The qualitative aspects of non-alcoholic beer (Ma-al-Shaeer)

Sohrabvandi, S.[1*], Mousavi, S. M. [2], Razavi, S. H.[2], Mortazavian, A. M.[1] , Rezaei, K.[2]

1.National Nutrition and Food Technology Reserch Institute, Faculty of Nutrition Sciences and Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
2. Department of Food Science, Engineering and Technology, Faculty of Agricultural Engineering and Technology, University of Tehran

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Non-alcoholic beer (Ma-al-Shaeer) is a commonly consumed and popular beverage in Islamic countries. Its popularity originates not only from the pleasurable sensory attributes and relatively low cost, but also from its health beneficial effects when consumed in moderate amounts. Qualitative aspects of non-alcoholic beer from the consumer point of view, which is so-called here as "functional qualitative aspects" (flavor, color, foaming property, body, viscosity and mouthfeel, colloidal stability, nutritional and medicinal aspects as well as hygiene) play a crucial role in its acceptability. This article reviews these qualitative aspects, in physical and chemical categories.

Keywords: Chemical; Flavor; Health; Non-alcoholic beer; Nutritional; Physical; Quality

1. Introduction

Non-alcoholic beer, beverage made from malt (germinated barely), hop, water and possibly yeast, is widely consumed in Islamic countries as well as all over the world [1-3]. This beverage is under special interest because of satisfactory organoleptic attributes and favorable health characteristics (in moderate consumption) as well as relatively low cost [4-9].

The basic ingredients of non-alcoholic beer are malted barley (produced by soaking and germinating the grains), hops (which add a characteristic bitter flavor), and possibly brewer's yeast [10-12]. Various factors during production of non-alcoholic beer influence characteristics of non-alcoholic beer such as the variety of barely and the malting process, temperature and pH during mashing, sparging, variety of hops added during wort boiling fermentation and storage conditions [13-15]. The legal definition of non-alcoholic/alcohol-free non-alcoholic beer varies from one country to another. For instance, this type of non-alcoholic beer must contains maximum alcohol levels of 0.1% V/V (Arabic countries), 0.5% V/V (Iran, England, Germany and Holland), 1% V/V (Spain) and with no experimental detectable amount, for example less than 0.05% W/V (US, and preferential amount in Arabic countries) [4, 5, 13]. The current worldwide increasing demand for alcohol-free non-alcoholic beers among a population is different aspects such as health, diet, safety in the workplace or within the framework of the road traffic or prohibition of alcohol consumption in factories and shops and shops caused by labor protection laws. There are also countries (such as Islamic countries) where alcohol consumption is completely forbidden by law [16, 17]. In addition, people are becoming aware of problems that alcohol can bring regarding civil responsibilities [17]. Alcohol-free non-alcoholic beers are also recommended for specific groups of people such as the the pregnant women, sporting professionals, people with cardiovascular and hepatic pathologies, and medicated people [11, 12].

Organoleptic characteristics of non-alcoholic beer complies flavor, color, foaming property, body, viscosity, mouthfeeling and colloidal stability [17]. Flavor is by far the most important sensory attribute of this

*Corresponding author E-Mail address. S_Sohrabvandi@yahoo.com

Apart from sensory properties, microbial quality of non-alcoholic beer is an important issue, because it can affects sensory profile and shelf life of the final product as well as health state of consumers. Because on one hand, there is no record of pathogens ever having been found in non-alcoholic beer and on the other hand, activity of spoil-forming microorganisms would lead to the destruction of non-alcoholic beer physical (foaming property, body, viscosity and mouthfeel, color and transparency, and colloidal stability) and/or chemical (flavor and chemical hygiene) characteristics, microbiological aspect of quality has been not explained in a distinct section in this article, but it has been mentioned within the sections. The aim of present article was to review the qualitative aspects of non-alcoholic beer from the consumer viewpoint (functional qualitative aspects), in two main classes, namely, physical and chemical attributes.

2. Qualitative aspects of non-alcoholic beer

Qualitative aspects of non-alcoholic beer can be classified to physical and chemical parameters. Physical attributes include foaming property, body, viscosity, mouthfeel, color, transparency and colloidal stability. Chemical characteristics comprise definitely wide and important range of attributes including flavor (as critical value of non-alcoholic beer), nutritional (nutrients containment and bioavailability) and medicinal (preventive and therapeutical impacts) aspects as well as chemical hygiene (chemically originated- or microbial-derived chemical compounds which are harmful for human health). Qualitative aspects of non-alcoholic beer along with the main relevant responsible ingredients have been summarized in Table 1. It should be pointed out that factors affect different aspects of non-alcoholic beer quality can be classified in different ways, e.g., intrinsic (formulating) and extrinsic (process) factors, indigenous and additives factors (such as malt extract compounds versus additive compounds), or positive and negative factors.

Positive factors are those impart satisfactory and characterized attributes to non-alcoholic beer in different aspects (Sensory, nutritional, medicinal and hygienic), while negative factors deteriorate these parameters in various ways. The negative factors could be indigenous (e.g., coming from malt) or additive (e.g., chemical additives or contaminant microorganisms), as might be a positive factor in excess amount which is regarded as a negative factor. Table 1 represents principal qualitative aspects of non-alcoholic beer and the main relevant responsible ingredients.

2.1. Physical attributes

2.1.1. Foaming property

Foaming property in non-alcoholic beer is a mixed property including aspects such as CO_2 retention and foam stabilization which produce foam-head on top of the glass (foam head retention), foam quantity, lacing (adhesion or cling), bubble hazing and bubble gushing (bursting or efferrescence) [17, 18]. Proper foam-head stability in non-alcoholic beer poured in a glass is deemed as a desirable characteristic. Polypeptides, peptides, glycoproteins, polyphenols, dextrines and some types of gums, which occur in colloidal state of non-alcoholic beer, are potent foaming agents [14, 18]. The malt variety influences type and amount of foaming agents extracted in wort and as a result, the foam quality of non-alcoholic beer. Addition of glycerol and/or sugar alcohols reinforces the foaming property of non-alcoholic beer [19]. Proteins with MW>5000 and higher hydrophobic area are correlated well with foam head retention [18]. Hops iso-alpha-acids and their oxidized or reduced derivatives as well as isohumulone and isoadhumulone enhance foam stabilization [20, 21]. High molecular weight non-starch polysaccharides such as β-glucans and arabionoxylans improve foam stability via increasing non-alcoholic beer viscosity [18]. It has been reported that among the metal ions, iron possesses positive effect on foam stabilization [22]. Also, binding metal ions such as Mn^{2+} and Al^{3+} to iso-alpha-acids significantly improve the foamability of latter compounds [18]. Melanoidins might increase foam stability in non-alcoholic beer. Addition of adjunct grains such as wheat malt considerably increases foam stabilization and haze formation in non-alcoholic

Table 1. Qualitative aspects of non-alcoholic beer and the main relevant responsible ingredients.

Qualitative aspect	Main responsible ingredients
1. Physical	
1.1. Foaming property	Polypeptides, glycoproteins, phenolics, dextrins, some gums, iron and copper
1.2. Body, viscosity and mouthfeel	Proteins, gums, polyphenoles and polynulcletides as well as their compositions; additives such as silica, PVPP and glycerol, CO_2 gas, fatty acids, pH (contaminating microorganisms have an adverse effect)
1.3. Colour and transparency	Sugars, amino acids, peptides, proteins, polyphenols, purines, perimidines, nucleotides and polynucleotides as well as their compositions; riboflavin, addition of some colorants, iron and copper
1.4. Colloidal stability	Solubilization of Polypeptides and polyphenols as well as their compositions and derivatives
2. Chemical	
2.1. Flavour	Phenolics, proteins, carbohydrates and nucleotides as well as their compositions; organic acids (type and titrable acidity), pH value, CO_2 gas. Some volatile compounds such as several aldehydes, ketones, carboxylic acids, fatty acids and essential oils, sulphur-containing volatiles, minerals (iron and copper) and leaked packaging materials cause off-flavour above determined level.
2.2. Nutritional nutrients/calorie ingestion	B-vitamin complex and selenium, digestible carbohydrates and proteins
2.3. Medicinal Anti-carcinogenic, cardioprotective, immunomodulation, anti-osteoporosis retardation of dementia and aging, prevention of diabetes, anti-microbial and anti-viral, anti-stomach ulcer, Radio-protective, tension reduction (relaxation), promotion of bowel function in the elderly, Facilitating renal excretion of Al, Estrogenic properties in women	Phenolics, folic acid, dietary fibres, proteins and amino acids, β-pseudouridine, low pH and high acidity, salisic acid, glycine betaine,
2.4. Chemical hygienic Concentration of chemical detrimental compounds in non-alcoholic beer below the standard limits, as much as possible	Toxic amines, nitrates, aluminium (also, spoil-forming microorganisms)

beer due to increase in protein content of the wort [23, 24]. pH of non-alcoholic beer is inversely correlated with foam stabilization [18]. Lipids have been recognized as the most important foam inhibitors in non-alcoholic beer [14].Bubble haze, the formation of microbubbles in whole liquid, is influenced by the type and amount of the minerals occur in non-alcoholic beer, presents of surface active agents in the surface of the bubbles and bubble entrainment of container (related to its material and shape) [25-30]. Gushing/efferrescence, i.e., the overflow behavior of CO_2 after opening the container is strongly dependent on ingredients which induce the nucleation of the bubbles with an especial mechanism [31, 32]. Overcarbonation, presence of microcrystals of calcium oxalate, iron, nickel, tin and molybdenum (especially in the presence of iso-alpha-acids) as well as long-chain saturated fatty acids enhance gushing. In contrast, alpha-acids, hulupones and unsaturated fatty acids suppress this phenomenon [18].

2.1.2. Body, viscosity and mouthfeel

Although non-alcoholic beer is a colloidal system, its viscosity is Newtonian, because of low concentration of colloidal materials in aqueous phase [14]. Seed gums such as β-glucans (as high-molecular weight carbohydrates), which are present in some varieties of barely in relatively high amount; markedly rise viscosity to such extent that might not be appropriate for non-alcoholic beer. Excessive amounts of β-glucans cause soupiness texture and degrade smooth mouthfeel, while deteriorating sharpness and lively sensations [14]. Arabinoxylans and especially dextrins are also known as viscosity enhancers [18]. Some additives such as silica gel, polyvinyl-polypyrolidine (PVPP) and glycerol have improving effects on the body of product [19]. The body of non-alcoholic beer is characterized during the dispensing and pouring, circulating and drinking. The “light” body for non-alcoholic beer is defined as favorable body from the consumers’ point of view [17]. Polynucleotides formed during the malting process increase viscosity and improve mouthfeel of non-alcoholic beer [14]. Fatty acids of malt cause oiliness sensation in the mouth which is known as “oily mouth feel” [14]. Polyphenols generated during malt heating contribute some mouthfeeling aspects such as dispersion and roughness [14]. Carbon dioxide influences mouthfeeling via formation of wriggling sensation in mouth and stomach [17]. It has been reported that at pH<4.0, mouthfeel of stored non-alcoholic beer significantly improved [33]. Type and amount of adjunct grains used directly influence on non-alcoholic beer mouthfeeling. For example, corn imparts fulling property to non-alcoholic beer in mouth [14]. Lactic acid bacteria as well as acetic acid bacteria, as spoil-formers in non-alcoholic beer, might cause ropiness due to synthesizing polysaccharide capsules and strands. Also, growth of wild yeast during fermentation yields ropiness and causes formation of inadequate body due to consumption of dextrins [14, 34, 35].

2.1.3. Color and transparency

Non-alcoholic beer might comprise a wide spectrum of colors dark, dark amber, almost brown, red undertones and pale amber. The wort color is substantially representative of non-alcoholic beer color [14, 36]. Heating conditions in drying kiln during malting process strongly affect color characteristics of non-alcoholic beer [37]. Various compounds present in non-alcoholic beer such as sugars, amino acids, small peptides, simple- and polyphenols as well as some carbonyl compounds contribute in non-alcoholic beer color. Melanoidins (polymeric and colored final products of the Maillard reaction), which are from the most important colorants normally present in non-alcoholic beer, are responsible for its wide color spectrum from relatively dark yellow to dark brown. In some countries, caramel colorants are also added for darkening of non-alcoholic beer [14, 18, 36]. Polyphenols affect non-alcoholic beer color especially in oxidized form in the presence of iron or copper [18]. Purines, perimidines, nucleotides and polynucleotides formed during the malting process also contribute to non-alcoholic beer color via interactions with other components [14]. Riboflavin can also significantly contribute to non-alcoholic beer color in pale non-alcoholic beers [18].

The “brilliant” appearance from transparency point of view is mostly demanded by the consumers for non-alcoholic beer. High turbidity regards as inappropriate characteristic. Achieving transparency is done by separation of chill haze derived from proteins-polyphenols interactions in clarified-chilled non-alcoholic beer [14, 38]. It has been speculated that adding some part of hop extract after wort boiling mediate color intensity of non-alcoholic beer [14].

2.1.4. Colloidal stability

Loss of colloidal stability of non-alcoholic beer during storage might adversely influence transparency, eye-appeal smoothness and integrity, body, viscosity and mouthfeel [17]. In kettle-boiling and finishing stages of non-alcoholic beer production, residual colloidal materials (including polypeptides and polyphenols) condense with other compounds following by precipitation or formation of colloidal haze through cold storage (e.g., ageing stage). The proteins responsible for haze formation (which are so-called as "haze-active" proteins) are usually rich in proline. Not all the polyphenols present in non-alcoholic beer are haze-active; proanthocyanidine and flavonols are the most important ones [18]. Some metal ions such as cupper, iron, aluminum as well as carbohydrates (pentoses, arabinose and xylose) have been found in non-alcoholic beer haze [18]. Haze may be rarely formed by calcium oxalate or carbohydrates such as retrograded starch, β-glucans and pentosans. These types of hazes are denoted as "calcium oxalate haze" and "carbohydrate haze", respectively [18]. During non-alcoholic beer freezing, while aqueous phase concentrates gradually, some soluble materials gradually become insoluble (falling-out phenomenon) and precipitate. Trough the melting of non-alcoholic beer, dregs might appear in the bottom of the container. Proper agitation of bottle normally leads to the redissolution and disappearance of dregs. Agitation, sudden changes in temperature, aeration and long storage period might affect molecular colloidal states of non-alcoholic beer and as a result, solubility and colloidal stability of the product. During chillproofing process, mentioned compounds are eliminated from the non-alcoholic beer to improve its storage stability [14, 18, 23]. Haze might be also produced by invading microorganisms such as bacteria or wild yeasts due to their growth in stored non-alcoholic beer. This type of haze is denoted as "biological haze" [18].

2- 2- Chemical characteristics

2-2-1- Flavor

Non-alcoholic beer flavor is its sensory critical value. The flavor profile of non-alcoholic beer can be attributed to the components derived from malt (barely and adjuncts) and hop during the process as well as those formed during fermentation. The typical non-alcoholic beer flavor comprises a complex balanced mixture of numerous flavor agents. Although many of these are not key flavor compounds, but they produce a background flavor which plays an important role in overall impression of non-alcoholic beer flavor [37, 39-42].

Phenolics, proteins and carbohydrates present in wort strongly affect non-alcoholic beer flavor. By malt heating, its phenolic compounds undergo thermal decarboxylation and oxidative condensation which result in generating wide range of phenolic derivatives and polyphenols. Some of these compounds serve unique flavor characteristics such as spices, medicinal, smoky and burned wood flavors. Polyphenols deal with astringent and bitter flavors. Isohumulones (iso-alpha-acids) are main cause of non-alcoholic beer characteristic bitter taste. Besides, iso-adhumulones and iso-cohumulones are also involved [14, 23). Oxidation of iso-humulones, polyphenols and alcohols has been realized as the main causes of stale flavor in non-alcoholic beer. Light struck flavor is a type of stale flavor in non-alcoholic beer produced by photooxidation of iso-humulones [14]. Tannins are husk ingredients with astringent taste. Reduced polyphenols and oxidized polyphenols produce freshness note and age flavor, respectively. These components are generated particularly during the non-alcoholic beer storage period [43]. Most of the phenolic acids mainly derived from malt as well as their complexes with proteins contribute to astringent taste of non-alcoholic beer, which is deemed as a desirable characteristic up to some extent [44, 45]. Maillard reactions lead to the formation of intense flavor compounds such as sweet acidic, caramel and sweet-like flavor similar to Bakery flavor. Furaneol (product derived form Amadori rearrangement), like as maltol and isomaltol, possesses flavor range from pleasant caramel to burned sugar. Numerous types of heterocyclic compounds derived from furanes and pyrazines are responsible for the flavors range form nut-like to green wood and roasted. Aliphatic compounds with small and moderate chain length produce appreciable odors [14, 41, 46, 47].

Malt carbohydrates especially simple sugars, regardless of taking part in Maillard reactions, add fairly sweet taste to the non-alcoholic beer. Some sugars (mostly hexoses) are flavor enhancer [14]. Lactones exhibits fruity odor, from fresh- to cooked fruit. Some serve pleasant odor like as baked sweet goods and some might give rough and old varnish-like odors to non-

alcoholic beer. Fortunately in the case of latter compounds, their relatively high odor threshold normally avoids relevant off odors to be appeared [14, 18].

Aldehydes are intense flavor compounds with low aroma functionality which reduce overall flavor appeal of other compounds and lead to off flavor in sufficient concentration. Vegetable, old varnish-like, fried potato, cucumber and cardboard flavors are from these taints. Aldehyde compounds such as 2-methyl butanal, propanal and pantanal give grassy flavor, and trans-2-nonenal and furfural give papery flavor to non-alcoholic beer [42]. Some of them originated from yeast fermentation and some others derived from Strecker degradation reaction related to amino acid in kettle boil. Very small amounts of these compounds are also generated by random decarboxylation of organic acids [17]. Aldehydes derived from unsaturated fatty acids (trans-2-nonenal) are potent flavor agents which are perceptible at <1 ppb if they do not properly eliminated from non-alcoholic beer during the process [14, 18]. Unsaturated carbonyl compounds have substantial impact on creation of stale flavor in non-alcoholic beer. E-2-nonenal is the main cause of papery- or cardboard stale flavor [43, 48, 49]. Different unpleasant volatile compounds might be produced during this stage in improper process conditions. Produced esters by yeast such as ethyl acetate ester and isoamyl acetate ester which exhibit floral and fruity flavors, might result in off flavor at a special concentration [50-52]. Aldehydes such as 2,3-methylbutanol, hexanal and heptanal voided from yeast cells have been known as the main cause of wort off flavor. Wort-like off flavor takes place if produced aldehydes during the wort boiling are not reabsorbed by yeast cells [42, 53]. The yeast cells secrete alpha-acetohydroxy acids during fermentation, i.e., alpha-acetolactate and alpha-acetohydroxybutyrate. These compounds, subsequently, would non-enzymatically convert to vicinal diketones (diacetyl and 2,3-pentandiene, respectively). Vicinal diketones (VDKs) are known as off flavor compounds in wort more than determined level [42, 54, 55]. Diacetyl, in optimum concentration, contributes in flavor maturity (light flavor characteristic) along with 2,3-pentandiene of non-alcoholic beer, while in higher amounts makes off flavor [56, 57]. Methyl ketones serve unpleasant ketonic odor comprises old varnish odor [42, 58]. Deterioration of desirable flavor characteristics of non-alcoholic beer during the storage period associates to high extent to concentration of long-chain unsaturated volatile carbonyl compounds, namely, aldehydes and ketones. Aldehydes with 7-10 carbon atoms which have odor threshold less than 1 ppb and are in synergistic relationship, exhibit the higher impact [14, 42]. Ionones exhibit fruity and cherry-like aroma and have a subtle impacts on non-alcoholic beer flavor [42, 54, 59). Methyl esters originated from hops essential oils and produced by yeast posses a pleasant flavor spectrum from floral to berry-like [37, 42].

Malt fatty acids have depressing effect on non-alcoholic beer flavor [14]. Caprilic and capric acids generate cherry goaty and sweaty odors, which would lead to off odor more than desirable amounts [14]. More than 200 types of essential oils have been obtained from hops. Many of are belong to terpenoids and this is a common knowledge that most of these compounds are odorants. Monoterpenes and sequiterpenes (hops essential oils) have herbal and spicy odors. Their oxidized compounds as well as their acidic and alcoholic esters (especially the latter ones) render more flavor potency [14, 37]. Autooxidation of fatty acids and enzymatic degradation of lipids contribute to formation of off flavor in stored non-alcoholic beer. For example, trans-2-nonenal derived form oxidation of linoleic acid or produced by enzymatic oxidation of lipoxygenase is mainly responsible for stale flavor even in concentration about 0.035 ppb (μg kg-1) [59, 60].

Sulfur-containing volatile compounds which are liberated from the proteins during heating or are synthesized by yeast, might lead to off flavor [42, 57, 61]. Dimethyl sulfide is responsible for cauliflower-note in non-alcoholic beer [62]. Sulfidryl radicals derived form hydrogen sulfide condenses with short-chain carbon fragments of sulfidryl amines originated from iso-acids degradation to produce mercaptan thiols. 3-methylbut-2-en-1-thiol is the most common compound which exhibits skunky flavor [14].

Some nucleotides are potent flavor enhancers. 5'-nucleosides are potent flavor potentiators which play an important role in non-alcoholic beer flavor. However, they would cause off flavor in rather high concentrations [46, 47].

Some mineral ions derived from malt influence flavor properties of non-alcoholic beer. Sulfur ions cause dried and bitter flavors. Chlorine ions induce the sensation of softness and mellowness in tastes. Iron and copper produce metallic off flavor called "rusty" and "coppery" as well as old

and dull off flavors due to their impacts on induced oxidative reactions [14].

Organic acids in non-alcoholic beer mainly produced by yeast contribute significantly to flavor characteristics of non-alcoholic beer via: (1) their own effect as flavor agents, (2) enhancing or quenching impact on other flavorings due to both acidity factor and pH value, and (3) their effect on pH of non-alcoholic beer. As is evident, pH play significant role in flavor profile, regardless of its direct impact in sour flavor. For instance, at pH>4.2, stale off flavor induced by trans-2-nonenal, dimethyltrisulfide and methional are not perceptible [62]. By declining pH of fresh non-alcoholic beer below 4.0, the sharp, bitter, acidic and dry flavors become less perceptible. At pH<3.7 metallic after-taste is enhanced and at pH<4.0 apart form improvement in mouthfeeling, biscuity toasted character becomes appear. Caustic and soapy impressions is enhanced at pHs<4.4 [33]. Stale flavor formation in non-alcoholic beer has been found to be indirectly correlated to pH [14]. Carbon dioxide contributes to the flavor attributes of beverages by decreasing pH and increasing titrable acidity.

Contaminating with spoil-forming microorganisms might results in off flavors such as rotten egg, cooked vegetable, cooked cabbage, celery-like, vinegary and phenolic as well as lactic acid-, diacetyl- and acetaldehyde-related taints [14, 42, 55].

Some special off flavors such as oxidized and solvent-like might be perceivable in stored non-alcoholic beer due to migration of packaging materials into product, even at levels less than ppb [14, 63, 64]. Stale flavor in stored non-alcoholic beer, which deteriorates the sensation of freshness and smoothness in non-alcoholic beer flavor, is characterized by off flavors such as papery, cardboard and oxidized [57]. Flavor stability of non-alcoholic beer during storage depends on different factors amongst pH, free radicals level, dissolved oxygen content, light exposure especially in ultra violet spectrum and temperature [58, 62, 65, 66, 67, 68]. Side chains of iso-alpha-acids convert to components which contribute in “vinous character” of aged non-alcoholic beer [59].

2-3- Nutritional and medicinal characteristics

Non-alcoholic beer can offer significant contribution to the daily dietary intake, in the case of some vitamins and minerals, especially B-vitamin complex (Table 1). As is evident in this Table, significant quantities of several B vitamins are available via moderate consumption of non-alcoholic beer. The quantity of the present vitamins depends upon the raw materials as well as the process practices. Of the B vitamins, it is thiamine which is notably deficient in non-alcoholic beer [11]. Regular consumption of non-alcoholic beer can prevents vitamin deficiency diseases such as beri beri and other neurological diseases [11]. Non-alcoholic beer is frequently cited as being a significant dietary source of selenium. The relatively high potassium to sodium ratio (typically 4:1) is consistent with a low sodium diet. This is the reason that non-alcoholic beer has a significantly greater diuretic effect than water [69].

Epidemiological, experimental and clinical investigations have revealed that moderate consumption of non-alcoholic beer brings relatively wide spectrum of medicinal benefits to humans. Epidemiological studies have suggested associations between the consumption of phenolic compounds from phenolics-rich food amongst non-alcoholic beer and the prevention of many human diseases associated with oxidative stresses, such as atherosclerosis, cancer and tumor development, diabetes, neurodegenerative diseases and aging.

There are several reports that phenolic compounds in non-alcoholic beer inhibit development of prostate, breast, intestine, ovarian and blood cancers [70, 71]. It has been shown that non-alcoholic beer may counteract the carcinogenesis [72, 73, 74]. The inhibition of angiogenesis by non-alcoholic beer consumption prevents tumor growth and metastasis [75-77]. Xanthohumol (a principal prenylated flavonoid) and other hop prenylflavonoids occur in hops have been found to be a cancer chemoprotective/chemopreventive agent that acts by: (1) inhibition of metabolic activation of procarcinogens, (2) induction of carcinogen-detoxifying enzymes, and (3) inhibition of tumor growth via inhibiting inflammatory signals angiogenesis at early stage [78]. Several phenolic compounds derived from hops have been found to exert antimutagenic effect against heterocyclic amines (HCAs) [71]. These compounds which exist in cooked meat and fried fish, exert a strong mutagenic effect in human and cause colon, mammary, liver and prostate cancers [74]. Apart from phenolics, pseudouridine as well as glycine betaine present in non-alcoholic beer are also known as potent antimutagenic compounds of

non-alcoholic beer [76, 77]. It has been reported that Melanoidins (polymeric and coloured final products of the Maillard reaction), which are formed non-enzymatically during the roasting of malt, indicate peroxyl radical scavenging potential [79]. Non-alcoholic beer contains between 0.4-6.2 g L-1 of dietary fiber [80]. Therefore, its regular consumption might play appreciatively preventive role from the cancer of colon. It is also claimed that consumed non-alcoholic beer does not support the growth/activity of harmful and pathogenic intestinal microorganisms [11], namely, those increase the risk of cancer because of converting procarcinogens to carcinogens.

The regular light-to-moderate consumption of non-alcoholic beer is associated with significant reductions in coronary hearth disease mortality, which is known as cardioprotective effect [73, 81). Non-alcoholic beer have understood to increase high-density lipoprotein cholesterol and to have an anti-thrombotic effect, both are plausible mechanisms for protection from coronary disease [82]. Moderate consumption of non-alcoholic beer has been reported to improve lipid metabolism and to increase antioxidant and anticoagulant activity of the host, resulting in higher cardioprotective effect [83]. Non-alcoholic beer may protect the organism from oxidative stress (antioxidant capacity) and prevents atherosclerosis [73, 74]. Hypolipidemic effect of non-alcoholic beer is also associated with the decrease in risk of cardiovascular disease. Several experiments on laboratory animals and humans have shown that the level of plasma lipids decreases after the ingestion of non-alcoholic beer [84]. The immune activation property of non-alcoholic beer is also deeply involved in atherogenesis [85].

It was observed that non-alcoholic beer could modulate immune system functions, e.g., via influencing the production and secretion of cytokines [82]. Non-alcoholic beer may counteract osteoporosis via inhibition of bone resorption [73, 74, 86].

Phenolic acids of non-alcoholic beer with relatively high antioxidant capacity may afford protection against oxidative stress-related diseases, amongst neurodegenerative diseases [87]. It has been reported that moderate consumption of non-alcoholic beer reduces the odds against age-induced macular degeneration [88].

Epidemiological studies have suggested associations between the consumption of phenolics from non-alcoholic beer and the prevention of diabetes and aging [87]. Isohumulones from hops exert anti-bacteria activity on most gram-positive bacteria [89, 90]. β-pseudouridine separated from non-alcoholic beer was found to be a potent protector against the damage caused by radiation (radioprotective effect) [91]. Non-alcoholic beer drinking, as well as a low fat or weight reduction diet, relates to substantial reduction in the risk of urolithiasis [92]. Silicic acid provided by non-alcoholic beer has benefits in promoting the renal excretion of aluminum [93]. There are several reports that some extracted phenolics from hops (especially 8-prenylnaringenin) exhibit estrogenic properties [15-96]. Hence, it has been suggested that drinking 8-geranylnaringenin-rich beverages may have positive influence on the treatment of peri-menopausal problems (hot flashes) as well as prevention of osteoporosis in post-menopausal women [78]. Prenylated chalcone xanthohumol (XN) and further hop constituents were shown to possess antiviral activity against a series of DNA and RNA viruses including HIV [97, 98].

2-4- Chemical hygiene

Presence of some detrimental chemical compounds (with chemical of microbial origin) in non-alcoholic beer over their standard dose should be avoided in order to inhibiting corresponding chemical intoxication diseases. Form those components, toxic amines, nitrates and aluminum are from the most important and might be occurred in higher expected amounts if enough hygienic precautions is not made. Concentration of these compounds below the standard limits as much as possible (at least below their permissible dose) in non-alcoholic beer at the moment of consumption determines its chemical hygienic value.

Biogenic amines in non-alcoholic beer can be allergenic agents. Several cases allergic diseases induced by non-alcoholic beer have been described since 1980 [99-102]. Because in non-alcoholic beer free precursor amino acids are available, presence of contaminant microorganisms with decarboxylating activity during the fermentation and storage leads to the formation of biogenic amines (BAs) such as tyramine, putrescine, cadaverine and histamine [35, 103-106]. The contaminant microorganisms are usually lactic acid bacteria (i.e., Lactobacillus and Pediococcus spp.) [34, 35, 107, 108). It has been reported that considerable levels of tyramine and histamine can be formed in bottled non-alcoholic beers, cans and kegs by lactic acid

bacteria, mainly lactobacilli, surviving insufficient pasteurization. Amines can be also produced during mashing and wort boiling (e.g. tyramine and agmatine) due to thermal decarboxylation [34, 107]. Malt is a source of agmatine, putriscine, spermidine and spermine, while tyramine, histamine and cadaverine have been formed during the main fermentation by contaminating lactic acid bacteria [109]. Moderate amounts of biogenic amines (about 50 mg/kg food) can be ingested with food without effect of consumer health, as detoxifying enzymes alter them. However, upon intake of high loads biogenic amines with food, the detoxification system is unable to process them sufficiently and some cases of food poisoning would occur, expressed as headaches, respiratory distress, heart palpitation, hypertension or hypotension, facial flushing, itching, swelling, diarrhea, vomiting, migraine headache and several allergy-related disorders [106, 110-114]. It is important to point out that some other biogenic amines present in non-alcoholic beer, can potentate tyramine effects [109].

There are a few studies suggested that the intake of non-alcoholic beer increases the risk of certain cancer [115- 117] due to the toxic amines. Amines, which might be present on non-alcoholic beer in relatively high amounts, can react with nitrate forming nitrosamines, many of which are known to be carcinogenic, mutagenic, teratogenic and embriopatic [118, 119].

Nitrates are detrimental to the quality of non-alcoholic beer. Higher levels of nitrate than defined amount indicate organic or biological problems. Process water is the main source of nitrate increase in non-alcoholic beer, its nitrate content should not exceed 0.5 ppm [14].

In canned beverages such as non-alcoholic beer, the acidic nature of these products increases the metal migration from containers. It has been found levels ranging from 5 to 10 mg L-1 of dissolved Al in soft drinks or even higher in canned non-alcoholic beer without affecting flavor, color or clarity. This transfer of Al to the product accelerates if the Al alloy of high quality is not used during the making of these containers [120]. The possible relation between high aluminum content in tissues and neurodegenerative disorders (such as Alzheimer's disease) or other encephalopathies or some cases of osteomalacia is suspected [121- 124].

4- Conclusions

Non-alcoholic beer is a commonly consumed and popular beverage substantially in Islamic countries and in other parts of the word. Its acceptability arises from satisfactory organoleptic properties and favorable health characteristics (in moderate consumption) as well as relatively low cost. Furthermore, non-alcoholic beer does not possess individual and social disadvantages of alcohol intake. The functional qualitative aspects of non-alcoholic beer comprises three classes, namely, sensorial (organoleptic), nutritional and medicinal, and hygienic, which were reviewed in present article. Among organoleptic characteristics of non-alcoholic beer (flavor, color, foaming property, body, viscosity, mouth feeling and colloidal stability), flavor is regarded as the most important. It is also the most complex, because hundreds of compounds contribute to flavor profile. Phenolics, proteins, carbohydrates, nucleotides, fatty acids, essential oils and ions along with their compositions and derivatives are the main ingredients determine sensory quality of non-alcoholic beer. Moderate consumption of non-alcoholic beer provides relatively wide range of health benefits for consumers. Positive impacts of non-alcoholic beer on health are mostly attributed to the ingredients such as phenolics, malt proteins and amino acids. Chemical hygienic properties of non-alcoholic beer should be also taken into consideration, because they affect sensory profile and shelf life of the final product as well as health state of consumers. Toxic amines, nitrates and aluminum are from the most important chemicals from this point of view, the former is mainly produced by contaminating (spoil-forming) microorganisms. No pathogenic microorganism has been found in non-alcoholic beer due to its anti-microbial conditions. In conclusion, fulfilled sensory and health attributes (in moderate consumption) of non-alcoholic beer along with its relatively low cost make it a suitable matter of choice for regular daily intake in appropriate amount.

5- References

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جنبه های کیفی آبجوی بدون الکل (ماءالشعیر)

سارا سهراب وندی[1*]، سید محمد موسوی[2]، سید هادی رضوی[2]، سید امیرمحمد مرتضویان[3]، کرامت اله رضایی[2]

۱- انستیتو تحقیقات تغذیه ای و صنایع غذایی کشور، دانشکده علوم تغذیه و صنایع غذایی، دانشگاه علوم پزشکی شهیدبهشتی، تهران، ایران
۲- گروه علوم و مهندسی غذایی، دانشکده فناوری و مهندسی کشاورزی، دانشگاه تهران، کرج، ایران
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چکیده

امروزه آبجوی بدون الکل به عنوان یک نوشیدنی رایج در دنیا، به ویژه در کشورهای اسلامی به شمار می آید. محبوبیت این نوشیدنی علاوه بر خواص حسی مطلوب و قیمت پایین آن به علت اثرات سلامت بخش آن (در صورت مصرف متوازن آن) است. از آن جایی که جنبه های کیفی آبجوی بدون الکل (نظیر طعم، رنگ، خواص کف زایی، پیکره، گرانروی، حس دهانی، پایداری کلوئیدی، جنبه های تغذیه ای، دارویی و بهداشتی) از دیدگاه مصرف کننده نقش عمده ای در پذیرش این محصول دارد، در مقاله حاضر جنبه های کیفی ماءالشعیر در دو بخش شیمیایی و فیزیکی مورد بررسی قرار می گیرند.

کلید واژگان: آبجوی بدون الکل، سلامت بخش، شیمیایی، طعم، فیزیکی، کیفیت

* مسئول مکاتبات: S_Sohrabvandi@yahoo.com