



Health communication to reduce sugar consumption in Thailand

Kanokpong Muangsri^{1*}, Wittayatorn Tokaew², Supaporn Sridee², Kamon Chaiyasit¹

¹Integrative Nutrition and Herbal Medicine Association, Thailand; ²Department of Communication Arts, Sukhothai Thammathirat Open University, Thailand

*Corresponding author: Kanokpong Muangsri, Integrative Nutrition and Herbal Medicine Association, Thailand

Submission Date: August 10th, 2021; Acceptance Date: September 2nd, 2021; Publication Date: October 4th, 2021

Please cite this as: Muangsri K., Tokaew W., Sridee S., Chaiyasit K. Health Communication to Reduce Sugar Consumption in Thailand. *Functional Foods in Health and Disease* 2021. 11(10): 484-498. DOI: <https://www.doi.org/10.31989/ffhd.v11i10.833>

ABSTRACT

Excessive sugar consumption is one of the critical health behaviors contributing to Non-Communicable Diseases or NCDs, which are the leading causes of mortality among the Thai population. It is reported that Thai people have a continuous increase in sugar consumption every year



associated with higher incidences of NCDs in the country. Therefore, health communication to raise awareness and modify the sugar consumption behavior in Thailand focuses on integrative communication in terms of public policies in accordance with the National NCDs Strategic Plan, guidelines and knowledge in sugar consumption including healthy and unhealthy sugar sources, sugar substitutes and their use in functional foods, health problems related to sugar consumption, the use of GDA Nutrition label, and the application of Healthier Choices standards with appropriate sugar content. With changing lifestyles, social media and technologies play a higher role in health communication regarding sugar consumption, resulting in the development of health applications in conjunction with IoT technology that can be used via smartphones. All these communications aim to promote the reduction of sugar consumption in the prevention of NCDs, thus reducing the premature death rate of the Thai population accordingly.

Keywords: health communication, sugar consumption, sugar, sweetener, sugar tax, social media, non-communicable diseases, NCDs, nutrition label, GDA label, IoT

©FFC 2021. This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0>)

INTRODUCTION

Health communication is a process of transmitting health information, knowledge, awareness, and risk of diseases to modify the targeted health behaviors of the intended audiences, especially in the area of consumption. Nutrition communication is a purposive communication to disseminate nutritional knowledge to change attitudes and consumption behavior to reduce public health problems and promote sustainable good health [1].

Chronic Non-Communicable Diseases or NCDs, such as cancer, cardiovascular disease, diabetes, hypertension, and obesity, are among the most critical public health problems as they are the leading cause of death in the Thai population. With the high

cost of medical care, NCDs can be prevented by promoting healthy consumption. Both public and private sectors have administered health communication through various media and channels to promote nutritional knowledge. Emphasis is placed on the prevention of NCDs, such as the promotion of less-sweet-less-disease health schemes to modify the consumption behavior to reduce the incidence rate of NCDs. Due to the change in the way of life and media consumption nowadays, Thai people spend more time on social media than ever, including Facebook, Instagram, YouTube, Twitter, to access various information, particularly health and disease prevention [2].

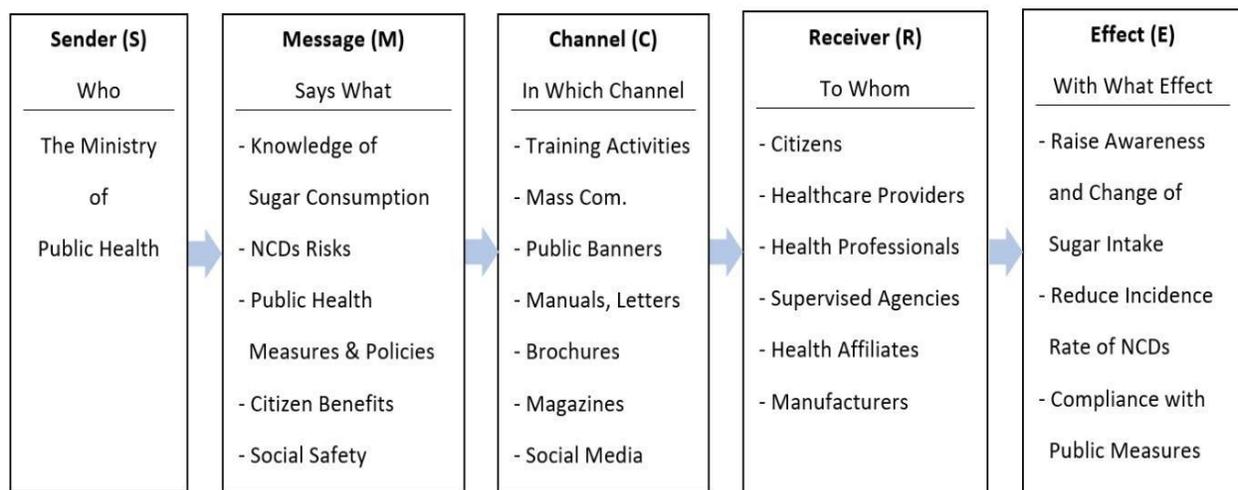


Figure 1. The elements of health communication to reduce sugar consumption

Health Communication to Reduce Sugar Consumption: The elements of health communication to reduce sugar consumption stem from the senders (S) as shown in figure 1. The Ministry

of Public Health is a primary sender responsible for the prevention, control, and treatment of diseases related to overconsumption of sugar, including the promotion of healthy diets. The sender

communicates with specific health purposes directly to the public and the supervised agencies in driving the key health messages, policies, and actions to the receiver within the timeframe. The senders must identify the health problems and communication barriers of the receivers, and the nutritional needs for their health, which will lead to the design of nutritional health media and content specifically for the receivers [3].

The health message (M) herein is a compilation of nutritional knowledge including a sugar intake, risks of adopting health problems or NCDs, citizen benefits, social safety, and health measures and policies. The health message must be of the greatest benefit to the receivers, its presentation should be attractive and suitable for the certain age range and interests of the receivers. The receivers will eventually decide to consume a health message through programs and channels according to their preferences and interests. Therefore, the communication style of the presentation depends on these factors. Sometimes the emphasis is on a visual presentation, a narrative with an interesting tone, an illustrated picture, or a video clip via YouTube or Facebook programs [4].

The health communication channels (C) are not limited to mass communication, instead, disseminated through appropriate and various selective communication media, including training activities, health manuals, letters, public banners, magazines, brochures, and the use of social media. At present, Thai people tend to search for and consume health information via social media channels. There is a dedicated grouping of people via social media on various interests, especially health issues [5].

The receivers (R) in health communication to reduce sugar consumption includes Thai citizens, healthcare providers, health professionals,

supervised agencies, network health affiliates, and the manufacturers in the health industry. If the receivers are satisfied with the benefits of the health media, receivers may turn into senders simultaneously and share the message to their peers or others. Designing an appropriate and compelling health communication pattern may enable greater information sharing and a broader impact [6].

The effect (E) of health communication to reduce sugar consumption aims at promoting public awareness and reinforcing change in consumer's health behavior to reduce sugar consumption including the compliance with public health measures. According to the National NCDs Strategic Plan, the average sugar consumption and incidence rate of NCDs in the country are expected to decline within the timeframe [7].

Social Media and Health Communication: Social media is the popular medium that Thai people choose to consume, exchange and search for information, including various health information. Over the past ten years, the use of social media has increased and evolved to reach more people, primarily via smartphones [8]. Social media are widely used in public health events to promote health information and knowledge. Nevertheless, what needs to be taken into account is that the information via social media must be considered appropriately formatted and content, also taking into consideration the personal factors of the recipients, including age, gender, and economic status, resulting in different interests in health media [4]. Some people frequently share information via the LINE application, while others prefer to use Facebook. The Club House application is popularly used to bring up health issues for live discussions.

Due to much information on social media, the audiences often choose to consume the media by the contents of interest via the desired channels according to the principles of uses and gratifications. With this trend of health communication on social media, the World Health Organization (WHO), the Centers for Disease Control and Prevention (CDC), and the Food and Drug Administration (FDA) have chosen media as a means to communicate various health information and campaigns continuously, including Facebook, YouTube and Twitter. Social media is also a communication tool for lifestyle modifications and metabolic indicators to prevent NCDs. In particular, it promotes the increment of physical activity as well as the reduction in sugar and fat consumption [9].

It was found that most of the Thai working-age population prefers to consume food based on social media. Food images and restaurant reviews both have an impact on food choices, especially on Facebook media, which has over 48 million Thai users. Most of them are Gen Y aged 19-36 years old who are interested in posts about food or cooking that looks appetizing. Meanwhile, Twitter has over 9 million Thai users, mainly Gen Z aged 15-24, most of whom are interested in unique foods and signature dishes such as bubble tea. In terms of social media exposure behavior, it is revealed that Thai people tend to consume spicy food such as spicy salad, tom yum, and sweet food such as Thai desserts, cakes, croissants, and bubble tea. Therefore, food communication via social media has a vast influence on Thai people's food choices, which significantly affects health-related problems and diseases [10].

Sugar Consumption and Health Problems: Sugar is a subunit of carbohydrates after being digested, which is one of the primary sources of energy. We should be

consuming sugar only 5% of our total daily energy needs or up to 6 teaspoons per day [11]. However, it was found that Thai people consumed an average of 25.5 teaspoons of sugar per day, which is five times higher than the amount recommended by the World Health Organization. It is currently a significant public health problem in Thailand because excessive long-term consumption of sugar or sugary foods can elevate the risk of developing NCDs. For example, long-term ingestion of fructose directly affects the fat metabolism, resulting in an increment of lipid within the liver cells (intrahepatocellular lipid). Also, the production of fat from non-fat foods by which the process converts glucose into lipids (De novo lipogenesis). Lipids will accumulate in the body, especially in the liver, as a form of fat until it develops into the fatty liver [12]. Long-term intake of fructose and sugar can lead to insulin resistance and the accumulation of body fat. It was reported that the ingestion of fructose for subsequent six days resulted in a 79% increase in triglyceride levels [13].

Sugar potentially causes an inflammatory process. Both glucose and fructose are types of monosaccharides found in table sugars commonly consumed in daily life, which can trigger inflammation in the body. It was found that the ingestion of glucose stimulates the neutrophils to secrete inflammatory cytokines called IL-6 and TNF-alpha. The secreted IL-6 can also cause insulin resistance and elevate the level of acute inflammatory reactive protein (CRP), thereby increasing the risk of cardiovascular diseases [14]. Prolonged inflammatory processes from sugar consumption result in insulin resistance, increasing the risk of diabetes, cancer, kidney impairment, high blood pressure, and atherosclerosis, all of which belong to the NCDs group [15]. Therefore, reducing or controlling sugar intake is beneficial in preventing

NCDs, which are the leading cause of death among the Thai population.

SUGAR MARKET IN THAILAND

White Sugar vs Brown Sugar: There are various types of sugar frequently consumed in Thailand, including white sugar, brown sugar, crystalline sugar, nutritive and non-nutritive sweeteners, and coconut sugar. Although governments and health organizations have promoted campaigns to reduce sugar consumption, there are still social trends in sugar communication that confuse consumers. For example, brown sugar is claimed to be more healthful than white sugar. Therefore, it is recommended to use brown sugar for consumption and cooking as a substitute for white sugar. This perception stems from the natural appearance of brown sugar's color and aroma, which is perceived to undergo a less purifying process, thus giving higher nutritional value beneficial for health than white sugar. Brown sugar is produced by boiling sugarcane juice to evaporate without separating the molasses or undergoing a bleaching process, leaving some residual trace elements such as iron and calcium. However, the amount of nutrients that brown sugar contains is only slightly more, which is not enough for the body's daily needs. Hence there is no noticeable difference in health benefits [16].

In terms of nutritional value, brown sugar and white sugar provide nearly the same amount of energy, approximately 20 kcal per 1 teaspoon. These sugars have a molecular structure made up of monosaccharides, namely glucose and fructose. When fructose is present in the molecule, it is as easy to trigger inflammation as white sugar. In terms of nutritional function, brown sugar acts as the same source of energy as white sugar. Excessive consumption also increases the risk of obesity and can lead to NCDs [17]. Therefore, the purpose of

choosing white sugar or brown sugar is merely to add sweetness to the taste of food according to preferences and type of food. Neither of these two types of sugars provides significantly different or more benefits for health.

Coconut Sugar: Coconut Sugar became famous among health communication trends because it is a natural organic sweetener, claiming that coconut sugar is not absorbed as quickly as regular white sugar. Coconut sugar differs from white sugar and brown sugar in terms of its source. Table sugar is produced from sugar cane. At the same time, coconut sugar is produced from the coconut palm tree by simmering the sap obtained from the coconut bud until it becomes syrup and crystallizes as coconut sugar. Taking into consideration the Glycemic Index (GI), coconut sugar has a glycemic index of 35 compared to 58-82 for regular sugar, and has a higher content of minerals. Thus, it is often quoted as the recommended healthier source of natural sweetener and communicated to the broader health-conscious community, especially those who like natural organic foods. Because the glycemic index of coconut sugar is lower than regular sugar. Therefore, the effect on blood sugar levels is perceived to be less than other types of sugar in the high glycemic index group, especially the impact on insulin resistance that affects the risk of developing subsequent NCDs [18]. Coconut sugar is also considered a source of energy. However, there is a risk of obesity when consumed in large quantities, and obesity is a significant contributor to NCDs. Communication regarding the benefits of coconut sugar can possibly mislead consumers that there is no limitation on the consumption amount.

Sugar Alcohol: In addition to the sugar types mentioned earlier, sugar alcohol is also a sweetener prevalently consumed among Thai people. Sugar alcohol provides approximately 2 kcal per 1 gram, which is half of the energy provided compared to regular sugar. Sugar alcohols such as xylitol, mannitol are popular ingredients used as sweeteners in many functional foods & beverages with low calories for those who are concerned with the management of caloric intake, weight control, diabetes and metabolic syndrome. However, caution has been found in patients with small intestinal bacterial overgrowth (SIBO). Exposure to such sugars may cause gas and flatulence. In addition, abnormal gastrointestinal symptoms may be worsened [19].

Non-Nutritive Sweetener: Non-nutritive sweeteners, also known as artificial sweeteners, are used instead of sugars to sweeten the flavor with few or no calories. These types of sweeteners also conform with patients with small intestinal bacterial overgrowth (SIBO). Non-nutritive sweeteners commonly used in Thailand consist of Sucralose, Aspartame, Acesulfame K, Luo Han Guo (monk fruit extract), saccharin, and stevia. They are primarily used in non-energy sweetened food and beverages [20]. The non-nutritive sweetener in the Aspartame group requires caution in patients with Phenylketonuria, a genetic disorder that lacks an enzyme to break down the amino acid called phenylalanine. As a result, it is necessary to limit the intake amount of phenylalanine, of which Aspartame consists of such amino acids [21]. In Thailand, Aspartame and Acesulfame K are widely used as sweeteners in functional foods in the form of functional drinks such as the curcumin beverage plus vitamin C, flavored with aspartame for good taste.

The Thai FDA has approved the use of these non-nutritive sweeteners. However, the forbidden use of these substances in patients with Phenylketonuria must be clearly communicated on the product label. In addition, the Ministry of Public Health has promoted the consumption of foods and beverages that are low in sugar within the specified criteria, allowing food and beverages containing such sweeteners to engage in health communication through the use of "Healthy Choices" symbol on the product label. Researchers in some consumer groups reported that artificial sweeteners alter the balance of gut probiotics, thereby increasing the risk of insulin resistance [22].

The American Heart Association (AHA) and the American Diabetes Association (ADA) issued a warning that caution must be taken when using sweeteners as a substitute for regular sugar to prevent obesity, diabetes, and metabolic syndrome [23]. Although the use of sweeteners enhances the satisfaction of the sweet flavor without calories, it cannot change consumer behavior of sweet taste addiction in the long term. Health communication about artificial sweeteners consumption instead of sugar needs to educate about the amount and frequency of consumption, contraindications including long-term health effects, which the general people need to know and maybe indicated on the product label.

Natural Sweeteners: Natural sweeteners are a group of plant-derived sweeteners with the extraction of active substances that provide sweetness without giving energy to the body. Some Thai people who are health conscious prefer to consume the so-called Ketogenic diet, which has a proportion of low carbohydrate, moderate protein, and high fat. Consequently, these consumers tend to use natural

sweeteners providing no energy in their cooking. The most famous natural sweeteners used in Thailand are stevia and monk fruit extract (luo han guo). Initially, stevia was widely known as a plant-based sweetener obtained from the plant species *Stevia rebaudiana* Bertoni, providing an active substance called Stevioside which is 200-300 times sweeter than regular sugar. There has been a cultivation of stevia in northern Thailand due to the suitable cold weather. At present, Thai FDA has approved the use of stevia products in the form of tea beverages and the use of steviol glycosides as food additives [24].

Since stevia is a naturally occurring substance, consumers are interested in using both syrup and powder forms in cooking as a sugar substitute. Stevia extract is resistant to high temperatures, making it feasible to use in cooking without compromising its sweet flavor. It is reported that stevia increases insulin sensitivity in rats, and it is beneficial in controlling the blood glucose level in humans, which is an advantage compared to other types of artificial sugars [25]. Stevia is widely used as a sweetener in some functional foods and beverages, such as probiotics yogurt, fermented drink kefir, sport drink, and fortified plant-based diets.

However, some consumers are not familiar with the sweet taste of stevia extract. Thus, there has been some development of sweeteners in the food industry made from the monk fruit (Lo Hang Guo) which is originally an industrial crop of China. Researchers found that Mogrosides substance from monk fruit was 250 times sweeter than regular sugar and was similar in taste. Some Thai consumers then prefer to apply monk fruit in beverages and cooking. Due to its properties of highly soluble and resistance to acidity and alkalinity, Monk fruit is popularly used as a sweetener in functional herbal drinks and fortified dairy products. Correspondingly, Erythritol is

a very low-calorie sugar alcohol sweetener which is popular among Ketogenic diet consumers. Erythritol is widely used in many countries including the USA, Japan, Canada, Brazil and China. Erythritol tastes like regular sugar with slightly less sweetness. The sweetness of Erythritol is approximately 60-70% compared to regular sugar. It possesses antioxidant and antimicrobial properties, especially against *Streptococcus mutans* bacteria, a major contributor to cavities and tooth decay [26]. Resulting in the widespread use by commercial ketogenic diet manufacturers to satisfy consumers with natural sweet flavor with low energy that has no impact on the body's insulin levels. Erythritol is broadly used as a low caloric sweetener in some ketogenic diets and functional drinks, such as fortified oat milk and pistachio milk.

Sugar Substitutes/Natural Sweeteners used in Thai

Functional Food Products: There are higher trends towards widely functional food consumption in Thailand which are dispensed in various forms, including beverages, ready-to-eat products, and medical foods. Most of the functional food products are flavored to be more appetizing, especially the sweet taste. Nevertheless, the use of regular sugar as a flavor enhancer in functional foods may expose consumers to excessive amounts of sugar intake. Therefore, sugar substitutes and natural sweeteners are preferably used in the manufacturing of functional foods, which must be conformed to the Food Act under the supervision of the Thai FDA. The commonly used substances are presented as follows.

Aspartame: Aspartame (Aspartyl phenylalanine methyl ester) is a non-caloric sweetener containing a group of amino acids called phenylalanine as an essential component of the molecule [27]. Aspartame

is licensed as a food additive from the Thai FDA with restrictions on its use in whole and functional food products according to the types of food. The amount must not exceed 350 mg/kg in dairy beverages, 6000 mg/kg in beverages, cocoa or chocolate products 3000mg/kg, 1000 mg/kg medical food, 800 mg/kg in weight control diets, 1000 mg/kg in diets with special purpose in nutrition promotion, and 5500 mg/kg in dietary supplements [27]. However, it is contraindicated in patients with phenylketonuria which is a genetic disorder that is unable to produce digestive enzymes to break down phenylalanine [28].

Sucralose: Sucralose is a non-caloric sweetener providing approximately 600 times sweeter than regular sugar. It has good water solubility, high product stability, and relatively high safety reports. However, there are reports that sucralose may produce chloropropanols, a group of toxic chemical compounds, when exposed to extreme heat. Sucralose may alter the levels of insulin and glucagon-like peptide (GLP-1), a group of gastrointestinal hormones that have hypoglycemic effects, thus potentially affecting changes in blood sugar regulation [29]. Thai FDA therefore determined the amount of sucralose used in whole and functional food products which shall not exceed 300 mg/kg in dairy beverages, 580 mg/kg in beverage, 800 mg/kg in cocoa or chocolate products, 400 mg/kg in medical foods, 320 mg/kg in weight control diets, 400 mg/kg in diets with special purpose in nutrition promotion, and 2400 mg/kg in dietary supplements [27].

Stevia: Stevia is a natural sweetener that provides a glycoside extract from the leaves of the *Stevia rebaudiana* Bertoni plant with relatively high safety. The Thai FDA has approved only whole stevia leaves to be produced in the form of herbal teas. However,

the extracted active substances called steviol glycosides are permitted as food additives [30]. Thai FDA has determined the amount of steviol glycosides used in various whole and functional food products with the amounts not exceeding 70 mg/kg in milk beverages, 1150 mg/kg in beverages, 200mg/kg in coffee and cereal beverages without cocoa, 350 mg/kg in the medical diets, 270 mg/kg in weight control diets, 660 mg/kg in diets with special purpose in nutrition promotion, and 2500 mg/kg in dietary supplements [27].

Sorbitol: Sorbitol is a sweetener in the sugar alcohol family, providing approximately half the energy of regular sugar. In addition, xylitol and mannitol are also considered sugar alcohols. Sorbitol is used in a wide variety of whole and functional foods. Caution should be exercised in patients with SIBO as it can cause severe gas and bloating after ingestion. Thai FDA has determined the amount of sorbitol to be used in unlimited amounts with due appropriateness in the group of dairy beverages, medical diets, diets with special purpose in nutrition promotion, and weight control diets [27].

Erythritol: Erythritol (Meso-erythritol; Erythrite tetrahydroxy butane; 1,2,3,4-Butanetetrol) is a low-caloric sugar alcohol which is commonly used in various whole and functional foods. Similarly, erythritol can be used in unlimited amounts with due appropriateness in the group of dairy beverages, medical diets, diets with special purpose in nutrition promotion, and weight control diets [27].

Policies for Communication and Promotion to Reduce Sugar Consumption in Thailand: The Department of Health, Ministry of Public Health has communicated maximum sugar intake

recommendations of no more than six teaspoons per day [31]. Emphasis is placed on the form of sugar added to food or beverages (added sugar). It is found that the consumption guidelines referring to the added sugar do not cover all dietary sources of sugar. Subsequently, the word "free sugar" was introduced and communicated, conforming to the broader definition of sugar sources revised by the World Health Organization, which covers the extensive meaning of sugar added or cooked in food by the consumers, the manufacturer, and the culinarian. Definition of free sugar also includes some natural sugar sources presented in honey, syrup, fructose syrup and fruit juices [32].

Some Thai foods are sugary, especially Thai fruits and desserts, most of which contain sugar as the main ingredient. Furthermore, Thailand is located in the tropical zone, so there are abundant seasonal fruits throughout the year. The famous sugary fruits include longan, durian, ripe mango, watermelon, and pineapple. Often, patients are diagnosed with high

blood sugar levels from excessive long-term consumption of sugary fruits. The former health communication focused on limiting the amount of table sugar which is added into the foods of no more than six teaspoons daily. Some Thai people perceive that fruit is a healthful product, therefore consuming an unlimited amount of fruits and fruit juice, as they presume that those fruits are natural and not added with complementary sugar. Therefore, hyperglycemia is often found in people consuming large amounts of sugary fruits, even if they do not add extra sugar into their regular diet. The consumption of honey or syrup results in a high amount of sugar intake likewise. Although the Thai government and public agencies have promoted the reduction in sugar consumption, the incidence rate of NCDs patients has not decreased [7]. Emphasis should be placed on communicating knowledge regarding the limitation of free sugar intake and its implications for the risk of developing NCDs in order to raise public awareness.

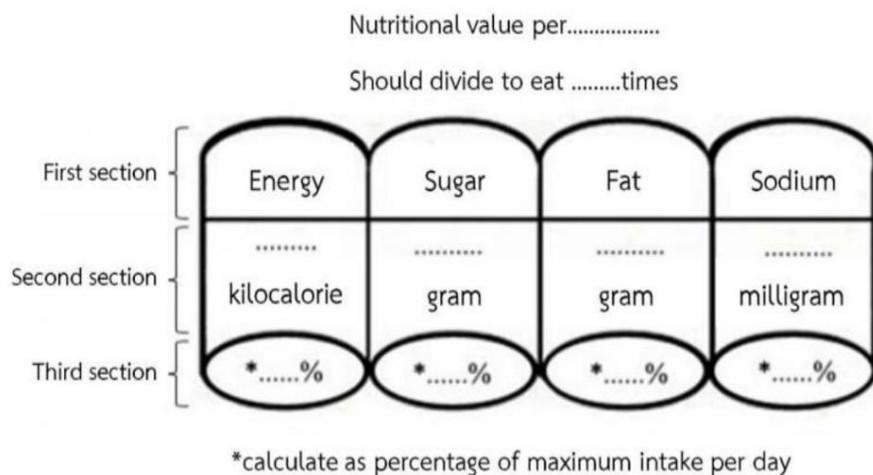


Figure 2. Guideline Daily Amounts (GDA) Label; a guideline for nutrition labeling of the total amount of energy and important nutrients including sugar, fat, and sodium. Sources: Notification of Ministry of Public Health (No. 394) B.E.2561 (2018) Issued by virtue of the Food Act B.E. 2522

The Ministry of Public Health of Thailand has communicated policies to reduce sugar consumption

by establishing nutrition labels presented on food package labels. The original nutrition labels were

those that contained information on energy, carbohydrates, fats, proteins, and vitamins. However, it was found that some consumers had little understanding towards the original nutrition labels. There is often confusion over the recommended consumption units per serving with the total energy content within the food package. Consequently, a Guideline Daily Amount (GDA) nutrition label has been developed, specifying the total energy content of a food per package focusing on the amount of

sugar, fat, and sodium. All the nutrients contribute to the risk of NCDs. The GDA nutrition label shown in figure 2 is enforced to display on the food package of certain ready-to-eat products in the categories of baked goods, chocolate, snacks, chilled and frozen foods, semi-finished foods, ice cream, instant coffee, and dairy products. The energy content and the specific amount of sugar, fat and sodium of the food are clearly indicated on the food package to facilitate consumers' decision-making in food choices.



Figure 3. Healthier Choice logo: A symbol displayed on food products that pass the respective criteria on the amount of sugar, fat, and sodium content of a particular food category.

Sources: The Notification of the Ministry of Public Health No. 373 (BE 2559)

Health food standards are also communicated through the Healthier Choice symbol, a voluntary mark that is optional on food labels. The Healthier Choice symbol certifies that a product has met the recommended criteria of sugar, fat, and sodium content of a particular food category. Communication through nutrition labels is a tool for consumers to make an initial decision on food choices appropriate to their nutritional conditions. In accordance with the Notification of the Ministry of Public Health No. 373 regarding the display of nutrition symbols on food labels, it is required to display the message under the

symbol specifying the name of the certified food category [33] as shown in figure 3.

In addition to the communication through food labels to promote people's knowledge and awareness in consuming less sweetened products, public measures were also communicated with the taxation on sugary beverages. Based on the notion that sugar contributes to NCDs such as liver cancer, fatty liver disease, cardiovascular disease, paralysis, diabetes, and obesity, all of which impose the financial burden for the state to spend at least 4-5 hundred billion baht per year for healthcare expenses. Raising the tax on

high-sugar beverages is aimed to reduce sweet consumption, and the state can allocate the collected tax for public medical expenses. The state has given time for manufacturers to adjust formulas and reduce the sugar amount in the beverages prior to the enforcement of tax measures. Taxation on beverages containing more than 6 grams of sugar per 100 milliliters of beverages, including three-in-one powdered beverages, has commenced in 2017. The tax rate will be increased every two years at the progressive rate to achieve 6% in 2023 to allow time for industrial entrepreneurs to prepare. After the tax measures were enforced, it was found that Thai people consumed less sugary beverages by 15.3% in 2018 and 14% in 2019 [34]. Therefore, tax measures are one of the tools that can help to control sugar consumption from imported beverages and large industrial markets. However, the sugar tax measures in Thailand do not cover other types of beverages, including freshly prepared and homemade beverages. In addition, the sweetness tax still does not apply to other types of foods that contain sugar. Communication to provide the public understanding and awareness towards sugar consumption and the risks of health problems or NCDs remain an extremely important factor.

Technology and Communication to Reduce Sugar

Consumption: The use of technology plays an increasingly important role in daily life. A smartphone is used as a communication tool for media exposure via social media to reduce sugar consumption. With the development of mobile applications that report the food energy, users are able to record their food

intake, especially the sugary foods, and then evaluate them as energy and the daily proportion of food consumption. Such applications include Cal Diary, DooCalorie, Foodvisor, and Calkcal. Internet of Things (IoT) Technology is integrated to provide connectivity and control between smartphone applications and devices in the system via the Internet. Upon reading or scanning through the smartphone's camera, IoT technology will process data from the cloud and links back and forth between the connected devices [35].

In Thailand, the concept of nutrition labeling combined with technology has been developed as a health communication tool directly to people to change their attitudes and behaviors of sugar consumption, aiding in the selection of food choices with the appropriate amount of sugar. Product information, including the total energy, sugar content, product ingredients, and nutrition label, will be recorded in the database and then linked to a specific numbered barcode on each food package. FoodChoice, an application developed using IoT technology in collaboration with a network of partners of the Ministry of Health and educational institutions and non-profit organizations, serves as an aid for health promotion communication. In principle, a smartphone's camera is used to read or scan the barcode on the product. The system then processes the nutrition label information of each product recorded in the cloud database and presents the new data in an easy-to-understand format. The energy and sugar content are calculated in color whether it is in the proper range. As a result, users can decide whether or not to purchase or consume the product as shown in figure 4 [36].

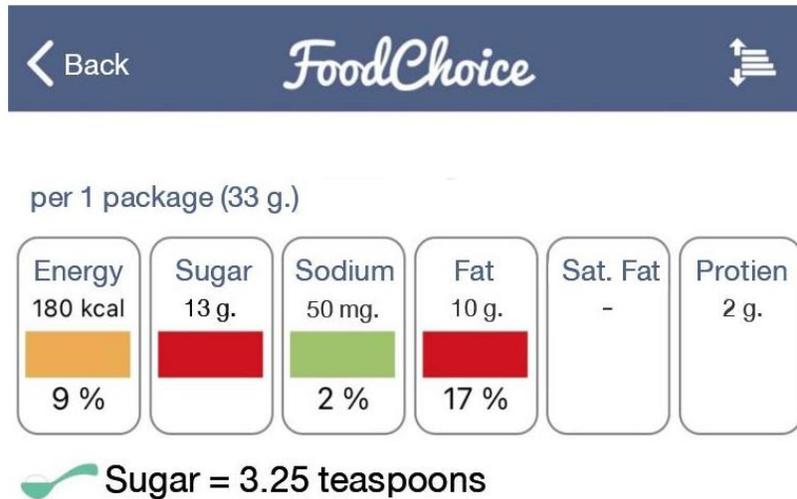


Figure 4. FoodChoice Application
Sources: The National Electronics and Computer Technology Center (NECTEC)

However, upon using the FoodChoice application to scan the food barcode and none of the products is found, users can share images and additional product information with the application to keep the database complete and up-to-date at all times. The application display uses text, images, and colors as the primary means of communication. Green indicates the amount of energy, nutrients, and sugar content within specified criteria. Yellow means the amount of energy, sugar, and nutrients is moderate. Red alerts that the amount of energy, nutrients, and sugar content exceeds twice the specified criteria. In terms of sugar content, it is based on the criteria that people aged 12 years and higher should consume no more than six teaspoons of sugar per day. The FoodChoice application displays the amount of sugar in snacks and beverages as a visual number of teaspoons full of sugar. One teaspoon of sugar is defined as 4 grams. Nutrition label information is derived from the Food Label Survey and the Nutrition Information Database of food and beverage products in sealed containers prepared by the FoodDivision, Thai FDA, Ministry of Public Health since 2015. The intellectual property of the FoodChoice application belongs to the National

Electronics and Computer Technology Center (NECTEC) under the National Science and Technology Development Agency (NSTDA), Ministry of Science and Technology [36]. Conclusively, other related or similar applications still need further development to help communicate health campaigns to reduce sugar consumption among the Thai population.

DISCUSSION

The integration of technology makes health communication more accessible to people and conforms to the changing lifestyles. However, strategic development should be employed in designing health content to stimulate the audience's interest and be presented through the appropriate communication channels. Currently, smartphone applications are developed to raise Thai people's awareness over the sugar content in food to help making easier decisions in daily food choices. However, the use of those applications is not prevalent. Additionally, the application can only be used with barcoded products, and the alternative options are still rare. Therefore, applications should

be developed by integrating IoT technology to expand their use on various devices according to users' preferences. Future applications may be developed to communicate with the cloud database using voice commands or food photography. The artificial intelligent system (AI) then automatically assesses the amount of sugar according to the proportion of the diet.

Food databases should be further developed to incorporate Thai local and daily foods, especially Thai fruits and functional food products. Furthermore, Applications users should be able to share desired information to their favorite social media platforms to create a social impact. The integration of technology in health communication is to raise people's awareness of health problems as a consequence of excessive long-term sugar consumption.

CONCLUSION

A primary goal of health communication to reduce sugar consumption is to prevent the risk of NCDs. Although government and private sectors have mutually driven various health communication and strategies, the sugar consumption of Thai people is still four times higher than the recommendations of the World Health Organization, and it is likely to increase in the future. In addition, some Thai people perceive that sugar consumption from specific food sources is beneficial to the body resulting from the exaggerated health beliefs spreading on social media. Therefore, the government and relevant parties should play a central role in assembling accurate and reliable information for public communication to enhance people's awareness towards NCDs, sugar consumption, sugar

substitutes, healthy foods, and functional food products. Continuous health communication elevates people's cognitive skills to be able to assess and make their own healthier food choices, which contributes to a new standard for sustainable healthy living.

List of abbreviation: GDA: Guideline Daily Amounts, FDA: Food and Drug Administration, NCDs: Non-communicable diseases, IoT: Internet of things,

Competing Interests: The authors have no financial interests or conflicts of interest.

Authors' contribution: All authors contributed to this study.

Acknowledgment and Funding: The authors declare no acknowledgments or funding.

REFERENCES

1. Verma A, Mehta S, Mehta A, Patyal A: Knowledge, attitude and practices toward health behavior and cardiovascular disease risk factors among the patients of metabolic syndrome in a teaching hospital in India. *J Family Med Prim Care* 2019. 8(1):178-183.
2. Panpeng Y, Hongvoranant K: Health communication through social media with ncds based on building health leads fixing health. *Interdisciplinary Sripatum Chonburi Journal* 2020. 6(1):56-67.
3. Juthavijit K, Tantaviwong A: Communication for structural changes. In *Health Communication for Healthy Society*. Bangkok: Thai Health Promotion Foundation; 2017. 39-47
4. Saengsingkaew N, Ingkaninan K: Communication for change in health behavior. In *Health Communication for Healthy Society*. Bangkok: Thai Health Promotion Foundation; 2017.20-30.
5. Art and Culture for Health Literacy: Community media program for health communication 2020-2021. Bangkok: Thai Health Promotion Foundation; 2021.

6. Louiyapong K, Hinwiman S: Communication principles for health promotion. In Health Communication for Healthy Society. Bangkok: Thai Health Promotion Foundation; 2017, 6-19
7. NCDs Situation Report "Kick Off to the Goals" [<http://www.thaincdnet.ihppthaigov.net/2019/06/02/รายงานสถานการณ์โรค-ncds-๓/>] Retrieved July 7, 2021.
8. Huo J, Desai R, Hong YR, Turner K, Mainous A, Bian J: Use of social media in health communication: findings from the health information national trends survey 2013, 2014, and 2017. *Cancer Control* 2019. 26(1):1-10.
9. Mendoza-Herrera K, Valero-Morales I, Ocampo-Granados ME, Reyes-Morales H, Arce-Amaré F, Barquera S: An overview of social media use in the field of public health nutrition: benefits, scope, limitations, and a Latin American experience. *Prev Chronic Dis* 2020. 17:E76.
10. Thai Health Watch 2020 [http://elibrary.nfe.go.th/e_library/ebook/0/ebook/1591931020.pdf] Retrieved June 24, 2021.
11. Breda J, Jewell J, Keller A: The importance of the World Health Organization sugar guidelines for dental health and obesity prevention. *Caries Res* 2019. 53(2):149-152.
12. Rippe JM, Angelopoulos TJ: Relationship between added sugars consumption and chronic disease risk factors: current understanding. *Nutrients* 2016 Nov 4. 8(11):697.
13. Faeh D, Minehira K, Schwarz JM, Periasamy R, Park S, Tappy L: Effect of fructose overfeeding and fish oil administration on hepatic de novo lipogenesis and insulin sensitivity in healthy men. *Diabetes* 2005. 54(7):1907-13.
14. Alipour A, van Oostrom AJ, Izraeljan A, Verseyden C, Collins JM, Frayn KN, Plokker TW, Elte JW, Castro Cabezas M: Leukocyte activation by triglyceride-rich lipoproteins. *Arterioscler Thromb Vasc Biol* 2008. 28(4):792-7.
15. The Sweet Danger of Sugar [<https://www.health.harvard.edu/heart-health/the-sweet-danger-of-sugar>] Retrieved June 24, 2021.
16. Colonna WJ, Samaraweera U, Clarke MA, Cleary M, Godshall M, White JS: Sugar. In *Encyclopedia of Chemical Technology*. New York: John Wiley and Sons, Inc.; 2006.
17. National Food Based Dietary Guidelines for Maldives [[http://health.gov.mv/Uploads/Downloads//Informations/Informations\(167\).pdf](http://health.gov.mv/Uploads/Downloads//Informations/Informations(167).pdf)] Retrieved July 6, 2021.
18. Asghar MT, Yusof YA, Mokhtar MN, Ya'acob ME, Mohd Ghazali H, Chang LS, Manaf YN: Coconut (*Cocos nucifera* L.) sap as a potential source of sugar: Antioxidant and nutritional properties. *Food Sci Nutr*. 2020. 8(4):1777–1787.
19. Chaiyasit K, Permpoon V, Wutthikongsombat W: Therapeutic nutrition for small intestinal bacterial overgrowth (SIBO). *Journal of Community Pharmacy Association* 2017. 95:53-58.
20. Ruiz-Ojeda FJ, Plaza-Díaz J, Sáez-Lara MJ, Gil A. Effects of sweeteners on the gut microbiota: A review of experimental studies and clinical trials. *Advances in Nutrition* 2019. 10(Suppl 1):31-48.
21. Newbould E, Pinto A, Evans S, Ford S, O'Driscoll M, Ashmore C, Daly A, MacDonald A: Accidental consumption of aspartame in phenylketonuria: patient experiences. *Nutrients* 2021. 13(2):707.
22. Liauchonak I, Qorri B, Dawoud F, Riat Y, Szewczuk MR. Non-nutritive sweeteners and their implications on the development of metabolic syndrome. *Nutrients* 2019. 11(3):644.
23. Mathur K, Agrawal RK, Nagpure S, Deshpande D. Effect of artificial sweeteners on insulin resistance among type-2 diabetes mellitus patients. *J Family Med Prim Care* 2020. 9(1):69-71.
24. Notification of the Ministry of Public Health (No.390): Prescribed foods which have criteria, condition, and method of use in food produced for sale, imported for sale, or sold [http://food.fda.moph.go.th/law/data/announ_moph/V.English/No.390.pdf] Retrieved April 23, 2021.
25. Anton SD, Martin CK, Han H, Coulon S, Cefalu WT, Geiselman P, Williamson, DA: Effects of stevia, aspartame, and sucrose on food intake, satiety, and postprandial glucose and insulin levels. *Appetite* 2010. 55(1):37-43.
26. Regnat K, Mach RL, Mach-Aigner AR. Erythritol as sweetener-wherefrom and whereto? *Appl Microbiol Biotechnol* 2018. 102(2):587-595.
27. Notification of the Ministry of Public Health No. 389 B.E. 2561, Re: Food Additives (No. 5) [http://food.fda.moph.go.th/law/data/announ_moph/P389.pdf] Retrieved Aug 28, 2021.
28. Maher TJ, Wurtman RJ: Possible neurologic effects of aspartame, a widely used food additive. *Environ Health Perspect* 1987 Nov, 75:53-7.
29. Schiffman SS, Rother KI: Sucralose, a synthetic organochlorine sweetener: overview of biological issues. *J Toxicol Environ Health B Crit Rev* 2013. 16(7):399-451.

30. Notification of the Food and Drug Administration, Re: Prescribing food prohibited for manufacturing, importation, or sale
[http://food.fda.moph.go.th/law/data/announ_fda/P390-P391.pdf] Retrieved Aug 28, 2021.
31. Good health starts with reducing sweet, oily and salty foods adding more fruits and vegetables[http://nutrition.anamai.moph.go.th/download/article/article_20160323141632.pdf] Retrieved April 23, 2021.
32. Reducing Sugar Consumption To Prevent And Control Noncommunicable Diseases In The Eastern Mediterranean Region
[<http://www.emro.who.int/pdf/noncommunicable-diseases/publications/questions-and-answers-on-reducing-sugar-consumption-to-prevent-and-control-noncommunicable-diseases.pdf?ua=1>] Retrieved July 11, 2021.
33. Notification of the Ministry of Public Health (No.373): The Display of Nutrition Symbol on Food Label.
[http://food.fda.moph.go.th/law/data/announ_moph/V.English/No.373_Notification_Nutrition_Symbol.pdf] Retrieved July 11, 2021.
34. Who Encourages Thailand To Raise Sugar Tax To Reduce NCDs
[<https://dol.thaihealth.or.th/File/media/046e4428-e47d-484b-b4a2-e4113f79706b.pdf>] Retrieved July 11, 2021.
35. Sundaravadivel P, Kesavan K, Kesavan L, Mohanty SP, Kougianos E: Smart-Log: A Deep-Learning Based Automated Nutrition Monitoring System in the IoT. IEEE Transactions on Consumer Electronics 2018. 64(3):390-398.
36. FoodChoice: Application that Displays Information on Nutrition Labels
[<https://www.nectec.or.th/innovation/innovation-mobile-application/foodchoice.html>] Retrieved July 11, 2021.