

Vegetables as a source of important nutrients and bioactive compounds: their human health benefits

Abstract

Malnutrition is a worst problem in under developing countries and it results because of improper or lack of nutrition. Every year many people die because of malnutrition in different countries. Vegetables are rich source of carbohydrates, proteins, oils, vitamins and minerals. About 200g (Per person/per day) of vegetables are recommended in daily diet. By taking recommended daily amount of vegetables we can reduce the problem of malnutrition. Vegetables besides being a source of important nutrients required to our body for proper functioning, provides many other health benefits by preventing or curing number of chronic diseases such as diabetes, obesity, cancer, neurodegenerative, aging and cardio vascular diseases. It is considered that those people who make sure vegetables to be in their daily diet as an important part are less likely to be susceptible to many diseases. These properties are due to many bioactive compounds present in vegetables such as polyphenols, carotenoids, lycopene, tocopherols, flavanols and phytosterols. Popularity of these bioactive compounds of vegetables increased their use in many field such as food science, nutraceutical companies, agro- chemical companies, cosmetic etc. All of these fields are working to explore potentially active vegetable compounds and improving their application pathways. Our present manuscript is also about to address the maximum health benefits of vegetables for prevention of malnutrition and chronic diseases.

Keywords: malnutrition, phytochemicals, polyphenols, chronic diseases, medicinal plant extracts

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Introduction

Food is a basic need of human beings, animal and plant has been used as a food source. Among different food sources vegetables are very cheap and rich source of different nutrients, besides providing energy to support our daily activities vegetables provide many important compounds those which are biologically very active with numerous health promising benefits for human beings. In different seasons more than 35 different kinds of vegetables are grown in different regions of Pakistan, during winter season a large variety of vegetables lettuce, onion, carrot, turnip, coriander, fenugreek and carrot are available in surplus amount. During spring and summer season brinjal, tomato, gourds, okra, potato, cucumber and chilies are very common. In Pakistan area under vegetable cropping is 0.62million hectare which is about 3.1% of total area under different crops.

Vegetables have at least a substance which helps to prevent or cure any disease such as cancer, cardiovascular disease and diabetes. Many studies have been conducted to show the possible beneficial health effects of vegetables as such whole or their specific bioactive compound against chronic diseases. Bioactive compounds are “Many essential and non-essential compounds those which are very abundantly present in vegetables such as (Vitamins, phytochemicals etc.) and have many beneficial health effects”. From many decades investigations are accelerated on the role of different bioactive compounds in prevention of early stage diseases development especially cancer disease. Among different bioactive compounds polyphenols, carotenoids, lycopene, tocopherols and phytosterols are considered most important in human diet.¹ A red color pigment present in tomatoes helps to maintain prostate gland

health and reduces the risks of cardiovascular diseases, glucosinolates compound of green vegetables, including brussels sprouts, kale, broccoli and allyl sulphides of garlic and onion are associated with prevention of cancer.^{2,3} As these phytochemicals are mostly present in vegetables so it seems to confirm that high intake of vegetables reduces the risk of different type of cancers.^{3,4} These phytochemicals are extremely heterogeneous compounds because of their different structures, distribution in different vegetables, and concentration range in vegetable and human body, site of biological action and effectiveness. Different researcher has been found that increase in daily intake of vegetables in diet reduces the risk of chronic diseases. Bioactive compounds are getting prime importance for their use in many fields such as modern pharmacology, food science, cosmetics, nano-bioscience, agro-chemical etc. All of these areas are working to identify the bioactive compounds resources, synthesis and improving their application pathways.⁵ Our present manuscript is focusing on nutritional and health benefits of different type of vegetables to spread knowledge among the consumers for increase in daily intake of vegetables in their diets.

Polyphenols

There are many phenolic compounds also known as polyphenols (flavonols, anthocyanins, cinnamic acid derivatives) present in vegetables, those which are biologically very active substances. More than 8000 polyphenolic compounds are known up to now. Structurally polyphenolic compounds are made of one or more phenolic rings substituted with many hydroxyl groups.^{6,7} Most of the properties of polyphenolic compounds are expressed by their antioxidant activities by preventing oxidation reaction which is very harmful for health.

Oxidative stress occurs during disease, improper or lack of nutrition. In these situations “Reactive oxygen species” ROS (Hydrogen peroxide, superoxide anion and hydroxyl radicals) play an active role in lipid peroxidation and damage of other very important molecules such as nucleic acid and protein. Hence, many evidence supported the role of polyphenolic compounds in prevention of many diseases such as cardiovascular disease, cancer, neurodegenerative disease

(Parkinson and Alzheimer), inflammatory disorders, premature ageing and diabetes mellitus. Vegetables are set as a first line of control for modern life style associated diseases such as obesity, diabetes and cardiovascular diseases, so vegetables are under investigation for the search of natural compounds as anti-obesity agents and for increase in insulin sensitivity.⁸ Total phenolic contents of different vegetables are given in Table 1.^{9–14}

Table 1 Phenolic content of different vegetables

Sr. No.	Vegetables	Phenolic content mg GAE/100g fresh	References
1	Carrot	96	Marinova et al., ⁹ Deng et al. ¹⁰
2	Okra	153.7	Marinova et al., ⁹ Deng et al. ¹⁰
3	Salad	116.2	Marinova et al. ⁹
4	Lettuce	124.5	Marinova et al., ⁹ Deng et al., ¹⁰ Santos et al. ¹¹
5	Brussels sprout	161.5	Marinova et al., ⁹ Deng et al. ¹⁰
6	Broccoli	101.7	Marinova et al., ⁹ Deng et al., ¹⁰ Santos et al. ¹¹
7	Radish	160	Marinova et al., ⁹ Deng et al. ¹⁰
8	Onion	154.1	Marinova et al., ⁹ Chu et al., ¹² Deng et al. ¹⁰
9	Cabbage	139.3	Marinova et al., ⁹ Chu et al., ¹² Deng et al. ¹⁰
10	Spinach	72	Chu et al., ¹² Proteggente et al., ¹³ Deng et al., ¹⁰ Santos et al. ¹¹
11	Cauliflower	30	Deng et al. ¹⁰
12	Tomato	30	Deng et al. ¹⁰
13	Beetroot	257	Lin and Tang et al. ¹⁴

Nutritional importance of vegetables

Vegetables are one of the important parts of our diet. Vegetables provide nutrient to support our daily life activities. Besides being a source of energy vegetables have many bioactive compound with potential to prevent human diseases. It is considered that those people who make the vegetables a chief part in their daily diet are less likely to be effected by any chronic disease. Vegetables folate is needed by our body for the formation of new red blood cells, potassium helps to maintain normal blood pressure, vitamin A keeps the skin and eyes healthy, vitamin C play its role in wound healing and iron absorption. Vegetables provide many important nutrients, which are very beneficial for health and body maintenance. Human well-being is highly associated with diet which we consume. Now a day's lack of physical activity and high energy diet intake is resulted into several health complications like as diabetes mellitus, obesity and cardiovascular diseases. Vegetables have polyphenols and other bioactive compounds for the prevention of these chronic diseases. By adequate consumption of vegetables and fruits about 2.7 million deaths can be saved.¹⁵ Vegetables are an important source of dietary fibers, although this component of vegetables is not well defined but fiber matrix of vegetables helps to transport bioactive compounds from human gut to colon. Dietary fiber of vegetables helps to lower the cholesterol level in blood and reduces cardiovascular diseases.

Fibers are considered very important for bowel to function properly.¹⁶

Malnutrition and mortality rate in preschool going children's and other susceptible groups is very serious issue in under developing countries and poverty is a main factor of it. As vegetables are the cheapest source of many important carbohydrates, proteins, vitamins and other micro nutrients so we can solve problem of malnutrition by taking a recommended amount of vegetables in our daily diet. Recommended amount of vegetables is 200g per day for a person,¹⁷ but now a days total vegetable consumption amount is very less in many countries. In Pakistan daily vegetables consumption (per person per day) is about 100g which is very lower than recommended amount of 200g.¹⁸ Daily consumption of vegetables (g per person per day) in different countries is given in Table 2.^{19,20}

Table 2 Vegetables consumption in different countries (g per person per day)^{19,20}

Countries	Vegetables (g per person per day)
Estonia	259
Belgium	211

Table continue

Countries	Vegetables (g per person per day)
Norway	211
France	187
Austria	183
Portugal	173
Denmark	159
India	152
Macedonia	144
Croatia	142
Ireland	111
Pakistan	100
Ukraine	87
Latvia	83
Uzbekistan	78
Azerbaijan	46
Kazakhstan	35

Vegetables source of vitamins

Vitamins are essential micronutrients required in very small amount but their presence in our diet is very important. As vitamins

have various kind of functions in human body, they are involved in growth of cells and tissues, function as a cofactor for enzyme or precursor of them and hormone like function for the regulation of different metabolic process of human body. There are two different categories of vitamins, one is water soluble (vitamin B-complex and vitamin C) and other is fat soluble (vitamin A, D, E and K). Different vegetables vitamins and concentrations are given in Table 3.²¹⁻²⁹

Vegetables source of minerals

Minerals are inorganic compounds, required in very minute amount 1 to 2500mg and categorized in two groups macro (Sodium, calcium, phosphorus and chloride) and micro (magnesium, cobalt, iron, copper, zinc, iodine, potassium, molybdenum, selenium, arsenic, chromium, fluoride, manganese and sulfur) elements. All of these minerals are very important for all body tissues and fluids, as calcium is required for bone formation, normal functioning of body muscles and nerves. Sodium, potassium and chlorine are involved in maintains of osmotic balance between body cells and interstitial fluids and phosphorous play its role as an important part of adenosine tri-phosphate, nucleic acid and teeth and bone formation. Iron is a part of hemoglobin; it is a pigment of red blood cells to carry oxygen for body, without iron hemoglobin can't work properly and its deficiency in our body causes anemia disease which result into decrease in oxygen carrying capacity of blood cells. Iodine is needed to develop thyroid hormone in body and magnesium, molybdenum, zinc, copper and selenium act as a co-factor for different enzymes to work properly in different enzymatic pathways. Quantity of macro-minerals required for body is more than 100mg/dl and micro-minerals less than 100mg/dl.³⁰ All of these macro and micro minerals are very important in optimum concentration for body metabolisms and structures. Different macro and micro minerals concentration in different vegetables are given in Table 4.^{22,23,29,31}

Table 3 Vitamins of different vegetables and concentrations (mg/ 100g fresh weight)

Sr. No.	Vegetable	Vitamins		Concentration	Reference
1	Carrot	Vitamin C	Ascorbic acid	1.4-5.8	Sharma et al. ²¹
		Vitamin E	As alpha-tocopherol	0.19-0.7	Arscott et al. ²²
					Hanif et al. ²³
		Vitamin A	Carotenoid as a precursor	0.32-17	
		Vitamin B1	Thiamine	0.05	
		Vitamin B2	Riboflavin	0.05	
2	Tomato	Vitamin B5	Niacin	0.5	
		Vitamin B1	Thiamine	0.1	Hanif et al. ²³
		Vitamin B2	Riboflavin	0.03	Bahorun et al. ²⁴
		Vitamin B5	Niacin	0.5	
3	Onion	Vitamin C	Ascorbic acid	26	
		Vitamin C	Ascorbic acid	18.77	Petropoulos et al. ²⁵

Table continue

Sr. No.	Vegetable	Vitamins		Concentration	Reference
4	Broccoli	Vitamin C	Ascorbic acid	74.81	Bahorun et al. ²⁴ Pellegrini et. ²⁶
5	Cauliflower	Vitamin B1	Thiamine	0.09	Hanif et al. ²³
		Vitamin B2	Riboflavin	0.08	Bahorun et al. ²⁴
		Vitamin B5	Niacin	0.9	Pellegrini et. ²⁶
		Vitamin C	Ascorbic acid	45	
6	Lettuce	Vitamin B1	Thiamine	0.06	Samuolienė et al. ²⁷
		Vitamin B2	Riboflavin	0.1	
		Vitamin B5	Niacin	0.5	
		Vitamin C	Ascorbic acid	10	
7	Chili pepper	Vitamin C	Ascorbic acid	34.44	Bahorun et al. ²⁴
8	Potato	Vitamin C	Ascorbic acid	22-69	Liu et al. ²⁸
		Vitamin B6	Pyridoxine	0.31	Hanif et al. ²³
		Vitamin B1	Thiamine	0.1	
		Vitamin B2	Riboflavin	0.5	
		Vitamin B5	Niacin	1.2	
9	Spinach	Vitamin B1	Thiamine	0.13	Tanumihardjo et al. ²⁹
		Vitamin B2	Riboflavin	0.15	Hanif et al. ²³
		Vitamin B3	Niacin	0.9	Bahorun et al. ²⁴
		Vitamin C	Ascorbic acid	76	
10	Cabbage	Vitamin B1	Thiamine	0.06	Hanif et al. ²³
		Vitamin B2	Riboflavin	0.05	Bahorun et al. ²⁴
		Vitamin B3	Niacin	0.4	
		Vitamin C	Ascorbic acid	55	

Table 4 Amount of macro minerals in 100g of different fresh vegetables

Sr. No.	Vegetable	Fe	K	Na	P	Ca	Reference
1	Carrot	1.4	102	69	35	33	Arscott et al., ²² Tanumihardjo et al., ²⁹ Hanif et al. ²³
2	Sweet potatoes	0.75	240	55	47	30	Arscott et al., ²² Tanumihardjo et al., ²⁹ Hanif et al. ²³
3	Tomato	0.7	114	5	24	10	Arscott et al., ²² Tanumihardjo et al., ²⁹ Hanif et al. ²³
4	Spinach	6	202	79	49	99	Arscott et al., ²² Tanumihardjo et al., ²⁹ Hanif et al. ²³
5	Broccoli			27	66	48	Arscott et al., ²² Tanumihardjo et al. ²⁹
6	Lettuce	1.1	58.5	10	20	18	Arscott et al., ²² Tanumihardjo et al. ²⁹
7	Potato	0.75	240	11.3	46	8	Hanif et al. ²³

Table continue

Sr. No.	Vegetable	Fe	K	Na	P	Ca	Reference
							Luis et al. ³¹
8	Radish	0.7	10	63.9	28	33	Hanif et al. ²³
9	Bottle gourd	0.8	87	1.7	37	12	Hanif et al. ²³

Vegetable role against diseases

Let your food be your first medicine” this old quotation has been serving humans from ancient of times because of its meaningful link between nutrition and well-being. And now in this modern world large number of people are diverting towards natural sources. From ancient of times Chinese, Greeks, Egyptians and Indians has been using plant and their extracts as natural herbal medicines. More over these plant extract are considered as base of modern medication, for example digitalis and aspiril willow for digoxin.³²

Obesity

In our society obesity is a most prevailing disease which causes many other disorders such as cardiovascular diseases, neuropathy, nephropathy and kidney problems. It is spreading and becoming an alarming problem all over the world. There are many definitions and classification of obesity but most acceptable classification is the one that is developed by world health organization (WHO) on the base of body mass index (BMI). According to this classification underweight, normal, over weight (pre-obese), obese, class I obesity, class II obesity and class III obesity are (<18.5), (18.5–24.9), (25.0–29.9), (≥30.0), (30.0–34.9), (35.0–39.9) and (≥40.0) respectively. Among all above mentioned type of obesity class III obesity is very sever and is caused by many inter related factors but most significant are genetic and environmental factor. According to worldwide review it has been estimated that obesity every year resulted into 2.5 million deaths and 320 million peoples are reported as obese by applying the criteria of BMI greater than 30, while 1.1 billion are calculated as overweight having BMI greater than 25.^{33,34} This disease is increasing at very high rate, if it is not controlled along with causing many health complication it has many worst effects on economy. Obesity is a state in which excess fats are stored in our body. There are many factors which are responsible for this disease such as our sedentary life style, eating fast foods etc. But most important is genetic and environmental factor.

Balance diet and different exercises on daily bases are recommended to control body weight. Many drugs are available for the treatment of diabetes. Drawback in use of commercially available drugs such as high cost and side effects of drugs increased the use of herbs for the treatment of many diseases.³⁵ Many researchers have studied the possible impacts of herbs on diabetes.³⁶ studied the impact of green tea on weight loss of 34 chines obese womens and from results it was found that as compare to control there were considerable weight loss of these womens.³⁷ investigated ginger impacts on hypocholesterlaemic, hypoglycemic and hypolipidaemic effects. It was found that herbs have potential for the treatment of obesity. Before insulin discovery in 1920 and other therapeutic agents, diabetes mellitus was treated by diet control and therapeutic plant use. Nutraceutical are defined as the ingredients provide the health benefits along with its own nutrients. The increase in the demand of nutraceutical and functional food is that provide health benefits in such a way to cure and manage the disease. Purpose of using nutraceutical components or products are to achieve

the appropriate outcome with decreasing the harmful effects as compare to other medicine and it has encountered with great economic achievement. Currently, in the food market more than 470 functional and nutraceutical products are available that provides health benefits. These foods stuff are being used for treatment and inhibition of many health disorders that derived from the kingdom plantae. Nutraceutical products may keep the doctor away that is replaced by ancient quotes or apple a day will keep a doctor away.³⁸

Taghizadeh *et al.*,³⁹ Experiment was conducted on supplemented diet containing green tea, capsaicin and ginger extract to investigate their effects on weight loss and metabolism of overweight women. Clinical trials were conducted on 50 overweight women who were divided to 2 groups. Group A (n=25) was given 125mg green tea ,25mg capsaicin and 50 mg of ginger extract while group B (n=25) were given placebos twice in lunch and twice in dinner for the duration of 8 weeks. From the results it was found that supplemented diet containing green tea, capsaicin and ginger decreased the weight (−1.8±1.5 vs. +0.4±1.2 kg) and body mass index(−0.7±0.5vs. +0.1±0.5 kg/m²). It was also studied that in those subjects which were given green tea, capsaicin and ginger extract considerable decrease in serum insulin concentration (−2.6±3.9 vs. −0.6±2.0μ IU/mL) and increase in insulin sensitivity(+0.01±0.01 vs. +0.001±0.01) were found.

A research was carried out to evaluate the occurrence of obesity among students of medical field of Malaysia. Total 240 students including 122 boys and 118 girls were enrolled and their height and weight was measured and BMI was calculated. Their gender, age, ethnicity, frequency of exercise and entertainment and number of meals were also recorded. The results indicated that mean weight height and BMI of students were 69 kg, 166.1 cm and 21.8 kg/m² respectively. 68.8% participants were found to be heaving normal body weight and 16.1% were either overweight or obese based on the world health organization international classification of body weight. Furthermore 15% participants were found as underweight 55% participants were found as normal body weight, 30% were found as overweight as per the world health organization. Out of overweight subjects neither obese grade 2 nor grade 3 were found. Boys were found more significantly overweight or obese as compare to girls and importantly high percentage of girls was found under weight. Results also indicated that high number of overweight/obese participant did not take their breakfast as related to normal weight participants. Over weight/obese participant had extra carbonated beverages and less intake of breakfast in week than normal weight participants.⁴⁰

According to an epidemiological study of world the incidence of obesity has doubled globally from past 35 years. In 2014 11% males and 15% females aged 18 or above were obese, in year of 2013 52 million children having age less than 5 years found to be overweight. About 36% population of US having age 20 years is obese, where as 34.3% males and 38.3% females are obese and obesity among population of US varies by socioeconomic status, gender and race. Adult population of Canada has lower obesity rates as compare to

US, in 2011–2014 the prevalence of obesity in child's of America was 17% and it also differs by race, gender and age. Frequency of childhood obesity in Canadian population is also lower as compare to US by gender.⁴¹

A study was carried out in the Shandong province of china to evaluate the occurrence of obesity in their children's and adolescents. Total 30459 students (15210 girls, 15249 boys) were included in this study from 17 different districts of Shandong having age between 7 to 18 years old. All the students were found primary and secondary schools and in the study 3 rural and 3 urban public schools were included from each of 17 districts. All data or measurements were taken by expertise. Physical parameters such as weight, height and BMI as well as waist circumference were evaluated. The findings of this study expressed as that the incidence of general obesity 10.99%, central obesity 8.47% and combined obesity 8.70% was in boys. Whereas general obesity 9.47%, central obesity 5.12% and combined obesity 3.20% were in girls. These findings showed that the frequency of obesity is more in males as compare to females. The overall 3 types of obesity are higher in boys with percentage of 28.16 then girls 17.78%. The incidence of these 3 types of obesity regarding to age and gender were as followed , for children 7–12 years old 33.33 % in boys and 22.22 % in girls whereas for 13–18 year old 22.33 % in males and 12.68 % in females. This showed that the presence of obesity is more in children than adolescents. According to the area the more incidence of obesity were 25.60% in males and 16.53% in females which showed that frequency of obesity is more in children and adolescents of urban area as compare to rural area.⁴²

A survey based study was carried out in Sweden to evaluate the incidence of obesity in elderly people aged 65 to 99 years. In this study 2558 subjects who were male and female were selected and data related to their height, weight, BMI, physical activity, physical mobility and intake of fruits and vegetables were collected. The results showed that according to BMI 15% females and 9% males were underweight where as 19% females and 15% males were obese while 48% males and 38% females were overweight. According to physical activity, elders were more obese 22% with inactive physically and less obese 13% with physical active. According to physical mobility the elders were more obese 28% who was impaired physical mobility as compare to physical mobility 14% were obese. The study is also indicated that there was found a connection between physical mobility, physical activity and obesity.⁴³

A research was carried out in India to check the incidence of overweight and obesity and central obesity among university students. In this study 800 students were enrolled in which 541 were boys and 259 were girls aged 17–20 years. Anthropometric measurements were taken by trained team, which were included height, weight, BMI and waist circumference. Dietary habits, fruits and vegetables consumption and 24 hours dietary recall were collected from all participants. The results showed that median body mass index was 21.7 and waist circumference was 78.7 cm, these both parameters were higher in males as compare to females. Overall prevalence of underweight was 11.7%, over weight 26.8% and obesity was 10.7%. More boys were overweight then girls and central obesity 16.4% was more in girls as compare to boys. According to this study 21% students took 5 or more than 5 serving of vegetables and fruits a day, 65.2 % students took their breakfast regularly, 84.8% students took limited amount of red meat, 30% students try to take fiber and 31.5% students avoided to take cholesterol and fat, 80.2 % students did moderate to high physical activity.⁴⁴

A study was conducted in the Lalitpur district of Nepal to check the incidence of overweight and obesity in primary school. Out of 125 schools 7 schools were selected for the study and 986 student's aged 6–13 years were enrolled in this study. Data was collected by the research assistant. Anthropometry, height and weight were measured and BMI was calculated by using height and weight. The findings of study concluded that the incidence of overweight and obesity among children were 25.90%. Out of this 14.6 % children were overweight where as 11.3% children were obese.⁴⁵

A study was concluded to assess the role of obesity in etiology of diseases which are related to arsenic. In that study 960 subjects 35 to 69 years old were enrolled from Canada. Their BMI was calculated by measuring the weight and height as well as their waist circumference, body fat, fat mass and fat free mass was also analyzed. Data was collected related to intake of protein and inorganic arsenic as well as their dietary behavior like ingestion of fruits, whole grains, vegetables, eggs, and dairy products. The results indicated that younger males and those who were from Cape Breton Island were show more score on dietary pattern score related to obesity as compare to those who lived in main land Nova Scotia, elderly people as well as women. The score was positively associated to waist circumference, body fat %, fat mass index, fat free mass index, BMI as well as overweight and obesity and also abdominal obesity. The results also indicated that there was negative association between the level of arsenic concentration, the presence of high amount of arsenic in toenail clippings and dietary pattern score.⁴⁶

A study was held at Jalalabad city in Afghanistan to estimate the occurrence of obesity and obesity associated factors. For this purpose 1200 subjects having age between 25 to 65 years of both genders were enrolled. BMI was calculated by using the measurement of their weight and height and waist circumference was also measured. Waist circumference was used to identify the central obesity. Other parameters such as blood pressure were also measured by using the sphygmomanometer. Samples of blood were collected at fasting for biochemical analysis like blood sugar, cholesterol, LDL, triglyceride and HDL. The data was examined by the help of STSS software version 20. The results indicated that 29.4% study individuals eat 3 or more than 3 servings of fruits in a week and 78.8% study subjects eat 3 or more than 3 servings of vegetables in a week. About 51.95% were using solid fat for cooking and 21.2% oil for cooking. About 35.8% study individual was strongly active and 69.8% were moderately active where as 35% has sedentary life style. The results also indicated that 6.1% were under weight, 34.4% were normal weight, 32.1% were overweight as well as 27.4% were obese. Moreover according to waist circumference, central obesity was 51.5%. Weight, height and waist circumference were higher in men as compare to women whereas mean BMI was high in females as compare to males. Triglycerides and LDL cholesterol were importantly different in men as compare to women. The difference in serum concentration of glucose, cholesterol and HDL were not significant. The relation between total glycerides and obesity was significant where as other types of lipids were not significant relation. The results also indicated that weight, height, BMI, cholesterol, triglycerides, LDL, HDL and blood pressure were different importantly between obese individual and non-obese individual.⁴⁷

A research work was established to analyze the incidence of obesity and its relation to metabolic diseases like diabetes mellitus and hypertension. This study used data from different countries like Pakistan, India, china, South Africa, Uruguay, Argentina, Bangladesh,

chili and Peru. Total 31118 subjects having age between 20 to 79 years were enrolled. The results indicated that the highest occurrence of general obesity was presence in cities of south Asia where as highest prevalence of obesity was found in South America. A proportion of general obesity was lower than proportion of central obesity, 11%–22% and 19%–79% respectively. Every standard deviation high in body mass index was related to 1.65 times higher probability of diabetes mellitus in men and 1.60 times was highest in women of 40 to 69 year olds where as 1.42 times higher possibility of hypertension in men and 1.28 times in women of 42 to 69 year olds.⁴⁸

A study was carried out on adolescent of turkey to evaluate the dietary behavior as a risk of cardiovascular diseases. Total 300 students from different public high schools were enrolled whereas 135 students were boys and 165 were girls aged 12 to 19 years old. The findings showed that 20.7% males and 17.5% females were overweight while 22.2% boys and 18.2% girls were smokers. About 22.2% boys were significantly more physical active as compare to girls only 10.3%. About 48.2% boys and 52.1% girls were moderately active whereas 29.6% boys and 37.6% girls were physically inactive. In average intake of energy, almost 1876 Kcal were consumed per day. Consumption of more energy intake was found in boys than girls. Intake of vitamins like E, B6 and folic acid was also less than normal recommended range. Intake of vegetables and fruits was also low.⁴⁹

A research based study was conducted to assess the incidence of obesity on dyslipidemia and high blood pressure in type 2 diabetic people. Total 157 subjects were enrolled and their measurements were taken. Blood samples of all participants were collected for biochemical analysis of lipid profile and blood pressure was also measured. The results indicated that 36.9% obesity was found by using body mass index and 68.8% by using waist circumference. About 91.7% subjects were using oral hypoglycemic medicines, 51% were using antihypertensive medicine and 54.1% subjects were using lipid lowering medicines. Risk of abdominal obesity had more in subjects with BMI greater than 30 kg/m² as compare to those who had less than 30 kg/m². Blood pressure was similar in both subjects either with or without general obesity. Subjects with central obesity had 5.5 times more chances of elevated diastolic blood pressure. High level of physical activity in diabetic subjects showed reverse relation with central obesity. The level of triglycerides was high with general obesity as well as central obesity. Risk of central and general obesity was found high in women as compare to men. Results indicated that women subjects were more vulnerable to obesity and hypertension and their relation was found with general and central obesity.⁵⁰

Scenario of obesity in Pakistan

A cross sectional research study was carried out in 12 primary schools of Lahore to evaluate the frequency of overweight and obesity in children having age 5 to 12 years. In this study 1860 children were enrolled from different primary schools of Lahore to check the overweight and obesity in children. The most popular method BMI was used. For data collection selected schools were visited prior to study. About 75 % children were from urban areas where as 25% children from rural area. The study showed that 17% were overweight whereas 7.55% found to be obese. Furthermore 2% children were severe obese. Boys were more over weight as compare to girls and mostly boys were obese than girls.⁵¹

A research work was designed in university of Punjab, Pakistan. to evaluate the presence of PONC R236G mutation in Pakistani population. For this purpose 475 individual were recruited in this

study out of 475, 250 subjects were selected as case groups and 225 were as control group. Serum blood samples were collected from the entire participants for the analysis of blood concentration of glucose, insulin, leptin concentration and lipid profile. Half blood sample were used to isolate the DNA and reaming half sample were used to get serum. The results indicated that level of blood glucose, leptin , insulin, blood pressure as well as lipid profile was high in case group as compare to control group. Only one subject from case group was detected that having R236G mutation and there was no subject from control group.⁵²

Another research was carried out to estimate the perception, knowledge and attitude of the students of dental surgery about obesity. This study was conducted on the students of Riphah international university, Islamabad and total 218 subjects were enrolled in this study. Out of 218 students 63.3% were girls and 36.7% were boys. All the participants were asked to fill the self-administered questionnaire which varying from strongly agree to strongly disagree. The questionnaire comprise of three section, perception, knowledge and attitude. Data was analyzed by using SPSS software. The results indicated that 79% students told that they have only 0 to 1 hour for education related to obesity as a part of their study course. About 70.6 % students replied positively when they were asked that whether they had any course attended regarding to health in understanding obesity. About 69.6% students were thought that obesity is a medical condition and 22% students were able to describe obesity. All of them only 30% students were agreed to make special place in their offices for obese person and lot of student stated that the dietary assessment of their patients is very important. Nearly 47% students showed their interest in courses related to obesity in dental institution. More than half of the students were showed uncomfortable to examine the obese patients and asked about their dietary behavior.⁵³

A study was held for research purpose on Pakistani individuals to check association between obesity related gene and HDL and LDL. In this study 475 subjects were enrolled in which 250 were obese and 225 were normal or controlled. Their data regarding to physical activity, exercise, job nature and dietary habits was recorded. Up to the completion of study samples of blood were taken from every subject and each sample was divided into 2 groups, 1 group for DNA isolation and 1 group for biochemical parameter. Data was analyzed by using SPSS software. The results indicated that there was a minor allele frequency more in obese subjects than to no obese. There was no relationship found regarding to age or sex in single nucleotide polymorphism in study subjects. Results also indicated that the relationship was found between rs3551812 and obesity in population of Pakistan. The subject with GT and TT genotype were high in obese subjects than to control group, there was a high number of subjects with GG genotype and very low with TT genotype showed that a single nucleotide polymorphism had significant role in developing obesity in the population of Pakistan.⁵⁴

A survey based study was conducted in the rural areas of Pakistan to evaluate the frequency of dyslipidemia, obesity and metabolic syndrome. Total 1658 volunteers were selected from 44 villages of Pakistan aged between 20 or above. From which 600 subjects were men and 1058 subjects were women, their data like age, name and gender was recorded. Their body fat and blood pressure were also measured. After the completion of study blood sample from all individual were collected for biochemical analysis. The results indicated that there was a high incidence of hypertension, IFG, IGT and diabetes mellitus. The prevalence of cholesterol, triglycerides

and LDL were high whereas HDL was low. Women had high value of LDL, total cholesterol and triglycerides whereas values of HDL were similar. Results also indicated that all values of lipid profile were increased with age except HDL cholesterol.⁵⁵

An experimental research was held on peoples living in Karachi, Pakistan to evaluate the effects of genetic difference in FTO gene on obesity related traits and type 2 diabetes mellitus. For the purpose 296 subjects with type 2 diabetes mellitus and 198 individual as a control group was enrolled. Their age was equal or more than 45 years. Individual with heart, kidney and liver diseases were excluded as well as those having type 1 diabetes mellitus and pregnant women were not included in this study. DNA was also isolated from blood and data was analyzed by using SPSS software. The results indicated that subjects with type 2 diabetes had importantly high level of weight. Experiment group had high level of systolic blood pressure, blood concentration of glucose and triglycerides where as low level of HDL as compare to control group. The incidence of overweight, obesity as well as abdominal obesity was higher in individuals with type 2 diabetes than control individuals. The incidence of “A” allele of FTO gene was importantly high in diabetic people as compare to non-diabetic peoples.⁵⁶

Diabetes

Diabetes is a metabolic disorder results due to hypoglycemia because of decrease in insulin secretion or its sensitivity. Diabetes mellitus is responsible for large number of mortalities every year. If it is left uncontrolled can affects other body organs such as kidney, heart, blood vessels, nerves and eyes (Surayia *et al.*)⁵⁷ Most of time diabetes is categorized in two main types, Type 1 diabetes which results because of insufficient or complete diminish in secretion of insulin; and Type 2 diabetes which is caused by both decrease in insulin secretion and its sensitivity. Type 2 diabetes is considered more common while type 1 develops in children. Overall both type of diabetes results into increase in blood glucose level and main reasons of this are lack of physical activity, sedentary life style, high energy diet and obesity.^{58,59,60} Besides malfunctioning in carbohydrates, proteins and lipids metabolism, diabetes may also results into many other complication like as immune dysfunction, oxidative stress and cardiovascular diseases.⁶¹ Cardiovascular diseases are highly associated with major reasons of mortality all over the world. More over increase in low density lipoprotein (LDL) oxidation and high level of cholesterol initiates atherosclerosis.⁶²

Although there are many synthetic medicines which are available in markets but because of their chemical side effects and decrease in their effectiveness has changed people mind to use herbal medicines for diabetes and its related complications.⁶³ Selection of diet and physical activities are most important strategies those which are highly recommended by physician in case of diabetes and its associated complications including stress, dysfunction and cardiovascular diseases. There are many vegetables those which play their very active role against diabetes by lowering body weight and blood glucose level. Sulfur containing compounds (thiosulfonates and cysteine sulfoxides) of garlic has been reported as antidiabetic (Lawson *et al.*, 2001).⁶⁴ Allin is a main bioactive compound of garlic which helps in reduction of glucose and cholesterol level of blood.^{65,66} Many studies have shown the possible effects of ginger, garlic and onion against diabetes by lowering blood glucose, alanine aminotransferase (ALT), aspartate aminotransferase (AST) and lactate dehydrogenase (LDH) enzymes action.⁶⁷⁻⁶⁹

Cardiovascular diseases

Cardiovascular diseases are one of the chief reasons for powerlessness and early deaths around the globe, frequency of CVDs ascends with continuing time. It has been normal that by the year 2020, the frequency of CVDs will ascend by 75% with predominance. About 17.3 million mortalities are reported due to CVDs and that number is supposed to be reached to 23.6 million by 2030 year. Among different problems because of CVDs financial and social problems has extended the load on family sufferings, economic yield, medicinal services framework and Disability Adjusted Life years (DALYs) all around the world.⁷⁰ In Pakistan number of people suffering with this dangerous disease is increasing as a result of undesirable dietary practices, poor sanitation and cleanliness homes, brisk urbanization, deficient resources, nonappearance of physical action and destructive way of life. Females impart a more prominent mass of CVDs than males in view of inert way of life, regenerative strain and poor dietary administration. In Pakistan, CVDs speak to 19% of the extensive number of deaths event among people of 30–70 year.⁷¹ Obesity is the most well-known nutritious issue, obesity causes cardiovascular and vascular sickness.⁷² A sound eating program is a vital component to keeping up and enhancing general safety. The relationship of physical inertia and hoisted body mass index (BMI) with cardiovascular infection (CVDs) hazard is entrenched. The relationship dietary caloric admission and CVDs hazard is less sure and presumed that obesity and lower level of physical moment were autonomously related with diminished CVDs survival. Besides, when BMI, physical action, and other significant attributes were considered, intake of calories was not identified with CVDs mortality.⁷³ The long standing affiliation exist between lifted triglyceride levels and cardiovascular disorder (CVDs).⁷⁴ Vegetables have various kind of agents such as polyphenols, carotenoids, flavonoids and glucosinolates have an immediate connection with prevention of CVDs and other related complications.⁷⁵ Evidence has been proposed that diet including in vegetables help in lowering the risk of cardiovascular disease and stroke. These properties of vegetables are due to their multiple very beneficial compounds including polyunsaturated fatty acids, n-3 fatty acids, vitamins, minerals, antioxidants, phytochemicals, plant protein and fiber. Such type of diets are recommended to prevent cardiovascular and many other chronic diseases.⁷⁶ Isothiocyanate compounds of cruciferous vegetables, organosulfur of garlic and onions have been well known for cardio protective effects. Tomato and its product contain lycopene which helps to prevent cancer and cardiovascular diseases.⁷⁷⁻⁸³

Conclusion

This manuscript is about nutritional and health benefits of different kind of vegetables. Vegetables being source of very important nutrients are highly recommended for dietary intake. Besides providing nutrition to support healthy activities of life, most of vegetables provide biologically very active compounds (Vitamin, polyphenols, flavanol etc.) those which are involved in prevention and cure of many chronic diseases such as diabetes, obesity and cardiovascular diseases. Many researchers have been investigating the role of these vegetable bioactive compounds for human benefits from many decade and their studies have revealed that those people who considers vegetables as an important part of diet are less likely to get any chronic disease.

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Conflicts of interest

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References

- Carbonell-Capella JM, Buniowska M, Barba FJ, et al. Analytical methods for determining bioavailability and bioaccessibility of bioactive compounds from fruits and vegetables: A review. *Comprehensive Reviews in Food Science and Food Safety*. 2014;13(2):155–171.
- Heber D. Vegetables, fruits and phytoestrogens in the prevention of diseases. *Journal of Postgraduate Medicine*. 2004;50(2):145–149.
- Joseph OI, Emmanuella BT, Babatunde HJ, et al. Effect of drying methods on the quality of tomato and pepper powder. *BAOJ Food Sci & Tec*. 2017;1(2):008.
- Biesalski HK, Dragsted LO, Elmadfa I, et al. Bioactive Compounds: Definition and Assessment of Activity. *Nutrition*. 2009;25(11-12):1202–1205.
- Guaadaoui A, Benaicha S, Elmajdoub N, et al. What is a bioactive compound? A combined definition for a preliminary consensus. *International Journal of Nutrition and Food Sciences*. 2014;3(3):174–179.
- Helmja K, Vaher M, Gorbatoeva J, et al. Characterization of bioactive compounds contained in vegetables of the Solanaceae family by capillary electrophoresis. *Proc. Estonian Acad. Sci. Chem*. 2007;56(4):172–186.
- Ignat I, Volf I, Popa VI. A critical review of methods for characterisation of polyphenolic compounds in fruits and vegetables. *Food chem*. 2011;126(4):1821–1835.
- Kotowska DE. Health promoting effects of bioactive compounds in plants. *University of Copenhagen*. 2013.
- Marinova D, Ribarova F, Atanassova M. Total phenolics and total flavonoids in Bulgarian fruits and vegetables. *Journal of the University of Chemical Technology and Metallurgy*. 2005;40(3):255–260.
- Deng GF, Lin X, Xu XR, et al. Antioxidant capacities and total phenolic contents of 56 vegetables. *Journal of functional foods*. 2013;5(1):260–266.
- Santos J, Oliveira MBPP, Ibáñez E, et al. Phenolic profile evolution of different ready-to-eat baby-leaf vegetables during storage. *Journal of Chromatography A*. 2014;1327:118–131.
- Chu YH, Chang CL, Hsu HF. Flavonoid content of several vegetables and their antioxidant activity. *Journal of the Science of Food and Agriculture*. 2000;80(5):561–566.
- Proteggente AR, Pannala AS, Paganga G, et al. The antioxidant activity of regularly consumed fruit and vegetables reflects their phenolic and vitamin C composition. *Free Radic Res*. 2002;36(2):217–233.
- Lin JY, Tang CY. Determination of total phenolic and flavonoid contents in selected fruits and vegetables, as well as their stimulatory effects on mouse splenocyte proliferation. *Food Chemistry*. 2007;101(1):140–147.
- Javed IM, Abbas A, Nawaz F, et al. Different kind of food products development and physicochemical analysis. Pakistan: MedCrave Group LLC; 2018.
- Asif M. The role of fruits, vegetables, and spices in diabetes. *International Journal of Nutrition, Pharmacology, Neurological Diseases*. 2011;1(1):27–35.
- Keatinge JDH, Yang RY, Hughes JDA, et al. The importance of vegetables in ensuring both food and nutritional security in attainment of the Millennium Development Goals. *Food Security*. 2011;3(4):491–501.
- Khokhar KM. Production status of major vegetables in Pakistan, their problems and suggestions. *Agriculture Corner*. 2014.
- Kearney J. Food consumption trends and drivers. *Philos Trans R Soc Lond B Biol Sci*. 2010;365(1554):2793–2807.
- Sachdeva S, Sachdev TR, Sachdeva R. Increasing fruit and vegetable consumption: challenges and opportunities. *Indian J Community Med*. 2013;38(4):192–197.
- Sharma KD, Karki S, Thakur NS, et al. Chemical composition, functional properties and processing of carrot-a review. *J Food Sci Technol*. 2012;49(1):22–32.
- Arscott SA, Tanumihardjo SA. Carrots of many colors provide basic nutrition and bioavailable phytochemicals acting as a functional food. *Comprehensive Reviews in Food Science and Food Safety*. 2010;9(2):223–239.
- Hanif R, Iqbal Z, Iqbal M, et al. Use of vegetables as nutritional food: role in human health. *Journal of Agricultural and Biological Science*. 2006;1(1):18–22.
- Bahorun T, Luximon-Ramma A, Crozier A, et al. Total phenol, flavonoid, proanthocyanidin and vitamin C levels and antioxidant activities of mauritian vegetables. *Journal of the Science of Food and Agriculture*. 2004;84(12):1553–1561.
- Petropoulos SA, Fernandes A, Barros L, et al. Morphological, nutritional and chemical description of “Vatikiotiko”, an onion local landrace from Greece. *Food chem*. 2015;182:156–163.
- Pellegrini N, Chiavaro E, Gardana C, et al. Effect of different cooking methods on color, phytochemical concentration, and antioxidant capacity of raw and frozen brassica vegetables. *J Agric Food Chem*. 2010;58(7):4310–4321.
- Samuolienė G, Sirtautas R, Brazaitytė A, et al. LED lighting and seasonality effects antioxidant properties of baby leaf lettuce. *Food chem*. 2012;134(3):1494–1499.
- Liu RH. Health-promoting components of fruits and vegetables in the diet. *Adv Nutr*. 2013;4(3):384S–392S.
- Tanumihardjo SA. Food-based approaches for ensuring adequate vitamin A nutrition. *Comprehensive Reviews in Food Science and Safety*. 2008;7:373–381.
- Soetan KO, Olaiya CO, Oyewole OE. The importance of mineral elements for humans, domestic animals and plants-A review. *African journal of food science*. 2010;4(5):200–222.
- Luis G, Rubio C, González-Weller D, et al. Comparative study of the mineral composition of several varieties of potatoes (*Solanum tuberosum* L.) from different countries cultivated in Canary Islands (Spain). *International journal of food science & technology*. 2011;46(4):774–780.
- Robbers JE, Tyler VE. Tyler’s herbs of choices the therapeutic uses of phytochemicals. CBS. Publ. New Delhi India. 2002;20–51.
- Ahmed A, Shehab NA. Obesity medical management. *Int. j. Res. in Ayurveda Pharm*. 2014;5(1):69–73.
- Alam DS, Talukder SH, Chowdhury MA, et al. Overweight and abdominal obesity as determinants of undiagnosed diabetes and pre-diabetes in Bangladesh. *BMC obes*. 2016;3:19.
- Adeneye AA, Agbaje EO. Hypoglycemic and hypolipidemic effects of fresh leaf aqueous extract of *Cymbopogon citratus* Stapf in rats. *J ethnopharmacol*. 2007;112(3):440–444.

36. Chan CC, Koo MW, Ng EH, et al. Effects of Chinese green tea on weight, and hormonal and biochemical profiles in obese patients with polycystic ovary syndrome—a randomized placebo-controlled trial. *J Soc Gynecol Investig.* 2006;13(1):63–68.
37. Al-Amin ZM, Thomson M, Al-Qattan KK, et al. Anti-diabetic and hypolipidaemic properties of ginger (*Zingiber officinale*) in streptozotocin-induced diabetic rats. *Br j nutr.* 2006;96(4):660–666.
38. Singh R, Cuervo AM. Lipophagy: connecting autophagy and lipid metabolism. *International journal of cell biology.* 2012;12.
39. Taghizadeh M, Farzin N, Taheri S, et al. The effect of dietary supplements containing green tea, capsaicin and ginger extracts on weight loss and metabolic profiles in overweight women: A randomized double-blind placebo-controlled clinical trial. *Ann Nutr Metab.* 2017;70(4):277–285.
40. Boo NY, Chia GJ, Wong LC, et al. The prevalence of obesity among clinical students in a Malaysian medical school. *Singapore med j.* 2010;51(2):126–132.
41. Arroyo-Johnson C, Mincey KD. Obesity epidemiology worldwide. *Gastroenterol Clin North Am.* 2016;45(4):571–579.
42. Jie Z, Xia H, Zhong SL, et al. The gut microbiome in atherosclerotic cardiovascular disease. *Nat commun.* 2017;8(1):845.
43. Asp M, Simonsson B, Larm P, et al. Physical mobility, physical activity, and obesity among elderly: findings from a large population-based Swedish survey. *Public health.* 2017;147:84–91.
44. Pengpid S, Peltzer K. Prevalence of overweight/obesity and central obesity and its associated factors among a sample of university students in India. *Obes Res Clin Pract.* 2014;8(6):e558–e570.
45. Koirala M, Khatrri RB, Khanal V, et al. Prevalence and factors associated with childhood overweight/obesity of private school children in Nepal. *Obesity research & clinical practice.* 2015;9(3):220–227.
46. Yu ZM, Fung B, Murimboh JD, et al. What is the role of obesity in the aetiology of arsenic-related disease? *Environ int.* 2014;66:115–123.
47. Borgeson E, Johnson AM, Lee YS, et al. Lipoxin A4 attenuates obesity-induced adipose inflammation and associated liver and kidney disease. *Cell metab.* 2015;22(1):125–137.
48. Patel VB, Mori J, McLean BA, et al. ACE2 deficiency worsens epicardial adipose tissue inflammation and cardiac dysfunction in response to diet-induced obesity. *Diabetes.* 2016;65(1):85–95.
49. Baş M, Altan T, Dinçer D, et al. Determination of dietary habits as a risk factor of cardiovascular heart disease in Turkish adolescents. *Eur J Nutr.* 2005;44(3):174–182.
50. Anari R, Amani R, Latifi SM, et al. Association of obesity with hypertension and dyslipidemia in type 2 diabetes mellitus subjects. *Diabetes Metab Syndr.* 2017;11(1):37–41.
51. Mushtaq Q, Inam M. December. LA. Semigroup. In Proceedings of the International Conference on Algebra 2010: Advances in Algebraic Structures. 2011;22:442–448.
52. Shabana, Hasnain S. The p. N103K mutation of leptin (LEP) gene and severe early onset obesity in Pakistan. *Biol res.* 2016;49:23–28.
53. Khan AR, Awan FR. Leptin resistance: a possible interface between obesity and pulmonary-related disorders. *Int J Endocrinol Metab.* 2016;14(1):e32586.
54. Qureshi AI, Palesch YY, Barsan WG, et al. Intensive blood-pressure lowering in patients with acute cerebral hemorrhage. *N Engl J Med.* 2016;375(11):1033–1043.
55. Zahid A, Akbar AM, Abid AR, et al. Frequency of complete heart block in acute inferior wall myocardial infarction and its relation with severe obstructive disease of the infarct related artery. *Journal of Cardiovascular Disease.* 2008;10:114–117.
56. Fawwad A, Siddiqui IA, Basit A, et al. Common variant within the FTO gene, rs9939609, obesity and type 2 diabetes in population of Karachi, Pakistan. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews.* 2016;10(1):43–47.
57. American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes care.* 2014;37(S1):s81–s90.
58. American Diabetes Association. Standards of medical care for patients with diabetes mellitus. *Diabetes care.* 2002;25(S1):s33–s49.
59. Yajnik CS. The insulin resistance epidemic in India: fetal origins, later lifestyle, or both? *Nutrition reviews.* 2001;59(1):1–9.
60. Craig ME, Hattersley A, Donaghue KC. Definition, epidemiology and classification of diabetes in children and adolescents. *Pediatr diabetes.* 2009;10(S12):3–12.
61. Rana JS, Nieuwdorp M, Jukema JW, et al. Cardiovascular metabolic syndrome—an interplay of, obesity, inflammation, diabetes and coronary heart disease. *Diabetes Obes Metab.* 2007;9(3):218–232.
62. Matsuura E, Hughes GR, Khamashta MA. Oxidation of LDL and its clinical implication. *Autoimmun rev.* 2008;7(7):558–566.
63. Zakir S, Sarwar, M, Allen, J, et al. Impact of sweet potato cultivars on blood glucose level in diabetic and healthy participants. *International Journal of Agriculture and Biology.* 2008;10(3):316–320.
64. Tapiero H, Townsend DM, Tew KD. Organosulfur compounds from alliaceae in the prevention of human pathologies. *Biomed pharmacoth.* 2004;58:183–193.
65. Chowdhury SR, Chowdhury SD, Smith TK. Effects of dietary garlic on cholesterol metabolism in laying hens. *Poult Sci.* 2002;81(12):1856–1862.
66. Sterling SJ, Eagling DR. November. Agronomics and allicin yield of Australian grown garlic (*Allium sativum*). In II International Symposium on Edible Alliaceae. 1997;555(6):63–73.
67. El-Demerdash FM, Yousef MI, El-Naga NA. Biochemical study on the hypoglycemic effects of onion and garlic in alloxan-induced diabetic rats. *Food Chem Toxicol.* 2005;43(1):57–63.
68. Bhandari U, Kanojia R, Pillai KK. Effect of ethanolic extract of *Zingiber officinale* on dyslipidaemia in diabetic rats. *J ethnopharmacol.* 2005;97(2):227–230.
69. Ahmed RS, Seth V, Banerjee BD. Influence of dietary ginger (*Zingiber officinale* Rosc) on antioxidant defense system in rat: comparison with ascorbic acid. *Indian J Exp Biol.* 2000;38(6):604–606.
70. Amiri M, Majid HA, Hairi F, et al. Prevalence and determinants of cardiovascular disease risk factors among the residents of urban community housing projects in Malaysia. *BMC Public Health.* 2014;14(S3).
71. WHO/UNICEF. Progress on drinking water and sanitation Joint Monitoring Programme update 2014. World health organization. 2014; 1–78 p.
72. Hall JE, Crook ED, Jones DW, et al. Mechanisms of obesity-associated cardiovascular and renal disease. *The American journal of the medical sciences.* 2002;324(3):127–137.
73. Fang J, Wylie-Rosett J, Cohen HW, et al. Exercise, body mass index, caloric intake, and cardiovascular mortality. *American journal of preventive medicine.* 2003;25(4):283–289.
74. Miller M, Stone NJ, Ballantyne C, et al. Triglycerides and cardiovascular disease: a scientific statement from the American Heart Association. *Circulation.* 2011;123(20):2292–2333.
75. Chen J, Lieffers J, Bauman A, et al. Designing health apps to support dietetic professional practice and their patients: qualitative results from an international survey. *JMIR MHealth UHealth.* 2017;5(3):e40.

76. Hu FB. Globalization of food patterns and cardiovascular disease risk. *Circulation*. 2008;118(19):1913–1914.
77. Rao AV, Agarwal S. Role of antioxidant lycopene in cancer and heart disease. *J Am Coll Nutr*. 2000;19(5):563–569.
78. Alam MA, Subhan N, Hossain H, et al. Hydroxycinnamic acid derivatives: a potential class of natural compounds for the management of lipid metabolism and obesity. *Nutr metab (Lond)*. 2016;13:27–32.
79. Hu FB. Plant-based foods and prevention of cardiovascular disease: an overview. *Am J Clin Nutr*. 2003;78(S3):544S–551S.
80. Kris-Etherton PM, Hecker KD, Bonanome A, et al. Bioactive compounds in foods: their role in the prevention of cardiovascular disease and cancer. *Am J Med*. 2002;113(S9):71S–88S.
81. Nicolle C, Simon G, Rock E, et al. Genetic variability influences carotenoid, vitamin, phenolic, and mineral content in white, yellow, purple, orange, and dark-orange carrot cultivars. *Journal of the American Society for Horticultural Science*. 2004;129(4):523–529.
82. Wild S, Roglic G, Green A, et al. Global prevalence of diabetes. *Diabetes care*. 2004;27(5):1047–1053.
83. World Health Organization. Waist circumference and waist-hip ratio: report of a WHO expert consultation; 2008 Dec 8–11; Geneva: WHO; 2011.