Chinese Honey Composition, Production, Trade, and Health Benefits

16

Rahil Razak Bhat, Ambreen Shabir, Midhat Bilal, Sheikh Bilal Ahmad, Shafat Ali, and Rabia Farooq

Abstract

Honey is regarded as the first and most primitive source of sweet food used by human beings. Apart from carbohydrates, honey also contains proteins, enzymes, polyphenols, minerals, amino acids, trace elements, vitamins, and fragrance compounds. Honey has been shown to have antimicrobial, antiviral, antioxidant, antimutagenic, antitumor, antiparasitic and anti-inflammatory properties that could favor and benefit the human health. Chinese honey consists of more than 180 components, most of which are altered during maturation process. Chinese honey consists of 81% sugars, water 17%, and 2% of volatile, nonvolatile compounds, enzymes, phenolic compounds, and flavonoids which determine its medicinal properties. The production, consumption, import, and export of honey vary among different countries. China serves as a main source

R. R. Bhat · S. B. Ahmad (✉)
Division of Veterinary Biochemistry, Faculty of Veterinary Sciences and Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir, Alusteng, Shuhama, (SKUAST-Kashmir), Srinagar, Jammu and Kashmir, India
e-mail: sbilal@skuastkashmir.ac.in

A. Shabir
Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir (SKUAST-Kashmir) Rangil, Srinagar, Jammu and Kashmir, India

M. Bilal
Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir (SKUAST-Kashmir), Benhama Ganderbal, Jammu and Kashmir, India

S. Ali
Centre of Research for Development, University of Kashmir, Srinagar, Jammu and Kashmir, India

R. Farooq
Department of Biochemistry, College of Medicine, University of Bisha, Bisha, Saudi Arabia

M. U. Rehman, S. Majid (eds.), *Therapeutic Applications of Honey and its Phytochemicals*, https://doi.org/10.1007/978-981-15-6799-5_16

of honey production all over the world. The production of Chinese honey accounts for over 20% of the overall honey production worldwide. Various Chinese scriptures including that of Shen Nong's Herbal Classic and Compendium of Materia Medica have documented the medicinal properties of honey.

Keywords

Honey · Production · Composition · Medicinal properties

16.1 Introduction

Honey "a natural sweetener substance processed from the nectar of plants or from secretions of living parts of plants or excretions of plant sucking insects on the living parts of plants by honey bees, which they collect and process by combining them with their own substances to dehydrate and deposit in the honey comb to ripen and mature" (FAO 1987). Honey is fundamentally a supersaturated solution of sugars in water. This is a sticky liquid and naturally sweet substance created by bees that is made when certain particular honey bees gather and deposit nectar and sugar from plants into the honeycomb. The honey is subjected to maturing process which involves the transformation of nectar into honey by honey bees (*Apis mellifera* L.), elimination of water and addition of a few enzymes. Depending upon the source from where nectar is obtained, honey may be unifloral or multifloral, unifloral honey is originated from single flower which is regarded as more valuable due to their good quality and pure flavor in China while as multi-floral honey is obtained from various types of flower species. Hence, market prices in china or in any country are determined by its botanical origin, and the increased value of some modifies the major proportion of sugars in the nectar (Ball 2007). About 3 days of time is required to convert honey from nectar (Ball 2007). Bees fills the honey comb –cells until the cells are full of honey and subsequently cap the filled cells by newly produced bee wax which may take a week or more depending on the period of flowering, environment, size of bee colony, and other factors.

16.2 The Health Benefits of Consuming Honey

Honey is regarded as the first and most primitive source of sweet food used by human being (Ghorbani and Khajehroshanaee 2009). Apart from carbohydrates, honey also contains proteins, enzymes, polyphenols, minerals, amino acids, trace elements, vitamins, and fragrance compounds. Honey has been shown to have antimicrobial, antiviral, antioxidant, antimutagenic, antitumor, antiparasitic, and anti-inflammatory properties that could favor and benefit the human health. Consuming natural honey in general imparts diverse and numerous health benefits to human body. Above all, honey is a great source of energy. Its dry matters are largely

constituted by carbohydrates, mainly fructose and glucose. And there are in total 25 saccharides (Bogdanov et al. 2008). As an important source of energy, honey played a significant role in *Homo sapiens*' diet since their beginning. Some anthropologists claimed that it could furnish essential energy to boost human brain and allow it to out-compete other species (Crittenden 2011).

According to nutritionists, higher doses intake of honey will have a range of beneficial nutritional and health effects (Bogdanov et al. 2008), such as, the jujube one of the Chinas most commonly consumed honey has been shown to have antioxidant and preventive potential on alcohol-induced hepato injury in mice (Cheng et al. 2014). Another study highlighted the ability of the honey in preventing obesity (Samat et al. 2017).

16.3 Composition of Chinese Honey

Honey a natural sweetener, converted by enzymatic reactions from nectar or honey dew by removal of water and decomposition of sucrose to simple sugars (Ball 2007) because of its antioxidant and antimicrobial functions and for the enhancement of immunity and anticarcinogenic properties it has found its use in ancient medicine (Fukuda et al. 2010). Chemically honey comprises around 80% sugars such as glucose, fructose, sucrose, maltose, and some other sugars, 19% of the water and 1% other compounds (Majtan et al. 2014). The honey has pH value 3.4–6.1. Proline is the common amino acid in honey, which contributes for nearly 70% of the total amino acids present in it (Ruckriemen et al. 2015). The total amino acid constitutes 1/1000 of the total dry matter (Pätzold and Brückner 2006). In addition there are also different flavoring compounds and pigments present in honey (da Silva et al. 2016). 5-hydroxymethyl-2-furadehyde (5-HMF) a heterocyclic compound is typically synthesized in honey when stored for longer durations or exposure to high temperature or sometimes both. The production of 5-HMF has been shown to be responsible for reducing the consistency of the honey and creating polymers such as pigment (Aslanova et al. 2010). The production of 5-HMF in honey was assumed to be due to a condensation reaction whereby acids initiate sugar reduction and degeneration (Capuano and Fogliano 2011). This was derived from the synthesis of 5-HMF in organic or amino acid sugar solutions. Chinese honey consists of more than 180 components (da Silva et al. 2016), most of which are altered during maturation process (Vyviurska et al. 2016). Chinese honey consists of 81% sugars, water 17%, and 2% of volatile, nonvolatile compounds, enzymes, phenolic compounds, and flavonoids which determine its medicinal properties (Sushil et al. 2019). Volatile compounds are essentially responsible for flavor and aroma which increases its aesthetic value and appreciates its consumer's acceptance. The Chinese born *Apis cerana* (Acc) is an important ecotype of the eastern honey bee. With more than three million colonies, Acc has importance not only for the beekeeping industry in China but also in Asia for honey production, crop pollination, and ecosystem preservation.

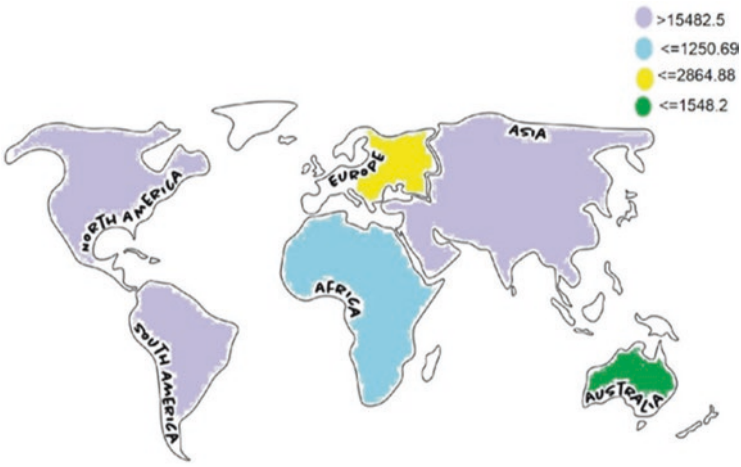

Fig. 16.1 Global honey production density, total average from 2001 to 2016, data source FAO

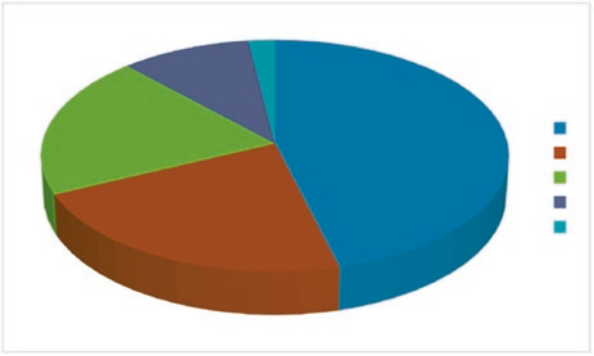

Fig. 16.2 Global production share of honey by region data source FOA

16.4 Honey Production in China

The production, consumption, import, and export of honey vary among different countries. The FAO has pictured the world honey production distribution from the average production density (Fig. 16.1) to the average production shares among different continents (Fig. 16.2). According to FAO, the top ten honey producing countries are China, Turkey, Argentina, Iran, U.S., Ukraine, Russian federation, India, Mexico, and Ethiopia (Fig. 16.3). China serves as a main source of honey production all over the world (Guoda and Chun 2003). For instance, one European article interpreted that Europe could not satisfy its growing demands of honey without China (Tamma 2017).

China exports honey as raw material like other developing countries, while as developed countries export honey as packaged products (CBPA (China Bee Products

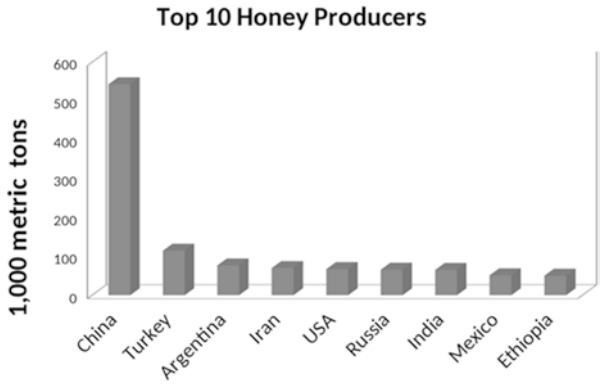

Fig. 16.3 Top ten honey producing countries of the world data source FOA

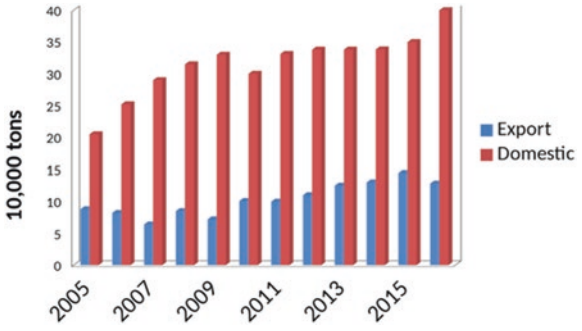

Fig. 16.4 Domestic consumption of honey and its export from China (2005–2016)

Association) 2013) there has been an unusual trend in the honey related trade in china from last few years. From 2000 to 2002, the amount of honey exported from the China dropped sharply. This could be explained by the fact that Chinese honey was banned or heavily taxed by many countries since 2000 when adulteration, impurities and pollution of heavy metal and antibiotics had been reported (Wu et al. 2015). After 2004, however, the exporting amount was again increasing slowly but steadily, because the ban was lifted shortly.

16.5 Honey Consumption in China

Domestic consumption of honey in China has a fast growing trend which is quite clear from Fig. 16.4 such trend was captured by comprehensive report of China Bee Products Association (CBPA) as well. The report emphasized that china has become world's largest nation in honey consumption. As far as the data from China Bee Products Association (2008) is concerned, the volume of honey consumed domestically is greater than three quarters of its annual production.

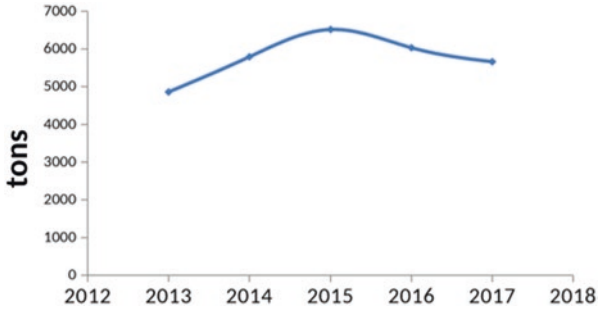

Fig. 16.5 Honey imports to China from 2012 to 2017 data source FOA

According to literature from china, the increase in raw honey consumption in China is up to 10% per year (Zheng et al. 2011). The reasons for increased demand of honey consumption in China include increased population, increased employment, health consciousness, and honey product diversification. From the perspective from honey consumption per capita, it grew on 0.11 kg per capita in 2001 to 0.3 kg per capita in 2012 (CBPA 2013). Compared with the developed countries, however, it is still a small figure that has a big potential to increase. For instance, the annual honey consumption in Germany, Austria, and Switzerland ranges from 1 to 1.8 kg per capita (Bogdanov et al. 2008). Notably, the amount of honey imported is also growing (Fig. 16.5). Imported honey prices in China are three to ten times higher than Chinese domestic honey, often even more, still, higher prices do not guarantee the good quality. There were cases of adulteration or contamination in imported honey as well, which were reported by Entry-Exit inspection Quarantine Bureau in recent years (CBPA (China Bee Products Association) 2013; Sun et al. 2017). Given increased importance and preference in China toward imported honey, the agricultural ministry in collaboration with other departments of the country organized World honey and Bee products show in Beijing in 2017 and repeated the same event in 2018 with a view to aware the people about the importance of honey consumption as well as to exhibit the honey products at national as well as international level.

16.6 International Trade Status of Chinese Honey

The price of honey is growing as well, which was captured in the price research of honey. During 2012–2015, enormous research work has been performed in china for determining the market status of honey in different cities of country and it was observed that there was acute rise in price of honey as well as demand of honey products. During 2012–2015, the average honey price increased from 55.6 to 79.8 renbinmi (RMB) per kilogram. The reasons behind this trend were as a result of rising costs and higher income and health awareness of consumers (Gao and Zhijun 2016). Chinese consumers express serious concerns over food scares (Table 16.1).

Table 16.1 Consumer images of Chinese-brand honey, honey from local bee keeper, honey imported from EU and their comparisons

	Chinese-brand honey (Mean ± SD)[a]	Honey from local bee keeper (Mean ± SD)[a]	Honey imported from EU (Mean ± SD)[a]	*p*-value
Healthy	3.92 ± 1.02	4.07 ± 1.04	3.57 ± 1.14	<0.001**
Safe	3.95 ± 1.07	4.05 ± 1.01	3.59 ± 1.11	<0.001**
Tasty	3.94 ± 1.02	4.08 ± 1.00	3.58 ± 1.11	<0.001**
Authentic	3.87 ± 1.05	4.09 ± 1.01	3.55 ± 1.14	<0.001**
Sustainable	3.89 ± 1.05	4.01 ± 1.06	3.49 ± 1.13	<0.001**
Environment friendly	3.87 ± 1.05	4.02 ± 1.05	3.56 ± 1.12	<0.001**
Affordable	4.13 ± 1.04	4.15 ± 1.01	3.32 ± 1.16	<0.001**
Value for money	3.93 ± 1.07	4.03 ± 1.03	3.24 ± 1.14	<0.001**
Trustworthy	3.87 ± 1.05	4.06 ± 0.98	3.55 ± 1.12	<0.001**
Free of hazards	3.78 ± 1.07	4.05 ± 1.01	3.59 ± 1.09	<0.001**

[a]Denotes that values were measured in a 5-likert scale. Reproduced from thesis "Consumer Attitude and Behavior Towards Honey in China" by Zhang Minzhu for award of International Master of Science in Rural Development from Ghent University (Belgium) 2018

**Highly significant

Food safety has been the highest priority for consumers in China with regard to healthy beverages (Lee et al. 2014a, b). One extensive survey study in china showed that about 83% of the respondents had a high degree of concern and understanding of food hazards risk (Liu 2014).

Families with children are more likely to show higher concern over food safety. For instance melamine contamination of milk in 2008 had greatly plummeted milk consumption among house holders, particularly those with young children. However, most Chinese consumers had little knowledge of the food safety law that actually came into effect 3 months ago (Qiao et al. 2010, 2012). A literature review paper examined the decision-making process on safe food for Chinese consumers with respect to healthy. And they suggested that Chinese consumers have a level of awareness but little knowledge of healthy foods, and they have low recognition of labels. Hence, Chinese consumers have little capacity to recognize healthy foods (Liu et al. 2013). Their conclusion was in line with many other papers. A survey in Beijing food consumers concluded that less than 20% of the respondents were aware of HACCP, a management system aiming at reducing food safety risks. The same study revealed that respondents after receiving information of HACCP were ready to spend extra price for HACCP-certified products (Wang et al. 2008).

Honey exports from china are interesting because of the important role China plays in global development and commerce. The production of Chinese honey accounts for over 20% of the overall honey production worldwide (FAO 2010). Meanwhile, there is growing evidence emerging from many countries which shows that safety standards for honey have been changed by several major countries (Gu and Zhang 2003; Yang and Zhen 2007), but as of now no verifiable data have surfaced with regards to quantitatively examined the effect of changing safety standards in other countries on Chinese honey exports. Hence, exporting honey from

Table 16.2 The MRL of chloromycetin in honey and honey import (million US$ in 2000 constant) from China 1996–2009[a]

Item	1996–2001	2002	2003–2004	2005–2009
The MRL of chloromycetin (ppb)				
EU	10	0.1	0.1	0.3
Japan	5	5	0.3	0.3
US	5	5	0.3	0.3
Canada	–	–	–	0.3
South Korea	–	–	–	0.3
Others[b]	–	–	–	–
Annual honey import from China (US $million)				
EU	32.3	6.8	1.6	22
Japan	31.3	48.3	38.2	43.2
US	19.6	7.8	30.7	13.2
Canada	2.4	1.0	2.9	0.7
South Korea	0.1	1.3	0.7	1.5
Others[b]	3.2	9.6	15.0	12.0

[a]WTO (2010), Hangzhou Entry-Exit inspection Institute (2007). Reproduced from thesis "Consumer Attitude and Behavior Towards Honey in China" by Zhang Minzhu for award of International Master of Science in Rural Development from Ghent University (Belgium) 2018
[b]Malaysia, Singapore and Hong Kong

China is suitable case for evaluating the effect of food safety requirements on agricultural trade. China's honey export was at peak in 2000 with 103,000 tons, accounting for 42% of total production (246,000 tons). After 2000, though production continued to increase however exports dropped to 88,000 in 2005 and 73,000 tons in 2009, respectively. In 2009 only 18% of the total production was exported. In conclusion, the rise in the honey production in China in recent years is associated with decline in export since the early 2000s. Table 16.2 indicates the substantial decrease in the export of China's honey since 2000 is explained by other factors rather than tariff adjustments. Except for India the tariff rated levied by its major importers have either dropped or remained unchanged (Table 16.2 columns 2 and 3). Some studies have argued that nontariff initiatives and other exporting countries such as Argentina and Canada have weakened China's low price competitiveness (Ying and Zhou 2005; Zhou and Qi 2010). Some scholars suggest that Argentina has broadened its international market share and replaced some of the existing markets in the China (Li and Wu 2009). Some, however, claimed that decline in the export of Chinese honey is linked to food safety requirements imposed by importers. Honey exports in China declined sharply as major importing major countries (EU, the US, and Japan) increased safety standard requirements. Wang and He (2008) reported that the increase in chloromycetine MLRs in the US, Japan, and Germany drastically reduced export of between 2000 and 2005. Given the importation of honey from China by more than 50 countries/regions; most of China's honey goes through limited number of nations. Chinese top five importers, including Japan, the US, Belgium, the United Kingdom, and Spain account for approximately 77% of total China's exports between 2005 and 2009 (Table 16.2). Japan was the

leading importer of the China's honey between 2005 and 2009. Its import from China accounted for 46% of China's overall export. China's honey export to the US during this period was around 14% of China's overall export. Together Belgium, the United Kingdom, and Spain imported around 16% of China's total exports. Around 2005 and 2009, Chinas top 16 importers accounted for almost 95% of China's overall honey export. Throughout the past decade there has been a noticeable diversified trend on China's honey exports. Japan, Belgium, South Korea, Singapore, Poland and India increased their imports of honey significantly during 1996 and 2009. Certain importers such as the US, the United Kingdom, Spain, Dutch, Germany, Hong Kong, Canada, and France recorded negative annual growth rates from China during the same time.

16.7 Food Safety Standards and Honey Export

Food health regulations have become more critical in the honey trade over the last decade. As one of the main measure for quality food protection in importing countries, honey related sanitary and phytosanitary (SPS) measures were put in place now and then by main importing countries and the number of SPS warnings has increased. These increasing alerts on honey came from the EU, Japan, the US, Canada, South Korea, Poland, and India. Between 2001 and 2009, South Korea's alerts were released at least once in a year. The EU, Japan and India have regularly received SPS alerts. SPS notification trend shows that honey protection requirements attract rising attention from importing countries. Another essential honey health criterion of China concerned by these countries is the maximum residual limit (MRL) of chloromycetine (Ch). Ch. is a bacteriostatic antibiotic used against broad range of gram + and gram negative bacteria including many species (Falagas et al. 2008).Ch. is commonly used for treating bee diseases (Katznelson 1950). The Ch. therapy results in bone marrow toxicity and occurs in two different forms: one is the suppression of bone marrow a direct toxic effect of the drug and is reversible and aplastic anemia which is rare, impredictable, and independent of dose and often lethal (Rich et al. 1950). Most countries therefore have set Ch. MRL on food items to take care of human health. The smaller MRL Ch has resulted in more strict safety standards. Table 16.2, reveals the MRL of Ch. that had been changing in four major honey importing countries (EU, Japan, the US, Canada, and South Korea) between 1996 and 2009, and honey safety standards have become more stringent in these countries.

16.8 Therapeutic Properties of Honey

Meda et al. (2004) documented that honey is becoming appropriate to traditional medical practitioners and the general public as an acceptable and effective therapeutic agent. Various Chinese scriptures including that of Shen Nong's Herbal Classic and Compendium of Materia Medica have documented the medicinal properties of the use of *A. cerana* (multifloral honey bee).

16.9 Antibiotic Effects of Chinese Honey

The jujube honey, commonly used honey in China has been proved its antioxidant and preventive potential on alcohol-induced liver damage of mice (Cheng et al. 2014). An antimicrobial effect of Chinese honey is well documented in Chinese literature since centuries. Chinese honey serves as an essential therapeutic tool for combating infection. Zaghloul et al. (2001) revealed that honey has powerful antimicrobial effects including both pathogenic as well as nonpathogenic microbes even against those which develop antibiotic resistance to many antibiotic drugs. Depending upon the concentration used, antimicrobial properties of honey can be bacteriostatic or bactericidal. However certain factors such as high osmolarity (low water activity), low pH and hydrogen peroxide and non-peroxide compounds have been associated to antimicrobial activity (Taormina et al. 2001; Tanih et al. 2009). In addition, honey being a highly saturated sugar solution; such sugar compounds dispel high attraction to water molecules sparing less or no water to sustain the microorganism's production. The microorganisms thus get dehydrated and ultimately die (Malika et al. 2004). In addition, many pathogens get inhibited by natural acidity of honey. Most of pathogens typically have pH around 4.0–4.5. The main antimicrobial potential of honey is attributed to hydrogen peroxide (Temaru et al. 2007), which is synthesized by glucose oxidation a reaction carried by glucose-oxidase enzyme during the dilution of honey (Iurlina and Fitz 2005). On decomposition hydrogen peroxide produces various free radical species that kill the bacteria. Hydrogen peroxide activity in honey can be diminished by heating or by the action of catalase. Given this, other honeys possess different mechanism to that of peroxide effect, exhibiting a strong and robust antibacterial action (non-peroxide activity), (Alvarez-Saurez et al. 2009) and are referred as non-peroxide honeys. Manuka honey (*Leptospermum scoparium*) and jelly bush (*Leptospermum polygalifolium*) from New Zealand and Australia are non-peroxide honeys that, in addition to hydrogen peroxide production, are postulated to possess unidentified active components. Honey also possess other bacterial inhibiting compound, non-peroxide inhibins also referred as phenolic compounds, aromatic acids, and other phytochemicals (Lee et al. 2014a, b).

16.10 Role of Chinese Honey on Liver Disease

The damage to liver by consuming alcohol is obvious and alcoholic liver disease is known to be the most prevalent cause of avoidable morbidity and mortality liver disease worldwide (Mathurin and Bataller 2015; Addolorato et al. 2016). Within the liver, the metabolic center of the human body, ethanol is oxidized by alcohol dehydrogenase to acetaldehyde and subsequently to acetic acid in a reaction catalyzed by acetaldehyde dehydrogenase (Liu 2014; Mello et al. 2008). This cycle produces hepatic cytochrome P4502EI (CYP2EI0 and generates reactive oxygen species (ROS), resulting in enhanced microsomal ethanol oxidation system (MEOS) activity and increased hepatic injury (Cederbaum et al. 2015; Neuman et al. 2015; Lu

and Cederbaum 2016). Therefore, oxidative stress reduction must be a primary factor for preventing alcoholic damage to the liver. Acute alcohol consumption is a common way to drink alcohol, which accounts for the majority of alcohol consumption and has resulted in a specific chronic alcohol related liver damage. Most of the people who consume alcohol suffer from alcoholic associated liver injury (Stahre et al. 2014).

Honey is important for its established role as antioxidative effects against free radicals and antimicrobial activity (Alvarez-Saurez et al. 2009). Honey's key ingredients are saccharides such as fructose and glucose, water, and few other compounds viz. trace elements, some proteins, vitamins, organic acids, phenolic, and volatile compounds (da Silva et al. 2016; Solayman et al. 2016). Phenolic compounds have specifically established a class of biochemically active compounds which play their role as antioxidants and scavenge free radicals (Can et al. 2015; Sousa et al. 2016). A number of in vivo studies have shown that honey improves serum antioxidant function by enhancing oxidative stress defenses (Gheldof et al. 2003; Cheng et al. 2014, 2015). As the research on honey has progressed, it has been documented that honey has possible hepatoprotective role against chemically induced liver damage and large number of researchers have demonstrated protective role of honey (Yıldız et al. 2013; Wang et al. 2015; Saral et al. 2016). *Apiscerana fabricius* (*A. cerana*) bee reared for honey making is a multifloral honey produced from the nectar of flowers of various plants of honey source which are distributed all over the mountains in China. *A. cerana* honey has found its application as a traditional medicine thousands of years prior to the introduction of *A. mellifera* in China. Traditionally, *A. cerana* due to its longer nectar cycle and the large variety of nectar sources cerena honey is more nutritious than other honey species. Zhao et al. (2017) conducted a study on hepatoprotective role of chines honey made by *A. Cerana* honey Bees, where they demonstrated curative role of honey on chronic alcoholic liver injury that was previously documented by Cheng et al. (2014). Zhao et al. (2017) concluded that polyphenols in *A. Cerana* honeys resulted in enhanced antioxidant properties in vitro. The research work was conducted on mice using honey from Qingling Mountains of China for 12 weeks which resulted in serum antioxidant inhibition, depleted liver index, despondent dehancement of serum amino transferases, improved hepatic MDA output, SOD and GSH-Px activities and increased TGF-β expression. Therefore they revealed *A. cerana* has a hepato protective role in mice because of its antioxidant and prevention of oxidative stress potential. Wang et al. (2015) conducted a study where they selected 14 vitex honey from China for investigation to assess the antioxidant and hepatoprotective potential against paracetamol-induced liver damage in mice and concluded that vitex honey has a prominent role against the hepatic damage by its antioxidant activity.

16.11 Conclusion

Honey is the natural bee-derivative consumed by human civilizations since ancient times as sweet food as well for medical purposes owing to its innumerable health benefits. Honey contains a broad spectrum of valuable phytocomponents that make

it a potent candidate in healthcare system. Chinese honey consists of more than 180 components including sugars, water, volatile, nonvolatile compounds, enzymes, phenolic compounds, and flavonoids which determine its medicinal properties. Volatile compounds are essentially responsible for flavor and aroma which increases its aesthetic value and appreciates its consumer's acceptance. China tops the world in the production of honey and exports large amounts to Europe. The Chinese honey serves as an essential therapeutic tool for combating infection, exerting hepatoprotective effects, and so on. In addition to serving the science of medicine, honey production has boosted economy all over the world, especially in China. Further, extensive research work is needed on honey worldwide including Chinese honey to unravel and confirm its effective therapeutic role in wide range of diseases including tumors, diabetes, and the current Covid-19.

References

Addolorato G, Mirijello A, Barrio P, Gual A (2016) Treatment of alcohol use disorders in patients with alcoholic liver disease. J Hepatol 65:618–630

Alvarez-Saurez JM, Tulipani S, Romandini S, Bertoli F, Battino M (2009) Contribution of honey in nutrition and human health: a review. Mediterr J Nutr Metab 3(1):15–23. https://doi.org/10.1007/s12349-009-0051-6

Aslanova D, Bakkalbasi E, Artik N (2010) Effect of storage on 5-hydroxymethylfurfural (HMF) formation and color change in jams. Int J Food Prop 13:904–912

Ball DW (2007) The chemical composition of honey. J Chem Educ 84:1643

Bogdanov S, Jurendic T, Sieber R, Gallmann P (2008) Honey for nutrition and health: a review. J Am Coll Nutr 27:677–689

Can Z, Yildiz O, Sahin H, Turumtay EA, Silici S, Kolayli S (2015) An investigation of Turkish honeys: their physico-chemical properties, antioxidant capacities and phenolic profiles. Food Chem 180:133–141

Capuano E, Fogliano V (2011) Acrylamide and 5-hydroxymethylfurfural (HMF): a review on metabolism, toxicity, occurrence in food and mitigation strategies. LWT- Food Sci Technol 44:793–810

CBPA (China Bee Products Association) (2013) Current situation and development of honey industry in China (White Paper)

Cederbaum AI, Lu Y, Wang X, Wu D (2015) Synergistic toxic interactions between CYP2E1, LPS/TNFα, and JNK/p38 MAP kinase and their implications in alcohol-induced liver injury. In: Biological basis of alcohol-induced cancer. Springer, Cham, pp 145–172

Cheng N, Du B, Wang Y, Gao H, Cao W, Zheng J, Feng F (2014) Antioxidant properties of jujube honey and its protective effects against chronic alcohol-induced liver damage in mice. Food Funct 5:900–908

Cheng N, Wu L, Zheng J, Cao W (2015) Buckwheat honey attenuates carbon tetrachloride-induced liver and DNA damage in mice. Evid Based Complement Alternat Med 2015:1–8

Crittenden AN (2011) The importance of honey consumption in human evolution. Food Foodways 19:257–273

da Silva PM, Gauche C, Gonzaga LV, Costa ACO, Fett R (2016) Honey: chemical composition, stability and authenticity. Food Chem 196:309–323

Falagas ME, Grammatikos AP, Michalopoulos A (2008) Potential of old-generation antibiotics to address current need for new antibiotics. Expert Rev Anti Infect Ther 6:593–600

FAO (1987) Codex standard for honey. http://www.fao.org/docrep/w0076e/w0076e30.htm

FAO (2010) Food and agriculture organization FAOSTAT online statistical service

Fukuda M, Kobayashi K, Hirono Y, Miyagawa M, Ishida T, Ejiogu E, Sawai M, Pinkerton K, Takeuchi, M (2010) Jungle honey enhances immune function and antitumor activity. eCamdoi: https://doi.org/10.1093/ecam/nen086

Gao Y, Zhijun C (2016) Chinese honey positioning and price trend in domestic market. Agri Sci Tech 17:1446–1450

Gheldof N, Wang XH, Engeseth NJ (2003) Buckwheat honey increases serum antioxidant capacity in humans. J Agri and Food Chem 51:1500–1505

Ghorbani M, Khajehroshanaee N (2009) The study of qualitative factors influencing on honey consumers demand: application of hedonic pricing model in Khorasan Razavi Province. J Appl Sci 9:1597–1600

Gu G, Zhang C (2003) Export competitiveness of Chinese honey. Chin Rural Econ 7:60–64. (in Chinese)

Guoda G, Chun Z (2003) World honey trade. Bee World 84(4):177–183

Iurlina MO, Fritz R (2005) Characterization of micro-organisms in Argentinean honeys from different sources. Int. J. Food Microbiol 105:297–304

Katznelson H (1950) The influence of antibiotics and sulfa drugs on Bacillus larvae, cause of American foulbrood of the honeybee, in vitro and in vivo. J Bacteriol 59:471–479

Lee JH, Friso S, Choi SW (2014a) Epigenetic mechanisms underlying the link between non-alcoholic fatty liver diseases and nutrition. Nutrients 6:3303–3325

Lee PY, Lusk K, Mirosa M, Oey I (2014b) The role of personal values in Chinese consumers' food consumption decisions. A case study of healthy drinks. Appetite 73:95–104

Li H, Wu J (2009) Comparative analysis on the international competitiveness of China honey trade. J Int Trade 6:29–31

Liu J (2014) Ethanol and liver: recent insights into the mechanisms of ethanol-induced fatty liver. World J Gastroenterol 20:14672

Liu R, Pieniak Z, Verbeke W (2013) Consumers' attitudes and behaviour towards safe food in China: a review. Food Cont 33:93–104

Lu Y, Cederbaum AI (2016) Alcohol Upregulation of CYP2A5: Role of Reactive Oxygen Species. React Oxyg Species (Apex) 1(2):117–130

Majtan J, Majtanova L, Bohova J, Majtan V (2014) Honeydew honey as a potent antibacterial agent in eradication of multi-drug resistant Stenotrophomonas maltophilia isolates from cancer patients. Phytother Res 25:584–587

Malika M, Mohamed F, Chakib EA (2004) Microbiological and physico-chemical properties of moroccan honey. Int J Agric Biol:1560–8530/2005/07–5–773–776

Mathurin P, Bataller R (2015) Trends in the management and burden of alcoholic liver disease. J Hepatol 62:S38–S46

Meda A, Lamien CE, Millogo J, Romito M, Nacoulma OG (2004) Therapeutic uses of honey and honeybee larvae in Central Burkina Faso. J Ethnopharmacol 95:103–107

Mello T, Ceni E, Surrenti C, Galli A (2008) Alcohol induced hepatic fibrosis: role of acetaldehyde. Mol Asp Med 29:17–21

Neuman MG, Malnick S, Maor Y, Nanau RM, Melzer E, Ferenci P, Cohen LB (2015) Alcoholic liver disease: clinical and translational research. Exp Mol Pathol 99:596–610

Pätzold R, Brückner H (2006) Gas chromatographic detection of D-amino acids in natural and thermally treated bee honeys and studies on the mechanism of their formation as a result of the maillard reaction. Eur Food Res Technol 223:347–354

Qiao G, Guo T, Klein KK (2010) Melamine in Chinese milk products and consumer confidence. Appetite 55:190–195

Qiao G, Guo T, Klein KK (2012) Melamine and other food safety and health scares in China: comparing households with and without young children. Food Cont 26:378–386

Rich ML, Ritterhoff RJ, Hoffmann RJ (1950) A fatal case of aplastic anemia following chloramphenicol (chloromycetin) therapy. Ann Intern Med 33:1459–1467

Ruckriemen J, Schwarzenbolz U, Adam S, Henle T (2015) Identification and quantitation of 2-Acetyl-1-pyrroline in manuka honey (Leptospermum scoparium). J Agric Food Chem 63(38):8488–8492

Samat S, KanyanEnchang F, Nor Hussein F, Wan Ismail WI (2017) Four-week consumption of Malaysian honey reduces excess weight gain and improves obesity-related parameters in high fat diet induced obese rats. Evid Based Complement Alternat Med 2017:1342150. https://doi.org/10.1155/2017/1342150

Saral Ö, Yildiz O, Aliyazıcıoğlu R, Yuluğ E, Canpolat S, Öztürk F, Kolayli S (2016) Apitherapy products enhance the recovery of CCL_4-induced hepatic damages in rats. Turk J Med Sci 46:194–202

Solayman M, Islam M, Paul S, Ali Y, Khalil M, Alam N, Gan SH (2016) Physicochemical properties, minerals, trace elements, and heavy metals in honey of different origins: a comprehensive review. Comp Rev Food Sci Food Saf 15:219–233

Sousa JM, de Souza EL, Marques G, Meireles B, de Magalhães Cordeiro ÂT, Gullón B, Magnani M (2016) Polyphenolic profile and antioxidant and antibacterial activities of monofloral honeys produced by Meliponini in the Brazilian semiarid region. Food Res Int 84:61–68

Stahre M, Roeber J, Kanny D, Brewer RD, Zhang X (2014) Peer reviewed: contribution of excessive alcohol consumption to deaths and years of potential life lost in the United States. Prev Chr Dis 11:1–12

Sun Z, Zhao L, Cheng N, Xue X, Wu L, Zheng J, Cao W (2017) Identification of botanical origin of Chinese unifloral honeys by free amino acid profiles and chemometric methods. J Pharm Anal 7:217–323

Sushil A, Margaret D, George L, Edwin CKP, Nitin M (2019) Agastache honey has superior antifungal activity in comparison with important commercial honeys. Sci Rep 9:1–4

Tamma P (2017) Honeygate: how Europe is being flooded with fake honey—EURACTIV.com. https://www.euractiv.com/section/agriculture-food/news/honeygate-how-europe-isbeing-flooded-with-fake-honey/

Tanih NF, Dube C, Green E, Mkwetshana N, Clarke AM, Ndip LM, Ndip RN (2009) An African perspective on Helicobacter pylori: prevalence of human infection, drug resistance, and alternative approaches to treatment. Ann Trop Med Parasitol 103:189–204

Taormina PJ, Niemira BA, Beuchat LR (2001) Inhibitory activity of honey against food-borne pathogens as influenced by the presence of hydrogen peroxide and level of antioxidant power. Int J Food Microbiol 69:217–225

Temaru E, Shimura S, Amano K, Karasawa T (2007) Antibacterial activity of honey from stingless honeybees (Hymenoptera; Apidae; Meliponinae). Pol J Microbiol 56(4):281–285

Vyviurska O, Chlebo R, Pysarevska S, Spanik I (2016) The tracing of VOC composition of acacia honey during ripening stages by comprehensive two-dimensional gas chromatography. Chem Biodivers 13:1316–1325

Wang Y, He C (2008) An empirical analysis of the influence of standard gap over our agricultural trade. J Int Trade 24:26–29

Wang Z, Mao Y, Gale F (2008) Chinese consumer demand for food safety attributes in milk products. Food Policy 33:27–36

Wang Y, Li D, Cheng N, Gao H, Xue X, Cao W, Sun L (2015) Antioxidant and hepatoprotective activity of vitex honey against paracetamol induced liver damage in mice. Food Func 6:2339–2349

WTO (2010) World Trade Organization SPS Information Management System (SPSIMS). [2010-11-15]

Wu S, Fooks JR, Messer KD, Delaney D (2015) Consumer demand for local honey. Appl Econ 47:4377–4394

Yang X, Zhen X (2007) The impacts of TBT on China's honey trade. Xinjiang State Farms Econ 10:13–17. (in Chinese)

Yıldız O, Can Z, Saral Ö, Yuluğ E, Öztürk F, Aliyazıcıoğlu R, Kolaylı S (2013) Hepatoprotective potential of chestnut bee pollen on carbon tetrachloride-induced hepatic damages in rats. Evid Based Complement Alternat Med 2013:1–8

Ying R, Zhou L (2005) Analysis on regional revealed symmetric comparative advantage of Chinese honey export. J Int Trade 8:41–46

Zaghloul AA, El-Shattaw HH, Kassem AA, Ibrahim EA, Reddy IK, Khan MA (2001) Honey, a prospective antibiotic: extraction, formulation, and stability. Pharmazie 56:643–647

Zhao H, Cheng H, He L, Peng G, Xue X, Wu L, Cao W (2017) Antioxidant and hepatoprotective effects of A. cerana honey against acute alcohol-induced liver damage in mice. Food Res Int 101:35–44

Zheng HQ, Wei WT, Hu FL (2011) Beekeeping industry in China. Bee World 88:41–44

Zhou H, Qi C (2010) Research on the effect of US antidumping against China in honey case. Ecol Econ 7:119–124