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To what extent does a high sugar diet affect obesity in China?

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Abstract. The aim of this dissertation is to provide an answer about to what extent does a high sugar diet affect obesity. The goal of answering this question is to find the substitution of sugar and the number of sugar intake that won't increase the risk of obesity. The dissertation will be separated into this part and uses the available literature to identify them. What is obesity and the impact of varying degrees of obesity on health. What is sugar and how sugar contribute to obesity. Comparing the amount of sugar in different substance and the limiting numbers of sugar intake to give advice about how many substances intake won't increase the risk of obesity. Exploring what is sweeteners and the potential hazard of them to determine whether the sweeteners is good substitution or not. Also, the article will find another factor affect obesity and explore the nature of them. Through this part, it is concluded that excess sugar intake increases the risk of obesity by convert glucose into fatty acid and the nature of the other factors that affect obesity is to stimulate people to take in more sugar. Meanwhile, sugar alcohol could be considered as the best sugar substitution and it is suitable for people to consume the amount of added sugar like white sugar which is lower than 36g. For fructose, it is suitable for people to consume lower than 50g.

Keywords: high sugar diet, obesity, diet in China

1. Introduction

Obesity is one of the major causes for reduced life expectancy [1]. Obesity is an abnormal or excessive fat accumulation that presents a risk to health. Over weigh can also poses a similar threat to health. The difference between them is the BMI of obesity is greater than 30 and overweight is greater than 25 but less than 30 [3]. According to WHO, globally population of obesity has nearly triple since 1975 [4]. As shown in the figure 1, the percentage of obesity in adult has been growing. Between 1975 to 2016, the percentage of obesity in adult increase from 4. 30% to 13. 20% [2].

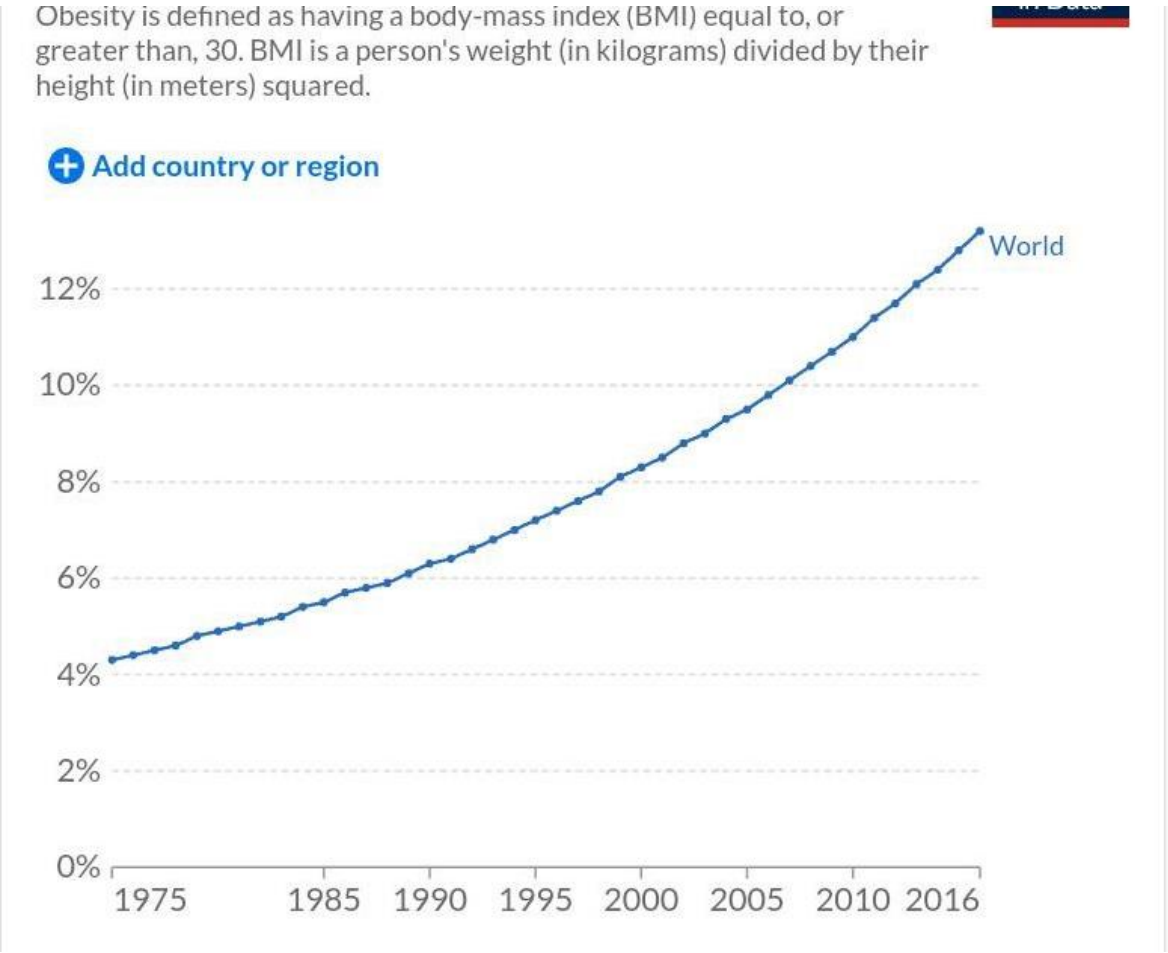

Figure 1. Share of adults that are obese, 1975-2016. Ritchie and Roser (2017) [2]

Meanwhile, more than 124 million of children and adolescents are obese. In percentage, 6% of girls and 8% of boys are classified as obese in 2016. After 5 years, the proportion of obese girls have increased to 8% and obese boys have increased to 10%. It is postulated that the population of obese children will increase to 14% and 17% in 2035 [5]. Thus, we need to put in effort to reduce obesity in the global population.

Obesity can also diminish almost every aspect of health. Statistics displayed that 62. 5% of people died from obesity-related conditions in 2019 [2]. Obesity can lead to chronic diseases such as diabetes, heart disease and high blood pressure. Moreover, obesity can also contribute to variance cancer e. g. Adenocarcinoma of the oesophagus, pancreas, and liver [8].

Sugars can play various functions especially as additive added to food to make it sweet and tasty [11]. However, too much sugar intake can contribute to obesity. Although there are a lot of factors contributing to obesity, high sugar consumption is one of the leading reasons (Chiadi, 2023). In that case, as we pay attention to International Sugar Organism. It said that sugar average consumption in the world had fallen to 21. 4Kg in 2021. It is down 0. 2 kg from the previous year and lower than the 2016 high of 23. 0 kg. One of the factors is inferring that alternative sweeteners have led to the reduced consumption of raw sugar [12] as sweeteners may have a potential to play a role in losing weight. Thus, this paper will attempt to investigate the impact of sugar in diet and how can it contribute to obesity.

2. Research review

2.1. Sugar

Sugar is a carbohydrate and has 2 main forms, simple and complex. Their chemical structure determines how these two sugars are digested and absorbed [18]. The simplest sugar are glucose, fructose, and galactose, which are also called monosaccharides. This sugar cannot be further hydrolysed. [27]. 2 monosaccharides can combine to form a disaccharide. Take sucrose as an example, it is a fructose and a glucose molecule. They are combined via glycosidic linkage and broken down via hydrolysis, with a water molecule as by- product.

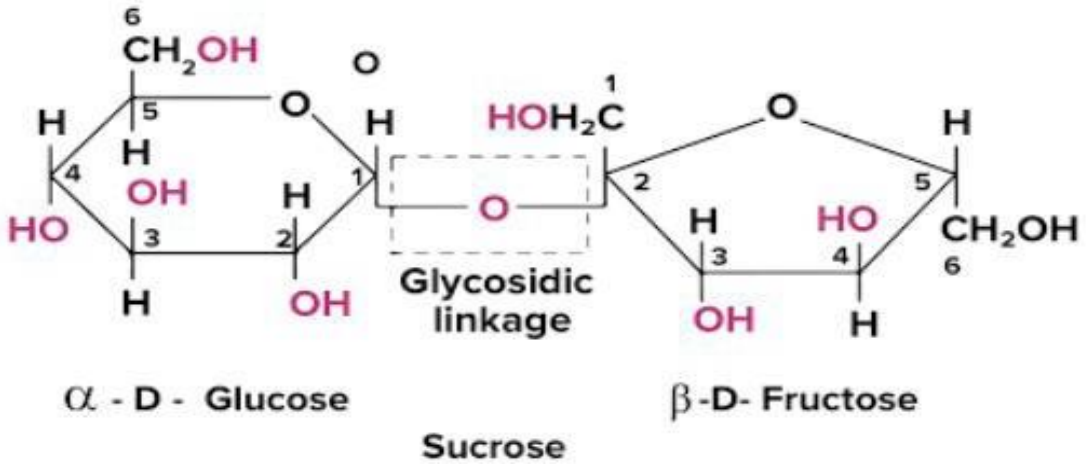

Figure 2. Structure of Sucrose Showing the Glycosidic Linkage Between α-D-Glucose and β-D-Fructose

Similarly, complex sugars like starch and glycogen are formed via glycosidic bonds. However, complex sugars are composed of chains of monosaccharide linked by glycosidic bonds, making it difficult to be absorbed and broken down.

Glucose is the major fuel for cells. The energy provided is called calories which is an amount of energy required to raise 1 kilogram(kg) of water by 1 C. It is known as a kilocalorie and its unit is Kcal. The energy needed depends on various factors such as activity climate and weight. The average allowance for men of reference size (77 kg) is 2, 300 kcal/day; for women, it is 1, 900 kcal/day. A normal variation of ±20% is accepted as for younger adults. [28].” Glucose is the number one food for the brain, and it's an extremely important source of fuel throughout the body," says Dr Kristina Rother, an NIH paediatrician and expert on sweeteners. [29]. The brain requires a large amount of glucose to meet with the high energy demand. This energy is used to maintain neuronal and non-neuronal cellular and produce neurotransmitters [30]. In terms of the body, glucose is the major fuel material of cells. When the amount of glucose is sufficient for cellular activities, the excess glucose can be converted into glycogen for storage or fat. [33]. In the adipocytes, glucose is converted to fatty acid by a complex mechanism with the help of many substances acetyl-Coenzyme A (acetyl-CoA). This reaction can take place in other cells for example in liver cells. It will be mainly triggered in the adipocytes when the net intake of calories exceeds the consumption of calories a lot. [31]).

Although mainly used to fuel cellular activity, sugar can have other implications on our body. For example, the activity of the hypothalamic-pituitary-adrenal (HPA) axis, which is related to stress management, has been shown to be reduced through the consumption of sugar-containing food [32]. In addition, consumption of sugar or high-sugar food is normally associated with happiness. Sugar contributes to happiness as the consumption initiates dopamine production, which is a neurotransmitter that acts on areas of the brain to induce feelings of pleasure, satisfaction and motivation [34]. However, according to an experiment using mice model, dopamine, which is produced from sugar can have similar action as an addictive drug. The experiment also revealed that in under specific conditions, the intermittent access to sugar can lead to behavioural change and neurochemical change, which is an effect of abused substance.

In daily consumption, both natural sugar and added sugar are easily accessible in our diet. Natural sugar is appeared in whole, unprocessed food such as fruits and vegetables. Added sugar is found from processed food and drinks [19]. In China, white granulated sugar, soft white sugar, brown sugar, corn syrup, glucose syrup is the most common added sugar in food processing industry [35]. Most of them are mixtures of simple sugar such as glucose, fructose and sucrose, which means the difference between them are the different proportions of simple sugar. Also, simple sugar like them can provide varies number of calories to human body. Glucose provides 3. 75Kcal/g during aerobic respiration in human body. Sucrose contains 3. 9Kcal/g and fructose contain 3. 68Kcal/g. The number of calories in different simple sugar is vary with a little figure. It shows that there may be slight differences in the amount of calories added to two different types of sugar. Take white sugar and brown sugar as an example,99. 5 percent of white sugar are sucrose and it contain 385 calories per 100g [20] while brown sugar contains at least 85% sucrose with 380 calories per 100g [21].

Sweeteners are developed to improve the flavour of processed food and drinks, mainly to increase the sweetness to appeal to consumers. In August 2020, component of 18 kinds of the most famous sugar-free drinks in China market are analysed. Additives involve ansemi, sucralose, aspartame, erythritol, xylitol, stevia glycoside, and cyclamate. These sugars are chemically synthesised or extracted via plants. Interestingly, all of them are 0 calories sweeteners. Among them, ansemi and sucralose are mostly used in the industry. [67]

The sweeteners which provide little to no calories work by binding specific receptor proteins to produce a chemical signal that something sweet was consumed without involving in digestion [36]. The sweeteners listed can be categorised into sugar alcohol, which contains a hydroxyl group on each carbon atom and artificial sweeteners.

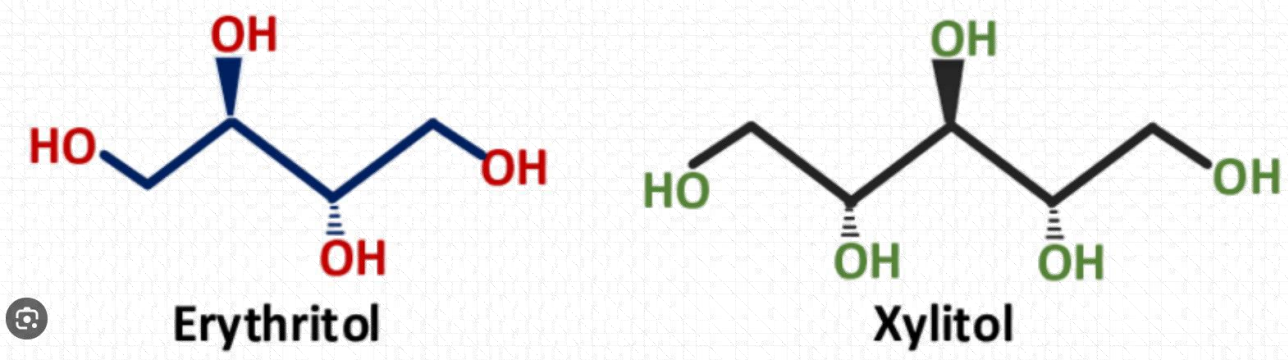

Figure 3. Chemical Structures of Erythritol and Xylitol (https://www. researchgate. net/figure/1-The-chemical-structures-of-erythritol-and- xylitol_fig5_320036965)

Take erythritol as an example, it can be absorbed by small intestine but will be eliminated from the body in the end. Although they can provide sweet taste and little number of calories, it is 60% to 80% as sweet as sugar (Cleveland Clinic, 2023).

Sweeteners synthesis chemically synthesised are called artificial sweetener. These sweeteners can be very sweet as compared to normal sugar. Sweetness of aspartame is 200 times sweeter than sugar and sucralose is 600 times sweeter than sugar [66]. Meanwhile, artificial sweeteners do not have a common structure like sugar alcohol. Sweeteners can have very distinct structures which contribute to varies ways to taste sweet but are not consumed by cells.

Take aspartame as an example, aspartame will participate in metabolism reaction in to form methanol and amino acids phenylalanine and aspartic acid. While this process will release calories, the calories can be negligible as they are very little. And some of them can't be absorbed by people like Sucralose. Glycosidic enzymes unable to distinguish and digest it. Therefore, most of them are excreted to the outside of the body through the gastrointestinal tract [50].

Nevertheless, sweeteners may not be as safe as it was presumed. Some studies claim that sweeteners play an opposite role in losing weight. According to research at University of California-San Diego, researcher found that sugar activated regions of the brain involved in food reward, while sucralose did not [66]. This conclusion reflects that sweeteners may strengthen the desire to consume sweet food or drinks. However, there is no evidence which support that sweeteners can increase appetite. In recent year, WHO has reported that aspartame can increase the probability of developing cancer, but the evidence is limited.

Therefore, they suggest that it is suitable for people to intake 40 mg/kg per day [3]. Another hazard of aspartame had been defined. As mentioned earlier, aspartame is involved in metabolism in human body to generate phenylalanine. Thus, aspartame is not suitable for phenylketonuria. Sugar alcohol is relative safer than artificial sweeteners. Taking erythritol as an example, it is listed as "Generally Recognized as Safe" foods by the FDA.

2.2. Obesity

Definition of obesity is mentioned earlier. The World Health Organization has defined it as abnormal or excessive fat accumulation that presents a risk to health. An easy way to determine if people has obesity or not is to calculate the Body mass index (BMI) [38]. A person is considered obese if the BMI is above 30. Besides BMI, the simplest way is to wrap a tape measure around your waist. For women, 35 inches or more is considered obsess. For men, it is 40 or more. Another method is to divide waist size by hip size. Waist-to-hip ratio higher than 0. 85 in women and 0. 90 in men indicates abdominal obesity (Cleveland Clinic 2023).

Fat accumulation is crucial to determine whether a person is obese or not. The main distributions of fat are subcutaneous and visceral where it is stored in the abdominal cavity around the organ. Some fat is stored in abnormal sites such as liver, pancreas, heart and muscle. Although they are around the organs, they are called ectopic fat instead of visceral fat. Not only these areas can accumulate fat, bone marrow, around joint and this can greatly impact quality of life. Meanwhile, the distribution of fat is influenced by gender and sex hormone. For male, fat is easy to accumulate at abdominal.

Due to the actions of testosterone, fat in man can be used effectively and consumed easily when testosterone level start to increase during puberty and then fall progressively after 20-30 years. This study concludes teenagers can lose weight easily and efficiently. For women, with the help of oestrogens, fat tend to accumulate at subcutaneous before menopause. After menopause, oestrogen level falls and fat distribution become similar to that seen in men.

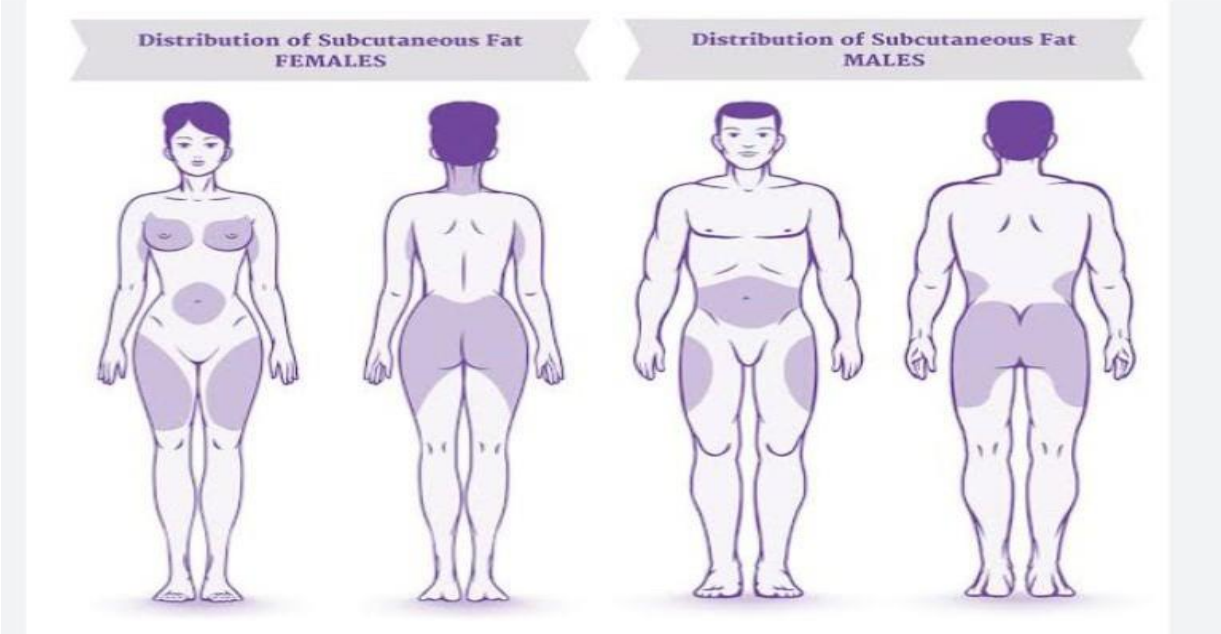

Figure 4. Distribution of subcutaneous fat (Taylor, M (2020) [17])

2.3. Relationship between sugar and obesity

In short, extra sugar in human body will be converted into fat, and accumulation of fat will cause obesity. A meta-analysis including 56 579 participants and 11 821 incident cases of obesity showed relationship between intake drink contained sugar and obesity is an inverse linear does-response relationship. Risk of obesity will increase by 12% when a person consumes 250ml of sugary drink per day [56]. Meanwhile, diet high in sugar also presented the same relationship. From 2004 to 2018, the total number of Chinese adults who are obesity increased to an estimated 85 million adults, which tripled compared to 2004 [24]. According to National Library of Medicine, a major change of diet in China, which is the increased consumption of vegetable oil, proceed food high in refined starch, sugar, salt, and unhealthy fat and the change of staple food could potentially be the reason behind increased prevalence of obesity. Since 1980s, consumption of sugar increase gradually with almost 2% every year. Most of them are used in sweets, carbonated drinks and sweetened drinks such as milk tea. Since 2004, the availability of high sugar food such as easy-prepped meals and bobas increase dramatically. Meanwhile, more processed food and instant food are available with the blooming of processed food industries had encouraged the consumers to eat unhealthy high sugar food to replace their staple.

3. Discussion / Development

3.1. Other factors affect obesity

3.1.1. Genetics

Genetics is a factor that can influence the risk of obesity. For example, a mutation of MC4R, which participates in regulation of food intake and homeostasis. When a gene mutation occurs, the patient often has high BMI, huge appetite, increased bone mineral density, and hyperinsulinemia [51]. However, this mutation is not commonly found in obese patients. An investigation with 899 participants had been recruited to investigate the prevalence of this mutation. It was only found that 22 persons had the mutation [52]. Thus, for most people with obesity, the reason why they are obese is that they do not have a healthy lifestyle and consume more food than needed.

To some extent, gender can influence obesity. In terms of biological factors, the most reliable reason is appetite difference between female and male. A survey shows that men tend to crave savoury food like fish and meat, whereas women tend to crave sweet like chocolate. In 2 studies with sample of college students and people who joined in a weight loss treatment program, women report a higher food craving in which they have a greater response when presented with palatable food images. However, an investigation produced by CDC shows that males consume an average of 178 kcal from sugar drinks on any given day, while females consume 103 kcal and mean consumption of sugar drinks is higher in males than females at all ages except among 2- to 5-year- olds [58]. Thus, it is difficult to evaluate the impact of gender in sugar intake.

3.1.2. Distribution of fat

Excess sugar intake can result in fat accumulation. Fat will mainly accumulate in the body in the form of subcutaneous and visceral fat. As mentioned earlier, BMI is one of the methods to identify obesity. However, BMI cannot provide a very comprehensive conclusion. For example, adults with higher body fat and lower muscle mass may be classified as normal, while lean individuals with higher muscle mass but lower body fat percentage may be classified as overweight. Therefore, it is essential to understand the accumulation of fat and how it can contribute to obesity.

Excess subcutaneous fat contributes to varying health problems. Take cardiometabolic risk as an example, excess fat accumulation will increase the risk of high blood pressure. The relationship is found by an investigation which had 2306 participants (mean age 60 years, 54. 4% women) which is when fat accumulates 50cm3, systolic blood pressure will increase 2. 16and0. 88mmHg [41]. Thus, when the fat accumulation is too high, the blood pressure might overtake normal and contribute to higher risk of health. During this investigation, it was found that the volume of subcutaneous fat in upper body will increase the BMI by 2. 65kg/m2 for every increase of 50cm3 of fat. However, this is not definite and cannot be apply without considering other factors in evaluating health.

Visceral fat is also the most common type of fat in human body. Excess accumulation of visceral fat contributes to health problem such as diabetes, heart disease and stroke. The number and distribution of visceral fat is mainly affected by gene. However, when connecting to sugar, different sugar can have a different impact on lipid metabolism. A clinical trial in 2012 has shown that fructose and sucrose can affect lipid metabolism, which results in a higher level of cholesterol and free fatty acid as compared to equal amount of glucose. This suggested that the choice of sugar can influence the metabolism.

3.1.3. Dietary sugar

There are many sources of carbohydrates or dietary sugar. Pastries, ice-creams and sweets are high sugar food which are easily accessible these days in developed cities. Naturally occurring sugar, sourced from fruit and vegetable can also added up to the daily sugar consumption. This section will discuss the sugar content of food and evaluate where excess sugar intake is mainly consumed. Calories will be used as a reference for comparison below.

According to American Heart Association, the limit of added-sugar per daily consumption is 6 teaspoons or 24g (equivalent to 100 calories) for women and 9 teaspoons or 36g equivalent to 150 calories for men [59]. However, there are a lot of food which are high in sugar, such as Chocolate, cakes, biscuits, carbonated drinks and ice cream. [60].

According to JD Sales Ranking in November 2023. the top three chocolate brands sold are Snickers, Dove, and Ferrero. They each contain 45g, 15g and 10g sugar. It is clear that a single bar of

Snickers contain more sugar than the suggestion. Therefore, it is very easy to eat a lot of added sugar without awareness. Besides chocolate, soft drinks can also easily overtake this suggestion. Still looking at JD sales ranking, excluding sugar free drinks and energy drinks, Coca Cola, AD calcium and Minute Maid occupy the top. Coca Cola usually uses sucrose as a sweetener which contains 39g in a bottle, more than the suggestion of 36g for male and 24g for female. According to the product nutrition label, the energy content of AD calcium is approximately 137KJ, which is approximately 32. 46Kcal per 100 millilitres. Normally, a bottle of AD calcium is 220 milliliters, which means that a bottle of AD calcium contains approximately 71. 41 kcalr. Minute Maid also needs to see the product nutrition label, which contain approximately 39. 89Kcal per 100ml.

Similarly, a bottle of Minute Maid occupies 450ml which means it contains approximately 179. 505Kcal. Most of the drink contained sugar is easy to overtake the suggestion. In ice cream, taking a brand called Beryer as an example, the highest sugar contained product is 22g and the lowest sugar contained product is 5g. Sugar intake is easy to exceed the suggestion if people choose the highest one, but when people choose the lowest sugar contained product, the intake of sugar is far from reaching the suggestion. Therefore, it is important to make the right choice to select low sugar content snacks and drinks to keep up with a healthy life.

Carbohydrate is an important energy source for people. 45 to 65 percent of these energies come from carbohydrate, which is 1035Kcal to 1495Kcal for man and 855Kcal to 1235Kcal for woman (What are My Calorie, Protein, Fat, & Carbohydrate Needs (k-state. edu)); Potato, corn, rice and flour are the most common staple food (McDaniel et al,2023). Rice contain 130Kcal per 100g. In China, a bowl of rice is around 250g to 450g. Therefore, a bowl of rice contains around 585 calories which means the energy intake is around 1755Kcal by these in 3 meals, which overtake the adequate amount. Thus, each meal consume 1 bowl of rice is the most suitable; A cup of flour contain 442. 5Kcal [61]. 1 cup is equal to 250g, the sum of calories in 3 meals is around 1327. 5Kcal which means it is suitable to eat 1 cup for a person each meal like rice. In some area, potato and corn serve as a staple food. Potato contains 77Kcal per100g and corn is 86Kcal per 100g. Therefore, potato or corn could be a suitable staple for people who want to lose weight. Comparing them with rice and flour, they have lower calories which means they can compensate excess sugar in other food.

Excess fructose is harmful to the liver and may cause fat accumulation on the liver. [63]. However, it is difficult to consume a lot of fructose. 1 cup of figs contain 23g fructose approximately and 1 cup of dried apricots contain 16. 4g approximately. These are high in fructose but it is way below the suggestion of 50g to cause harm fruit [65].

3.1.4. Sweeteners in food industry

Sugar has been used widely in food industry. Recent years, as people has increased awareness to sugar intake, the sugar consumption has reduced. Consumption of sugar in America has declined from 15. 4% in 1960-1980 to 6. 4% in 2001-2010[53]. Meanwhile, total consumption of sugar worldwide from2021 to2023 increase from 155. 8million to 180. 05million. However, grow rate is slow in each year and there is a decline period from 2018 to 2020 that decrease from 173.

86million to 171. 25million [54]. Instead of sugar, consumption of sweeteners increased. Take erythritol as an example, in Nikken Chem and Mitsubishi Chem, the production of erythritol increased from 1000t in 1991 to 12000t in 1997, in which the demand overtook the supply.

This continues to grow until today. Sweeteners like aspartame has also been used widely, more than 6000 products add aspartame in their goods in the America [55].

The consumption of sugar free carbonated drinks also increases in recent years. In China, market scale of sugar free carbonated drinks increases from 600 million yuan to 546 million yuan.

Also, more and more company involve in develop sugar free carbonate drinks. Coca Cola launched approximately one third low sugar drinks or sugar free drinks in 4000 products in 2017. PepsiCo also launched their own sugar free drinks in this year. Chi Forest launched sugar free bubble water in 2018 and obtain 1billion sales volume in 2019 [64]. These statistics explain than companies realize the people's awareness to sugar intake and try to modified their product with decreasing sugar contained to satisfy consumer's demand.

4. Conclusion

In conclusion, obesity has become a seriously social problem. It is essential for everyone to pay more attention on it. Obesity is caused by excess fat accumulation. And excess sugar intake will stimulate the fat accumulation by converting glucose into fatty acid with under a complex mechanism. Although there are some other factors will influence obesity, the essence of these factors is to stimulate people to consume more sugar. However, people must consume sugar due to sugar is a main energy source which can maintain life activity. Therefore, limiting extra sugar intake should be considered instead of refusing to consume any sugar.

Here are some advices to limiting extra sugar intake. If people make some carbohydrates like rice, noodles as staple food, it is better for them to avoid consuming food made of carbohydrates like bread or pizza in the free time because energy obtained from carbohydrate is sufficient from 3 meals and if carbohydrates are consumed from other sources, the energy will be more likely to exceed the limit, which will increase the risk of obesity; It is better to don't eat snack foods. If you want to eat snacks, it's best to pay attention to whether their calorie or sugar content exceeds 150 calories or 36g of sugar; sugar free drinks may be a good way to combat the desire to consume sugar. Nevertheless, artificial sweeteners' harmful is discovered completely. Therefore, people cannot drink sugar free drinks as frequent as water. Sugar alcohol is much safer than artificial sweeteners.

Thus, sugar free drinks contained sugar alcohol may be a first choice.

Combating obesity is a responsibility of every aspect of society. Each part of society has their particular ability to limit sugar intake. For government, they may can use law to restrict company how many sugars they add into their goods. And they can also publicize the harmful of taking in too much sugar. Company could develop their goods and explore the wilder usage of sweeteners.

Scientist can make an effort by discovering the confirm hazard of sweeteners or investigating the newest sweeteners without hazard. Individual or video producers are able to involve in the campaign of government to make more people the harm of taking in excess sugar.

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