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Journal of Natural and Applied Sciences Pakistan

Journal homepage: http://jnasp.kinnaird.edu.pk/

NUTRITIONAL COMPOSITION AND THERAPEUTIC POTENTIAL OF CHILLI-A REVIEW

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Abstract

Capsicum annuum L. (chilli) is a commonly used vegetable throughout the world in different varieties belongs to the family Solanaceae. It is used as nourishments and spice. Fresh chilli is a good source of different vitamins including vitamin E and C as well as provitamin A and carotenoid components with well-known beneficial antioxidant properties. It is also used as pain relief, immunity booster and prevents us from cardiovascular disorders. The aim of this review is to highlight nutritional composition and potential medicinal uses of chilli.

Keywords
Capsicum Annuum L., Chilli, Medicinal Importance, Chemical Composition

1. Introduction

1.1 Botanical Classification of Chilli

Capsicum annuum L. is commonly known as chilli, belongs to kingdom Plantae. Its sub-kingdom is Tracheobionta, super division: Spermatophyta, division: Magnoliophyta, class: Magnoliopsida, sub-class: Asteridae, order: Solanales, family: Solanaceae and genus is *Capsicum* (Milind and Sushila, 2012).

1.2 The Family Solanaceae

It is a great family, well dispersed in tropics and sub-tropics, however a few members are found in moderate zone. The family includes 2,700 species belonging to 98 genera. Several members are cultured throughout the world for their great economic position; among them are *Solanum tuberosum* (potato), *Solanum melongena* L. (bringal), *Solanum lycopersicum*

(tomato) and *Capsicum annuum* L. (chilli), etc. *Capsicum annuum* L. is an important vegetable throughout the world and belongs to family Solanaceae. Mostly members of this family contain strong alkaloids and some of them are extremely toxic. Solanaceae family members are found in all continents except Antarctica whereas its wide variety of several species observed in Central America and South America.

1.3 The Genus Capsicum

Capsicum is classified as a genus of different flowering plants in the family Solanaceae, also called as nightshade. Its several species belongs to America and they have been cultivated for thousands of years. *Capsicum* is a genus of chilli and now it has been developed around the world. *Capsicum* species are used as a key component in several food varieties. They used as flavours as well as vegetables. Some *Capsicum* species are also used as medicinal purposes.

2. Medicinal Importance of Chilli

2.1 Pain Relief

Capsaicin is the main bioactive compound in chilli. It has some unique functions i.e. as an analgesic in nasal sprays, topical ointments and dermal patches to release ache. It is naturally occurred in quantities from 0.025 to 0.1 %. It is useful in cream form for the impermanent relief of slight pains such as pains of muscles and joints linked with arthritis, backache, strains and sprains. It is helpful in reducing the symptoms of peripheral neuropathy i.e. post-herpetic neuralgia (Fattori *et al*., 2016).

2.2 Immunity Booster

Intake of adequate amount of vegetables, fruits, nuts and seeds is needed to human body for nutrients that immune system of the body needs. Chilli is known to have huge quantities of β-carotene, vitamin A and vitamin C. These components help in the normal functioning of immune system whereas the active part capsaicin also increases the defence system of the human body (Milind and Sushila, 2012).

2.3 Cardiovascular Benefits

Chilli decreases the risk of several chronic heart problems including heart attack, stroke and pulmonary embolism by decreasing the levels of blood cholesterol, triglycerides and aggregation of platelets. It decreases the heart rate and blood pressure. The initial step in atherosclerosis includes the deposition of fats at blood vessel walls due to free radicals. This process is prevented by chilli constituents (Milind and Sushila, 2012).

2.4 Anti-inflammatory Agent

Anti-inflammatory is defined as the property of a constituent or treatment that decreases inflammation or swelling. Capsaicin, an active component is a strong inhibitor of substance P[19], which is a neuropeptide linked with different inflammatory reactions. It decreases the rate of inflammation through the blood flow to effected area and prevents lung tissues.

2.5 Gastro Protective Agent

Chilli protects stomach ulcers by killing bacteria (ingested through diet), protective buffer solution and enhance the mucus secretion.

Helicobacter pylori, a becteria is responsible for stomach ulcer. Capsaicin has antibacterial ability against *Helicobacter pylori*. It is also reported that capsaicin-sensitive (CS) sensory nerves linked to a defence process against gastric ulcers (Milind and Sushila, 2012).

2.6 Anti-Rhinitic Agent

Rhinitis is commonly called coryza. It is defined as inflammation and irritation condition of the mucous membrane present inside the nose. Its symptoms include runny nose, stuffy nose and sneezing. The inflammation is initiated by viruses, bacteria, irritants or allergens. Its most common kind is allergic rhinitis, which is typically activated by airborne allergens including pollen and dander. Chilli increases the nasal secretions and prevents from congested nose. It is a component of nasal sprays and thus prevents and relief against different allergies and sinus problems.

2.7 Anti-cancer Agent

It is observed that chilli is an effective anti-cancer agent. It has ability to stop programmed cell death or apoptosis within the cells causing cancer of prostate gland within the body. Capsaicin cause potent anti-proliferative effect on prostate cancer. Another study represents that orally consumption of capsaicin decreases the rate of development of pancreatic cancers in mice (Milind and Sushila, 2012).

3. History and World Distribution of Chilli

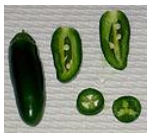
According to archeologists, nine thousands years ago *Capsicum* species was used as foodstuff in Mexico. They evaluated that cultivation of chilli peppers were happened broadly in South and Central America and were passed in 1493 to Spain till whole Europe became aware with *Capsicum annuum* L. The cultivation of *Capsicum annuum* L. occurred in these areas for more than seven thousand years. Chilli become presented to the entire world around 15^{th} and 16^{th} centuries. Christopher Columbus encountered chilli species on his discovery of Caribbean islands and then chilli was carried back to Europe where chilli was used as a substitute of black pepper because black pepper was very expensive since chilli had to be transported from Asia. Chilli plants are now cultivated and used throughout the world. Asia ranks at the top of world in production of chillies upto 65.8 %, followed by Europe, standing at 2^{nd} position and produces upto 12.1 % then 3^{rd} position is obtained by Africa with 9.5 % of total world manufacturing of chillies. Production in Europe is majorly of minor type of chilli (Milind and Sushila, 2012). The major countries for chilli production are United States, Mexico, Spain, Turkey, India, China, Italy, Korea and Pakistan (Figure 1). Its arrangements are diverse, from large to small, sweet to sour and very hot/pungent to tasteless. Chilli varieties from world are summarized and described in Table-1.

Table 1: Varieties of Chilli in the World

S.No.	Name of Variety	Figure	Country	Description
1	Aleppo		Turkey	It is used in dried powder form, and also known as aleppo pepper.
2	Anaheim		USA	It is known as mild variety of new Maxico chile. When mature, change into red colour called as Colorado.
3	Bird's eye		Southeast Asia	A cultivar is known as Thai chilli in the United States. It has a thin fruit with pointed tip.
4	Canary bell		USA	Round shape chilli usually yellow in colour.
5	Cascabel		Mexico	It is a small having round shape fruit. Mostly in dried form and nutty flavour.
6	Cayenne (red)		Mexico	It is a long thin fruit, mostly it is dried and used in powder form.
7	Cherry		Spain	It is known as cherry because of its resemblance. It is small, red and round shape.
8	Cheongyang		Korea	It has medium sized, developed by hybridization of Jejudo chilli with bird's eye chilli.
9	Chilaca		USA	It is famous in Mexican food, and present in dried form. It has a dark brown colour and smoky flavour.

S. No.	Name of Variety	Figure	Country	Description
10	Chiltepin		South and North America	This small cultivar usually eaten by birds. Evidence proves that it has been consumed by human previously.
11	Cubanelle		-	It has medium thickness, initially it is green but then change into red colour when mature.

12	De árbol		Mexico	It is cylindrical fruit, its name is Spanish for “from a tree”.
13	Early jalapeño		USA	It is the most famous variety among all varieties. Its maturation process is very fast and produces high yields.
14	Facing heaven		China	It is a cone liked, hot chilli in size. It has a very tinny skin.
15	Bell pepper		Mexico	This cultivar has different colours such as yellow, red, orange and green, and highly beneficial for human health.
16	Fresno		USA	It has thinner walls and used in ripe stages containing higher vitamin content.
17	Friggitelli (Peperoncini)		Italy	It has sweet taste. It is used to make pickle.
18	Guntur sannam		India	It is used as vegetable and culinary supplement.

S. No.	Name of Variety	Figure	Country	Description
19	Jalapeño		Mexico	It is a popular vegetable and can easily be pickled.
20	Medusa		USA	It has sweet taste, used as ornamental purpose, and grows up to coloured fruit.
21	Miniature bell		USA	It has thin skin and bright colour.
22	Mirasol		Mexico	It is usually to make red sauce commonly.

23	Mulato numex big jim		Mexico	It is a mild to medium chilli pepper and used in dried form.
24	Numex big jim		USA	It is found in bright colour and long shape.
25	Numex halloween		USA	It is used for ornamental purpose having bullet shaped black pods, on maturation turns orange.
26	Numex twilight		USA	Colour transition from purple to yellow, orange and then red.
27	Poblano		Mexico	Popular fruit in Mexico having dark green colour and heart shape.
28	Serrano		Mexico	Thin fruit and upon maturation turns red and no need to peel before use.

S. No.	Name of Variety	Figure	Country	Description
29	Dundicut		Pakistan	It is small, round from upper side whereas pointed tip at lower side with dark red colour.
30	Red chillies		Pakistan	Chilli fruit when ripened and dehydrated becomes red chilli, which is additional grounded to produce red chilli powder.
31	Ghotki		Pakistan	The fruits of this diversity are tinny or thin long, straight, or curved with little amount of seeds inside.
32	Loungi		Pakistan	They are thick and have good amount of seeds inside. This variety is aware with farmers because they get more prices.

33	Talhar		Pakistan	Its fruits are lengthy, thick or dense, just like finger and straight. Fruits are less pungent if provided in green phase.
34	Sanam		Pakistan	Its fruits are long and cylindrical in shape.

4. Cultivation in Pakistan

The main cultivation of chillies is occurred in Sindh province. The annual production of chillies is around 85,000 tons, which covers to 85 % of the country's total production. Chillies are cultured on an area of approximately 40,000 hectares in Sindh with per hectare produce at 1.9 metric tons. Kunri is a small city in Sindh province also known as the "Chilli capital of Asia" alone yields up to 55 % of whole Sindh's production. Additional cultivation centers are Sanghar, Mirpur Khas, Badin and Hyderabad in Sindh province. In Punjab province; Kasur, Pakpattan, Sheikhupura, Multan, Sahiwal and Okara are main chilli producing areas. In Balochistan; Loralai, Khuzdar, Killa Saifullah and Musa Khel give good yield of chilli whereas in Khyber PakhtunKhwa; Dir, Bajour, Mohmand Agency are responsible for main chilli production (Figure 2).

Figure 2: Map of Pakistan Representing the Major Chilli Production Areas

5. Chemical Composition of Chilli

Chilli is commonly used as a flavoring agent. Chilli consists of several chemical components including vitamins, phenolics, minerals, steroids, capsaicinoids, flavonoids, amino acids, carotenoids and essential fatty acids (Milind and Sushila, 2012). Essential fatty acids and essential amino acids are basic nutritive for the regulation of human health (Koyuncu *et al*., 2014).

5.1 Capsaicinoids

Capsaicin (8-methyl-*N*-vanillyl-6-nonenamide) is an example of capsaicinoids. It is a significant part of chilli. It acts as an irritant for mammals including humans, and generates a burning feeling in any body tissue upon contact. Pure capsaicin has properties of hydrophobic, non-volatile, colourless and highly pungent. Capsaicinoids including nornorcapsaicin, dihydrocapsaicin, capsaicin, homocapsaicin I, homocapsaicin II, norcapsaicin, homodihydrocapsaicin I, homodihydrocapsaicin II, nordihydrocapsaicin and nornordihydrocapsaicin are present in different varieties of chilli. They are observed in different ratios including homodihydrocapsaicin (2 %), nordihydrocapsaicin (7.4 %), capsaicin (48.6 %), 6,7-dihydrocapsaicin (36 %) and homocapsaicin (2 %); variation is also observed due to different climates and soils (Milind and Sushila, 2012). Capsaicin has also beneficial properties including anti-bacterial, analgesic and anti-diabetic. It is a component in numerous commercially important preparations for the cure of muscle troubles, rheumatoid-arthritis, burning-mouth disease, post-mastectomy pain syndrome, gastric ulceration and painful diabetic neuropathy. It is also recommended for hypersensitivity of bladder, hyperreflexia of spinal basis and vasomotor rhinitis (Dias, 2012).

5.2 Flavonoids

Flavonoids contain of a vast variety of polyphenolic compounds and offer benefits in different ways to the human beings (Gurnani *et al*., 2016). The flavonoid group present in chilli includes myrecetin, kaempferol, luteolin, rutin, quercetin, catechin, apigenin, flavones and flavonone glycoside conjugates. Anthocyanins are a subgroup of plant elements known as flavonoids (Arnnok *et al*., 2012). Main flavonoids in the chilli are luteolin and quercetin. They are found in conjugated arrangement and their amount differs among cultivars extending from not measureable to 800 mg/Kg (Dias, 2012).

5.3 Phenolics

Phenolic compounds are assembly of chemical constituents in plants, which play a significant role throughout enzymatic browning reactions. They are generally complex organic ingredients, which comprise more than one phenolic group. Polyphenolics can be distributed into numerous altered subgroups. The main phenolic compounds present in chilli are gallic acid, chlorogenic acid and capsaicin. They behave as antioxidants because they have ability to donate hydrogen as well as perform as metal chelator (Gurnani *et al*., 2016).

5.4 Vitamins

Red or green hot chilies are good source of vitamin C as well as vitamin A, which support to inhibit certain conditions such as cancer, cell damage and illnesses linked to aging. They help to maintain the immune function. Vitamin C acts as an strong antioxidant. It is essential for healing of wounds and regulates immune functions within body. In chilli, β-carotene is present in large amounts, which is later converted into vitamin A within the body. Vitamin K is also present in chilli, which supports to strengthen bones, blood clotting, and helps in defending cells from reactive oxygen species. Red chilies also contain lycopene, which is helpful in prevention of prostate cancer as well as other types of cancers such as cervix, pancreas and bladder. Hot chilli peppers have remarkably great amounts of vitamins, only 100 g delivers (in % of recommended daily intake) 39 % of vitamin B6 (pyridoxine), 32 % of vitamin A and large amount of vitamin C content (ascorbic acid). Chilies are also worthy in B-complex set of vitamins including thiamin (vitamin B1), pyridoxine (vitamin B6), niacin and riboflavin. These all vitamins are vital for human health because body needs them from exterior sources to restock (Dias, 2012).

5.5 Minerals

Chilli provides appreciable amounts of calcium, phosphorous, manganese, potassium, zinc, magnesium, iron, selenium and copper. Potassium is known as vital mineral for normal functioning in our body, and its sufficient intake also helps in reducing the risk of heart diseases (Whelton and He, 2014). Copper acts a vital and important antioxidant trace element for healthy bones and neurons. In human body, manganese acts as a co-factor specifically for the antioxidant enzyme named as superoxide dismutase (Dias, 2012).

5.6 Essential Amino Acids

Amino acids and proteins are vital for proper human health and essential for the development, growth, reconstruction and regeneration of the body. They are also answerable for the generation of blood cells, hormones, antibodies and several enzymes (Sousa *et al*., 2014). Essential amino acids can't be produced by the body and that's why supplied through food or diet. Essential amino acids are present in chilli include tryptophan, methionine, linolenic acid, lysine, cysteine and phenylalanine.

5.7 Carotenoids

They are lipophilic yellow-orange-red pigments present in photosynthetic plants, algae and different microorganisms. Animals can't synthesize carotenoids by their self so their occurrence is because of dietary intake. These pigments are significant for plant and animal health as they perform a special function in protecting tissues from light and oxygen (Arimboor *et al*., 2015). The carotenoids content present in chilli includes α-carotene, β-carotene, lutein and zeaxanthin (Milind and Sushila, 2012). The keto-carotenoids, capsanthin, capsorubin and cryptocapsin are responsible to give red colour to chilli whereas β-carotene, zeaxanthin, violaxanthin and β-cryptoxanthin

impart yellow colour to chilli (Arimboor *et al*., 2015). The specific concentration of provitamin A carotenoids (α- and β-carotene) is present within various cultivars. Few cultivars of hot chilli have as greatly as 12 mg/Kg whole carotenoid content whereas remaining are below the measureable limit (Dias, 2012).

5.8 Steroids and Steroidal Glycosides

Steroids are present in chilli include lanosterol and lanostenol whereas capsicosides A, D and proto-degalactotigonin present as steroidal glycosides (Milind and Sushila, 2012). Another study indicates the presence of steroidal alkaloidal glycosides such as solanine, solaniline and solasodine (Newall *et al*., 1996).

6. Compositional Studies of Chilli

6.1 Physical Attributes Evaluation

Bidari *et al*. (2009) reported different physical properties in dry chillies (*Capsicum annuum* L.) cultivated in North Karnataka (India). Their results showed that fruits of Sankeshwar cultivar have higher size (36.00 length/beam ratio). The contribution of pericarp (47-55 %), seeds (38-47 %) and pedicel (6-11 %) to whole fruit weight was observed. Alibas and Koksa (2015) studied physical properties of some pepper cultivars seeds grown broadly in Turkey. They observed length, width and thickness, which were found to be in the range of 3.43-4.40, 3.00-3.72 and 0.66-0.82 mm, respectively. Rokayya and Khojah (2016) investigated different mechanical and physical properties included width, length, volume, thickness, surface area and mass in several varieties of *Capsicum annuum* L. They observed the highest average fruit mass of Red bell cultivar (217.99 g).

6.2 Chemical Composition Evaluation

Forgács *et al*. (1996) estimated the moisture content in *Capsicum annuum* L. powders by different methods. They concluded that moisture content can equally be determined by all procedures and presence of other compounds does not affect the reliability of resulted moisture content concentration. Bidari *et al*. (2009) reported moisture content (70.00-81.00 %), protein content (10.71-14.55 %) and total ash content (5.66-6.97 %) in dry chillies cultivated in North Karnataka (India). Shaha *et al*. (2013) observed decrease in titratable acidity and increase of pH (4.2-6.8) during ripening process of chillies. Boiko *et al*. (2017) studied carotenoid content in Ukrainian bitter peppers through spectrophotometric technique. They concluded that carotenoid content was observed 2076 μg/g of sample in dry weight basis where the yellow fraction represented carotenoid content 69.3 % and red fraction 30.7 %.

6.3 Phenolics and Antioxidant Evaluation

Materska and Perucka (2005) investigated the antioxidant activity of four cultivars of *Capsicum annuum* L. grown in Poland. They collected the samples at green and red stages, and observed strong antioxidant activity (9.3-76.5 % inhibition related to control). Guil-Guerrero *et al*. (2006) determined the nutrient composition and antioxidant activity among 10 pepper varieties cultivated in Almería (Spain). It

was observed that these varieties contain greater amount of vitamin C (102-380 mg/g) and carotenoid content (50-10,312 µg/g) as well as also showed strong antioxidant activity. Sim and Sil (2008) investigated the antioxidant activities of red pepper pericarp and seed extracts through several assays. They observed that the red pepper seed and pericarp extracts contain adequate amount of flavonoid content (21.27 and 27.49 mg/g) and phenolic content (29.10 and 47.52 mg/g), respectively, which was the cause of strong antioxidant activity. Broderick and Cooke (2009) also reported adequate amount of antioxidants in placenta, seeds and pericarp of *Capsicum annuum* L. from USA through fluorescence microscopy.

Another study investigateed the red and green paprika, and their leaves for phytochemical composition and antioxidant activity cultivated in Korea. It was concluded that the red paprika has the strongest antioxidant activity (IC_{50} = 55.23±6.77 µg/mL) with high concentration of capsanthin (58.33 mg/100 g dry weight) and L-ascorbic acid (1987.25 mg/100 g dry weight) (Kim *et al*., 2011). Shotorbani *et al*. (2012) investigated the phenolic content and effect of thermal treatment at various temperatures of two varieties of *Capsicum annuum* L from Urmia (Azerbaijan). They concluded that the phenolic and flavonoid contents are increased as a result of increasing temperature up to 65 °C. Medina-Juárez *et al*. (2012) reported phenolic components and estimated the antioxidant property of five pepper cultivars of Mexico harvested in the similar period, geographic zone and climatic situations. They concluded that the pepper cultivars, Caribe (154.30 mg/100 g) and Bell (103.26 mg/100 g) represent high phenolic contents as well as reveal the strong antioxidant properties and can be recommended as desirable for human intake.

Another study investigated the bioactive compounds and antioxidant activities of three varieties of chillies at different ripening stages. Bell pepper showed the maximum quantity of flavonoid content (2.59 µmol Q/g) in intermediate ripening stage whereas phenolic content (4135 µg GAE/g) at final stage (Shaha *et al*., 2013). Nora *et al*. (2012) investigated the bioactive compounds and antioxidant activities of Moroccan red pepper cultivar at different storage time period and conditions. They concluded that hot-air drying method resulting in a reduction of antioxidant activity. They also concluded that various storage conditions affected the amount of bioactive compounds.

Chávez-Mendoza *et al*. (2015) reported higher amount of phenolic (111.26 mg/100 g DW) and lycopene (4.23 mg/100 g DW) in Fascinato/Robusto variety among different Bell pepper cultivars. They also found the best time is September in Mexico for harvesting, and to obtain maximum amount of bioactive constituents in various cultivars.

6.4 Heavy Metals Content Evaluation

Awode *et al*. (2008) evaluated the quantity and distribution of Pb (114.79 and 18.90 mg/Kg), Cr (181.66 and 20.04 mg/Kg) and Cu (248.59 and 14.52 mg/Kg) in the soils and pepper (*Capsicum annuum* L.), respectively on the bank of river

Challawa (Nigeria). By correlation analysis they concluded that these metals show significant correlation among them, which represent possible transfer of these metals into the food chain and accumulation. Except Cu, concentrations of other metals are exceeded from recommended limit. Ahmed and Bouhadjera (2010) evaluated the metals accumulation in pepper (*Capsicum annuum*) and agricultural soil in Algeria. They observed high level of Pb (99.4-129.4 mg/Kg) in soil exceeding from permissible set whereas Cd (3.31-3.81 mg/Kg) and Zn (1300.07-1389.00 mg/Kg) were also higher. The soil represents strong contamination. In pepper, amount of Cd, Cu, Pb, Zn and Ni were found to above the permitted limits of the European Standards and thus dangerous for human health. Rao *et al*. (2017) determined heavy metal accumulation in chilli and soil samples of Jagdalpur (India). They observed higher Fe (0.03-11.4 and 12.42-19.32 mg/Kg) concentration above permissible range whereas Cu (0.60-1.19 and 0.42-1.59 mg/Kg), Pb (0.32-0.92 and 0.71-1.12 mg/Kg) and Cd (0.02-0.51 and 0.52-1.74 mg/Kg) in chilli and soil, respectively were within safe limits.

Zejnullahu *et al*. (2017) evaluated heavy metal content (As, Cr, Ni, Pb and Zn) in *Capsicum annuum* of Obiliq (Kosovo). They observed concentration of As, Cr, Ni were within the safe limit for fresh vegetable whereas Pb (0.31-0.66 mg/Kg) and Zn (88.28 mg/Kg) were found in higher amounts.

7. Conclusion

Chilli belongs to family Solanaceae. It is extensively consumed as vegetable all over the world. The literature showed that chilli contains sufficient amount of useful bioactive secondary metabolites including vitamins, phenolics, minerals, steroids, capsaicinoids, flavonoids, amino acids, carotenoids and essential fatty acids for healthy life, which could be a possible and natural mode of treatment for multiple diseases as alternatives to medicines.

8. References

Ahmed, A. B., & Bouhadjera, K. (2010). Assessment of metals accumulated in durum wheat (Triticum durum Desf.), pepper (Capsicum annuum) and agricultural soils. African Journal of Agricultural Research, 2795-2800.

Alibas, I., & Koksa, N. (2015). Determination of physical, mechanical and structural seed properties of pepper cultivars. International Agrophysics, 107-114.

Arimboor, R., Natarajan, R. B., Menon, K. R., Chandrasekhar, L. P., & Moorkoth, V. (2015). Red pepper (Capsicum annuum) carotenoids as a source of natural food colors: analysis and stability-a review. Journal of Food Science and Technology, 1258-1271.

Arnnok, P., Ruangviriyachai, C., Mahachai, R., Techawongstien, S., & Chanthai, S. (2012). Determination of total phenolics and anthocyanin contents in the pericarp of hot chilli pepper (Capsicum annuum L.). International Food Research Journal, 235-243.

Awode, U. A., Uzairu, A., Balarabe, M. L., Okunola, O. J., & Adewusi, S. G. (2008). Levels of some trace metals in the fadama soils and pepper (Capsicum annuum) along the bank of river Challawa, Nigeria. Asian Journal of Scientific Research, 458-463.

Bidari, B. I., Math, K. K., & Ninganur, B. T. (2009). Physical and chemical properties of dry chillies (Capsicum annuum L.) grown in north Karnataka under rainfed conditions. Asian Journal of Horticulture, 173-175.

Boiko, Y. A., Kravchenko, I. A., Shandra, A. A., & Boiko, I. A. (2017). Extraction, identification and anti-inflammatory activity of carotenoids out of Capsicum annuum L. Journal of Herbmed Pharmacology, 10-15.

Broderick, C. E., & Cooke, P. H. (2009). Fruit composition, tissues, and localization of antioxidants and capsaicinoids in Capsicum peppers by fluorescence microscopy. Acta Horticulturae, 85-90.

Chávez-Mendoza, C., Sanchez, E., Muñoz-Marquez, E., Sida-Arreola, J. P., & Flores-Cordova, M. A. (2015). Bioactive compounds and antioxidant activity in different grafted varieties of bell pepper. Antioxidants, 427-446.

Dias, J. S. (2012). Nutritional quality and health benefits of vegetables: A review. Food and Nutrition Sciences, 1354-1374.

Fattori, V., Hohmann, M. S., Rossaneis, A. C., Pinho-Ribeiro, F. A., Verri, W., & Nani, A. (2016). Capsaicin: current understanding of its mechanisms and therapy of pain and other pre-clinical and clinical uses. Molecules, 844.

Frogács, E., Kiss, V., Cserháti, T., & Holló, J. (1996). Determination of the moisture content of paprika (Capsicum annuum) powders: a comparative study. Food Science and Technology International, 23-27.

Guil-Guerrero, J. L., Martinez-Guirado, C., Rebolloso-Fuentes, M. d. M., & Carrique-Perez, A. (2006). Nutrient composition and antioxidant activity of 10 pepper (Capsicum annuum) varieties. European Food Research and Technology, 1-9.

Gurnani, N., Guptab, M., Mehtaa, D., & Mehta, B. K. (2016). Chemical composition, total phenolic and flavonoid contents, and in vitro antimicrobial and antioxidant activities of crude extracts from red chilli seeds (Capsicum frutescens L.). Journal of Taibah University for Science, 462-470.

Kim, J. S., Ahn, J., Lee, S. J., Moon, B., Ha, T. Y., & Kim, S. (2011). Phytochemicals and antioxidant activity of fruits and leaves of paprika (Capsicum annuum L., var. special) cultivated in Korea. Journal of Food Science, 193-198.

Koyuncu, F., Çetinbaş, M., & Ibrahim, E. (2014). Nutritional constituents of wild-grown black mulberry (Morus nigra L.). Journal of Applied Botany and Food Quality, 93-96.

Materska, M., & Perucka, I. (2005). Antioxidant activity of the main phenolic compounds isolated from hot pepper fruit (Capsicum annuum L.). Journal of Agricultural and Food Chemistry, 1750-1756.

Medina-Juárez, L. Á., Molina-Quijada, D. M. A., Toro-Sánchez, C. L. D., González-Aguilar, G. A., & Gámez-Meza, N. (2012). Antioxidant activity of peppers (Capsicum annuum L.) extracts and characterization of their phenolic constituents. Interciencia, 588-593.

Milind, P., & Sushila, K. (2012). A hot way leading to healthy stay. International Research Journal of Pharmacy, 21-25.

Newall, C. A., Anderson, L. A., & Phillipson, J. D. (1996). Herbal medicines, a guide for health-care professionals. The Pharmaceutical Press London, p. 154.

Nora, S., Hafida, H., Hassan, L., Aaziz, O., Said, E., & Hasnae, Z. L. (2012). Bioactive components and antioxidant activity of Moroccan paprika (Capsicum annuum L.) under different storage time and conditions. International Journal of Science and Research, 2036-2045.

Rao, P. S., Thomas, T., Hasan, A., & David, A. (2017). Determination of heavy metals contamination in soil and vegetable samples from Jagdalpur, Chhattisgarh State, India. International Journal of Current Microbiology and Applied Sciences, 2909-2914.

Rokayya, S., & Khojah, E. (2016). Physical-mechanical estimation of pepper (Capsicum annuum L.) fruit varieties. Journal of Northeast Agricultural University (English edition), 61-69.

Shaha, R. K., Rehman, S., & Asrul, A. (2013). Bioactive compound in chilli peppers (Capsicum annuum L.) at various ripening (green, yellow and red) stages. Annals of Biological Research, 27-34.

Shotorbani, N. Y., Jamei, R., & Heidari, R. (2012). Antioxidant activities of two sweet peppers Capsicum annuum L. varieties phenolic extracts and the effects of thermal treatment. Avicenna Journal of Phytomedicine, 25-34.

Sim, K. H., & Sil, H. Y. (2008). Antioxidant activities of red pepper (Capsicum annuum) pericarp and seed extracts. International Journal of Food Science and Technology, 1813-1823.

Sousa, E. C., Uchôa-Thomaz, A. M. A., Carioca, J. O. B., Morais, S. M., Lima, A., Martins, C. G., et al. (2014). Chemical composition and bioactive compounds of grape pomace (Vitis vinifera L.), benitaka variety, grown in the semiarid region of Northeast Brazil. Food Science and Technology, 135-142.

Whelton, P. K., & He, J. (2014). Health effects of sodium and potassium in humans. Current Opinion in Lipodology, 75-79.

Zejnullahu, B., Kucaj, E., Abazi, U., & Harizaj, F. (2017). Evaluation of heavy metal content in Capsicum annuum in Obiliq, Kosovo. American Journal of Engineering Research (AJER), 186-189.

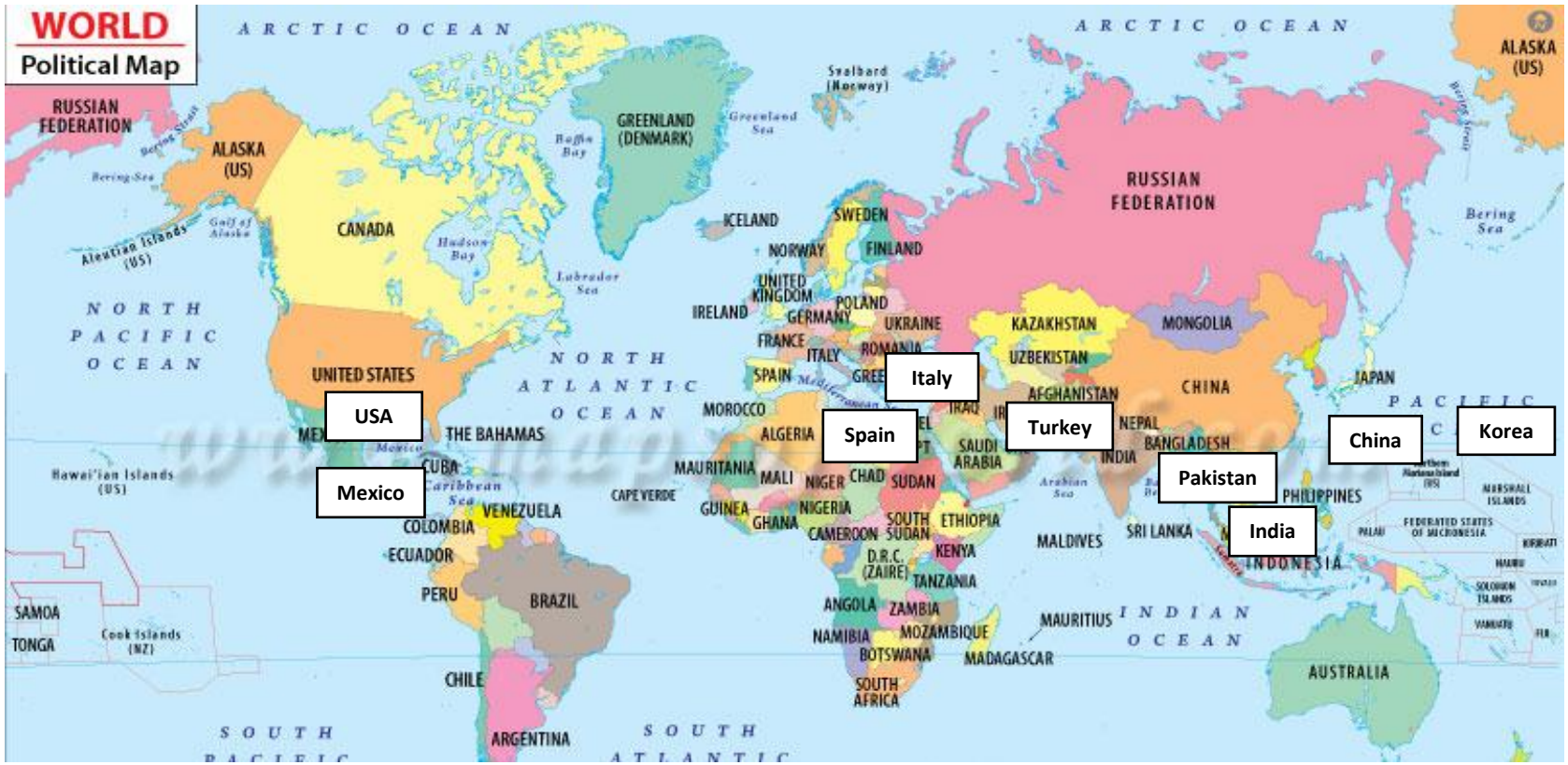


Figure 1: World Map Representing the Major Chilli Production Countries