https://doi.org/10.17221/117/2018-CJFS

# Alcohol and Health: Standards of Consumption, Benefits and Harm – a Review

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**Abstract**

Vieira I.M.M., Santos B.L.P., Ruzene D.S., Brányik T., Teixeira J.A., de Almeida e Silva J.B., Silva D.P. (2018): Alcohol and health: Standards of consumption, benefits and harm – a Review. Czech J. Food Sci., 36: 427–440.

In order to establish a clear limit between protective and harmful effects of alcohol consumption, it is necessary to define patterns of consumption. However, there is no universally recognized quantitative classification for patterns of consumption by alcohol doses. This is because the pattern of alcohol consumption does not only describe how much alcohol was consumed, but also takes into account a number of boundary conditions. This review deals with variabilities in the definitions of standard alcohol doses and patterns of alcohol consumption. These terms are being discussed with respect to the benefits and harms associated with alcohol consumption as well as the risks intrinsic to studies of such a complex phenomenon as the effect of alcoholic beverages on human health.

**Keywords**: abuse; alcoholic beverages; human health; moderate drinking; patterns of consumption; standard dose

The production and consumption of alcoholic beverages are considered to be one of the oldest activities developed by humanity (Dragone & Almeida e Silva 2010; Silva *et al*. 2016). It is assumed that man's first casual contact with alcohol occurred in the Paleolithic period, with the ingestion of grapes fermented by natural microflora exposed to the heat of the sun. Later, during the Mesopotamian civilization, around 8000 BC, brewing by fermentation was initiated, associated with the development of agriculture (Ferreira-Borges & Cunha Filho 2004). Over the centuries, the evolution of aseptic unit operations, industrial cooling, transport logistics and marketing has given the alcoholic beverage commodity year-round availability, practically everywhere (WHO 2014).

Ethanol ($C_2H_6O$), also called ethyl alcohol or simply alcohol, is a colourless liquid found in all alcoholic beverages, along with compounds such as methanol, higher alcohols, aldehydes, esters, organic acids etc. The maximum concentrations and ratios of these compounds vary according to the processes required to manufacture the most diverse types of beverages, thus conferring on them characteristic flavours (Heckmann & Silveira 2009). Initially, these beverages had relatively low alcohol content, since they depended exclusively on the fermentation process. With the advent of distillation, introduced

https://doi.org/10.17221/117/2018-CJFS

into Europe during the Middle Ages by people from Arabian regions, new types of alcoholic beverages appeared, being consumed in their distilled form (CEBRID 2014).

Alcoholic beverages are defined as liquids that contain alcohol (ethanol) and are intended for ingestion. Most of them are prepared through fermentation and distillation processes, but there are also those produced through the process of blending (WHO 1994; Mello *et al*. 2001). The Brazilian Legislation, through Decree 6.871 of 2009, defines an alcoholic beverage as one that contains a range of concentrations of alcohol from 0.5% to 54% in volume, at a temperature of 20°C. The alcohol content in alcoholic beverages is also indicated as a percentage of alcohol by volume, defined as the amount of millilitres of pure ethanol contained in 100 millilitres of the drink (% v/v) measured at 20°C (European Commission 2018). In the USA alcoholic beverage is any liquid beverage which contains not less than 0.5% of alcohol by volume and is intended for human consumption (CRF 2011). The International Agency for Research on Cancer (IARC 2012) states that most alcoholic beverages have a percentage of ethanol by volume between 4 and 40%, quite different from the ethyl content present in absinthe, up to 80%. In the ranking of the most consumed alcoholic beverages worldwide, intake of distillates represents 50.1% of total alcohol consumed, while beer represents 34.8%, followed by wine with 8% and other beverages representing the remaining 7.1% (WHO 2014). Statistics show that every year about 2 billion people consume alcoholic beverages, corresponding to about 40% of the world's population of 15 years or older (Anthony 2009).

According to the Centers for Disease Control and Prevention (CDC 2018), ingestion of alcoholic beverages can occur through different patterns of consumption which are associated with a range of harms and benefits. In addition to the type of consumption pattern adopted, several factors such as age, sex, ethnicity, physical condition, amount of food consumed prior to ingestion, use of recreational and prescribed drugs, family history and speed of consumption influence the possible benefits or harm arising from alcohol consumption. Although there is not yet consensus among experts about the benefits derived from alcohol consumption, mainly due to different opinions regarding the ideal amounts for ingestion, there is agreement regarding the detrimental effects of excessive consumption, and alcoholic beverages are considered to be the cause of several problems (Mokdad *et al*. 2004; Goeij *et al*. 2015; Cao & Giovannucci 2016).

When dealing with such a complex theme that is subject to several factors and variables, and due to the available scientific evidence, it is necessary to define a pattern of consumption, mainly to establish a clear boundary for protective roles to health, linked to light to moderate consumption, in contrast to risks arising from the extrapolation of this limit (Andrade & Oliveira 2009). In this context, the present work discusses relationships and controversies that exist between the patterns of consumption of alcoholic beverages and possible benefits and harm resulting from their ingestion.

## Standard dose of consumed alcohol

A standard drink corresponds to the volume of alcoholic beverage containing approximately equivalent amounts of pure alcohol, in grams, regardless of the type of beverage considered (WHO 1994). Quantification of the standard dose is not internationally recognized so there are variations in values by countries, making the setting of guidelines for patterns of alcohol consumption an arduous task. For Brazil, the standard dose corresponds to approximately 17 ml of pure alcohol or 14 g, corresponding to the ingestion of 40 ml of a distillate (cachaça, whiskey and vodka), 340 ml of bottled or draft beer and 140 ml of wine (Brazil Ministry of Justice 2011). Similarly to Brazil, the United States also stipulates that the standard dose corresponds to approximately 14 grams of pure alcohol (CISA 2014; NIAAA 2015). In Japan and Austria, the standard dose is 20 grams. Finland defines the standard dose as containing 12 g, while in Malta the standard dose consists of 8 g of alcohol. The WHO states that the standard dose is equivalent to 330 ml of beer at 4% alcohol content, 30 ml of 40% distilled beverage, 100 ml of 12% wine, 70 ml of 18% sherry, or 50 ml of 25% appetizer liquor (WHO 2010; CISA 2014). According to the International Alliance for Responsible Drinking (IARD 2018) there are also countries that have no standard dose stipulation.

Forecasts by the WHO up to the year 2025 point to an increase in alcohol consumption per capita for individuals older than 15 years. The largest expected increase is concentrated in populations of the WHO's Western Pacific region, mainly China, which estimates an increase in per capita consumption of 1.5 l of pure

https://doi.org/10.17221/117/2018-CJFS

alcohol. An increase in registered per capita alcohol consumption is also expected in WHO regions corresponding to the Americas and Southeast Asia. As for WHO regions of the Eastern Mediterranean and Africa, it is believed that alcohol consumption will remain stable. Despite the expected 0.6 l per capita decrease in alcohol consumption in the European region, it will remain the world's highest consumer (WHO 2014).

## Patterns of alcohol consumption

Since the consumption of alcoholic beverages is often associated with specific social and cultural circumstances, it can cause public health problems (Room *et al*. 2005; Sousa *et al*. 2008). On the other hand, literature published almost a century ago described moderate alcohol intake as being linked to potential health benefits (Pearl 1924). Given such a divergence of opinions, it is relevant to discuss the definitions of patterns of alcohol consumption. This parameter does not only describe how much people drink, but also the way in which they drink, including a number of variables such as when, where and with whom they drink, what other activities accompany their drinking, their general health, genetic risk factors, medication, age, sex, drink experience, and even what is being ingested (Single & Leino 1998).

Within this theme that is full of controversies, different terminologies are used to define a different alcohol consumption patterns. Among the existing classifications, the following types of consumption will be approached in this review: moderate, social, excessive, binge drinking and heavy/intense (WHO 1994; CISA 2014).

## Moderate consumption

According to Green *et al*. (2007), inconsistencies associated with the lack of well-defined definitions for the differences between moderate or heavy drinking, combined with the media's attention to both risks and benefits of ingestion of alcoholic beverages, can result in a confusing and complicated message. Public understanding of alcohol-related harm can also be affected by under-estimates of the volume of alcohol stipulated in consumption patterns and by divergent research results on the relative benefits and harm linked to different types of alcoholic beverages.

In general, moderate consumption is linked to very positive social situations, such as celebrations, banquets, food tastings and other aspects of social well-being (Heath 2000). The consumption of alcoholic beverages in that way neither does harm to the individual who drinks, nor to society. Thus maximizing benefits and minimizing harm to the consumer's health are related to moderate consumption which does not cause problems (NIAAA 1992; WHO 1994). In addition, Eckardt *et al*. (1998) summarized a number of definitions of moderate consumption as any consumption that is not considered as an intoxicant, since intake should be controlled or restricted. In another conceptualization, moderate consumption is considered 'statistically normal', taking into account the definition of the norm or mean value of consumption for a given age or population group, within the standard deviation of the mean of the group. Another definition is one that treats alcohol consumption in a 'non-harmful' way, whose cumulative effect does not cause deterioration or damage to health. For this case, consumption is below an upper limit and when beyond it, the individual may have some health problems. Some levels of moderate consumption can still be seen as having some specific positive health effects, which are identified in comparison with non-consumers and heavy consumers of alcoholic beverages.

For a better understanding of what it would be to consume moderately, quantitative definitions facilitate public understanding. As an example we note that in the USA, a moderate use of alcohol corresponds to the ingestion of up to one standard dose (14 g) per day for women and up to two standard doses (28 g) per day for men (HHS & USDA 2015). Similarly in Germany, low-risk alcohol consumption is up to 12 g per day for women and 24 g per day for men. In Ireland, low-risk drinking consists of drinking up to 110 g of alcohol per week for women and up to 170 g per week for men (IARD 2018). For countries such as Brazil, where there is no quantitative definition for the limits of moderate intake of alcoholic beverages for men and women, it is proposed to follow the recommendations of international organizations such as WHO (Andrade & Oliveira 2009; Brazil Ministry of Justice 2011).

When observing the quantitative definitions of moderate consumption, there is a distinction between values for men and women. Such a difference in the recommended dose is due to the specific physiological characteristics of each sex and that women, after

https://doi.org/10.17221/117/2018-CJFS

a similar consumption of alcoholic beverage in the same time interval, maintain an alcohol concentration in the blood stream greater than that found in men. Among the parameters that would be related to this higher concentration of alcohol are: (1) lower activity of stomach enzymes responsible for the breakdown of the alcohol, where once, enzymatic activity was considered to be four times higher in men than in women; (2) higher percentage of fat and lower percentage of water in women, raising the alcohol concentration in the body water of females (Frezza *et al*. 1990; NIAAA 1999; Milic *et al*. 2018).

In addition to the physiological differences that help us to understand why men and women are impacted differently by moderate consumption, Sayed and French (2016) argue that motivations and expectations associated with alcohol consumption could also be linked to these distinctions in health effects. Consumption for males is mainly related to social activity in conjunction with colleagues, while women consume to support the establishment and conservation of social bonds and to relieve stress.

## Social consumption

Social motives are one of the most common reasons that lead young adults to ingest alcohol (Kuntsche *et al*. 2005). Probably, the individual who socially consumes alcohol observes the people around him or her and, by analysing their beliefs and behaviours, uses the beverage to improve his/her experience with these people (Halim *et al*. 2012). The definitions established by the WHO recognize that social consumption occurs in the company of other people, as opposed to individual consumption, in a socially acceptable manner. The term is used, even if vaguely, as a synonym for the absence of problems with alcoholic beverages. However, it should not be confused with moderate consumption, since the latter is quantitatively delimited, although there is no global agreement on the limits. During festivities in some South American nations, alcohol consumption can result in a state of intoxication, but the consumption is regarded as social (WHO 1994).

## Excessive consumption

Excessive alcohol consumption is characterized by the extrapolation of intake parameters considered moderate. Individuals who fall into the category of excessive consumption reveal a range of multiple physical and psychological symptoms, including liver cirrhosis, certain forms of cancers, violence, fetal alcohol spectrum disorder, depressed mood, irritability, insomnia and anxiety (Heckmann 2006; Abrams *et al*. 2018).

In spite of its wide social acceptance, the consumption of alcoholic beverages, when excessive, ends up becoming a serious social problem, in such a way that the literature recognizes the substantial economic load that alcohol exerts around the world (Baumberg 2006; WHO 2014). In economic terms, the costs of alcohol abuse are divided into direct and indirect. Costs are direct when they involve spending on health, research and prevention, costs related to crime incidence and law enforcement, property damage and loss, administrative and welfare, and social work expenses. The indirect costs include expenditures due to premature mortality and reduced productivity, as well as costs of incarceration, job loss or early retirement and those associated with crime (Thavorncharoensap *et al*. 2009).

More specific definitions of excessive alcohol consumption have been attributed to four distinct situations that include binge drinking, heavy/intense consumption, consumption by underage individuals and by pregnant women (Bouchery *et al*. 2011; CDC 2017b). However, it is important to emphasize that individuals who consume alcoholic beverages excessively should not be automatically considered as dependent on alcohol, since the condition of dependency usually manifests in people who already have some type of predisposition to addictions related to biological, social, environmental and psychological factors (Heckmann & Silveira 2009; CDC 2016).

## Binge drinking

In quantitative terms, binge drinking is defined as a consumption pattern that brings blood alcohol concentrations to 0.08 g/dl. This pattern of consumption corresponds to the ingestion of five or more standard doses of beverage for men or four or more standard doses for women, both considering a single occasion and over a period of approximately two hours (Brewer & Swahn 2005; NIAAA n.d.; CDC 2017a; Carbia *et al*. 2018). Drinking these or larger amounts can lead to intoxications often associated with a number of physical, social and

https://doi.org/10.17221/117/2018-CJFS

mental problems (Naimi *et al*. 2003). The effects of this type of consumption may be aggravated according to the individual's weight, age, degree of saturation with food, speed of consumption, and the number of doses consumed. In most countries where a survey was made of this phenomenon, it was found that the social and health costs were higher than the benefits derived from the continuous use of alcoholic beverages. The survey conducted in Brazil pointed out that consumption in large quantities decreases with increasing age, and that binge drinking is typical for young people. Among all types of alcoholic beverages, beer was considered to be the most consumed during binge drinking, amounting to 73% of all doses consumed, followed by distillates with 13% and wine with 12% (Laranjeira *et al*. 2007).

## Heavy/intense consumption

When alcohol consumption is considered heavy, it means that it exceeds the standards for moderate consumption or, more mistakenly, social consumption. This standard has been defined in terms of exceeding a certain daily volume or quantity consumed on one occasion (WHO 2017). According to Anthony (2009), this consumption is also defined as a single occasion in which the individual ingests at least 60 g of alcohol. Another definition is given by the Dietary Guidelines 2015–2020, where heavy consumption of alcoholic beverages refers to consumption of at least 8 standard doses per week for women and 15 doses per week for men (HHS & USDA 2015).

The adverse health effects reported in the literature are many and range from unintentional physical injuries such as car accidents, hypothermia, falls, drownings, burns, suicide, sudden infant death syndrome, alcohol poisoning, hypertension, meningitis, acute myocardial infarction, gastritis, pancreatitis, sexually transmitted diseases and diabetes (Andrade *et al*. 2009).

## Action of alcohol in the body

Ethanol is a small molecule that is highly soluble in water, giving it the ability to permeate easily into all organs of the body, affecting many of their vital functions (Lieber 1992). Most tissues contain enzymes capable of oxidizing ethanol, or at least of non-oxidative metabolism, but significant activity occurs only in the liver and, to a lesser extent, in the stomach (Lieber & Abittan 1999). The human organism has an alcohol withdrawal capacity of the order of 0.2 g per kilogram of body mass per hour, which suggests that drunkenness occurs when alcoholic beverages are consumed in a proportion and speed capable of causing accumulation of alcohol in the blood (Leal *et al*. 2012). In addition, both absorption and metabolism of alcohol in the body are known to be susceptible to a number of factors such as age, gender, ethnicity, type of drink, alcohol intake concomitant with other drugs, beverages with higher concentrations of ethanol and low blood sugar levels; this leads to the conclusion that different individuals are impacted differently (Lieber & Abittan 1999; Jones 2008).

After ingestion, alcohol reaches the stomach first, where its absorption process begins, the speed of which is directly related to the presence or not of food in this organ. When food is present, the rate of absorption of alcohol is reduced as a result of increased gastric emptying (Guimarães *et al*. 2006). In a fasting individual, for example, about 10–20% of an alcohol dose is absorbed in the stomach (the volume of alcohol affects the absorption) and 75–80% is absorbed in the small intestine (Baselt & Danhof 1988). Absorption of alcohol in small amounts is initiated by the mucous membranes of the mouth and esophagus, followed by the stomach and intestines, where it continues to be absorbed and transferred into the bloodstream (Heckmann & Silveira 2009).

As the liver is only able to process a given amount of alcohol per hour, regardless of the amount consumed, alcohol metabolism occurs more slowly than its absorption (NIAAA 1997; CDC 2017b). After being distributed, ethanol metabolism can occur via three enzymatic processes: alcohol dehydrogenase (ADH), cytochrome P450 (CYP2E1) and catalase. However, the latter is quantitatively of minor importance due to the need for hydrogen peroxide for the reaction to proceed a compound that does not occur *in vivo*. Thus, the first catalytic reaction in the oxidation of ethanol occurs through the action of Class I ADH, located abundantly in liver cells and responsible for converting, through oxidation, the alcohol molecule into acetaldehyde, a metabolite considered to be toxic to the body. In the next step, oxidation of acetaldehyde to acetate occurs with the aid of the enzyme aldehyde dehydrogenase (ALDH), mainly located in mitochondria. Both the first and second

https://doi.org/10.17221/117/2018-CJFS

stages of ethanol oxidation require the involvement of a coenzyme, called nicotinamide adenine dinucleotide ($NAD^+$), which is converted to its reduced form (NADH) during the reaction. Acetate produced from the oxidation of acetaldehyde is metabolized to acetyl coenzyme A. The final products of ethanol metabolism are carbon dioxide and water (Lucas *et al.* 2005; Jones 2008).

The P450 enzyme involved in the metabolism of ethanol is designated as CYP2E1 and is also responsible for the oxidation of aromatic hydrocarbons such as toluene and benzene, as well as chlorinated alkanes, acetone, 1-butanol and 2-propanol (Teschke & Gellert 1986). The enzyme CYP2E1 has a higher equilibrium constant for the oxidation of ethanol (0.6–0.8 g/l) compared to ADH (0.02–0.05 g/l), which suggests that the blood alcohol concentration must exceed about 1 g/l for the enzyme to play a significant role in the elimination of ethanol from the bloodstream (Lieber & Decarli 1970).

The boundary separating the harmful effects and benefits of ethanol in the human body may be regarded as being dependent on both the amount of alcohol consumed and the followed consumption pattern (Dufour 1999; Ellison & Martinic 2007; Laranjeira *et al.* 2007). Given this context, there is an importance of reaching a consensus on the definitions of the different patterns of consumption, so that society becomes more aware of the consumption limits and understands the possible benefits and harms relating to the ingestion of alcoholic beverages.

## Benefits associated with alcohol consumption

In this scenario of divergent and even controversial information, moderate consumption assumes a prominent role as the literature reports a reduction in the general rate of mortality and on the protective role of such patterns of consumption on some chronic diseases (Andrade & Oliveira 2009; Sayed & French 2016).

Dubowski (1980) categorized the stages of acute alcohol influence/intoxication, showing that for a blood alcohol content of 0.03–0.12% (w/v) the corresponding alcoholic influence phase is euphoric, linked to characteristics such as sociability, conversation, increased self-confidence and reduced inhibitions. These factors are believed to be responsible for motivating a large proportion of the public to drink alcohol, since the literature reports that people with high levels of anxiety and stress expect alcohol to elevate mood and reduce stress and tension (Ashley *et al.* 1994).

There is an accumulation of scientific evidence indicating that daily consumption of alcoholic beverages, characterized as mild or moderate, can significantly reduce the risks of coronary heart disease, one of the main manifestations of cardiovascular diseases (Murray & Lopez 1997; O'Keefe *et al.* 2007). The results show that possible cardiovascular benefits seem to be the most important positive effects, with most studies showing reductions 30–35% in the

Table 1. Different beneficial effects of moderate alcohol consumption according to the literature

| Benefits | Authors |
|---|---|
| Decreased risks of coronary heart disease | NIAAA (1992); Ashley *et al.* (1994); Rimm *et al.* (1999); Kabagambe *et al.* (2005); Mukamal (2005); Beulens *et al.* (2007); Ellison & Martinic (2007); Rimm & Moats (2007); Chagas *et al.* (2017) |
| Reducing the incidence of stroke | Berger *et al.* (1999); Sacco *et al.* (1999); Reynolds *et al.* (2003); Klatsky (2005); Mukamal *et al.* (2005); Elkind *et al.* (2006) |
| Increased insulin sensitivity | Lazarus *et al.* (1997); Bell *et al.* (2000); Davies *et al.* (2002); NIAAA (2003); Koppes *et al.* (2005); Djousse & Gaziano (2008); Andrade & Oliveira (2009); Arranz *et al.* (2012) |
| Reduced risk of heart failure | Cooper *et al.* (2000); Abramson *et al.* (2001); Walsh *et al.* (2002); Bryson *et al.* (2006); Petrone *et al.* (2014); Larsson *et al.* (2017) |
| Increased HDL cholesterol | Agarwal (2002); Ferrières (2004); Schröder *et al.* (2005); Greenfield *et al.* (2005); Wakabayashi (2017) |

https://doi.org/10.17221/117/2018-CJFS

risks related to coronary heart disease (Kabagambe *et al.* 2005).

Table 1 presents a list of several studies that indicate the protective effect of alcohol in relation to different health problems, most of which are cardiovascular or related to insulin sensitivity linked to diabetes. The literature refers to cardiovascular diseases ranging from different manifestations of coronary arterial diseases, disorders of blood pressure regulation, arrhythmias and heart failure, to the various forms of ischemic and hemorrhagic cerebrovascular disease (Beilin & Puddey 2003; WHO 2017). The mechanisms underlying the cardio-protective effects of moderate alcohol consumption may be related to alcohol-induced changes in serum lipids, high density lipoprotein (HDL), platelets, blood coagulation proteins, inflammatory cytokines and insulin resistance (Papadakis *et al.* 2000; Freiberg & Samet 2005). However, because these parameters are interrelated through complex metabolic pathways, the exact contribution of each is difficult to prove statistically (O'Keefe *et al.* 2007).

The publications listed in Table 1 show differences between several parameters, such as age, sex, health status and physical factors, and were evaluated against the definition of what the authors considered to be moderate consumption. The variability of data still makes it impossible for the reported benefits to be admitted as incontestable for any individual and once again stress the importance of definitions and analysis of the cases. Curves in the form of 'J' or 'U' were used in several studies to describe the relationship between alcohol consumption and mortality, diseases of the cardiovascular system and other problems (Berger *et al.* 1999; Koppes *et al.* 2005; Klatsky 2005; Letenneur 2007; Ronksley *et al.* 2011; Bergmann *et al.* 2015). The J-shaped curve describes a relationship in which the relative risk decreases with alcohol intake from mild to moderate, but possibly with high alcohol intake, increases above the level of the reference population of the abstainers. On the other hand, the U-shaped curve describes a relationship in which relative risk decreases with mild to moderate alcohol consumption and then increases as alcohol intake increases, but does not increase above the reference population of the abstainers (Fernández-Solà 2015).

In addition to the benefits discussed so far, Arranz *et al.* (2012) reported that moderate consumption of alcoholic beverages has a beneficial effect on cellular damage caused by aging, cognitive functions and dementia, such benefits being verified in different patients. Investigations carried out by Ruitenberg *et al.* (2002) and Orgogozo *et al.* (1997) also pointed out that moderate alcohol consumption leads to a decrease in the risk of dementia and, despite the already advanced age of the individuals analysed and the cardiovascular problems associated with excessive alcohol consumption, moderate consumption was recommended.

Despite consensus among many authors on the beneficial effects, many still express differing opinions regarding the influence of the type of alcoholic beverage, giving voice to another thread of discussions. Part of the literature supports the argument that positive health effects are differentiated according to the type of drink and another part disputes such

Table 2. Harmful effects of alcohol abuse according to the literature evidence

| Harms | Authors |
|---|---|
| Increased risks of hypertension | Friedman *et al.* (1988); Fuchs *et al.* (2001); Xin *et al.* (2001); Klatsky (2004); Sesso *et al.* (2008); Hong *et al.* (2016) |
| Higher incidence of liver diseases | Fletcher & Powell (2003); Bau *et al.* (2007); Rehm *et al.* (2009); WHO (2014); Chacko & Reinus (2016); Leggio & Lee (2017) |
| Increased risks of cardiovascular disease | Greenspon & Schaal (1983); Gunzerath *et al.* (2004); Emberson & Bennett (2006); Larsson *et al.* (2015); Lia *et al.* (2016); Whitman *et al.* (2017) |
| Increased risk of developing cancer | Swaroop *et al.* (2004); Brown (2005); Baan *et al.* (2007); Arranz *et al.* (2012); Cao & Giovannucci (2016); American Cancer Society (2017) |
| Damage to the fetus | NIAAA (2003); Lebel *et al.* (2008); Andrade & Oliveira (2009); Naik *et al.* (2016); CDC (2016); Cohen *et al.* (2017); WHO (2017) |

https://doi.org/10.17221/117/2018-CJFS

statements. They argue that the alcohol present in alcoholic beverages is probably the only component responsible for the protective effect, such that the observed differences are possibly caused by the pattern of consumption of the beverage (Ashley *et al*. 1994; Conigrave *et al*. 2001; Matsumoto *et al*. 2014).

## Harm associated with alcohol consumption

Despite the existence of countless studies reporting benefits related to moderate alcohol consumption, many of these studies are not considered conclusive and experts worldwide warn of misuse of alcohol (Sayed & French 2016). Since excessive consumption of alcoholic beverages can damage various tissues, produce various physiological changes and impair and interfere with the hormonal and biochemical regulation of a variety of cellular and metabolic functions, such a consumption pattern is related to mortality and morbidity from chronic medical conditions (Brick 2004; Dawson 2011). Some of these conditions are presented in Table 2.

The risk factors associated with heavy consumption and/or binge drinking are also of a social nature, resulting in increased crime (homicide, robbery, domestic and sexual violence) and accidents, possibly involving motor vehicles, drownings etc. (NIAAA 1997; Zador *et al*. 2000). In this context, Meloni and Laranjeira (2004) made explicit that the problems of a social nature related to ethanol ingestion are public disorder, vandalism, educational and social conflicts.

Since the liver is the main site of alcohol metabolism, and considering the high concentration of alcohol that reaches it, as well as the toxicity of some metabolites of alcohol, damage to the liver may be among the most likely physiological consequences of alcohol abuse (Brick 2004). In the survey by Leggio and Lee (2017), it is stated that the higher the daily intake, the greater the emerging risk of liver disease. However, there are differences between individuals and related risk factors that modify the incidence of disease. Such differences include genetic predisposition, age, sex, metabolic syndrome, obesity, diabetes, smoking, iron overload and chronic hepatitis B or C. The spectrum of alcoholic liver disease comprises simple steatosis (fatty liver), fibrosis, alcoholic hepatitis, alcoholic cirrhosis and liver failure (Chacko & Reinus 2016).

As regards cardiovascular diseases, the NIAAA (2017) points out that the ingestion of excessive alcoholic beverages, either on a single occasion or recurrently over time, has harmful effects, such as the development of some diseases that include cardiomyopathies, arrhythmias, strokes and high blood pressure. Based on previous evidence, Rehm and Roerecke (2017) argued that there are several reasons for deleterious cardiovascular effects: (1) excessive alcohol content acts as a toxin responsible for weakening the heart muscle; (2) alcohol consumption causes elevation of blood pressure; (3) alcohol has a negative impact on vascular function, associated with oxidative stress; (4) chronic intensive consumption is usually associated with other risk factors such as malnutrition or smoking, resulting in a negative synergistic effect on cardiovascular diseases, especially in already disadvantaged individuals.

Damage caused to the fetus by ingestion of alcoholic beverages during pregnancy is part of what is termed Fetal Alcohol Spectrum Disorder, which, in turn, corresponds to a set of abnormal physical, mental, functional and behavioural conditions (Flak *et al*. 2014; CDC 2016; WHO 2017; Landgraf *et al*. 2018). Research has indicated a higher rate of aggression among children exposed to alcohol during pregnancy than those who were not exposed, as well as deficits in both the development and healthy organization of the nervous system of the affected individual (Sood *et al*. 2001; Lebel *et al*. 2008). In this context, pregnant women are advised to abstain, since the minimum dosage that causes problems to the fetus is not yet known (O'Leary & Bower 2012; Cohen *et al*. 2017). Prolonged and/or excessive alcohol intake may also increase the risk of stroke due to increased blood pressure and the development of dementia, as well as weakening of the immune system, making the body more susceptible to diseases such as tuberculosis and pneumonia (NIAAA 2003; Rabin 2009; WHO 2017).

## Problems in studies

Criticism of research that investigated the benefits of mild to moderate alcohol consumption stem from alleged methodological errors in these studies. Berger *et al*. (1999) warned that these studies, which reported the protective effect of alcohol against cardiovascular and cerebrovascular diseases, used comparisons between individuals who drink and in-

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dividuals who abstain, where the group of abstainers could have included people who discontinued the use of ethanol due to health problems. However, subsequent studies that eliminated the sick quitters from analyses also verified the appearance of the same 'J'-shaped curve pattern associated with that type of consumption and its benefits. Nevertheless, with regard to the cardiovascular system, Whitman *et al*. (2017) agreed with other studies that the cardiovascular effects of alcohol abuse are not found in population-based research. The reason for this is that the vast majority of epidemiological studies are based on self-reported alcohol consumption by individuals, making this method of verification particularly imprecise.

At the end of the 1990s, researchers pointed out that evaluation of the harmful and beneficial effects of alcohol consumption should be made through large epidemiological studies, in which a survey on all causes of mortality should be carried out. They should take into account a sufficient numbers of individuals so that the risks were reliably estimated in the subgroups, which should be classified according to age, gender and smoking (Thun *et al*. 1997). Ten years later, Rimm and Moats (2007) highlighted the existence of substantial epidemiological evidence from geographical comparisons, large cohort studies, and many meta-analyses, with a more cautious approach to the relevance of standards of consumption, frequency, quantity and type of alcoholic beverage ingested, considering physical and health conditions and alcohol intake during the adult life of the participants analysed. More recent publications consider the observational character of epidemiology, but agree that the exact magnitude of the protective effect of alcohol is associated with patterns of consumption of individuals and populations, and therefore these conditions should be considered (Rehm & Roerecke 2017).

According to research in the area, the sensitive problems associated with alcoholic beverages would be better evaluated using results obtained through randomized trials. In these, potentially confusing factors could be minimized since the individuals' exposure to alcohol intake would be done in a random way, as compared to specific patterns, allowing comparison with a control group that would not be exposed to the potential factor (O'Keefe *et al*. 2007; Arranz *et al*. 2012; Alcohol and society 2014).

Another challenge for the scientific community, in relation to this type of test, is the absence of randomized long-term evaluations. The studies carried out have been mostly observational, contained methodological shortcomings or were of too short duration, whose period of time was considered insufficient to verify the incidence of death, cardiovascular diseases and cancer in the analysed population. One of the main obstacles to observational studies is to measure the impact linked to alcohol intake among moderate and abstemious consumers. Besides the possibility of these groups presenting divergent behaviours and motivations, there are several intrinsic factors that could influence the results of the research, such as the control over the amount consumed, since among the abstainers there could be the development of chemical dependence (Almeida-Pititto *et al*. 2013).

In order to obtain the best scientific evidence, conclusions drawn from the results of meta-analyses or systematic reviews should be based on randomized clinical trials. However, the absence of such trials prevents the conclusions of epidemiological studies being considered definitive (Arranz *et al*. 2012). In this context, some studies believe that is unwise, especially among abstainers, to encourage alcohol consumption as a public health measure based on its possible protective effects, due to the individuality of each human being and our different genetic vulnerabilities (Elkind *et al*. 2006; De Gaetano *et al*. 2016; Rehm & Roerecke 2017; O'Keefe *et al*. 2018).

## Final considerations

The consumption of alcoholic beverages is accepted worldwide and is regarded as being normal since alcohol is associated with pleasant social moments. However, the adopted pattern of consumption is a prime factor in predicting the potential benefits and harm imposed on consumers. The different definitions found in the literature regarding different patterns of consumption make it difficult for specialists to understand and agree on the protective effects of alcohol, as well as the realities of recommendations for safe intake. Although the deleterious effects of excessive consumption have been clarified and documented, mechanisms related to benefits derived from alcohol consumption are still the subject of discussion in the scientific community. Within this scenario, ingestion of alcoholic beverages should not be recommended to the temperate population, and those who consume moderately should be aware of the fine line that divides benefits and harm.

https://doi.org/10.17221/117/2018-CJFS

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Received: 2018–05–04
Accepted after corrections: 2018–11–19
Published online: 2018–12–20