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Review

Strategies of functional food for hypertension prevention in China

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Hypertension is not only among the common and leading causes of morbidity and mortality in China and the world, but also is the most important modifiable risk factor for life-threatening diseases. Prevalent reasons of hypertension in China involve heredity, obesity, diet with high sodium and low potassium as well as calcium intakes. All modifiable factors cause hypertension is summed up in dietary, especially the loss of functional components from whole grain to polished grain foods for dietary. The functional food with whole grains (germinated brown rice etc.) and functional vegetables (garlic etc.) as well as functional fruits for dietary, especially functional food with high minerals (K,Ca) and low sodium for hypertension prevention in China is necessary, for example barley grass powder.

Key words: Hypertension, functional food, prevention strategies, China.

INTRODUCTION

Hypertension is not only among the common and leading causes of morbidity and mortality throughout the globe (Zhong et al., 2010), but also is the most important modifiable risk factor for life-threatening diseases (Zeng et al., 2011). There were 972 million hypertension patients in the world, accounting for 26.4% of the adult population in 2000 (Kearney et al., 2005). There were 1.5 billion hypertension in the world, accounting for 21.4% of world population and 275 million people with hypertension accounting for 20.0% of Chinese population in 2011. The prevalence of prehypertension and hypertension in the rural adults of Liaoning province of China were 44.1 and 37.8% (Sun et al., 2007). Therefore, prevalence of hypertension in China.

Surgical knife plus pills cannot fundamentally solve hypertension problems. China had total medical costs from 14.32 billion (1980) to 1096.6 billion RMB (2007) (http://wholegrainscouncil.org/files/Yu2011conf.pdf), there in to medical expenditure for hypertension each year in China was 36.6 billion RMB. Functional food between food and medicine has globally propagated since 1993 (Swinbanks et al., 1993). There are a lots of crop against hypertension, such as watermelon, blueberries, sesame oil, walnuts and so on, but lack literature of functional crop. In 2010 the functional food market was worth $24 billion and it is growing by approximately 14% per annum. This review focuses on a wide range of functional foods for hypertension prevention in China and discusses new prevention strategies and causes of hypertension.

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Prevalent reasons of hypertension in China

Hypertension is considered a serious health problem and diet can play an important role in its prevention and treatment (Sánchez et al., 2011). Though, the exact cause of hypertension is not known, many factors such as heredity, obesity, diabetes, hyperlipidemia, abnormal metabolism, unhealthy life-style, stress etc. are associated with hypertension (Zhong et al., 2010). The prevalence of hypertension in market workers at Enugu, Nigeria was 42.2%, which may be explained in part by their sedentary lifestyle, salt-laden fast food and obesity (Ulasi et al., 2011). First of all, heredity is a major factor that causes hypertension. The prevalence of hypertension is in turn black (19.8%) > South Asian

(17.0%) > Chinese (15.1%) > white (13.7%) (Chiu et al., 2010). The epigenetic mechanisms have been involved in essential hypertension by suppression and changing the relational genes with essential hypertension (Zhong et al., 2010). Choi et al. (2011) have identified two novel genetic mutations that can trigger hypertension in up to a third of patients suffering from a common cause of severe high blood pressure. In hypertensive population, the MTHFR gene C677T mutation homozygous may be the important genetic factors to elevated homocysteine and H-high blood pressure and exist gender differences (Zong et al., 2011). The β2-adrenoceptor Arg/Gly gene polymorphism was possibly associated with essential hypertension in Han's nationality from Hebei Province in China (Peng et al., 2010). Myeloperoxidase gene polymorphism was associated with susceptibility of essential hypertension in Chinese population (Fang et al., 2009). The T allele of 573 T>C polymorphism at AT1R gene was possibly the susceptible factors to essential hypertension in Kazakans of Xinjiang (Li et al., 2008). The ADD1 gene G460W polymorphism and eNOS gene G894T polymorphisms are associated with essential hypertension in Mongolia (Wang et al., 2007). A difference in the immunogenetic background between the positive and negative auto antibodies with hypertension or norm tension (Zhu et al., 2011).

Secondly, obesity is the most important risk factor of primary hypertension. Hypertension and diabetes are frequently associated with obesity (Masuo et al., 2011; Luo et al., 2010). Weight loss achieved through lifestyle interventions are safe and moderately effective measures for management of hypertension and diabetes in obesity (Pappachan et al., 2011). β2-Adrenoceptors may regulate blood pressure, sympathetic nervous system and β2- and β3-adrenoceptor polymorphisms in obesity (Masuo and Lambert, 2011). The serum level of adiponectin in old obese patients with essential hypertension was significantly lower than that in the simple obese old subjects (Wang et al., 2008). Waist-to-height ratio is significantly correlated with components of metabolic syndrome and office blood pressure in hypertensive patients (Liu et al., 2010). Serum tumor necrosis factor-α level was increased in hypertensive patients and positively correlated with obesity and insulin resistance (Wang et al., 2010). The risk of hypertension in individuals with central obesity is high than those with normal waist circumference within three body mass index categories (Zhang et al., 2009). Different types of obesity were closely related to the prevalence of hypertension (Jian et al., 2010). Overweight/obesity is an independent risk factor for hypertension, diabetes, dyslipidemia and metabolic syndrome (Zhang et al., 2009).

Third, high sodium and low minerals intakes especially potassium and calcium are the major factor of hypertension caused in China. Dietary Approaches to Stop Hypertension is widely promoted in the USA and UK. The current high-salt intake of 9 to 12 g/d is the major factor increasing blood pressure (He et al., 2011) and a blood pressure-lowering effect through reduced salt intake in hypertensive patients (Matyasa et al., 2011). World Action on Salt and Health's mission from 81 countries is to achieve a reduction in dietary salt intake around the world from the current intake of 10 to 15 g/day to the World Health Organization target of 5 g/day (Webster et al., 2011; http://www.worldactiononsalt.com/). High salt intake in China causes blood pressure increases (Yang et al., 2011). The carbohydrate and sodium intakes were the risk factors of hypertension, but protein, riboflavin, niacin, calcium, phosphorus, zinc, magnesium, potassium and iron were the protective factors for hypertension (Wang et al., 2009). Potassium intake to 4.7 g would shift the population systolic blood pressure distributions to 1.7 to 3.2 mmHg lower (Van Mierlo et al., 2010). The US recommended intake for calcium is 1,000 mg per day for most adults, but 700 mg for UK. Sodium and potassium intake affect metabolic syndrome prevalence, but dietary changes are warranted within hypertension treatment strategies (Teramoto et al., 2011). Low potassium (1.7 g per day) and calcium intake (391 mg per day) may increase risk of hypertension in China. The goal from 2011 to 2015 in China is to reduce salt intake by 3 g per day and increase potassium intake by 2 g per day (Wang, 2011). Potassium citrate has a similar effect on blood pressure as potassium chloride (Zhang et al., 2006). The calcium-activated potassium channels current density attenuate with aging and the attenuation was extremely correlative with the vascular remodeling of hypertension (Kan and Ye, 2006).

Fourthly, some vitamins and functional components deficiency associated with hypertension are the major factor of hypertension caused in China. Anthocyanins and some flavone and flavan- 3-ol compounds may contribute to the prevention of hypertension (Cassidy et al., 2011). Vitamin D deficiency in early life increases arterial blood pressure (Griffin et al., 2011). Low vitamin D levels among black people might be a powerful factor that contributes to the racial differences in hypertension (Fiscella et al., 2011). Percentages of vitamin D deficiency and insufficiency in the middle-aged Chinese population were 69.2% (Lu et al., 2009). Daily intake of 500 mg supplementary vitamin C may have beneficial effects on blood pressure (Nezhad et al., 2009). Treatment with either α- or mixed tocopherols significantly increased blood pressure, pulse pressure and heart rate in individuals with type 2 diabetes (Ward et al., 2007). Combined Ebselen and vitamin E treatment was most affective in protection of heart damage from oxidative stress in the NO-deficient hypertensive rats (Zhou et al., 2008). Fifthly, whole grain to polished grain foods for dietary is the major factor of hypertension caused in China. Low potassium and calcium intake may increase risk of hypertension in China. The elements content loss from brown rice to white rice is Mg (61.8%) >Zn (61.0%) > K (55.9%) > Fe (31.7%) >Ca (31.2%), that is,

magnesium (380,174 tons) >potassium (285,507 tons) >calcium (9,551tons) > zinc (4,045 tons)> iron (1,934 tons) in China, however, magnesium (1,333,945 tons) > potassium (1,001,780 tons)> calcium (33,511 tons) > zinc (14,194 tons)> iron (6,787 tons) in the world, according to calculation based on Zeng et al. (2009a, b) and 198.7 million tons of Chinese and 697.9 million tons of global rice yield in 2010. The loss of functional components associated with anti-hypertension from brown rice to white rice is in turn total flavones (79.20%) > γ- amino-butyric acid (GABA, 78.82%) > total alkaloids (40.55%) (Zeng et al., unpublished data), that is, total flavones (158,648 tons) > total alkaloids (54,652 tons) > GABA (19,942 tons) in China, however total flavones (556,661 tons) > total alkaloids (191,957.85 tons) > GABA (69,971 tons) in the world, according to calculation based on Zeng et al. (2010) and USDA nutrient database (http://www.nal.usda.gov/fnic/foodcomp/search) and 198.7 million tons of Chinese as well as 697.9 million tons of global rice yield in 2010. The nutrition loss associated with anti-hypertension from whole grains to white flour of wheat for dietary is also a major factor that causes hypertension. The nutrition loss in flour milling process from whole wheat flour to make white flour is in turn zinc (98%) > vitamin E (86%) > magnesium (85%) > potassium (77%) > iron (75%) > calcium (60%) (http:// realfoodliving.com/faqs/ wheat-faqs), that is, potassium (4,588,091 tons, 789,151 tons) > magnesium (1,357,042 tons, 233,411 tons) > calcium (156,312tons, 26,886 tons) > zinc (80,455 tons, 13,838 tons) > iron (31,363 tons, 5,394 tons), according to calculation based on USDA nutrient database (http://www.nal.usda.gov/fnic/ foodcomp/search/) and 668 million tons of global and 115 million tons of China wheat yield in 2010.

STRATEGIES OF FUNCTIONAL FOOD FOR HYPERTENSION PREVENTION IN CHINA

Hypertension leads to stroke and heart disease and costs more than $300 billion each year. Adoption of healthy lifestyle modifications has proven to be highly effective in the prevention and treatment of hypertension (Brill, 2011). For recent 40 years, because of the rapid change in lifestyle and diet from whole grain to polished grain foods including good quality production in China, there is concern that hypertension and so on may become epidemic (Zeng et al., 2011).There are 6 established lifestyle interventions for the prevention and treatment of hypertension (Brill et al., 2011). There are lots of functional food for anti-hypertension in China. The following healthy diet is essential in the treatment of hypertension.

First of all, functional food with whole grains is major way of hypertension prevention in China.

1) Brown rice: Brown rice is commonly considered to have an effect on various diseases, especially hypertension. Many researchers have reported that GABA has several physiological functions, especially acting as an antihypertensive (Hayakawa et al., 2002). The high GABA content in brown rice can prevent the increase of blood pressure; the market for brown rice in China is now growing.

The raw and cooked noodles containing germinated brown rice and rice bran contained more GABA contents (2751.6~4176.7 and 5522.0~9617.8 nmol/20 g of fresh noodle, respectively) than those of non-germinated brown rice and rice bran (Kong et al., 2010).

(2) Bean: Under optimal culture conditions, GABA content for germinated fava bean reached up to 2.41 g kg^{-1} dry weight, about 48 times that in raw seeds (Li et al., 2010). The concentrated mung bean sprout juice has potential applications in the preventive management of hypertension (Hus et al., 2011).

(3) Purple corn: The purple corn could be useful in designing health-management programs for hypertension and so on (Ranilla et al., 2009). The solution produced by enzyme from corn protein has anti-hypertensive activity and obtained five angiotensin converting enzyme inhibitor peptides (Li et al., 2006).

(4) Buckwheat: Raw buckwheat extract and germinated buckwheat extract contained a mean content of rutin of 1.52 ± 0.21 and 2.92 ± 0.88 mg/g, respectively; however, germinated buckwheat extract has an antihypertensive effect and may protect arterial endothelial cells from oxidative stress (Kim et al., 2009). The prevalence rate of hypertension consumed buckwheat was 18.22% and consumed corn was 23.31%, therefore, consumption of buckwheat seed may be a preventative factor for hypertension in the pasture land Mongolian population (Zhang et al., 2007).

(5) Barley: Whether high in soluble (barley) or insoluble fiber (whole wheat and brown rice) for whole-grain foods can reduce blood pressure and may help to control weight (Behall et al., 2006).

(6) Oat: The addition of oat cereals to the normal diet of patients with hypertension significantly reduces both systolic blood pressure and diastolic blood pressure; Soluble fiber-rich whole oats may be an effective dietary therapy in the prevention and adjunct treatment of hypertension (Keenan et al., 2002).

Secondly, functional food for some vegetables is a major way of hypertension prevention in China.

(1) Garlic: China is the largest producer and exporter of garlic, which accounting for over 77% of world output. A clove of garlic a day for 12 weeks has great effects in the treatment of hypertension. Aged garlic extract is superior to placebo in lowering systolic blood pressure (Ried et al., 2010). Garlic in moderate dose (250 mg/kg) with added hydrochlorothiazide possesses synergistic cardio-protective and antihypertensive properties (Asdaq et al., 2011). The eating lots of sulfur rich vegetables such as garlic and onions may help protect against hypertension (Yang et al., 2008).

(2) Celery: The effect of apigenin in celery on lowering blood pressure in spontaneously hypertensive rats was related to up-regulating the expression of angiotensin – converting enzyme in kidney (Sui et al., 2010). The roots of Apium graveolens extract can depress blood pressure in rats with renal hypertension (Chai et al., 2010). Celery juice can decrease the systolic blood pressure of renovascular hypertensive rats and relax the rat aortic rings (Tang et al., 2007).
(3) Others: Broccoli sprouts have been shown to reduce blood pressure in rats with hypertension due to the presence of a compound called glucoraphanin (Noyan-Ashraf et al., 2006). Taking a tomato extract supplement may lower blood pressure in people with mildly high blood pressure (Engelhard et al., 2006). *Mentha cordifolia* extract inhibited progress of hypertension in N- nitro-L-arginine methyl ester group and this effect might involve the antioxidant capacity of the extract (Pakdeechote et al., 2011).

Third, functional food for some fruits is a major way of hypertension prevention in China. Anthocyanins and some flavone and flavan-3-ol compounds from blue-berries and strawberries may contribute to the prevention of hypertension (Cassidy et al., 2011). The watermelon supplementation improves aortic hemodynamics through a decrease in the amplitude of the reflected wave in individuals with prehypertension and consumption of 6 g of L-citrulline extract from watermelon extract for six weeks normalized the blood pressure of all nine adults in the study who previously had elevated blood pressure (Figueroa et al., 2011). Olive oil consumption is associated with a reduced risk of hypertension among men from Mediterranean population (Alonso et al., 2004).

Fourth, functional food with high minerals (K, Ca, and Mg) and low sodium is a major way of hypertension prevention in China, such as barley grass powder, beans, almonds, walnuts, peanuts, potato, eggplant, bamboo shoots, seaweed, sesame paste, millet, buckwheat noodles and so on. Barley grass powder is made from the dried young leaves of the barley plant, and is mainly used in hypertension prevention in China, based on it is rich in calcium (330~819 mg/100mg, that is, 482.4□192.3 mg/100mg, n=5), potassium (2400~4300 mg/100mg, that is, 3547.4□627.7 mg/100g), Magnesium (110~235 mg/100g, that is, 73.8□39.7 mg/100g) and Protein (19.9 ~ 29.25%, that is, 25.8%□3.3%) and low sodium (50~405 mg/100g, i.e. 227.2□148.4mg/100g). The amounts of calcium in barley grass powder is apparently more than 50 times the amount of calcium in rice and it's potassium is apparently 34 times the amount in rice, according to calculation based on Zeng et al. (2009a). WHO recom-mends that salt intake per person per day should be controlled in 5 g below. Sodium intakes decreased by 860 mg day^{-1}, meanwhile, systolic and diastolic blood pressure decreased significantly by 4.6 and 3.9 mmHg, respectively (Harnden et al., 2010). The goal from 2011 to 2015 is to reduce salt intake by 3 g (50 mmol Na^+) per day and increase potassium intake by 2 g (50 mmol) per day (Wang, 2011). Bananas with rich in potassium can reduce the risk of high blood pressure (Jha et al., 2011).

CONCLUSIONS AND FUTURE PROSPECTS

Main reasons of the prevalence of hypertension in China are heredity, obesity, diet with high sodium and low potassium as well as calcium intakes, whole grain to polished grain foods for dietary. Prevention and control of hypertension is a large and complex task, but no more so than many of the challenges that have confronted China in its long history and especially in its last 50 years. The strategies of hypertension prevention in China are the functional food with whole grains (germinated brown rice, germinated fava bean, purple corn, barley, buckwheat, oats and so on) and some vegetables (garlic, onions, broccoli sprouts, tomato and so on) as well as fruits (blueberries, strawberries, watermelon and so on) for dietary. The government needs to recommend a high potassium/low sodium diet for functional food. Functional food with high minerals (K, Ca, Mg) and low sodium for hypertension prevention in China is necessary, such as beans, almonds, walnuts, peanuts, potato, eggplant, bamboo shoots, seaweed, sesame paste, millet, buckwheat noodles and so on, especially barley grass powder.

We hope that this type of study will open new areas of research for functional food and hypertension prevention in the world. Our goal is to establish one research center of functional foods with members from the manufacturers, breeding scientists, education, medical and news media, to promote functional foods.

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