’s grain components should be whole. The 2010/2015 Dietary Guidelines for Americans recommended to make half of the consumed grains whole grains. Then, they provided examples of ounce equivalents to facilitate compliance. They also added that foods with more than 8g/ounce equ8ivalent of whole grains will provide benefits beyond fiber (USDA, 2015).

Having an established and consistent definition of whole grain foods will encourage manufacturers to produce foods with meaningful amounts of whole grains, allow easy labelling and messaging, and allow consumers to readily identify whole grain products to achieve their dietary recommendations and health goals. It has been argued that the lack of a clear explanation of whole grain foods may be contributing to the current consumer failure to meet the dietary recommendations (Ferruzzi, 2014). Indeed, the lack of a standard definition has increased consumer and researcher confusion (Ferruzzi, 2014). Establishing a clear and consistent definition will not only improve consumer compliance but provide guidance and standards for food manufacturers to translate those recommendations as an important step for better prevention of chronic diseases. (Ferruzzi, 2014).

Each part listed in Figure 13 contains health promoting nutrients: The bran is the fiber-rich outer layer consisting of B vitamins, magnesium, copper, iron, zinc and phytochemicals and antioxidants. The germ is rich in healthy fats, B vitamins and vitamin E, phytochemicals and antioxidants. The endosperm holds the carbohydrates, proteins, and very small amounts of B vitamins.

Whole grains are abundant in fibers (Slavin, 2013) in addition to vitamins, antioxidants and minerals (Slavin, 213), most of which are lost in the refining process when the germ and bran are stripped away. Table 1 below, extracted from the Whole Grain Council website, highlights the considerable nutrient differences between whole flour and refined flour. Refining wheat flour removes the bran and germ, decreasing essential nutrients by up to 92% (vitamin E) of the level naturally occurring in whole wheat flour. Fibers noticeably

decreased to a quarter of the initial content. Enriching refined wheat flour adds back some of these nutrients, but not all: Other nutrients stay at the low levels shown for refined flour.

Table 6: Nutrient differences between whole, refined and enriched wheat flour (Whole Grains Council).

In addition, Table 2 shows the composition of the bran and germ fractions of whole wheat The data is taken from the USDA National Nutrient Database. The disparities between whole wheat flour and refined flour are also displayed in Table 2, which shows that whole wheat flour contains all the beneficial nutrients, while refined flour contains only more energy and starch per 100g. Apart from its high energy content, mostly from carbohydrates, the endosperm is the least nutrient rich part of the kernel. Whole flour holds five times more fiber than refined flour and twice as much folate. The majority of the vitamins and minerals are located in the germ. Therefore, whole bread not only provides loads of fibers, but allows consumers to meet the essential nutrients daily allowances.

	Whole wheat flour	Refined wheat flour	Wheat germ	Wheat bran
Energy kcal/100g	340	364	360	216
Protein, %	13.2	10.3	23.2	15.6
Fat, %	2.5	1	9.7	4.3
Starch, %	57.8	65	-	-
Dietary fiber, %	10.7	2.7	13.2	42.8
Iron, mg/100mg	3.6	1.2	6.3	10.6
Vitamin E, mg/100g	0.71	0.06	16	1.49
Thiamin (B1), mg/100g	0.5	0.1	1.9	0.5
Folate, ug/100g	44	26	281	79

Table 7: Nutritional composition of different flour and wheat fractions

2. Whole grains history:

According to Spiller (2002), before recorded history, people used to cultivate whole grains, and they were likely consumed as is. Later on, it was discovered that if wheat grains were crushed and heated they could be transformed into porridges or pastes and eventually, products such as bread were produced. These products were nourishing and dark colored since they included the bran and the germ, and subsequently all the nutritional benefits of

whole grains. The old stone crushing process was a lengthy and difficult method used to separate the different fractions of the grain such as separating the bran from the endosperm. As centuries passed, crushing evolved to milling and the bran and germ were separated from the endosperm. Then, a tradition emerged where the whiter parts which produced more appealing and lighter bread were sought. In Roman times, the whiteness of the bread became an indicator of high social class (Slavin, 2004). White bread was embraced by a certain fraction of the population but soon after it became more common. Modern techniques enabled the easy separation of whole grains into their different parts, making refined products more familiar and readily accessible to the whole population. Removal of the outer layers helped resultant products to have tastier and more appetizing taste and textures. On the downside, it led to nutritional losses of the dietary fiber and many of the vitamins, minerals and phytonutrients. However, as it did, deficiency diseases such as pellagra (a disease caused by the lack of Niacin or Vitamin B3) became more prevalent (Spiller, 2002). Programs to enrich flour and bread with B vitamins and iron were implemented and diseases declined radically. This event highlighted the significance of the essential nutrients located in the disregarded fractions of white bread. Those highly nutritious fractions, or layers, contain important levels of many vitamins and minerals and their removal while processing white flour is a significantly contributing cause to the climbing rates of deficiency diseases (Doblado, 2012).

3. Connecting whole grains to health:

During the white flour milling process, the removal of the bran and germ from the starchy endosperm leads to a loss of fibers and important nutrients, thereby interfering with the nutritional quality of the grain (Slavin et al, 2000). Refining whole grains into white flour will result in a 10% increase of caloric density, 80% reduction in fiber content and almost 30% reduction in proteins levels (Durtshi, 2001). Hence, whole grains are nutritionally superior to refined grains. The positive health effects of whole grains are most likely linked to their dietary fibers and healthy compounds almost absent in refined flour (Bondia-Pons, 2013). In addition, the anti-oxidative capacities of phenolic acids are also responsible for the protective effects of whole grains (Vitaglione, 2008). The mechanisms by which whole grains act are manifold. It is most probable that their protective effect comes from the combination of different components rather than an isolated element. Those components are concentrated in the germ and especially in the bran. The healthy roles of vitamin E, B vitamins, phenolic acids and fibers are explained below; these nutrients have been selected because of their specific actions against NCDs.

- *Protective role of vitamin E:*

Vitamin E is an antioxidant, preventing the multiplication of free radicals. Free radicals are unstable and highly reactive molecular species which are capable of attacking and damaging important molecules such as Deoxyribonucleic acid (DNA), proteins, fats and carbohydrates (Young, 2001). Oxidative damage to DNA can lead to mutations that could contribute to causing cancer (Dizdaroglu, 2012). In addition, several studies have suggested

an inverse relationship between vitamin E consumption and death from heart disease in both men and women (Knekt P, 1994; Kushi LH, 1996).

- *Protective role of B vitamins:*

Folate, or vitamin B9, plays an important nutritional role in the pathogenesis of cardiovascular disease (The Homocysteine Studies Collaboration, 2002). Also, it has an effect on colon cancer development progression. Folate deficiency in normal tissues appears to predispose them to neoplastic transformation, and modest levels of folate supplementation suppress the development of tumors in normal tissues (Kim, 2006). Folate also contributes in DNA synthesis and replication and cell division (Choi, 2000). Therefore, folate deficiency could cause serious cellular damage. Niacin, or vitamin B3, has been widely used as a pharmacologic agent to regulate abnormalities in plasma lipid and in the treatment of cardiovascular disease (Ganji, 2003). Its action is mainly through decreasing fatty acid mobilization from adipose tissue stores, and by a long metabolic process resulting in decreased Low Density Lipoproteins (LDL) particles ("bad" cholesterol). The mechanism of action of niacin to raise High density lipoproteins (HDL) ("good" cholesterol) is by decreasing its catabolic rate (Ganji, 2003).

- *Protective role of phenolic acids:*

Whole grains are rich sources of phytochemicals, such as carotenoids, lignans, B-glucan, sterols, etc. Data from intervention studies which included aleurone, a layer in the bran fraction of the wheat grain that is rich in Ferulic acid, into daily diets showed significant results in reducing the plasma concentration of an inflammatory marker called C-reactive protein, which is considered a risk factor for CVD (Price, 2012).

Whole grains contain unique phytochemicals that complement those in fruits and vegetables. Some of them such as Ferulic acid, Diferulates and others are predominantly found in grains but are not found in significant doses in fruits and vegetables (Lloyd et al, 2000). The presence of those exclusive phytochemicals highlights the difference between cereal fibers and fruit and vegetable fibers and underlines the importance of whole grains consumption.

- *Protective role of fibers:*

Since fiber content is higher in the bran fraction, fibers are strongly reduced in refined flour as compared to whole grain flour. Epidemiological studies demonstrating the health benefits of dietary fiber have often highlighted whole grains (Liu, 1999). A universal definition of fiber does not exist, but the Codex Alimentarius Commission defined it as "carbohydrate polymers with 3 or more monomeric units which are neither digested nor absorbed by the human body" (Codex Alimentarius Commission, 2008). Even if fibers are not digested by our endogenous enzymes, they can influence absorption processes and digestion due to their physical presence and physiochemical properties (Cummings, 1987).

A higher fiber intake is associated with reduced risk of the leading chronic diseases (Dahl WJ, 2015). More than 40 years ago, Trowell associated the low prevalence of ischemic heart disease of sub Saharan Africans compared to Europeans and Americans with the difference in intakes of refined versus whole foods and formulated the "fiber hypothesis" together with Burkitt, proposing that diets low in fiber will increase the risks of many diseases. Studies where it has been possible to adjust for the intake of its constituents such as the bran component, thus demonstrating that bran is a key factor in determining whole

grains' benefits (Cummings, 2018). However, the biochemical mechanisms behind the health benefits of whole grains still remain speculative but can most likely be attributed to the concerted action of dietary fibers and a wide variety of phytochemicals, phenolic compounds, carotenoids, vitamins, sterols and phytates.

A higher consumption of dietary fibers is additionally linked to a decreased risk for type 2 diabetes, obesity, cardiovascular diseases, colon cancer, and can also improve immunity by modulating the gut microbiota (Kaczmarczyk, 2012). Most fibers are fermented to some extent in the digestive tract (Cummings, 1987). The products of fermentation – short chain fatty acids (SCFA), mainly acetate, propionate, and butyrate – and their effect on microbiota composition are considered as the means whereby fiber reduces disease risk (Leonel AJ, 2012).

Laxation: The benefits associated with laxation go beyond the prevention of constipation by increasing gut bacterial mass, and hence improving digestive health and the immune system (Alonso, 2013).

Type 2 diabetes: Also, a higher fiber intake may mitigate inflammation (Wannamethee, 2009). Since Type 2 diabetes and insulin resistance are thought to be caused by an inflammation at the tissues level (Connaughton, 2016), the role of propionate may have a role in mitigating this inflammation (Roelofsen, 2010) and therefore higher fiber and cereal fiber intake are associated with a decreased risk of type 2 diabetes (AlEssa, 2016). A better glycemic index (how carbohydrates affect blood glucose levels) is also demonstrated in individuals with type 2 diabetes when more fibers are consumed (Fujii, 2013).

CVD: The protective role of fibers in CVD is associated with more than the cholesterol-lowering effect of fibers (Gunness, 2010). Elevated cholesterol levels are considered major risk factors for CVD (Daou, 2012). Fibers have also been associated with decreased blood pressure, which may contribute to CVD risk reduction (Streppel, 2005). Suggested mechanisms for the hypolipidemic (lipid lowering) effect of fibers include reduced absorption of fat and cholesterol through the gut, decreased bile absorption and therefore increased bile synthesis. Bile is a fluid produced by the liver that aids in lipid digestion. Bile acids are synthetized from cholesterol (Javitt, 1994). Hence, when fibers are reducing both cholesterol and bile absorption simultaneously, the body will have to use its cholesterol reserves to synthetize more bile, explaining their hypolipidemic action.

Cancer: Many studies suggest that there is an association between high intake of dietary fiber and a low incidence of colon cancer, and that dietary fiber has anticancer properties (Kaczmarczyk, 2012). As mentioned earlier, SCFAs can stimulate microbiota growth, but they can also inhibit the growth of most cancer cells through complex molecular regulations (Heerdt, 1994).

- *Epidemiological evidence linking whole grains consumption with NCDs:*

A meta-analysis (Aune et al, 2016) examined the dose response relationship between whole grains intake and several major chronic diseases and showed reductions of 21%, 16%, 11% and 18% respectively of the relative risks of coronary heart disease, CVD, total cancer and

all-cause mortality for the highest versus lowest category of whole grain intake. More studies showing the link between whole grains consumption and NCDs are listed below.

Weight loss:

A high unhealthy caloric intake leads to the increase of overweight/obesity risks; increased BMI is a risk factor for NCDs (Webber, 2012). There are several mechanisms whereby whole grains can potentially prevent weight gain. For example, satiety may be increased due to the high dietary fiber content of whole grains (Pereira & Pins, 2000), and hence, lower quantities of food will be consumed. A study of 60 Danish adults at risk of developing metabolic syndrome (a cluster of metabolic disorders that increase the risk of NCDs) who participated in two 8-week dietary intervention compared whole grain diet and refined grain diet separated by a washout period (Roager, 2019). Compared to the refined grain diet, the whole grain diet reduced body weight and decreased systemic low grade inflammation. The C reactive protein (CRP), the systemic inflammatory marker, decreased during the whole grain diet compared to the refined grains diet (Roager, 2019). Additionally, the Nurses' Health Study in which 74,091 females were followed from 1984 to 1996 indicated that over a two- to four-year period, an increased intake of whole grains was associated with a 1.07kg less weight gain for women in the highest quintile (1.68 servings per 1000 calories/day) than those in the lowest quintile (0.07 servings per 1000calories/day) (Liu S, 2003). Another study compared two groups of people with an eight-week follow up. One group got a whole grains diet while the other received a refined grains diet. The whole grains group loss close to a 100 calories per day compared to the other (Wiedersehn, 2017).

Cardio Vascular Diseases:

Concerning CVD, studies suggest as much as a 30% decrease in risk of CVD with three or more servings of whole grains daily. The Nurse's Health Study showed that women who ate the highest level of whole grains daily had half the relative risk of developing cardiac diseases than did those who ate the fewest whole grains (Liu et al, 1999).

Type 2 Diabetes:

Meyer and colleagues (2000) reporting the Iowa women health study were the first to document the specific inverse relation between whole grains intake and risk of Type 2 diabetes. It was a prospective cohort study of 36,000 women over six years examining the incidence of diabetes and baseline dietary variables. Subjects were mailed a detailed questionnaire including a 127-item food frequency questionnaire (FFQ). After follow up surveys, it showed that women who consumed an average of 21 servings of whole grains per week, which is the equivalent of three servings per day, were 21% less likely to develop diabetes than women who consumed only one serving weekly. Additionally, in 2007, De Munter et al's systematic review showed that, based on pooled data from several studies, two servings of whole grain consumption per day was associated with a 21% decreased risk of Type 2 diabetes.

Cancers:

There was a statistically significant reduction in the risk of colorectal cancer when comparing populations with the highest to lowest dietary whole grain intakes (McRae, 2018). Also, from a survey of 13 colon and rectum case-control studies, it was shown that risk of colorectal cancer in the U.S. population could be reduced by 31% by an average increase in fiber intake of only 70% (Howe et al. 1992)

C. Importance of whole grains interventions, specifically in Lebanon:

Since 2000, the dietary guidelines for Americans included whole grains with the message "choose a variety of grains, especially whole grains" (Lang, 2003). The latter changed in the 2005 and 2010 guidelines to "eat at least 3 ounces equivalent daily." The Australian guide to healthy eating of 2013 also emphasizes on the importance of whole grains consumption (National Health and Medical Research Council, 2013).

As for the MENA region, the food based dietary guidelines' (FBDGs) review article of the Arab Gulf countries stresses the importance of fiber-rich foods in the prevention of chronic diseases (Marlett, 2002) as well as the crucial role of whole grains due to their noteworthy fiber content in addition to other beneficial nutrients, but without concentrating on quantity and instead recommending "at least half of your daily intake of grains must be whole" (Musaiger, 2012). What is the most interesting in Qatar's 2015 FBDGs is that they dedicated a paragraph to whole grains definition with their proportions and benefits (Seed, 2015). The Omani guide to healthy eating of 2009 underlines the preventive role of whole

grains in chronic diseases (Musaijer, 2012). The Lebanese food based dietary guideline manual for promoting heathy eating in the adult population was written by Hwalla et al. and published in 2013 by the American University of Beirut; it also stresses on eating cereals, especially whole grains, as the basis of daily meals while providing detailed serving examples to facilitate understanding and consumer compliance. As such, those whole grains recommendations worldwide and in the MENA region are intended to establish a basis for food and nutrition programs to foster healthy eating habits and lifestyles.

The food industry has responded to this dietary guidance with the booming of whole grain products marketing (Mozaffarian, 2013). For example, in 2010 in the United States, the number of foods marketed as whole grains was almost 20 times higher than the number of 2005 (Whole grains council, 2015). Over the period of 2001 to 2007, the percentage of whole grains cereals of all cereals purchased jumped from 30% to 46% (Morrison R, 2011). In addition, according to the statistics of the Whole Grains Council and Technavio, the global whole grain foods market is expected to grow at a compound annual growth rate of 6.71% from 2017-2021. Furthermore, whole grain intake significantly increased in the US across all age groups from 2003/2004 to 2013/2014 (Bowman S, 2017). Unfortunately, exact whole grains consumption and market data for the MENA and Lebanon do not exist yet.

The previous paragraphs explained the huge concern with whole grains' benefits and advantages, and the importance of nutritional recommendations in simultaneously promoting healthy food consumption thereby affecting consumer choices and shaping food systems' production and markets.

On one hand, promoting whole grains due to their ability to reduce chronic diseases is a way forward to an increased consumption and production. On the other hand, promoting whole grains for their environmental sustainability aspect is an overlooked element to consider when advocating for whole foods and nudging food systems in a healthier direction.

One bushel of wheat, by definition, contains almost one million individual kernels and weighs 60 pounds. It has been stated by the Whole Grains Council that one bushel of wheat can produce approximately 42 pounds of white flour, but 60 pounds of whole wheat flour. This means more whole wheat bread loaves from the same quantity of grains. Hence, this underpins the argument that whole grains not only benefit health, but also the environment. Already enough food is produced to feed everyone on the planet. Therefore, if the same food quantity (bread, in this example) needs to be produced, less flour is needed; since whole gain flour yields more loaves than the refined flour. Less flour required means less grains, leading to fewer resource use and decreased agricultural inputs. Additionally, if the bran and germ elements are used instead of thrown away, it will lead to less food waste and more importantly less waste of highly nutritional foods.

The health benefits of whole grains are clearly established and are being promoted through recommendation incentives and dietary guidelines. In addition, the notion of sustainability exists; but it needs to be expanded through further analysis and examination. However, despite the plethora of efforts and benefits associated with whole grains, overall consumption remains persistently low (Magalis, 2016).

As mentioned earlier, most FBDGs recommend to make at least half of our grains whole grains. The recommended daily amount of grains varies from 3 to 7 servings per day. Based on a 2000 calorie diet, 6 servings of cereals are favored (Lebanese FBDGs, 2013). Also, following the available definitions, a whole grain food is an item that contains a minimum of 8g of whole grains per serving. A serving of cereals is the equivalent of one quarter of an Arabic pita bread, one slice of toast, half a cup of cooked wheat, rice or spaghetti, etc. (Lebanese FBDGs, 2013).

Almost 93% of Americans do not meet the recommended amounts of whole grains while overconsuming refined grains, sometimes reaching 77% above the recommended daily amount (Burgess-Champoux, 2009). The MENA region faces the same dietary problem. The consumption of whole grains in this region is decreasing, with more dependence on refined cereals (Shu Wen et al, 2011). In Saudi Arabia, for example, it was found that the main contribution to fiber intake came from vegetable-based foods (31%), followed by cereal and their products (26%), and fruit and their products (Musaiger, 2002). Afshin et al (2015) stated that low whole grains consumption was one of the main dietary factor attributable to cardio metabolic deaths in the MENA region, and that during the 1990–2010 period, their consumption has decreased by 21% (Afshin et al, 2015). Also, a study examining the impact of diets on diabetes and cardiovascular mortality in 22 Arab countries showed

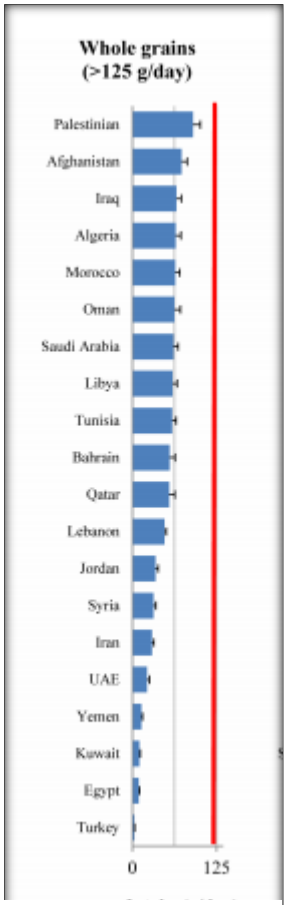

Figure 12: National intake of whole grains in the MENA region, 2010. (Afshin et al, 2015).

that a low intake of protective foods such as whole grains was the leading dietary risk factor accounting for almost 12% of deaths (Naja, Hwalla et al, 2017). Figure 12 (extracted from Afshin et al, 2015) shows a more detailed picture on the deficit in whole grains consumption of our region. Algeria barely reaches half of the recommended optimal level represented by the red line (125g/day) Lebanon is amongst the countries with the lowest whole grain consumption where a trend towards an increased consumption of refined cereals such as refined flour and pasta, at the expense of whole-grain cereals, has been reported (Lebanese FBDGs, 2013).

A lower intake of a valuable and nutritional food item should be sufficient to direct efforts towards increasing its consumption globally and more specifically in Lebanon. Additionally, grains are a crucial staple food item which makes them a perfect target to decrease chronic diseases. Worldwide, cereals provide nearly 50% of energy intake, yet the vast majority is composed of refined grains and flour (Awika et al, 2011). Also, FAO's 2018 forecast for worldwide cereal production showed that cereal utilization in 2017/2018 is currently at nearly 260 million tons, up 35.7 million tons from the previous year (FAO, 2018). Additionally, food use of wheat is projected to increase. So those numbers show that grains and more specifically wheat are a good starting point for dietary interventions globally and to channel actions towards healthier food systems and food choices.

As for countries of the MENA region, a study that assessed bread consumption habits among the people of Riyadh showed that 60.54% of the survey participants consumed bread every day of the week, which confirmed a high consumption rate of bread among people living in Riyadh (Aljobair, 2017). Also, high annual bread

consumption was demonstrated in many other countries, such as Libya, Egypt, Algeria, and Morocco (Pomeranz, 1988).

In Lebanon, a cross sectional food consumption survey done by Nasreddine et al in 2001 to measure and assess food consumption patterns of the adult population in Beirut showed that cereals intake provided 35% of daily energy intake with bread being the most highly consumed in this food group (Nasreddine, 2006). Similarly, the Lebanese FBDGs explained that cereal-based products contribute to almost a third of daily energy intake among the Lebanese adult population, with wheat (mainly consumed as bread) being the major staple cereal. In addition, a research done by BLOMINVEST BANK in September 2017 titled "breaking the bread market" stated that in terms of revenue composition, Lebanese bread sales are at the core of the bakeries' operations, taking up to 50% from the average total revenue and that Lebanese Arabic bread was the top selling good at four out of the five leading bakeries across the country. Besides, Mr Boubess, owner of a Lebanese mill, mentioned in an interview by the Miller Magazine in 2017 that the consumption of wheat flour is very high in Lebanon.

Those numbers and statements prove that bread is a food product that is very suitable for interventions in Lebanon in order to decrease the rising NCDs rates.

In order to develop effective interventions to increase whole bread intake in the Lebanese adult population, a better understanding of the factors that influence dietary behaviors and bread choices is needed.

Targeting consumer behavior at the individual level may be an effective way to increase whole grain bread consumption, but the assessment of consumer knowledge, investigating the acceptability and barriers to eating whole grain bread, requires a broader understanding. It is also crucial to discern the factors that influence food choices beyond the individual, or at the level of the food system. A more expansive knowledge and analysis of the whole bread value chain and food environment is required to suggest and discern the best intervention entry points. The following figure 13 shows the main actors within the Lebanese bread food system.

Figure 13: Main actors of the Lebanese bread food system.

D. Definitions and overview of a food system:

A food system can be defined as the complete set of elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities related to the production, processing, distribution, preparation and consumption of food, as well as the outputs generated apart from food, such as socio-economic and environmental outcomes (HLPE, 2017). Another general definition is: the aggregate of food-related activities and the environments within which these activities occur (Pinstrup-Andersen and Watson, 2011).

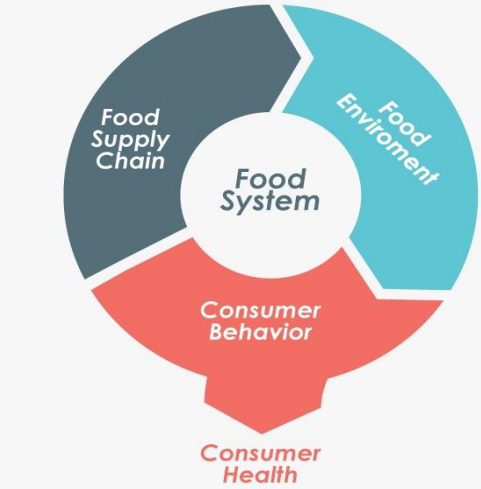

Figure 14: Components of the food system.

Food systems encompass a number of activities which influence a number of food security outcomes (Ingram, 2011). Both activities and their outcomes are influenced by the interacting environmental changes and socioeconomic drivers, while simultaneously, the outcomes can also feed back into the drivers (J. Ingram, 2001). The activities comprise producing food, processing and packaging and various related food transformations, retailing and distributing, and finally consuming. The last step includes the consumers themselves but also all the varied actors that can control what they consume, such as markets and advertisers (Ericksen, 2008; Ingram, 2009). The food security outcomes are related to their effects on the availability, access and utilization pillars of food.

Food systems have been central to recent trends in global poverty, hunger, and nutritional problems, but are also the foundation of future progress (Stordalen, 2018).

The three main constituents of food systems identified and defined by the High Level Panel of Experts (HLPE) as entry and exit points for nutrition are: the food supply chain, food environments and consumer behavior. Figure 14 shows how the food system contains all the steps related to the food supply chain, followed by the food environment encompassing all availability, access and consumer convenience, which will influence the consumer behavior and consumers' diet choices and quality by ensuring (or not) food diversity, adequacy and safety. The chain of actions in the food system will eventually influence the consumers' health.

1. ***Constituent elements of the food system:***

- *Food supply chain:*

The first component of a food system is the food supply chain, which encompasses all activities that move food from farm to fork (production, storage, distribution, processing, marketing...). The decisions made at any stage of this chain will have implications on the subsequent level. Therefore, it influences the types of food that will be available and accessible, as well as the way food is produced and consumed.

- *Food environment:*

The food environment on the other hand is the physical, economic, political and socio-cultural context in which consumers engage with the food system to acquire, prepare and consume food. The key aspects that influence food choices, food acceptability and diets are: physical and economic access to food (proximity and affordability); food promotion, advertising and information; and food quality and safety. Those aspects are influenced by many factors, but mostly by the personal determinants of food choices such as income,

education, values, skills, etc. Therefore, the food environment is all the surroundings, opportunities and conditions that create everyday prompts, shaping dietary preferences and choices and therefore nutritional status (Swinburn , 2014; GloPan, 2017). It serves as an interface that mediates the acquisition of foods by people within the wider food system (Hawkes, 2006). It should be noted that food availability does not in itself guarantee good health and food security levels at the community or household levels. Inadequate access to food – in the sense of physical as well as economic access – can increase the risk of undernourishment as well as of obesity and diet-related NCDs, depending on the context (Duran et al., 2015; Feng et al., 2010). In addition, easy access unfortunately does not guarantee improved health or food security levels. Previous research including Swinburn (2011) has shown that the dominating drivers of population weight gain are caused by the increasingly widely available, inexpensive, heavily promoted, and nutrient-poor but energy-dense foods. This problem falls under the umbrella of an uncontrolled food environment. The food environment, being the conditions that influence people's food and beverage choices and therefore nutritional status, is driving unhealthy diets and energy overconsumption (Vandevijvere, 2014) and their related obesity and NCD consequences in an upward trend. Controlling this environment and intervening is crucial to facilitate healthy eating patterns amongst consumers, and to reverse the obesogenicity of our current food environment. This point will be detailed in the following paragraphs. As such, healthy food environments are the ones that enable and encourage consumers to make nutritious food choices with the potential to improve diets and hence reduce the triple burden of malnutrition; consisting of over nutrition, undernutrition, and micronutrient deficiencies (Meenakshi, 2016).

- *Consumer behavior:*

The third element of a food system is consumer behavior, which is comprised of the choices consumers make and their decisions on what food to acquire and its allocation within the household. It is determined by personal preferences such as taste, convenience and other psycho-socio economic factors (Sobal and Bisogni, 2009). Nevertheless, consumer behavior is also influenced by the existing food environment. Hence, given these major powerful influences, healthy diets are more likely to occur when nutritious food is immediately accessible, acceptable and affordable, thus making healthy foods an easy choice. Therefore, diets are determined by food environments, which are shaped by food systems. The following section (C.2) will detail the consumer behavioral cycle, and how can we use the consumer as a leverage point in the food system. Understanding this is key to building effective interventions, because consumer food decisions have important impacts on the food system through their market demand, sometimes determining what food will be produced and by what methods. Also, the following paragraph will present implicitly how the food environment is a powerful diffusion mechanism of food behaviors, and how important it is in shaping consumer decisions and dietary habits, thus, consumer nutrition and health status. And that is why interventions on a consumer level should be applied synergistically with strategies addressing other parts of the food system; conversely, neglecting consumers will reduce the effectiveness of other interventions targeting producers, traders, and regulators because of the interdependence between these groups.

Billions of consumers make decisions regarding food every day, exerting a major force on the structure of the food system. This fact diverged a lot of attention to target consumer behavior as a strategic point for sustainability and public health interventions in food systems. However, these decisions are very complex and are highly influenced by the context in which they happen.

As Metabolic consulting company discussed in their Global Analysis Report of 2018, behaviors occur in a dynamic system where consumers interact with producers, farmers, traders, retailers, industries, governments, and a series of other actors. In light of this, consumer behavior cannot be the only fundamental driver of the market or the core issue necessary to move to a more sustainable state. In addition, socioeconomic factors and governance play a big part. Thus, the best means to guarantee long-term adjustments, modifications and progress is to holistically address the underlying structures and conditions that determine these behaviors, and to address issues across the whole food system.

2. Consumer behavioral cycle

The consumer behavioral cycle consists of several steps (filtering, processing, attitude and intention, behavioral gap and experience) which are all influenced by a multitude of variables. There is a variety of internal and social factors that can influence each step.

Before the processing phase, lots of new knowledge and messages reach the consumer but a significant amount will be filtered out and will not impact the behavioral cycle.

First, information and messages are filtered, and then they are either rejected or processed. Both internal and external factors can influence the processing mechanism. Most consumers are likely to react positively to optimistic, understandable messages framed with a positive outcome, coming from sources they trust and respect (Phanthong, 2011). Information filters arise from people's attitudes, social contexts and personal ideas. How important the facts and outcomes are to the consumer is a crucial factor to let the information pass to the next step (Ha Hong-Youl, 2002). Messages that have successfully passed will trigger processing in the consumer's mind.

Personal and contextual factors as well as internal and external factors play an important role in processing incoming messages. Socioeconomic and demographic factors will affect this step in different ways. For example, a younger age, better education and higher income can increase the willingness to adopt new products (Wei, 2005). In addition, external factors such as culture and the social norms present are influential in decision making. The individual's family, social status, level of education, geographical location as well as the marketing exerted on them will affect how much effort is put into processing (Stávková, 2008). Friedkin explained in 2010 that people unconsciously imitate the actions of those surrounding them and select their own behaviors according to the image they want to portray to others. This shows the importance of the processing step to be able to change people's attitudes and consume a new food product, as product-specific factors such as its relative advantages compared to its alternatives and compatibility with the consumer's existing backgrounds play a key role (Rogers, 2003). Processing will result in a positive or negative specific attitude towards the message (Grunert, 2011) For example, consumers

could have a positive attitude towards some foods, but it does not mean they intend to consume it. The following step is a phenomenon known as the behavioral gap, when consumers do not act consistently with their intentions. This gap occurs depending on a variety of external and internal factors (Grunert, 2011). Action is most likely to occur if the individual perceives or knows the efficacy of this action, and it must be strong enough with a desired outcome for the person to perform their intended behavior (Vermeir, 2006). This falls under the category of internal factors. Otherwise, they will feel like their purchase or choice will make no difference and will not bother with it. The uncertainty of outcome is an important contributor to the behavioral gap. This is where awareness and education can play a huge role. On the other hand, many external factors can also contribute to the behavioral gap. Contextual factors such as availability of adequate infrastructure, risk perception, technology and social norms can prevent intentions from becoming actual behaviors (Friedkin, 2010). Most importantly, the four A's of a product which are affordability, accessibility, availability and attractiveness have a high potential to reduce the occurrence of the gap (Hjelmar, 2011). For example, Gifford & Bernard (2006) mentioned that sustainable food should be easily available, affordable and acceptable to avoid the behavioral gap. Once the consumer carries out the behavior in question, they will register a positive or negative experience towards it. Whether the experience is considered as negative or positive will determine the likelihood of the consumer repeating the same action or purchase or rejecting it in the future. When the experience is considered positive, consumers are more likely to repeat it and turn it into a habit in the long term (Lally et al, 2010). Also, the context in which food is experienced can be altered to enhance this experience, as convenient and positive ones can become habits. Negative experiences will

lead to reconsideration, whether as effective ones will reinforce the attitudes and decrease the behavioral gap.

E. Problems of our current food systems:

The food system has widely benefitted from technological advances in agriculture, food technology and processing, while greatly increasing the quantity and types of foods that can be grown, produced and distributed (Floros, 2010). These advances provided benefits to retailers and individuals alike, allowing food to be transported further and stored longer while offering wider food choices. Moreover, the food industry has also been adjusted to the need to respond to, and even shape, individual food demands.

However, the current food system is facing many issues, and has dramatic effects on human and planetary health (HLPE, 2018). For example, agriculture is highly dependent on the climate (L. Ziska, 2014). Rising temperatures will exacerbate scarcity of soil moisture and water availability and therefore affect food availability, a crucial pillar of food security. Also, changes in the frequency and severity of droughts and floods could pose challenges for farmers and threaten food safety and thereby food security (Ziska, 2016). Overall, climate change will make it more complicated and difficult to grow crops and raise animals in the same ways and same places as in the past. Additionally, the food system is the largest contributor to environmental and to humanitarian impacts; by over exploiting natural resources and contributing to the triple burden of malnutrition. For example, agriculture now occupies roughly half of the land area of the planet while using 70% of extracted fresh water and, together with the rest of the food system, is responsible for 25 to 30% of

greenhouse gas emissions (Metabolic consulting, 2016). Hence, global food systems simultaneously contribute to and are affected by climate change.

The MENA countries are deeply affected by the current food system. The combination of increasing population and urbanization implies increasing food consumption, but domestic production cannot keep pace (UNESCWA, 2017). And with climate change, increased water scarcity and unsustainable agricultural practices, the widening consumption gap will have to be met by imports.

The world needs a food system suitable to satisfy every person's dietary needs every day, everywhere, while providing safe food and adequate nutrition; and a food system that can simultaneously adopt sustainable practices with regard to natural resource use. On the other hand, understanding the underlying causes of the triple burden of malnutrition requires broader, nutrition sensitive and specific approaches to be implemented through multiple sectors and most importantly across the food system. According to the Food and Agriculture Organization of the United Nations, with climate change in addition to increasing conflict, global hunger has increased since 2016, affecting 815 million people (FAO et al., 2017).

Globally, one person in three today is malnourished (IFPRI, 2015a). If current trends continue, one person in two could be malnourished by 2030, despite the SDGs and targets dedicated to end hunger and all forms of malnutrition by 2030 (GloPan, 2017). Food systems and diets are major contributors to the nutritional status of populations, and thus play an important role to address those issues. In parallel, obesity and over-consumption of

food are residing side by side with undernutrition, sometimes in the same country or even the same household (UNESCWA, 2017).

F. Food system's impact on diets, leading to non-communicable diseases:

Food systems have introduced radical changes in methods of food production, processing, storage, and distribution (WHO, 1990). Economic development coupled with modern marketing techniques and recent food technological innovations have influenced and modified dietary preferences, and consequently, led to major changes in the composition of diets. Nowadays, there is a radical shift towards high fat, refined carbohydrate and low-fiber diet (Popkin, 1998). Hence, current food systems are changing dietary patterns and food choices, replacing the traditional with mostly processed, westernized, and unhealthy patterns.

The global diet is going through a remarkable transition as grain products are becoming more refined, processed fats and meat intake are dramatically increasing, and an elevated number of meals are consumed outside the home, making households more reliant on the food industry and markets. In addition, food environments are promoting high energy intake through easily available and accessible processed, calorie-dense, nutrient-poor choices. For example, in 2017, McDonald's operated almost 40,000 restaurants worldwide, which is 4000 additional restaurants compared to 2016. (Statista, accessed in September 2018). Therefore, there is an increased powerful presence of an obesogenic food environment. The obesogenicity of an environment has been defined by Swinburn et al as "the sum of influences that the surroundings, opportunities, or conditions of life have on

promoting obesity in individuals or populations." Our obesogenic environment is perceived to be the main driving force behind the escalating obesity epidemic (Swinburn et al., 1999)

A large body of studies suggests that there are many barriers to access and consume a healthy diet, even when the consumer has a preference to eat well (Flynn, 2015). The structure of the food system underpins many of these barriers including the availability and accessibility of nutritious foods (Gustafson et al., 2016). Healthy choices are often more expensive than their unhealthy alternatives (Rao et al., 2013), and healthy, culturally acceptable options are often beyond the reach of low-income families (Barosh et al., 2014). This will result in situations where individuals, families or communities often consume foods in ways that lead to overweight and obesity. Consequently, food consumption is not only influenced by personal choices, but by a complex and ever-changing system with a range of social mechanisms. Therefore, obesity and overconsumption require actions that are multi-level and multi-directional with a deep understanding of the actions of interrelated stakeholders (Parkinson, 2017). This clearly shows the importance of intervening in the whole food system to solve our current issue instead of just targeting consumers at the individual level. Countries of the MENA region, and Lebanon specifically, are witnessing a fast rate of development with shifts in diet consumptions patterns (Sibai AM, 2010). The prevalence of obesity has been increasing worldwide since the 1970s (Parikh, 2007) and it has been associated with a wide range of NCDs (Kihara, 2015). Assuming a linear trajectory in obesity rates over time, the prevalence of obesity among Lebanese adults is expected to approach 40% by 2020 (Nasreddine et al, 2014).

The dietary transition is associated with the escalating trends of NCDs; the role of an unhealthy diet in the etiology of NCDs is extremely important (Popkin B et al. 2001).

G. Priorities for intervention in the food system:

Nutrition and food systems need to be prioritized and taken into consideration in different sectoral policies and programs in order to address the multiple burdens of malnutrition (Jones, 2016). The following section will address some objectives and methods along with examples of nutrition integration along the food system's three components. The examples will prove the importance of food systems in influencing dietary patterns and changing behaviors and hence the population's health and wellbeing. Both nutrition-specific and nutrition-sensitive interventions need to be taken into consideration. Most of the cited targets and methods that were selected from the available literature will inspire the answer to research question number two in the subsequent chapters by showing successful examples of food system interventions.

1. Strategies for changing the food supply chain:

Food supply chains can be improved to increase access to nutrient-rich foods while maintaining or increasing their nutritional value as they move along the supply chain. Nutritious foods' availability, acceptability and affordability can be enhanced through interventions across this chain. Therefore, diets and nutrition outcomes can be improved by supply chain analysis (Biénabe et al., 2017), as each step can have significant influence on food consumption consequences.

- *Effective examples of change in the food supply chain:*

TARGET	METHOD	EXPLANATION	EXAMPLE/SUGGESTION
Production systems	Improve landscape and dietary diversity	Studies showed the positive associations between farm diversity and dietary diversity (2014; Remans et al., 2011). Many poor and undernourished people are smallholder farmers (IFAD, 2016), who need to improve dietary diversity through diversified production.	Increase connections with rural areas, improve technologies and infrastructures, home gardens, bio fortification, and sustainable agricultural inputs… (Headey et al. 2012),
Production systems	Increase links between local farms and school meals	Farm-to-school programs can improve the provisioning of nutritious foods in schools while simultaneously improving linkages between farmers and schools and creating a guaranteed market for local farmers. (Joshi et al., 2008)	A systematic review concluded that garden-based nutrition intervention programs promote increased fruit and vegetable intake among youth and increased willingness to try fruits and vegetables among younger children (Robinson-O'Brien et al., 2009).
Storage and distribution	Reduce food losses and waste	Almost 1.3 billion tons of food per year are either lost or wasted globally, the reduction of food losses and waste is a major challenge for food and nutrition security (HLPE, 2014a).	Adequate transport and storage conditions, convenient infrastructure and distribution… (HLPE, 2014)
Retail and markets	Procurement of healthier foods in supermarkets	Supermarkets deeply influence people's dietary choices and	In East Africa, African leafy vegetables (such as kale, nightshades, cowpea greens

		purchases through which types of food are the most available and easily accessible	and pumpkin greens) have become a niche crop, and women farmers are supplying them to larger supermarket chains (Cernansky, 2015).

Table 8: Effective examples of change in the food supply chain.

2. *Strategies for changing the food environment:*

Healthy food environments facilitate healthier food choices. Having healthy food available and affordable in food retail and food service stores will allow consumers to make healthier and easier food choices. When nutritious foods are not available, people may settle for products that are higher in calories and lower in nutritional value. Those goods are most times favored over their healthy alternatives because they are cheaper, hence negatively affecting consumers' nutritional wellbeing while increasing micronutrient deficiencies and non-communicable diseases. Thus, creating and supporting healthy food environments is an important part of public health work and considerations (FAO, 2016).

- *Effective examples of change in the food environment:*

TARGET	*METHOD*	*EXPLANATION*	*EXAMPLE/SUGGESTION*
Food availability and access (physical access / proximity)	Address food deserts and food swamps[1]	The physical access to diverse types of food in a given food environment influences what consumers can purchase and subsequently consume.	Mobile markets and food carts can improve access to healthy foods, such as fruits, vegetables in both food deserts and swamps. New York City has implemented several initiatives to improve fruits and vegetables supply and demand: It reached all the population mostly low income neighborhoods; increasing their consumption and improving their nutritional status. (Dannefer et al., 2012).
Economic access / affordability	Taxes and subsidies to encourage healthier diets	Taxes and subsidies making nutritious foods cheaper/ unhealthy foods more expensive may be one way to influence consumers' behavior and subsequent food intakes (Eyles et al., 2012)	Excess intake of sugar sweetened beverages (SSBs) has been shown to result in weight gain (Escobar, 2013) Taxation of SSBs in Mexico led to a 12% decline in consumption (Batis et al.2016), improving the population's nutritional profile.
Economic access / affordability	Reduce price gaps		A study by AACC International in 2013 observed the differences in prices between refined and whole wheat alternatives, and calculated the additional

[1] Food deserts are geographic areas that have limited access to healthy food (Larsen, 2008)
A food swamp is a geographical area with adequate access to healthy food retail, but that also features an overabundance of exposure to less healthy food and beverages (Luan, 2015)

			price consumers had to pay to follow the FBDG "make half of your grains whole" recommendation: a family will have to pay 16% more (Ferruzi, 2014)
Advertising, promotion and information	Promote healthier food options	Promotion of foods, such as placement in markets or on store shelves, and branding, influence food preferences in ways that consumers may not be consciously aware of (Chandon and Wansink, 2012).	Display products at eye level, product grouping, establish a "healthy food" aisle, and make package designs more attractive especially for children… (Glanz et al., 2012).
Advertising, promotion and information	Increase transparency of nutrition labels	Nutrition labeling aims to provide consumers with information about the nutrient content of a given food.	Adopt easy-to-interpret labels (e.g., traffic light, star ratings, etc.) on packages or store shelves since most labels require a degree of nutritional literacy, and are difficult to interpret for many people (Hersey et al., 2013).

Table 9: Effective examples of change in the food environment.

3. *Strategies for changing consumer behavior:*

Consumers developed more dynamic and complex food demands. These changes, reinforced by adjustments in the other components of the food system, provide both threats and opportunities for the food sector (Grunert, 2005). In addition, consumers can shape the food supply through their behavior and demand for specific foods (HLPE, 2018). Demand-side interventions focus on awareness, behavioral change, willingness to pay and knowledge with the aim of increasing demand for nutritious foods and thereby improve dietary patterns.

- *Effective examples of change in consumer behavior:*

TARGET	METHOD	EXPLANATION	EXAMPLE/SUGGESTION
Education	Strengthen nutrition education	Nutrition education not only clarifies the biochemistry of nutrients but also stimulates critical analysis of food choices and helps develop practical skills for a wide range of food options and contexts (Brazil, 2012). It has to be coupled with other interventions to guarantee optimal effects.	Studies in South Asia have shown a greater impact on maternal and child nutrition outcomes when nutrition education was coupled with nutrition support in the form of a food supplement, micronutrient supplements… (Girard and Olude, 2012)
Education	Mass media campaigns	Mass media has an important role to deliver information to the vast majority of populations. Multi-component, community-based media campaigns can be beneficial in promoting nutrition education (HLPE,2018)	The North Karelia Project in Finland aimed to address risk factors for coronary heart disease (CHD). A variety of activities were implemented such as dietary education via posters and leaflets, newspaper and radio coverage, distribution of healthier, easy-to-prepare recipes. Diets improved substantially, and declines in blood cholesterol and blood pressure were observed, leading to reductions in CHD rates of 65% in the whole country from 1971 to 1995 (Puska and Ståhl, 2010).

Food acceptability	Taste and promotion	Acceptability can be influenced by the promotion of specific foods and diets as well as by consumer preferences.	A study that aimed to determine different thresholds to improve children's liking of whole wheat bread by gradually increasing the whole-wheat content of bread rolls determined 14 difference threshold steps necessary to increase the amount of whole wheat flour in a bread roll from 0 to 91% without people noticing a change in the rolls and without lowering consumption..(Bakke, 2007)

Table 10: Effective examples of change in consumer behavior.

While better practices to improve diets and nutritional status are emerging, there is no single solution to address NCDs. Interventions need to be adapted to each local context, and monitored for benefits and potential harm. Hence, a deeper understanding of Lebanese consumers' preference for bread and the food system will unfold cross-cutting intervention entry points at multiple levels in order to increase brown bread consumption and thereby help to curb NCDs. The following research questions and objectives were set accordingly.

Therefore, a deep understanding of Lebanese adults' bread preferences and the related food system will help unfold intervention entry points to increase whole wheat bread consumption in an attempt to decrease NCDs.

RESEARCH QUESTIONS AND OBJECTIVES

Research questions:

1. What are the determinants of whole wheat bread consumption among adult Lebanese consumers?
2. What kind of interventions are needed to increase whole grain consumption, and more specifically whole wheat bread consumption, across the Lebanese population?

Objectives:

1. Determine the drivers and barriers to whole bread consumption in Lebanon.
2. Explore perceptions and experiences of consumers, bakers, and millers with respect to whole wheat bread production and consumption.
3. Identify intervention entry points within the food system to promote and enhance whole wheat products consumption.

CHAPTER III

METHODOLOGY

A. Study design:

A qualitative and quantitative research design was adopted in this study in order to answer research questions number 1 and 2.

To investigate which type of bread (brown = whole wheat bread, or white = refined wheat bread) do Lebanese adults favor (research question number 1) consumer surveys were developed. In order to answer research question number 2, attitudes about brown bread consumption were also quantitatively evaluated to unlock the drivers of and barriers to whole wheat bread consumption. Additionally, consumers' knowledge about brown bread, including its definition, was evaluated. The results were analyzed on a gender-specific basis to identify specific intervention entry points for each sex, in addition to the education level. A binomial logistic model was adopted in order to do so.

Qualitative data was collected through open ended interviews with Lebanese bakers and millers. They provided insights on the differences between whole and refined flour and bread production processes, the reasons behind the price disparity between the two products, and their personal opinions about the factors affecting whole wheat bread consumption amongst the Lebanese adult population. Being part of the bread food system, involved from the raw materials to the final baked goods, and with their understanding and influence on the market and bread consumption patterns, millers and bakers also

contributed to answering research question number 2 by providing all the background operations and processes involved in bread availability and accessibility.

B. Study population:

1. Population:

The study population was composed of two groups: bread consumers, and millers and bakers:

- *Consumers:* A convenient sample of 150 consumers was approached by the graduate student in the areas of Beirut (Achrafieh) and Mount Lebanon (Dekwaneh, Hazmieh, Falougha, Hammana, Baabdat, Dhour el Chouweir, Aley) and Khalde. Those areas were selected because they culd be accessed by the graduate student in the timeframe provided to complete the thesis.
- *Bakers and millers:* Six mills were contacted and four responded and agreed to be interviewed. Six bakeries were contacted and five of them were interviewed.

It should be mentioned that there are 13 mills in Lebanon (BLOMINVEST BANK, 2016), However, the total number of bakeries is undetermined.

2. Inclusion criteria:

- *Consumers:*

In order to be included in the study population, consumers had to be: Lebanese adults (18 years old and above) and wheat flour bread consumers. If the approached individual had a non-Lebanese nationality, was less than 18 years old and/or did not consume wheat bread, they were excluded from the study sample.

- *Bakers and millers:*

In order to be included in the study population, bakers and millers had to be operating Lebanese-based mills and bakeries. Mills had to be producing flour to be used by Lebanese bakeries, and bakeries had to produce and sell both brown and refined bread. Only big bakeries were considered, since they provide the majority (an estimated 55%) of the total bread supply, whereas traditional "around the corner" bakeries have a 45% market share of the bread supply in Lebanon, and not all of them produce brown bread (BLOMINVEST BANK, 2017).

C. Data collection process:

1. Consumer data collection:

Data collection took place between June and September 2018, and the questionnaires and consent form were both presented in Arabic (See Appendix I and II). Individuals walking by bakeries and supermarkets were randomly approached by the graduate student and interviewed upon their consent and availability. The student explained briefly the purpose of the survey, and informed consumers that their participation is entirely on a voluntary basis and that they have the right to withdraw or discontinue participation at any time without penalty, and it would not affect their relationship with the American University of Beirut (AUB) at any level. Also, consumers were not asked to fill their name or any personal information that could be traced back to them to ensure confidentiality.

Before filling the survey, consumers were given a quick definition of what is meant by brown bread in the questionnaire, which is "bread made from whole wheat flour" to avoid any misinterpretations.

2. Bakeries and mills data collection:

Interviews were conducted from June until August 2018. Consumer assistance and/or sales departments were contacted by the graduate student either via phone or email. The phone numbers and email addresses used were listed on their brochures/online websites. The graduate student identified herself and the purpose of her interview, to get insights on the different activities in relation to white flour/bread and whole flour/bread availability, accessibility and sales, and what role could the respondents play to increase whole wheat bread consumption in Lebanon. If the interviewees were approached by phone call, the student asked for their business email to send the questionnaires, invitation script and consent forms in both English and Arabic. The participants read all the forms and accordingly agreed to meet. The documents were all reviewed and discussed during the subsequent face-to-face interview. One bakery and one mill preferred filling the detailed form and questionnaire and sending it by email because of their lack of availability to meet. The rest of the interviews were conducted upon the participants' availability and at a time and place of their choosing. There was no rigid structure that dedicated the flow of the discussion, but the student rather allowed the interviewees to feel free to give additional information about their opinions, suggestions and expectations. To end the discussion, the graduate student asked the interviewees if they had anything to add regarding the problems and solutions related to brown bread consumption in Lebanon.

D. Data collection tools:

1. Quantitative:

Quantitative data for this thesis was collected via the consumers' surveys that addressed bread preferences, knowledge and attitudes with respect to whole wheat bread. The survey was designed to address topics such as knowledge and ability to identify whole wheat bread, in addition to the perceived drivers and barriers to consumption. It was comprised of six sections that addressed several components: section (1) included socio-demographic characteristics such as gender, education level; section (2) focused on their favorite type of bread (brown or white) and approximately how much they consume per day. The third (3) section handled the knowledge regarding whole wheat bread definition and then, with reference to their favorite bread type, participants had to either go to section (4) and (6) if their answer in Section (2) was white bread, or only to Section (5) if their favorite was brown bread. Sections (4) and (5) presented several options regarding the reasons for not consuming (4), or consuming (5) brown bread and multiple answers were possible. Section (6) consisted of three questions aimed to directly identify possible intervention points, such as: If brown bread's price was equal to white bread's price, would you consume it? And, if brown bread's health benefits were explained to you, would you consume it? And, if brown bread's taste was improved, would you consume it?

Gender and the highest attained educational level were addressed in section 1. The results from section 3, 4 and 5 have been analyzed within the general population sample and also by gender in order to identify targeted intervention entry points; as interventions targeting women can differ from those targeting men. Section 3 provided choices of several types of

breads offered on the Lebanese market, such as multi-cereal bread, oat bread and so on. Participants had to pick the options they consider as brown bread; according to the definition mentioned at the beginning of the survey. This question helped unlock the misconceptions related to whole wheat bread definitions, and was influenced by the misidentified terms mentioned by the Whole Grains Bureau; such as multi-cereal bread and bran bread (Whole Grains Bureau, n.d).

The options presented in sections 4 and 5 were influenced by the results of several previously made studies. For example, a thesis entitled evaluating knowledge, attitudes and behaviors associated with whole grains consumption by Meera Raya Smiha of the Graduate School of the University of Maryland, in 2005 addressed changes in attitudes towards whole grains consumption pre and post intervention amongst her study population. The factors taken into consideration were the taste, cost, whole grain products availability in shops and their variety, and consumers' willingness to buy whole grains products if they knew they were healthier. Another study titled "Attitudes to and consumption of whole grain foods in Northern Ireland" by McMackin (2013) showed that the population's health motivations influenced their willingness to select whole grains. Many barriers to consumption were also reported in this study such as negative perception of sensory qualities and the inability to identify them.

Another study titled "Whole grains and health: attitudes to whole grains against a prevailing background of increased marketing and promotion" showed that its participants had a basic knowledge of whole grains' health benefits, and the prominent barriers to

consumption were mainly the sensory properties, perceived cost, family influences and ability to locate whole products (McMackin, 2013).

The last study that influenced the development of this thesis' consumer survey was another thesis entitled "Consumption & Attitudes about Whole Grain Foods of UNL Students Who Dine in a Campus Cafeteria" by Kimberly J. Bisanz in 2007. The student assessed her population's barriers and motivating factors for consuming whole grains though multiple choice questions. They were asked about the reasons for consuming, or not consuming, whole grains. Several choices were presented to depict the barriers, such as the taste and texture, ability to identify the products, products' availability, knowledge regarding their health benefits, and other. The facilitators of whole grain consumption options were as follows: health benefits, taste, texture, availability or other. This study also assessed the understanding and knowledge about whole grains products by asking the participants to mark as many as the provided options that, if seen on a product's package, would make them think that this product was whole grain.

Hence, this thesis' consumer survey was developed based on preliminary results unfolding the multiple drivers and barriers to whole grains consumption, in addition to the necessity to assess knowledge related to whole grains – in this case, whole wheat – products' definition and ability to identify them. Section 3 handled this sample's knowledge about brown bread definition by presenting multiple choices such as: Nkhaleh (bran) bread, tannour, multicereal, bread with fibers, oat bread, wheat bread, whole flour bread, cereals bread, whole wheat bread, and 100% flour bread. The graduate student selected those choices based on the bread labels available in Lebanese markets and bakeries.

The options presented in sections (3), (4), and (5) are presented in the Appendix I and II.

2. Qualitative:

Qualitative data for this thesis was collected via the millers and bakers' interviews. The questions of both open-ended interviews were developed based on the preliminary findings of consumer surveys evaluating the knowledge, barriers and facilitators of brown bread consumption. As the preliminary barriers reported in the surveys were mainly the unattractive organoleptic properties of brown bread, its higher price and decreased availability, and the main drivers were the good taste and its health benefits, the questions handled those matters in order to find the reasons behind them and how to improve them. All interviews were conducted in Arabic.

- *The interview with the millers (see appendix IV)*

This interview was designed to address topics such as the country of origin of their grains destined for bread and especially Lebanese bread production, differences between white and whole flour production processes and machineries, the differences between the average price, quantity produced and quantity sold of refined flour and whole flour, and the different flour types on the market, their prices and usage. In addition, millers were asked by the graduate student how their business would be affected if whole wheat flour demand increased, and if they are taking any measures to increase their whole flour sales. The interview ended with multiple open ended questions about the price difference between whole products and refined products and what could be the reasons behind it, and which measures can be taken to decrease/annul this price difference.

- *The interview with the bakers (see appendix III)*

This interview was designed to address topics such as the source of their flour, the purchase rate (in %) of refined flour over whole flour, and why. The discussion that followed focused mainly on the production processes and sales quantities of refined versus whole products, and whether the bakery is trying to increase whole wheat products' availability and accessibility. The conversation that came after revolved around the price and taste differences between the two products and how can they be improved.

E. Descriptive data analysis:

1. Consumer surveys:

Descriptive statistics were conducted using Excel 2016 with continuous variables presented as mean and SD and categorical variables as frequencies and proportions. Consumers' responses were analyzed by gender and educational attainment.

Second, the binomial logistic or logit regression model was used on STATA 15 to predict the odds of giving a correct/almost correct answer while defining a whole wheat product based on observed characteristics of the respondent such as gender and education level. In order to so, the following steps were followed:

Answers in section (3) were recoded to be as such: code (1) for those who answered completely correct to almost correct whereas code (0) was given for those who had a wrong answer.

"Whole wheat bread" is the only correct answer to question 4 (see Apendix…). People who only selected this answer were considered as being completely correct, people who ticked it

in addition to other options were considered as being almost correct whereas people who did not tick it at all were considered as completely wrong. Hence, answers to question 4 should be divided into three categories as follows: completely correct answer, almost correct answer and completely wrong answer. However, only one male individual got a completely correct answer and zero females picked up the completely correct answer. This statistical model requires positive answers in each category. Therefore, in order to facilitate the analysis and have a successful model, the completely correct category was merged with the almost correct category. Additionally, the elementary school section has only two respondents and both of their answers were correct/almost correct and none was wrong. Therefore, it has been merged with the high school category and both are considered as low education levels.

The second step is importing the raw data into the STATA statistical software. A binary logit model was applied. To run the model, base categories have to be assigned in order to compare the other variables to them. For this model, men and low education levels (as in elementary and high school) were considered as base categories. Hence, running the statistical model will display what are a female's odds of giving a correct/almost correct answer compared to a man; whatever the odds are for a man. Also, it will show the odds of an educated person giving a correct/almost correct answer compared to a low educated person, whatever the original odds of a low educated person are. This model will show if females (more educated individuals) are likelier to fall in the category of correct/almost correct only when compared to males (less educated individuals), and not in absolute terms.

After running the model, P values (with a significance level of 5%) and odds ratios were extracted.

2.Millers and bakers' interviews:

The thematic deductive analysis approach was followed to analyze the open ended interviews. First, the graduate student re-wrote all the notes taken during the interview into clear full sentences instead of bullet points and abbreviations. They consisted of two categories: Millers and Bakers. Some notes were translated into English because the graduate student wrote them in spoken Arabic to speed up the note-taking process.

The second step was conducting the thematic analysis. This analysis helped the researcher move from a broad reading of the data toward discovering patterns and construct the answer to research question 2. The thematic analysis is considered a method for identifying, analyzing and reporting patterns within the collected data (Braun & Clarke, 2006). An article by Braun and Clarke provided a six-step process for conducting this analysis.

Step 1 or phase 1 required the student to be fully immersed in the data by reading and re-reading the notes taken during the interviews. It familiarized her with all the discussed topics and opinions. Phase 2 was about generating codes by documenting where and how patterns occur. The graduate student created two categories (Millers, and Bakers) for a more efficient analysis. The final draft of each category was divided into two separate sections: common statements and individual statements. The common part reflected all the shared statements, perceptions, problems, ideas and suggestions of each category, whereas the "individual" section encompassed information mentioned by a single category member and not by the others. This allowed the graduate student to recognize which information

can be generalized and which can be applied to a specific context. During phase 3, the researcher combined themes within the categories and sections that seemed to specifically address research question 2 and provide facilitators, barriers and/or suggestions to increase brown bread consumption. In the 4th phase, the student reviewed, modified and developed the themes identified in phase 3. She also started to link the findings of the open-ended interviews to the data collected in the consumer surveys, allowing further expansion and revision. In phase 5, the final themes and subthemes were clearly identified. The final phase 6 was about producing the report, listing the findings in a way that supports the following chapter and hence, the question to research question 2. Collective and individual views were separated.

F. Ethical approval:

Approval from the Institutional Review Board (IRB) of the American University of Beirut was granted for the study prior to data collection. The research protocol was eligible for the exempt status. The graduate student successfully completed the appropriate Collaborative Institutional Training Initiative (CITI) course certificate in order to receive the IRB confirmation and be eligible to conduct the surveys. During the process of data collection, all contacted millers and bakers were sent the questionnaires in both English and Arabic, the consent form and the invitation script; all approved by the IRB. Consumers were also given the questionnaire and consent form in Arabic. Participants were all assured that their participation is voluntary, there are no incentives to participate, they are free to stop the questionnaire/interview whenever they want and skip any question they feel uncomfortable answering. They were also assured that their names; especially for the bakeries and mills,

and the market prices they provided during the interview will not be mentioned in the final thesis dissertation as their answers and identities are completely confidential. Additionally, it was guaranteed that the participants' relationship with AUB/AUBMC will not be affected if they refuse to participate in this study.

CHAPTER IV

RESULTS

This chapter is divided into two sections: the first reporting the outcomes of consumers' surveys, and the second section describes the findings from the interviews of Lebanese mills and bakeries.

A. Results from the consumers' survey:

Results from the first procedure:

Section (1): The total interviewed population consisted of 150 individuals. 64% (N=96) were females and 36% (N=54) were males.

Around 88.7% of participants attained a university degree, whereas 10% and 1.3% completed high school and elementary school, respectively.

Section (2): Bread consumption patterns were also reported: 58% of the total population favored white (or refined wheat) bread, and 42% favored whole wheat bread. Females consisted of 58.6% of white bread consumers and 71.4% of whole wheat bread consumers. 41.3 % of males on the other hand chose white bread and 28.5% chose brown bread.

Section (3): Several options were presented in the question "which bread type is considered as brown bread"? with reference to the definition given before filling the questionnaire. The expected correct answer was: Whole flour bread. Consumers were allowed to select

multiple answers. The presented options and the percentage of their selection were as follows:

Table 6: Consumer knowledge of what constitutes whole wheat bread (N=150).

Which bread type is considered as brown bread?	Percentage	Number
Whole wheat bread	74%	111
Bread with fibers	65.3%	98
Multicereal bread	56.7%	85
Nkhalé bread (bran bread)	42%	63
Oat bread	16.7%	25
Cereals bread	11.3%	17
Tannour bread (baked in a special barrel-shaped oven mould)	5.3%	8
Whole flour bread	4%	6
Wheat bread	0.00%	0
100% Flour bread	0.00%	0

74% of consumers in the sample ticked "whole wheat bread". 65% of respondents considered bread with fibers to be whole wheat bread. The concept of "wholeness" was commonly associated with fiber content. Multicereal bread was also misconceived with 56.7% selection.

Sections (4) and (5): Respondents were given the opportunity to indicate all the relevant suggestions to why they did, or did not, consume brown bread. Several answers could be

selected. White bread consumers only had to tick what prevents them from consuming brown bread, whereas brown bread consumers had to choose what motivates them into consuming brown bread.

Suggestions and answers are listed in the following tables:

Barriers to brown bread consumption:

Table 7: Reasons for not consuming whole wheat bread.

Reasons for NOT consuming brown bread	Percentage	N
Taste	78.4%	69
Don't like the texture	34.1%	30
Price	10.2%	9
Availability	8%	7
Don't know its health benefits	6.8%	6
Can't identify brown bread products	4.5%	4
Other (habits)	2.3%	2

Drivers of brown bread consumption:

Table 8: Reasons for consuming whole wheat bread.

Reasons for consuming brown bread	Percentage	N
Health benefits	71%	44
Rich in Fibers	53.2%	33
Taste	38.7%	24
Less Calories	37.1%	23
Dr / Dietician	17.7%	11
Texture	16.1%	10
Other (easier to digest)	4.8%	3
Availability	3.2%	2
Social Media	3.2%	2

Section (6): The three questions were the following: If brown bread's price was less or equal to white bread, would you consume it? If brown bread's taste was improved would you consume it? And if brown bread's health benefits were explained to you would you consume it?

The results are presented in the following figures:

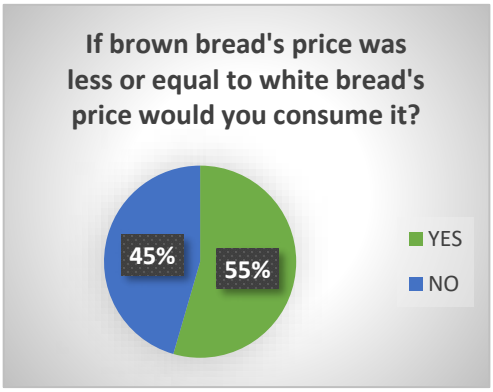

Figure 15: Answers to the first question in section (6).

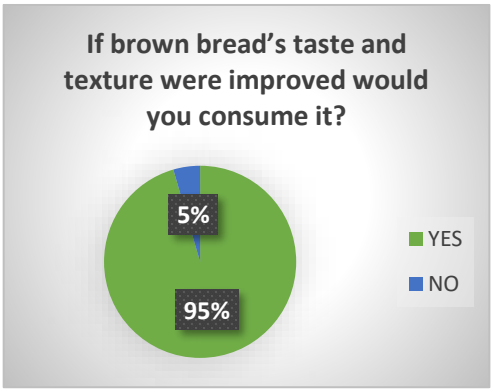

Figure 16: Answers to the second question in section (6).

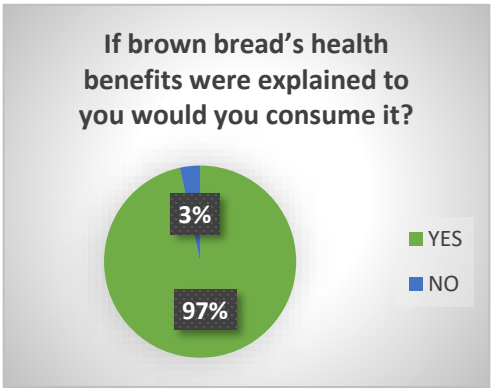

Figure 17: Answers to the third question in section (6).

Results from the second procedure:

The logit model's results were as follows:

knowledge	Odds Ratio	Std. Err.	z	P>z	[95% Conf.	Interval]
female	2.183799	0.8395522	2.03	0.042	1.02795	4.639311
edu_uni	1.148698	0.665762	0.24	0.811	0.3688642	3.577214
_cons	1.637486	0.9295284	0.87	0.385	0.5382551	4.98158

Table 9: The association between knowledge of whole wheat bread and sociodemographic characteristics of consumers.

B. Results from the interviews of Lebanese mills and bakeries:

Six Lebanese mills and six bakeries were contacted, of which four and five were interviewed, respectively.

All the information listed below were gathered during the interviews.

1. Mills:

- *Collective statements from the millers' interviews:*

The main themes that emerged during the interviews with the millers revolved around the raw materials and different wheat categories, governmental control, the milling machineries and flour prices. The discussion ended with their personal ideas on how to improve the sales and consumption of whole wheat bread across the Lebanese population.

a. Raw materials:

In preparation for human consumption, grains are usually subject to some type of processing. It will enhance various organoleptic properties in order to optimize shelf life

and consumer acceptance. The milling removes dust and contaminants, in addition to the bran and germ but only while producing refined flour.

For Lebanese bread production, all mills source unprocessed whole grains from foreign countries such as Russia, Ukraine, USA, and Australia.

All participants mentioned that Lebanese grown wheat cannot be used for Lebanese bread production because its protein and gluten levels are not suitable. Therefore, Lebanese bread, which is the most consumed bread in Lebanon, is purely dependent on imported grains.

b. Governmental control:

The government checks for specific microbial and fungal properties in all grains. Some mills have their own laboratories to test the kernels' safety and quality.

c. Wheat categories:

Wheat is divided into different categories depending on its protein and gluten levels. Yet, its price is affected by its protein content, whereby the price increases proportionally with the increase in protein levels. The numbers listed below are the calculated average prices of whole grains bought by the mills, derived from the values collected in the interviews.11 and 12% grains are not suitable for Lebanese bread especially whole wheat bread production.

Wheat category (protein %)	Average price of purchase USD/Ton
11	220
12	240
14	270
15	300

Table 10: Average prices (USD/Ton) of wheat grains per category purchased by the millers.

d. Milling machineries:

Another issue that was raised was related to the milling machineries. Commonly used modern machineries in the interviewed mills produce only white flour. Hence, the endosperm, and the bran and germ are separated.

Whole wheat flour machineries cannot be afforded as this product's market is still limited; therefore, the revenues cannot cover the price of new equipment.

The isolated bran is either sold as fine bran or as coarse bran. The fine bran can be combined with white flour in order to produce "whole wheat," which was commonly called premix, whereas coarse bran is sold as animal feed. Mills can sell premade premixes, or bakeries can purchase the bran, germ and refined wheat separately and blend them. However, modern milling machineries will result in a 3-5% loss of the original germ component's quantity.

e. Prices:

Prices are set per ton of flour. The average price for selling whole flour is approximately 400$ / Ton, refined wheat flour is 350$ / Ton, whereas a ton of bran was sold for almost 135$ /Ton. The prices are displayed in the table below:

	Whole flour sold	**Refined flour sold**	**Bran sold**
Average price per Ton (USD)	400	350	135

Table 11: Average prices (USD/Ton) of wheat flours and bran sold by the millers.

When asked why, in their opinion, are whole products more expensive than their refined equivalents, millers mentioned their lower shelf life. Fats, vitamins and minerals of the germ and bran will cause rancidity and a change of the bread's organoleptic properties. Therefore, if whole breads don't sell as fast as white breads, or are not consumed sooner, their quality will expire shortly and the products won't be edible. Consumers, and some bakeries, consider this wasted food and wasted money.

f. Improve consumption of whole wheat products:

As for how can Lebanese whole wheat bread consumption be increased, and what role can the millers play, most answers revolved around government control.

All millers acknowledged the healthy properties of whole grains compared to refined grains, and their crucial role in fighting NCDs.

Also, fraud was considered very frequent, as some bakeries sell products from poorly made premixes. Some mentioned that some bakeries add brown colorings, or even fry the raw materials so the final product can have the same brown color and be mistaken for a whole wheat product. They'll be sold for the same price as authentic whole wheat products whilst having a longer shelf life. Consumers will then appreciate this "whole" product for its better appetizing taste and its longer shelf life. Therefore, this bakery will attract more customers towards its fake whole products, distracting them from the real ones while making extra profit from a scam.

What the government can do to check the accuracy of whole wheat products is take samples and analyze the presence and portion of the germ. Some acknowledged that traditional bakeries could be more reliable, because trickeries can be more common and easier in bigger industries. The lack of Lebanese standards for whole wheat proportions and control is also responsible for selling false products.

- *Individual statements from millers' interviews:*

  a. Milling machineries:

- One mill mentioned selling almost 16% of its bran as animal feed against 4% for premixes and the remaining are thrown away or stocked. This highlights the limited demand.

-Another mill acknowledged the losses induced by modern milling processes, so they bought new machineries identical to the ones traditionally used: two huge stones that will crush the unrefined grains into "true" whole wheat. The final product will contain all the properties of the initial kernel. Even if the milling speed rate will be four times slower and

thus, fewer end products and less revenues, the interviewees are satisfied by selling higher quality pure whole wheat flour conforming to the bakeries and consumers' demand and rights. Another company declared milling only refined flour but importing high quality whole flour (higher protein content). This company's whole flour sales account for 25% of total sales, whereas other mills' whole flour sales account for only 5% of total sales.

b. Prices:

One mill sells its ton of whole flour at four times higher than the average price because of its high protein content. This mill's whole flour sales account for 25% of its total sales, versus approximately 5% of other mills 'total sales.

c. Whole wheat products' improvements:

One mill declared visiting their client's bakeries to train the dough masters on improving the volumes and textures of whole wheat products. Trainings are done approximately 5 times a year; depending on capital and products availability. The bran's fibers prevent the bread from reaching maximum volume and the dough's enzymes to fully react and the bread to rise. Hence, they experiment by adding yeast/enzyme bread improvers such as cellulase. Some of their clients increased their whole wheat products' sales, but they're still minimal compared to refined products, and training materials cannot always be afforded.

2. Bakeries:

The main themes that emerged during the interviews with the bakers revolved around the raw materials, the prices and sales of whole wheat products, and the bakers' role in influencing consumer behavior.

- *Collective statements*

a. Raw materials:

All interviewed bakeries source their flour from Lebanese based mills. Also, they have been producing whole wheat products for more than 10 years. Their motives were to increase their products' variety and meet consumer demand. They also recognized whole wheat's protective effects on health and NCDs.

b. Prices and sales:

The average price of whole products is almost 20% higher than their refined counterparts. Unfortunately, whole wheat products sell nearly 70-80% less than white breads.

All bakers mentioned the gaps in brown bread sales between richer and poorer neighborhoods. Whole products' demand was higher in wealthier points of sale. For example, a bakery in Khaldeh area sells less brown bread than the same chain in Rabieh.

Also, bakers stressed on the importance of knowledge and awareness to direct consumers towards whole grains; "a consumer who knows better will choose better"

Additionally, nutrition claims were stated to deeply affect purchasing behavior.

c. Bakers' role in influencing consumer choice:

It is worth mentioning that bakeries recognized their important role in influencing consumer choice and bread purchase decisions. Product availability, variety, displaying and advertising can direct purchases in a certain direction and expand consumption frequency. However, none was trying to increase brown products' availability nor accessibility nor acceptability because of the limited demand coupled with decreased shelf life. They would gladly do so with governmental financial support.

Rancidity risks and low purchases prevents bakeries from buying whole wheat in bulk, thus hindering them from accessing the products at a lower price.

Additionally, some dough masters produce whole wheat goods manually, whereas white breads are produced mechanically. Manual labor increases the cost.

Furthermore, small markets don't buy lots of whole wheat products because of their inferior shelf life and selling capacity; which will generate food and capital waste.

d. Suggested solutions:

When asked what can be done at a bakery level to boost whole wheat products consumption, suggestions were the following: trying to bake openly in an attractive setting to visually stimulate consumers, giveaway tasting samples, decrease the price with governmental intervention, pack whole products individually instead of in bulk so that consumers can buy the exact needed amount and decrease waste, and advise consumers on the spot to buy whole products instead of their refined counterparts.

- *Individual statements from the interviews:*

    a. Bakers' role in influencing consumer choice:

One bakery purchased a separate line machinery to manufacture brown bread and avoid the costs of manual labor, and was able to set the pricing at +10% instead of +20% from white bread. But even with those adjustments, brown bread sales didn't improve.

CHAPTER V

DISCUSSION

The purpose of this chapter is to explain and discuss this study's results, and to compare them with those found by other researchers in the literature.

The consumer survey was administered in order to answer research question number one, and to unlock perceptions and barriers to whole wheat bread from the customer's point of view in order to answer the second research question. The millers and bakers' interviews were conducted to understand the rest of the food system's components involved in bread production, sales and promotion. The outcomes will help identify intervention points and suggestions to increase whole wheat bread consumption in Lebanon and answer the second research question.

A. Results from the consumers' survey:

Section (1-2): Education level was considered for two reasons: additional descriptive information on the study population, and to try to find a correlation between highest attained

degree and whole wheat bread consumption. Higher education means additional information, empowering the consumer to navigate food aisles with knowledge. This knowledge could be linked to health outcomes and awareness regarding whole grains' benefits. However, almost 90% of the surveyed population reached university level, also, the majority favored white bread. Hence, no relationship could be found in this sample between high educational level and brown bread consumption.

Additionally, the Lebanese population preferring brown bread over white bread coincides with an almost similar assessment done in Riyadh (Aljobair, 2017) where nearly 60% of the studied participants consumed white flour bread; subjects consuming whole wheat flour and bran bread represented only 11.82 and 2.52%, respectively. This shows that this thesis' suggestions could be taken into consideration in other MENA countries in order to increase their whole wheat bread consumption levels and decrease NCDs.

As for section (3), the lack of ability to define and identify whole wheat products contributes to the consumption gap (Ferruzzi, 2014). Identification of whole wheat products is generally through food packaging and labeling. The lack of ability to properly identify them can influence the consumption of these foods. Considering the percentages of participants who selected the wrong options in this section, there can be a reason to question the validity of the reported consumption levels. The reported percentage of brown bread consumers could be greater than the actual consumption rate. Additionally, overestimation may have happened due to their unintentional ignorance in properly identifying brown bread, or to intentionally reporting false consumption patterns, possibly because they believed they should be eating whole grains. After all, some participants that

selected brown bread admitted halfway through the questionnaire that they actually consumed white bread, maybe for fear of judgment. Consequently, they were added to the white bread consumers' category.

Inability to identify can be also attributed to unclear packaging and labelling. For example, a US nationwide study showed that 90% of specialists, managers and procurers in military foodservices believed they were serving whole grains, yet only 22% in reality were (Warber, Haddad, Hodgkin, & Lee, 1996). Also, the Whole Grains Bureau mentioned some common terms misunderstood to mean whole grains such as "seven grain", "multigrain", "100% wheat", and "bran" (Whole Grains Bureau, n.d.) which are similar to the misidentified terms in this study: multicereal (56.7%) and Nkhalé or bran, (42%).

Sections (4-5):

- Barriers to brown bread consumption:

Unappetizing taste (78.4%) was the most frequently reported barrier to whole bread consumption. Therefore, its acceptability is relatively low, even though 38.7% mentioned taste as a driver for brown bread consumption. Taste is a critical factor for all food selection, and adverse experiences or expectations can alter choice. Some consumers stated that they did not follow their health professional's advice to consume whole bread because of a dislike of its sensory properties. In contrast, an appreciation of brown bread's sensory properties was one of the most influential consumption facilitators (38.7%). The second obstacle was the texture (34.1%), followed by the price (10.2%), and brown bread availability to consumers (8%). Some mentioned that brown bread had a very "fragile" texture and was difficult and unpleasant to handle while eating. Almost without exception,

whole foods are more expensive than their refined counterpart. Some consumers indicated that it was absurd and useless to pay more for bread. Hence, for many consumers the perceived cost represents a considerable barrier to brown bread consumption.

Higher cost of whole grain products was also a common barrier for American consumers at large (Adams & Engstrom, 2002; Lang & Jebb, 2003).

Lack of proximate availability is surely a factor compromising healthy food choices and access. Some consumers took issue with the reduced availability and variety of whole bread products, which compromises the extent to which they can be introduced to the diet without feelings of restriction or monotony, and brown bread availability outside big bakeries.

All of the barriers mentioned and especially those that got a significant number of responses are the issues that should be addressed in order to direct consumers towards whole wheat bread in an attempt to curb NCDs in Lebanon.

- Drivers of brown bread consumption:

The reasons for consuming brown bread depended strongly on knowledge of their health benefits; as it is the most selected reason (71%) for eating brown bread, followed by "rich in fibers" (53.2%). For some consumers, the benefits outweigh the cost, as they felt it was worth paying the extra money for beneficial foods. It means that despite sensory aversions, some participants were still willing to consume brown bread for its health outcomes. A study showed that Americans on average have reported this similar acceptance of whole grains for their health benefits (American Dietetic Association, 2000). Also, a study at the University of Nebraska (UNL) assessing the consumption and attitudes about whole grains

of its students showed that the top reason for consuming whole grains products was the health benefits, and the most reported barrier was taste (Bisanz, 2007).

Approximately 37.1% of consumers indicated that they consume brown bread because it has “less calories”, which is very interesting and noteworthy; since brown bread and white bread loaves have almost the same amount of calories. This is a striking misconception that should be changed through multi-faceted interventions. It is great that people are willing to consume whole wheat bread, but it should be done for the right reasons. Miscommunication could be behind the fewer calories concept, or simply the lack of proper awareness regarding their dietary instructions. Justified advice about brown bread’s health benefits can increase the consistency and regularity of consumption.

Finally, 17.7% of respondents mentioned consuming brown bread just because their doctor or dietician asked them to. Therefore, while encouraging brown bread consumption, it should be clear that it’s a path towards healthier food consumption patterns, and not for the sole purpose of losing weight.

In section (6), to endorse future interventions, the following three questions have been addressed only to the consumers who preferred white bread (N=87, 58%). Their purpose is to deepen the analysis of whole wheat bread’s barriers, and unlock and confirm future interventions.

Half the survey population is willing to switch to whole bread if its price was less or equal to white bread’s price. The results of this question are odd, since only 10.2% mentioned price as a barrier to whole bread consumption. Therefore, price could be a bigger barrier

than what the previous question showed, and maybe participants didn't mention it by fear of judgement. However, price is not as important as the taste, since almost the whole study population (95%) is willing to switch to brown bread if the sensory properties are improved, which makes sense since taste was selected as the major barrier (78%). However, 5% were not willing to switch even if taste was upgraded. This can imply that even if sensory properties are improved, cost, or maybe habits can still be barriers to some. In 1993, Wardle examined the relationship between health and taste appraisal and food consumption frequency. He showed that taste index was consistently higher than the health index, meaning that food choices appear to be determined by considerations of taste rather than health, which is why taste is the biggest barrier to brown bread consumption and improving it can be a great way forward. Additionally, Adams and Engstrom in 2000 postulated that time constraints, inferior taste, unfamiliarity and lack of knowledge of whole grains' health benefits contributed to their poor uptake.

As for the logit model's results, th***e P*** values show that there is a statistically significant relationship between the likelihood of properly identifying whole wheat products (the dependent variable) and the gender of the survey respondent ($P<0.05$), whereas the level of education of the survey respondent as a variable is non-significant ($P>0.05$). Women are more likely than men to correctly identify whole wheat products: A female's odd ratio of getting a correct/almost correct answer is on average twice a man's odds of getting a correct/almost correct answer. Hence, a female is twice as likely to give a correct/almost correct answer as a male. Whatever the original odds of a male's correct/almost correct

answer are, they double for the opposite sex. However, in this sample, the educational level does not affect the odds of falling into the category of correct/almost correct answers.

B.Results from the interviews of Lebanese mills and bakeries:

- ***Mills:***

Collective statements from the interviews:

Raw materials:

BLOMBANK mentioned in their 2016 study that there are two types of wheat grown in Lebanon: Durum wheat, only suitable for semolina (making pasta, breakfast cereals…) and soft wheat which has low protein and gluten levels (BLOMINVEST BANK, 2016), that's why locally grown wheat is not suitable for Lebanese bread production, as the grains have low protein and gluten concentrations.

Milling machineries:

Whole wheat flour consists of 80% endosperm, and 20% germ+bran. Almost 3-5% of the germ is lost during the milling process, and sometimes all of it is eliminated. Thus, the premixes cannot be considered as pure whole wheat flour since essential nutritional properties are lost, and they do not fit the definition mentioned in the previous chapters: "products made from whole grains should contain all the essential parts and naturally-occurring nutrients of the entire grain seed in their original proportions." Hence, the bran sold separately either contains fewer germ proportions or none at all. Additionally, not all premixes respect the 80-20% rule.

We can conclude that the baked products derived from premixes are sold on the Lebanese market as whole wheat products without being actual whole wheat products. Also, since the bran proportion is lower, this bread will have similar characteristics to white bread such as better taste and shelf life and will therefore attract more consumers than what millers called "authentic whole wheat bread". Further, millers mentioned that the presence of the germ decreases the bitter taste of whole bread. The more the proportions are respected, the better the taste.

Prices:

One problem was reported by all the interviewed mills- about the premixes and their prices.

If we wanted to compare the price of a ton of pure whole wheat flour; which consists of 80% endosperm and 20% bran+germ, and the price of a ton of the blend premix made from 80% refined flour and 20% added bran; the results would be the following:

With reference to the prices listed in table 11, in order to produce one ton of premix, 80% of a ton of refined flour and 20% of a ton of bran should be mixed. Their prices would be 80% of 350$ and 20% of 135$. Therefore, the end premix product will be worth 307$, with less nutritional qualities, because 3-5% of the germ is lost when milling white flour. Also, not all bakers respect the 80-20% rule. This product will unfortunately be sold and labeled as whole wheat bread while having less nutritional benefits.

In addition to having less nutrients, this product will be sold at the same price as "authentic" products made from whole wheat flour at 400$/Ton, which is surely a fraud in

terms of labelling and consumer rights. Individuals won't be getting the nutrients they're paying for.

- ***Bakeries:***

Collective statements from the bakers:

Prices and sales:

Bakers mentioned that brown products sell less by 70-80% than their refined counterparts. Which is why, brown bread and white bread's consumption rates being close (42-58%) is an odd phenomenon. This might be linked to the differences in the interviewees' economic status.

Subsequently, one study found a significant relationship between whole grain intake and income. Data from the NHANES 2005-2012 survey showed significant trends toward increased whole foods intake among high income adolescents nationwide in the U.S. that was absent among their low income peers (Tester JM, 2017).

In fact, as the consumer surveys showed, the leading factor for consuming brown bread was its health benefits, which denotes a certain level of consciousness and understanding of the beneficial outcomes. Therefore, increasing consumer response through awareness is a crucial step. Additionally, nutrition claims were stated to deeply affect purchasing behavior. The previous results showed misinterpretation of bread food labels, which underlines the significance of awareness for better nutritional choices.

Bakers' role in influencing consumer choice:

Small markets don't buy lots of whole wheat products because of their inferior shelf life and selling capacity; which will generate food and capital waste. This will cause limited brown bread availability outside big bakeries; and this was considered as a barrier for 8% of the consumer sample

- *Individual statements from the interviews:*

Bakers' role in influencing consumer choice:

One bakery mentioned buying one separate line machinery to produce whole wheat bread at lower costs (10% instead of 20%), but the sales did not improve. This emphasizes on the importance of bread's sensory properties, or on the inability of some consumers to even pay the additional 10%.

- Study limitations:

The aspects listed below influenced the interpretation of the results.

The sample size was a convenient one of 150 participants because of the lack of time and resources dedicated to this research. Increasing the number of interviewed consumers may enhance the generalizability of the findings. Also, they were only surveyed in Beirut and Mount Lebanon area. Hence, it led to a low variety in data collection, such as in educational levels. The low variety required merging categories as explained above in order to the statistical model to be successful. If the sample size was bigger, a higher chance of variability would exist and 3 categories would be taken into consideration and show more accurate comparison.

CHAPTER VI

SUGGESTIONS

The first research question was answered by the means of consumer surveys, and Lebanese adults turned out favoring white bread over brown bread. The findings of the consumer surveys coupled with bakeries and mills' interviews revealed the barriers and drivers to brown bread consumption, as well as potential intervention entry points within the food system to increase whole wheat bread consumption. Therefore, research question number two will be answered in this chapter. The main barriers reported were unfavorable taste and texture, high price, and low availability. Misconceptions about what constitutes whole wheat bread were also depicted. The predominant facilitators to brown bread consumption were its health benefits, its fiber content, good taste and its low calorie load. Interviewing millers and bakers gave an insight on the activities and processes related to whole bread before it reaches the consumer, clarifying some intervention targets. Additionally, the available literature exposes the important role of women in a family's nutrition practices and subsequently health outcomes, and the consumer questionnaire's analysis showed that females are likelier to give a correct/almost correct answer than males, or in other terms, whatever the odds of a male giving the correct/almost correct answer, it doubles for females. Therefore, women's knowledge about brown bread should be targeted and reinforced as a way of curbing NCDs.

Also, the knowledge gap showed that a special focus should be dedicated to men. They need to be convinced of brown bread's benefits, because household purchases in the Arab

countries are mostly dominated by men. Hence, is the woman wants to buy whole wheat bread, it is crucial that the man approves. A population based study in Australia, using self-completion surveys in 1456 adults, showed that men were less willing than women to attend health education sessions, were less interested in information on illness prevention, and were less willing to have an annual health check or to seek advice. The authors argue that targeted education is needed to encourage men to be engaged and to take more responsibility for their health (Deeks, 2009).

Hence, intervention entry points should revolve around: improving taste and texture, increasing awareness regarding whole wheat and whole grains' health benefits and the certainty of their outcome, and improve those products' accessibility and availability. Awareness could be done on multiple levels, such as education in schools, universities and providing workshops for parents and kitchen personnel with a special attention to women. Medias, internet and targeted marketing can also fit under the umbrella of awareness. Brown bread's presentation can be improved to attract more consumers, especially children. This includes its shape as a bread and how it is displayed in the points of sale. Governmental control is also mandatory to influence and control whole wheat bread's price and quality. Suggestions are listed below:

A. Improving taste and texture:

Taste was reported as the main obstacle to whole wheat bread consumption by 78.4% of the interviewed population, followed by texture by 34.1%. Appearance and taste of whole

wheat bread have been demonstrated to be important choice criteria for consumers (Burgess-Champoux, 2006). Research showed that products with higher aesthetic qualities create a better consumer experience (Alba, 2013). Also, consumers' expectations of a food product can influence enjoyment both before and during eating (Alba, 2013). Hence, in order to encourage consumption, brown bread's taste and texture should imperatively be improved.

Whole wheat flour produces dough with different characteristics when compared to refined dough. The causes have been reviewed in many papers (Doblado-Maldonado, 2012; Gan, 1989; Heiniö et al., 2016) and involved low loaf volume, hard texture, dark color and different flavors and aroma; which some may find unappealing. Those are the reasons listed by the interviewed consumers (Taste, texture) and bakers (lower bread volume, unattractive color and texture).

There's a need to improve whole wheat bread's sensory qualities to boost its attractiveness, and ultimately increase whole wheat bread intake amongst the Lebanese population and curb NCDs. As one interviewed bakery mentioned, and as listed in many papers, the inclusion of various ingredients to the dough can improve brown bread's properties. They're most commonly called bread improvers. Enzymes, emulsifiers, hydrocolloids (substance forming a gel in the presence of water) and oxidants could be added (Tebben, 2018).

Because of the presence of the bran, brown bread production necessitates process modifications when compared to white bread (Tebben, 2018). The dough will have a higher resistance to extension, because of the bran's inextensible physical properties (Altinel, 2017a) giving the loaf a harder and firmer texture with a lower final volume. Softer breads

like white bread achieve higher scores of overall acceptability (Armero & Collar, 1996). As for taste, consumer acceptability of whole wheat foods is challenged by negative flavor attributes because of bitter compounds (Bin, 2016).

Enzymes are the most commonly used bread improvers. Addition of α-amylase decreased the hardness of the bread after three days of storage, demonstrating its capacity in improving whole bread's shelf life (Matsushita et al., 2017). G4-amylase significantly expanded the volume of loaves to up to 1.2 times (Tebben, 2018). G4-amylase increases polymer fermentation into simple sugars. Yeast metabolizes these simple sugars and increases $C0_2$ emission leading to a leavened bread. Hence, the addition of G4-amylaze will boost yeast activity and bread volume. Cellulase and glucose oxidase will decrease the firmness of the dough, sometimes to a level similar to the white dough (Altinel, 2017b). As for the taste, the compounds such as Ferulic acid (Moskowitz, 2012)- responsible for the bitterness of brown bread have been identified, but further research is needed to suppress their action (Bin, 2012).

B. Increase awareness:

Nutrition knowledge has a profound influence on food choices and, concomitantly, nutrient intake (Dallongeville, J, 2001). Individuals' awareness or assumptions about food are key determinants of food choices (Furst, 1996). A significant link between dietary choices and aggregate health information has been found in several studies. For example, increases in the information related to the link between cholesterol consumption and heart disease had a significant negative effect on egg, pork, butter and lard consumption (Brown, 1990; Capps, 1991; Chern, 1995). Additionally, as the government built up campaigns informing on the

links between fat intake and health, consumption of fats and oils decreased (Ippolito, 1995). Purchases further decreased when food producers joined the campaigns. Those results can show promising outcomes if whole grains and whole wheat knowledge incentives and awareness campaigns are put in place, especially that the primary reason for consuming them was their health benefits; as listed in the results' section. Additionally, 97% of the white bread consumers' sample was willing to consume brown bread if its benefits are explained to them. Therefore, spreading whole wheat's advantages might greatly stimulate demand.

Whole grains/wheat awareness can be achieved through several methods such as education, media, and marketing. A systematic review by Suthers et al in 2018 identified the characteristics of successful public health interventions aimed at increasing whole grains consumption in many settings; including the use of social media/internet and education.

1. ***Education:***

Successful educational interventions of the review cited above encompass curriculum modifications to extend the whole grains knowledge base, menu planning and opportunities to taste whole products, while involving family members, food personnel and people who are responsible for providing food (Burgess-Champoux, 2008; Cohen, 2014). Embodying notions about whole wheat and whole grains' benefits in schools and universities is of great benefit, as lifelong eating habits may be instilled in young learners (Suthers, 2018). Behavioral patterns acquired as children, adolescents and university students are likely to determine long-term behaviors as adults (Neumark-Sztainer, 1999). Additionally, young children learning about the benefits of brown bread might come back home requesting to

eat more whole bread and grains. Flyers, chapters or projects on nutrition can be offered in schools and universities, as part of the science program or as an elective course. They could emphasize the huge contribution of bread to our daily diet, hence, substituting white bread for whole wheat bread is a crucial component of a healthy diet and a great way to combat NCDs. Those should be tailored to target all interests and university majors. As an example, a multi component school based pilot intervention was designed to increase consumption of whole grains by 4th and 5th grade children in the US (Burgess-Champoux, 2008) through a five-lesson classroom in addition to school cafeteria menu modifications and family oriented activities. It targeted whole grains knowledge and awareness in addition to products' availability in (cafeteria) and outside (home) the school. The lessons were added on a weekly basis to the standard school curriculum. They intended to improve the students' ability to identify whole grain foods. The class also included practical experiences that emphasized selecting, tasting and preparing whole-grain foods, build menu-planning skills. The outcomes were suggestive of positive changes in the consumption and identification of whole grains products. Parents' enabling behaviors were improved, and their intake of refined grains decreased. Those results show the positive impact and the importance of adopting a multi component intervention.

Also, if whole grains were introduced at an earlier age, and always available at home, they will be much more tolerated. In fact, a study assessing adolescents' perceptions about the factors that influence their food choices has listed the importance of their parents in teaching them what a healthful diet is (Neumark-Sztainer, 1999).

Parents surely influence what their children eat and how they perceive food. Workshops about healthy eating, or trainings for the parents can be executed at their children's school

or university. It could help modify their existing dietary behaviors; while emphasizing on the importance of whole wheat bread consumption for the whole family. After all, a person's choices will depend on the decisions of those surrounding them, and will follow the social norms around them (Metabolic consulting, 2016). For example, the same multi-component school based pilot intervention mentioned above by Burgess-Champoux in 2008 also included family oriented activities. This particular part of the intervention aimed to increase the availability of whole grains in the home environment. It also encouraged parental role modelling for consuming wholegrain foods while promoting clarifications and interactions between parents and children regarding the inclusion of whole-grain foods within the context of a healthy diet.

Studies have showed that efforts made to increase consumption of whole grain foods through knowledge alone had limited success (Walls, 2009) because people are influenced by various biases and factors in their environment when making decisions. Hence, education alone may not lead to significant sustained behavioral changes (Burgess-Champoux, 2006); highlighting the importance of intervening in the whole food system.

The certainty of impact of adopting a product is another important aspect of influencing behavior (Marian, 2014). Hence, when a population is better informed on a food product's protective effects, it is most likely to change its purchasing behavior when they're certain this food will have a beneficial impact on them. Bread is mostly purchased routinely; consumers buy it out of habit and do not consider it as much (STÁVKOVÁ, J. and TURČÍNKOVÁ, J. 2005). Effectively motivating consumers to change their habitual purchasing practices relies on their ability to recognize that this change will have a genuine

impact and a clear outcome (Vittersø & Tangeland, 2015). Therefore, education and awareness are very important components to stimulate consumer attentiveness and make them actively seek healthful products; until it becomes a habit. The findings also suggest that 6.8% listed "don't know brown bread's health benefits" as a reason for not consuming it. It is useful to consider that this percentage might be underestimated; because of the interviewee's fear of judgement and preference not to show ignorance.

Educational awareness should also be targeted towards the national FBDGs. In the US, it has been found that after the release of the US Dietary Guidelines in 2005 offering quantitative recommendations for whole grains consumption, in addition to related media attention, availability and sales of whole foods have increased (Mancino, 2008). Consumer demand also escalated by 13% more than the previous two months preceding the release of the Dietary Guidelines. Furthermore, a 2006 survey showed that 73% of Americans were trying to consume more whole grains after the release of the recommendations (International Food Information Council Foundation, 2006). Those numbers show the effect of FBDGs at a national level, and their potential influence on consumption patterns. Awareness of healthy eating and favoring whole products especially bread can be done via the FBDGs, by saying that the local guidelines are propagating their daily consumption and hence, it is important to follow those recommendations for a healthy lifestyle. Or, awareness regarding whole grains can be backed up by their presence in the FBDGs, validating and proving their beneficial outcome.

Food-based dietary guidelines are often developed at a national level to assist in bringing dietary intakes closer to nutrient intake goals and, ultimately, to prevent nutrition-related

diseases (Schönfeldt, 2013). In 2013, Lebanon launched its localized dietary guidelines manual at a conference presented by the American University of Beirut's Department of Nutrition and Food Sciences, more specifically by Dr. Nahla Hwalla. The guidelines emphasized on the importance of whole grains and provided practical examples of how to consume them as Lebanese adults. Awareness regarding our FBDGs; their existence and usage is crucial. Further research can assess food manufacturers and the Lebanese population's knowledge regarding FBDGs and how to follow them. Also, modifications can be made such as a tailored version for kids, which can be included in their school curriculum while taking into account the sustainability aspect of our dietary patterns.

2. ***Definition and clear labeling:***

Most importantly, whole grains and whole wheat definitions should be set and explained to the public while raising awareness about their health outcomes. As mentioned in the previous chapters, the lack of a single, consistent whole grains definition is affecting research, intake assessments and overall consumption. Additionally, this thesis' findings showed that even after explaining what brown bread is, consumers still couldn't identify it properly, and associated it with other labels such as Bran bread and Multi-cereals bread. The public should know what can be considered as a whole product and what shouldn't. Recognizing the many ways whole grain foods are labeled may be challenging for consumers and may be a barrier to consumption (Slavin et al., 2000; Kantor et al., 2001).

The whole grain stamp of the Whole Grains Council in the US is an effective search tool to identify authentic whole grains products. Making it easy to spot whole foods will render the process effortless. Stamps can be tailored depending on the whole grain content of the food

product to increase product identification. For example, the Whole Grains Council stamp has the different varieties: 100% means all the grain ingredients are whole grains; with a minimum requirement of 16g –a full serving- of whole grains per labelled serving, 50% means half of it is whole and one serving contains a minimum of 8g of whole grains, and the basic stamp is for the products that contain a significant amount of whole grain, but which contain primarily refined grains.

However, definitions and labeling are different across the EU. As mentioned in the earlier chapters, there is no universal definition of whole grain foods. There is no legislation regarding labelling of whole grains at the EU level. For instance, in Denmark and Sweden, a product is required to consist of at least 50% of dry matter from whole grain ingredients to be characterized as whole grain food (Fodevareinstituttet, 2008). In the Netherlands, 100% of the flour must be whole for breads to be labelled as 100% whole grain (EFSA, 2010). In Germany, whole grain bread must be at least 90% whole grain (BMEL, 1993). In the US and UK, whole grain foods must contain ≥51% whole grain ingredients by weight (FDA, 2001). Lebanon should either follow one of those definitions, or set a certain whole grains level threshold and adjust the stamps accordingly. It is worth mentioning that; in order for those stamps to be successful and credible, the Lebanese consumer has to have a certain level of trust towards their bakers and government in order to boost compliance.

3. ***Change misconceptions while encouraging consumption:***

Both consumers and Millers/Bakers surveys showed that whole bread misconceptions revolve around its utility and healthy outcome, its calorie level, and its unreliable content. Some participants mentioned orally that they won't pay extra for brown bread because it's

the same as white bread, with no added nutritional value. Others, including bakers and millers, said that they don't trust the bread they're offered because of fraud; inauthentic whole wheat bread mixes and even additives such as food coloring or frying the grains to give them a darker color. Awareness on healthful outcomes of whole grains and the necessity to replace refined bread can help, coupled with clear labelling. Marketing strategies could also assist, and will be discussed further in this chapter.

The most important wrong idea to be adjusted is that whole bread contains less calories than refined bread. It is coming either from defective and imprecise notions of peers or health professionals, or faulty media campaigns. It is crucial for health professionals and especially dieticians to first, recommend/require whole grains consumption; as 17.7% of the interviewees listed their doctor and/or dietician as a reason for consuming brown bread, and 3% mentioned social media. Second, while advocating for whole grains, the certainty of their benefits should be clearly explained so that the consumer knows that this product is a step further towards heathier food choices and NCDs prevention, and not for the sole purpose of losing weight. Seeing trustworthy people encouraging whole products consumption can greatly reinforce consumption.

4. ***Train the personnel:***

In this paragraph, what is meant by personnel is restaurant waiters and the foodservice department at bakeries and school/university cafeterias.

Waiters can convince consumers to switch to whole grain meals or whole wheat bread by pointing out their health benefits. Bakery staff can advise customers to purchase brown breads instead of their refined counterparts while also explaining their hearty outcomes.

Clarifications can be made in school and university cafeterias while serving all their products with brown bread instead of white bread; and try to make it a mandatory choice. In addition to spreading awareness, training the food service personnel is key to introducing whole grain products into school cafeterias (Ujszaszy. 2004). The choices they offer and the way the meals are prepared, in addition to the ingredients and recipes used can greatly influence the nutritional intake of their consumers. For example, Ellison et al. (1989) targeted the foodservice departments in two boarding schools; demonstrating that changes in food purchasing and preparation practices by the schools' food service departments markedly decreased sodium and modified fat content of foods. It resulted in significant changes in the nutrient intake of students. Even without an educational component directed at students who maintained their usual dietary practices, changes of the foodservice 's practices led to a 15% to 20% decrease in sodium intake and a 20% decrease in saturated fat intake.

5. ***Health campaigns/Media campaigns:***

One technique to change dietary behaviors is to conduct communication campaigns. Communication campaigns are communication activities, directed at a particular population for a particular period of time, to achieve a particular goal (Snyder LB, 2001). Health communication campaigns seek to promote healthy behaviors and to build healthy communities (Campbell, 2011). They have already been used to address many health related behaviors, such as alcohol and tobacco use, poor diet, physical activity, breastfeeding and so on. A campaign can use different communication activities such as

posters, handouts, announcements, discussion groups, all forms of media, etc. (Snyder, 2007).

The findings showed that the main reason for choosing brown bread is its health related benefits. Hence, it is necessary to effectively communicate the importance of whole grains and whole wheat bread consumption in Lebanon, especially since the main source of carbohydrates is bread; as mentioned in the literature review.

The mainstream media nowadays (television, radio, banners, internet and social media) are effective tools to reach large audiences and can play a key role in providing those who can access them with health related information as well as advice on individual behavior change tips and strategies (Campbell, 2011). Developing nutrition messages for whole grains benefits and the importance of refined grains substitution should be assisted by governmental entities, or/and the private sector and health professionals. They should also be tailored to reach the whole population and not just targeted groups, as campaigns dedicated for children differ from those dedicated to adults, or to women for example.

Past campaigns, such as those addressing fruits and vegetable intake and cancer (for example, the 5 a day campaign) have demonstrated that consumers are responsive to positive diet and health messages that are clear, actionable and sustained (Havas, 1998). Additionally, the systematic review by Suthers in 2018 examining the key characteristics of successful public health interventions aimed at increasing whole grains intake mentioned the use of social media and the internet as a successful intervention tool. For instance, J. Arts in 2016 conducted a nutrition intervention to increase whole grains consumption in college students while relating it to coronary heart disease. The exploratory aim was to

evaluate the impact of text messaging over a period of 6 weeks while displaying whole grains messages in campus dining halls. As a result, the overall consumption of whole grains increased over time (Arts, 2016).

A day can be chosen to celebrate "Whole Grains Day", just as there's a date attributed to "Eat more fruits and vegetables a day". All nutritional public health campaigns could focus on whole grains benefits this day to encourage consumption. Bakeries and mills can open their doors for visitors or students to take a look at how brown flour/bread is produced and participate in the process. Also, different whole grains recipes can be shared as well as free samples.

Foodies could also contribute to the media campaigns. They are commonly defined as hobbyists with a keen interest in the sourcing, preparation, presentation, consumption and discussion of food on the internet and social media platforms. Globally, people are spending more time reading about food online (46%) than in print (31%) and 40% learn about food from websites, apps or blogs (Maxwell, 2014). Hence, the content posted by the foodies has a potential impact on the food our food choices. Through their posts and inputs, foodies can spread awareness by addressing the health effects of whole grains consumption, as well as methods of preparation and incorporation in our daily diet. They can also celebrate the "Whole grains day" just as they celebrate, for example, chocolate day on their social media platforms.

Also, as discussed previously, women play a key role in a family's nutritional wellbeing. Therefore, they should be fundamentally taken into consideration in the mentioned suggestions. In fact, a study assessing the bread consumption habits among the people of

Riyadh revealed that bread eating habits relate to the mothers because they are responsible for preparing meals (Aljobair, 2017); highlighting their important position in impacting and changing bread preferences and consumption. Awareness campaigns as well as media advertisement and marketing can be tailored to grasp women's attention. Family oriented interventions and workshops can identify women's crucial role in society's food consumption patterns and allocating food resources. This sample's results showed that females are twice as likely to fall into the correct/almost correct category of the knowledge about whole wheat bread's definition. This knowledge should be developed, reinforced and stressed upon in order to alleviate NCD rates. Women's role should be considered as a key pathway by which to achieve impact.

C. Product availability and accessibility:

1. Small stores purchases:

Bakers mentioned during their interviews that smaller bakeries and small stores do not purchase enough; or do not purchase at all, brown bread to sell in their own markets. Subsequently, 8% of the surveyed consumer sample mentioned not consuming whole bread because it's not available in stores around them. An increased availability could boost consumption, however, it has to be coupled with increased awareness and demand, in addition to improved brown bread shelf life. If around the corner small stores purchased brown bread from big bakeries, but the neighborhood consumers didn't buy it, this would lead to profit losses and increased food waste. Deals could be made between the big

bakeries and smaller stores to sell brown bread at the same price as white bread in order to stimulate this product's availability around the country.

2. ***School and university cafeterias:***

As mentioned previously, the food environment can exert a strong influence on people's food decisions. In order to facilitate students to make healthier food choices and to develop healthy eating habits, it is important that school and university's food environment is healthy. Encouraging whole grains consumption in schools and universities will help prevent the onset of long term nutritional diseases. The inclusion of whole wheat bread; or even the substitution of all refined breads with brown breads in cafeterias can substantially increase effortlessly the intake of young adults and children of whole foods. However, foodservices need to carefully explore innovative methods to successfully incorporate such products in their daily menus. Those include recipe development, sensory testing, cost calculations etc.… An interesting research (Delk, 2007) examined different thresholds to whole wheat adjustments to improve children's liking of whole wheat bread rolls. Whole wheat content of the rolls was gradually increased and a series of concentrations was established so it can remain undetected by their consumers. Those thresholds can be applied in Lebanese schools and university cafeterias; as the author mentioned that they can be used by any foodservice manufacturer that wants to gradually increase the whole wheat content of bread or related products and keep that increase undetected by consumers. This can be included in the trainings mentioned above.

3. Restaurants:

Restaurant menus in Lebanon do not always offer brown bread or whole grains choices, and if they do, it's mostly limited to the "light menu section". Sometimes, substitution between white and refined buns and sandwiches is possible, but unfortunately for a higher price. Sometimes the consumer has to pay up to an additional dollar or two on average to substitute his white baguette to a whole wheat baguette. Hence, if a consumer is not very determined to pick a meal from the light section, or to pay more money in order to replace refined grains, then this is a major barrier to whole wheat consumption. Decreased availability, variety and accessibility can hugely negatively impact consumption.

4. Product variety:

Consumers represent a major demand source for variety, because each individual has different quality valuations, tastes or budget constraints. Hence, offering a wide range of products can satisfy a wider range of consumers. For example, bakers mentioned in their open ended questions that some consumers only like to purchase toast bread, or only French baguette and so on. Therefore, these products should also be available in whole wheat version to encourage substitution and increased consumption.

D. Marketing:

1. Store displays:

The retail environment is carefully crafted to encourage sales of specific products, and this can influence consumers' buying decisions. Whole wheat products should be displayed at eye level shelves to be seen directly and encourage buying behavior by an additional 35% (Ebster, 2015). Additionally, bakeries can set up attractive stands labeled as "the healthy

corner" or "healthy stand" and so on to catch consumers' eyes and direct them towards whole wheat breads and easily influence the consumer behavior cycle mentioned in the previous chapter. This step would decrease the processing time by making those customers directly and unconsciously associating brown bread to health. It will also modify their perception of brown bread on the spot by unconsciously associating whole wheat bread to heath. Also, as mentioned in the consumer behavioral cycle previously, such banners and stands are likely to attract consumers, as they are displaying positive and easily understandable messages. Those messages should also be translated into Arabic to reach all consumers.

2. ***Appealing environment:***

Bakers also mentioned that displaying and especially baking brown bread in an appealing environment would boost sales through increased demand. Baking it in an open oven in front of consumers would firstly provoke their attention and curiosity, then stimulate olfaction, their sense of smell. This could influence their decision making progress towards choosing this freshly baked appetizing brown bread instead of its refined counterpart.

3. ***Shaping:***

This section is mainly targeted towards attracting children into choosing whole bread, as interventions at young ages can determine future adults' healthy eating behaviors. In general, the visual appearance and shape of food is a very important factor in eating behavior (Wadher, 2014). Shape may provide more fun, pleasure and excitement in the choice. For example, a study assessed the effect of the visual appeal of fruits on their consumption levels by four to seven years old children. Displaying fruits with flagged

cocktail sticks increased their visual appearance as compared to regular fruits on a regular plate. Results showed that children ate twice as much of the visually appealing fruits as opposed to the regular fruit mix (Jansen, 2010). Also, another study examined whether the shape of bread rolls can stimulate consumption of whole wheat bread when children have the choice between whole and white bread rolls (van Kleef, 2014). The first outcome was that whole wheat bread rolls consumption increased when the rolls had a fun shape, and the second outcome was that consumption of brown rolls was higher than refined rolls in the condition in which these bread brown rolls had a fun shape, but white rolls didn't. This can be applied in Lebanese bakeries who could innovate and reformulate their brown bread products to attract more consumers; as adults are also attracted to fun shaped products. Additionally, an experiment suggested that children are more willing to try more pieces of a healthy food if a favored character is promoting that food (Kotler, 2012). Hence, bakeries can modify their brown bread's packaging to feature a well-known character such as a super hero to attract young consumers.

4. ***Tasting opportunities:***

During their interviews, bakers mentioned tasting samples as a way to increase brown bread consumption. It can help change sensory misconceptions and shift judgments about brown bread's taste. Tasting opportunities can come through free samples offers, and/or through in-stores tasting samples.

As mentioned in the previous chapters, consumers' eating habits and choices are widely influenced by their social circle. If a consumer; who has never tasted brown bread because of his entourage's negative sensory perceptions, tries a small, free whole wheat sample

(cheese can also be offered to improve the tasting experience), he might change his opinion about brown bread. Tasting samples can also eliminate the fear of spending money on an unknown, unexplored product that the consumer might not appreciate. Furthermore, in-store free samples presented at the point of purchase have an even greater impact on purchasing behavior. For example, studies have shown that nearly 70% of shoppers will try an in-store sample if approached (Jones 2001), and most in-store sample promotions yield a 500% or more sales boost for the product on the day of the promotion (Lindstedt 1999). As a result, free samples have been shown to boost sales on the day of the promotion anywhere from 37-50% (Jones 2001).

E. Governmental control:

1. Bread quality-Germ presence:

All interviewed mills mentioned that some Lebanese bakeries serve unauthentic brown bread labeled "whole wheat bread" after using poor quality premixes, food coloring or frying the grains. This information was also acknowledged by some of the interviewed bakers. They also highlighted the immediate need for governmental examinations and testing to depict fraud and guarantee high quality nutritional products for the Lebanese consumers. Millers indicated that the government tests the wheat, but only through microbiological screenings. An effective way, as suggested by the millers and bakers, is to test for the germ presence in the final whole flour or whole bread products. The absence of the germ can signal the use of inadequate premixes and colored/fried white grains.

2. ***Clear labelling:***

With the rise of NCDs associated with poor eating habits and practices, people should carefully read the nutritional information listed on the food packages. Their primary role is informing consumers of the food's nutritional values and ingredients, its manufacturer, health claims and possible allergens in a clear and understandable way in order to make better-informed dietary choices. The nutritional profile as well as the facts listed on the packaging should be neither false nor misleading. As mentioned earlier, labelling is an effective tool to help consumers identify whole wheat and whole grains products, which is why it has to be well regulated. Manufacturers should follow a clear definition of whole-wheat products, and should not list products made from poor premixes or not from whole kernels as whole-wheat products. Currently, the ministry of economy and trade with Libnor have regulations on products labeling, such as the country of origin, production and expiry dates, ingredients and so on (Lebanese ministry of economy and trade website, accessed on 20/11/18). Hence, an increased control over labeling can prevent ingredient fraud.

What could also be interesting is mentioning the sugar content on the package. Whole wheat bread's recipe should not contain sugar (Bakers, personal interview), contrary to white bread. Therefore, mentioning the sugar content on white bread's package could decrease consumption frequency, because nutrition label use may therefore lead to healthier food purchases (Mhurchu, 2018).

3. ***Subsidies:***

Subsidies could be granted for bakers to boost brown bread production at a decreased price, for example by subsidizing bread improvers and production equipment. Subsidies could be

also granted for millers in order to afford traditional machineries to produce whole wheat flour with minimal nutritional losses.

The Government of Lebanon currently subsidizes both the production of domestic wheat and the consumption of Arabic bread. The information listed in this paragraph are extracted from the latest "Lebanese Ministry of finance report on the wheat and bread subsidies policies report 2007-2011" on page 3. These two intertwined policies are implemented through the Directorate General of Cereals and Beetroot (DGCB).

When subsidizing domestic wheat, the DGCB purchases it from Lebanese farmers at guaranteed fixed prices, and then sells it at international market prices; which can vary. If the international market prices are lower than the guaranteed price of purchase from the Lebanese farmers, the DGCB will have losses which will be covered by the subsidies allocated in the National Budget for this purpose.

However, Lebanese grown wheat is not suitable for Lebanese bread production as mentioned earlier.

When subsidizing bread so it can be sold at a stable price, the DGCB imports wheat suitable for Lebanese bread production at international prices (which can vary), and sells it to the mills at subsidized prices. The solution that could be suggested is that the government can subsidize the imported whole grains, and not subsidize the imported refined grains in order to encourage the production of brown flour over white flour. However, all mills mentioned sourcing the whole kernels, and then milling them into either refined or whole flour. Hence, subsidizing the imported grain itself does not guarantee that the resulting flour and bread will be brown.

In addition, while interviewing the main actors of the bread supply chain, it was noted that the bakeries affect the final bread price more than millers do. The subsidy mentioned above will benefit millers who will buy the grain at a stable subsidized price.

What the government could do is to also cover the costs of whole wheat bread production at the bakery level in order to sell brown and refined bread at equal prices. Therefore, brown bread sales have a chance of expanding. Growing sales and demand could cover the extra costs of brown bread production. Revenues will increase, thus, the causes behind brown bread's higher price can be gradually eliminated (replace manual labor with machineries, increased demand will allow purchasing in bulk…) and then the government could lift the subsidy program.

On the other hand, the government could increase whole flour subsidies in order to boost its purchases by the bakeries.

Another suggestion is subsidizing new traditional-like equipment for mills, and subsidize machineries or as commonly called "lines" for bakeries to produce brown bread. Traditional milling machineries will produce authentic whole flour; avoiding nutritional losses and fraud. Traditional milling stones can cost for example 20 000 USD, and the price increases with the size, production capacity and if it is automatic or manually operated. However, production speed would dramatically decrease. One interviewed mill mentioned generating up to 200 tons of flour/day using advanced modern machineries, but only 50tons/day using traditional machineries. This drop in production might not be accepted by all the companies. Then, in the bakeries, automatic machineries will replace manual brown bread production; decreasing the costs. One interviewed bakery purchased a new separate line to increase brown bread availability and decrease its price. Baking lines can vary from

10 000 to 80 000USD and more, depending on the size and production capacity. Usually, whole products cost 20% more than their refined counterparts (Bakers, personal interviews). The new machinery allowed this bakery to drop this value to 10% instead of 20%. Unfortunately, sales did not improve much, because the demand remained low.

In addition to machinery improvements, the government could also finance bread improvers. During the interview, one mill mentioned training its associated bakeries on how to improve the sensory qualities of bread through enzymes. However, the trainings were infrequent because of the costs and limited budget. Hence, subsidizing bread improvers can also contribute to eliminate the two main barriers to brown bread consumption; taste and texture. The mill preferred not to mention the overall costs of the bread improvers, however, some online websites sell 1kg for around 100$. Amylases' recommended level is from 0.002-0.006% of flour weight (Smith, 2003). Cost calculations can be made depending on each bakery's recipes and production frequency.

CHAPTER VII

CONCLUSION

The previous chapters emphasized the role of the whole food system in influencing consumer decisions, and how consumer behavior can feedback on the food system's components. As such, individuals have an important impact on the food system through their food market demands, and they can also determine what food will be produced and by which methods. Shopping decisions appeared to be highly influenced by the context and environments in which they happen. Current food environments are favoring unhealthy choices; leading to rises in NCDs. If the influences of these environments are better understood, approaches that modify them, such as increasing the consumption of functional foods like whole grains, would have better potential to assist in the prevention of those multifactorial nutritional diseases. Changing behavior in any context is a challenge, especially dietary behavior, and attempting to change behavior in an environment that reinforces contrary unhealthy practices is quite difficult. That's why a combination of cross cutting strategies is the best option to create long-term dietary changes, and to accompany awareness and behavioral interventions with changes in the underlying structures and conditions that determine them. Hence, interventions on a consumer level should be applied synergistically with strategies addressing other parts of the food system. With reference to the consumer behavioral cycle, strategies that influence food choices' processing and adoption must be combined with strategies that enable and stabilize behavior. For example, spreading awareness on the benefits of whole wheat bread and/or whole grains with their

health outcomes is unhelpful without focusing on those product's availability and accessibility. If a consumer has the proper nutritional knowledge, but can't locate, identify or afford nutritional products, then awareness interventions lead nowhere; deepening the behavioral gap.

Given the significant contribution of bread to overall cereal intake in Lebanon, hence, whole bread's capacity to prevent and decrease NCDs, this thesis targeted Lebanese adult wheat bread consumers, as well as the actors involved in its production and distribution; mills and bakeries.

Results of a sample of 150 Lebanese adults showed that they favored white bread over whole wheat bread. Whole wheat bread was confused mostly with multi-cereal bread, bread with fibers and bran bread. The main barriers for consumption were the taste, the texture and the price, whereas the leading drivers were the health benefits of brown bread in addition to its fiber content and its taste. Millers and bakers also expressed their views on the production process of brown bread, its price difference, sales and distribution. Their insights gave a background idea on Lebanese bread's food system before reaching the consumer in order to suggest cross cutting intervention entry points for increasing whole wheat bread consumption and curb NCDs.

APPENDIX I

CONSUMER SURVEY, ARABIC

قبل البدء ، سأشرح لك ما معنى التعبير "الخبز الأبيض" و "الخبز الأسمر" المستخدم في هذا الاستبيان بالضبط

1) الجنس

1.1 أنثى **1.2** ذكر **1.3** افضل عدم الإجابة

2) اعلى درجة محققة في الدراسة

2.1 مدرسة ابتدائية

2.2 المدرسة الثانوية

2.3 الجامعة (البكالوريا ، ماجستير ..) أو المدرسة الفنية

2.4 غير_____

2.5 افضل عدم الإجابة

3) أي نوع خبز تستهلك وكم الكمية ؟

3.1_____:**3.2** الكمية/اليوم

_____:النوع

4) برأيك ، أي من هذه المنتجات يعتبر خبزًا أسمر؟ ***(عدة إجابات ممكنة)***

خبز نخاله خبز متعدد الحبوب خبز شوفان خبز طحين كامل بز أمحة كاملة

خبز تنور خبز مع ألياف خبز طحين خبز من الحبوب خبز طحين 100%

5) هل تفضل أخبز الأبيض، أو الأسمر، أو غير نوع

5.1 أبيض **يرجى الإجابة عل سؤال رقم 5.a**

5.2 أسمر **يرجى الإجابة عل سؤال رقم 5.b**

5.a) *(عدة إجابات ممكنة)* ما هي الأسباب لعدم استهلاكك الخبز الأسمر

لا أحب الطعمة	الخبز الأسمر غير متوفر في المتاجر	لا يمكنني تمييز الخبز الأسمر	لا أعرف فوائده الصحية	السعر	لا أحب تركيبته	غير

5.b) *(عدة إجابات ممكنة)* ما هي أسباب استهلاكك الخبز الأسمر

أحب الطعمة	وسائل الاعلام الاجتماعية	الحكيم أو اخصائية التغذية نصحتني بالخبز الأسمر	متوفر في المتاجر	قليل السعرات الحرارية	غني بالألياف	منع المرض	أحب تركيبته	غير

6) إذا كان سعر الخبز الأسمر أقل أو مساو للخبز الأبيض هل تستهلكه؟

6.1 **YES** 6.2 **NO**

7) إذا تحسن طعم الخبز الأسمر، هل تستهلكه؟

7.1 **YES** 7.2 **NO**

8) إذا شرح لك فوائد الصحية للخبز الأسمر هل تستهلكه؟

8.1 **YES** 8.2 **NO**

Any other questions or comments?

_____

_____

_____

Thank you!

Minerva Sadek

APPENDIX II

CONSUMER SURVEY, ENGLISH

Before starting, I will explain to you what the terms "white bread" and "brown bread" used in this questionnaire exactly mean.

1) **Sex:**

1.1 Female **1.2** Male **1.3** No response

2) **Highest attained degree:**

2.1 Elementary school

2.2 High school

2.3 University(Bachelor, Master's..) or technical school

2.4 Other: _____

2.5 Prefer not to answer

3) **What do you consume as bread and how much per day?**
3.1 Type of bread:_____**3.2** How much/day:_____

4) **In your opinion, which of those products are considered brown bread?***(Multiple answers possible)*

Whole grain bread Whole wheat bread Oat bread Multicereal bread
All bran bread 100% Wheat bread Cereal bread Wheat bread Added fibers bread Tannour bran

5) **Do you prefer white, brown, or other types of bread?**

5.1 White Please go **only** to question 5.a **and proceed**

5.2 Brown Please go **only** to question 5.b

5.3 Other: _____

5.a) In reference to your preferred bread type, what are the reasons for NOT consuming brown bread? *(Multiple answers possible)*

I don't like the Taste	I don't like the Texture	Price	I don't know its Health benefits	I am unable to identify brown bread products	Brown bread is not available in shops around me	Other :

5.b) In reference to your preferred bread type, what are the reasons for consuming brown bread? *(Multiple answers possible)*

I like the Taste	I like the Texture	Health benefits – disease prevention	Health benefits- Rich in fibers	Health benefits – Calorie difference	Brown bread is available in shops around me	My Doctor/ Dietician told me to consume brown bread	Internet/ Social media	Other :

6) If brown bread was at lower or equal price, would you consume it?

☐ 6.1 **YES** ☐ 6.2 **NO**

7) If brown bread's taste and texture were improved, would you consume it?

☐ 7.1 **YES** ☐ 7.2 **NO**

8) If all of brown bread's health benefits were explained to you, would you consume it?

☐ 8.1 **YES** ☐ 8.2 **NO**

APPENDIX III

BAKERS INTERVIEW, ENGLISH

Question Code	QUESTIONS	ANSWERS
B1	What is the source of the refined wheat (Lebanese mills or imported) sourced by the bakery?	1. LEBANESE 2. IMPORTED specify : _____
B2	What is the source of the whole wheat (Lebanese mills or imported) sourced by the bakery?	1. LEBANESE 2. IMPORTED specify: _____
B3	What is your purchase rate (in %) of white flour over whole flour?	RATE:
B4	What was the price of whole wheat per kilo / ton bought by the bakery over the past 30 days?	WW PRICE:
B5	What was the price of refined wheat per kilo / ton bought by the bakery over the past 30 days?	RW PRICE:
B6	Does your bakery produce whole grain products?	1. YES 2. NO
B6.a	If yes, which products?	

Open ended questions:

1. For how long has the bakery been producing whole grains products?
2. Are you trying to increase whole grains items' productivity and availability? If yes, how?
3. Has the sales volume of whole grains products sold by the bakery increased during the last 12 months? If yes, what do you think is the reason?
4. Has the sales values of whole grains products sold by the bakery increased during the last 12 months? If yes, why?
5. Is there a difference between the handling/baking process of refined grains products and the corresponding whole grains products?

6. Is there a difference in price between refined grains products and the corresponding whole grains products sold by the bakery? If yes, why?
   6. a. What is the average difference in price in %?
7. If the government required your bakery to sell whole grains products for the same price as refined products, how would the bakery be affected?
8. If you were fully aware of whole grains' benefits, are you willing to sell them at the same price, without any governmental requirement?
9. Some consumers complain that whole grain products have a bitter taste. Is this a complaint made by your customers?
10. Is there something that can be done by the bakery to reduce the bitter taste of whole grain products? If yes, what?

APPENDIX IV

MILLERS INTERVIEW, ENGLISH

Question Code	QUESTION	ANSWER
M1	What's the country of origin of the wheat used by this mill?	1. Lebanon 2. others : specify(if wanted) :
M2	Doe the mill source its wheat grains through a trading company? If yes, which one?	1. No 2. Yes Company(if wanted):
M3	What was the average price of whole grains per kilo / ton paid by the mill over the past 30 days? (for all flour types)	WG PRICE PAID:
M4	What was the average price of whole flour per kilo / ton sold by the mill over the past 30 days? (for Lebanese bread)	WF PRICE SOLD:
M5	What was the average price of refined flour per kilo / ton sold by the mill over the past 30 days? (for Lebanese bread)	RF PRICE SOLD:
M6	How much whole flour per kilo/ton did the mill produce over the past 30 days? (all flour types)	WF QUANTITY:
M7	How much refined flour per kilo/ton did the mill produce over the past 30 days? (all four types)	RF QUANTITY:
M8	Who are the mill's major purchasers of whole flour?(all flour types)	WF PURCHASERS:
M9	Who are the mill's major purchasers of refined flour?(all flour types)	RF PURCHASERS:

Open ended questions:

1. What can you tell me about the difference between refined flour and whole flour production (process, machinery, cost…?)

2. What can you tell me about the differences in flour prices when it comes to the protein content? And what are their different uses?

3. If bakeries and consumers started demanding whole flour products more than refined products, how would that affect you as a mill?

4. Why, in your opinion, are whole products more expensive than refined products on the market?

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