

Alcoholic beverages and their role in the culinary technology

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Abstract—Countries are very attached to their traditions and their diets are influenced by various factors i.e. product diversity, climate change, food availability, historical dishes. Consumers nowadays have much greater expectations and less trust. Organic, bio and fair trade are only a few of the terms gaining popularity in the food chain production circle. The ultimate goal is a sustainable food production and healthy diets.

The purpose of this review was to present the ways alcoholic beverages are incorporated in dishes from different regions and nationalities as well as to provide knowledge about the properties alcohol can exhibit while being an ingredient to a dish. This paper also introduces alcohol as a contemporary cooking fuel with both its advantages and disadvantages.

Alcoholic beverages add up to the aroma and taste of dishes prepared with them, but special attention has to be paid to the percentage of alcohol left in the meal. The growth of food variety and innovations offers an opportunity for the manufacturers and food industry to develop new, sustainable, nutritious and well-designed dishes.

Keywords *alcoholic beverages; dishes; ingredients; cooking techniques*

I. INTRODUCTION

Food is an inseparable part of human life. It took many centuries for people to discover food processing and thermal treatment. Humans initially learned how to preserve food with the use of drying, fermentation and salting [1]. After that, processes like boiling, roasting, autoclaving, sous-vide, etc. became known. There are numerous reports on the development of the culinary customs and traditions of people in different geographic areas. Culture specificities usually reflect on the typical dishes prepared by people. Food not only has to be nutritious but also well designed and lying on the traditional for the region ingredients. Sustainable healthy diets are trending and it is challenging to produce adequate food, which is sufficient, and at the same time containing enough nutrients.

Consumers cast a critical eye on the food they consume. Facing challenges such as climate change, resource scarcity, malnutrition, obesity, and health burdens, they have to turn to sustainable and health beneficial nutrition [2]. Products labeled as organic, whole, of free-from are gaining enormous popularity.

New recyclable packages are increasing their presence in the food production chain [3]. More efficient processes, in terms of energy, water use, waste reduction, and repurposing byproducts, have to be included in culinary technology. Manufacturers and culinary specialists are fighting for zero-waste food processing cycles.

Alcoholic beverages have served as sources of medicine and nutrients [4]. Fermented fruit/grains are in the base of alcohol making. Evidence of alcoholic beverages are found in many places throughout history i.e. China, India, Greece, etc. [5]. Cacao fruit, for instance, was used to produce wine around 1400 BC. Cacao wine, also known as theobroma, was valuable to the Aztecs and used in religious ceremonies [6]. Herbal wines were popular in Ancient Egypt [7]. In Greece, a fermented honey drink gained popularity. Georgian wine is considered one of the oldest found worldwide. There is evidence that it was produced as early as 6000 BC in Tbilisi. The oldest alcoholic beverage with definite proof is discovered in Jiahu (China) around 7000 – 6600 BC and was made from rice, honey, and hawthorn fruit and/or grape [8]. Literature has documented several examples of alcohol worshipping. A wine goddess was known to the Babylonians, while in the Sumerian culture Ninkasi blessed beer and brewing. In the eighteen and nineteen centuries, different attitudes existed towards alcoholic beverages: from encouragement to total prohibition.

Alcoholic beverages can be found as ingredients in numerous dishes i.e. soups, stews, sauces, desserts, etc. They contribute to the sensory profile of ready dishes adding sweetness, acidity, and flavor. Alcohol also enriches the aroma with its volatile compounds. Volatile compounds in alcohol exceed 800 in number but only a few of them are responsible for the distinctive sensation of alcohol when being consumed. Flavor active compounds belong to classes like esters, carbonyl compounds, sulphur compounds, volatile phenols, etc. [9]. Alcohol is usually classified by its alcohol content: around 40% v/v alcohol content in brandy; not more than 9 % v/v in wines; and 86% v/v in spirits [10]. Adding alcohol in culinary technology is challenging, as it can be either an asset or a liability to the dish. Alcohol can influence the mechanical properties of ingredients altering them in an unfavorable way. Simmering dishes containing alcohol leads to the evaporation of almost 95% of the alcohol. On the other hand, the flambé (French: to flame) technique contains up to 75% of the initial alcohol quantity used. It has been suggested that alcohol

improves the flavor in food by evaporation and molecular bonding. The volatile effect of the alcohol molecules works best when a dish contains less than 1% of alcohol. The alcohol helps release flavor molecules in foods and assists in dissolving fats, allowing ingredients to reveal their own unique flavors in ways that other liquids (like water or broth) or fats (like butter and olive oil) cannot.

In the field of food science, product quality and its sensory perception is a priority criteria. Resources from different regions/countries provide the traditional, exotic, or authentic taste of the dish. Globalization enables the infusion of cultural traditions and local cuisine. Consumers are constantly seeking new, previously seen as exotic, products to be incorporated in recipes.

The purpose of this review was to present the ways alcoholic beverages are incorporated in dishes from different regions and nationalities as well as to provide knowledge about the properties alcohol can exhibit while being an ingredient to a dish. This paper also introduces alcohol as a contemporary cooking fuel with both its advantages and disadvantages. Within the framework of the abovementioned, no discussion is made on the topic of pairing food with alcoholic beverages.

II. ALCOHOL AND HUMAN BODY

Personal health status is directly linked to menu a person chooses. Alcohol itself is seen as a drug, because it changes the operation of the tissue it diffuses in. In chemistry, alcohols are a large family of substances with similar molecular structure. In culinary practice when the term alcohol is used, it refers to ethanol or ethyl alcohol.

When being introduced into the digestive system, ethanol is quickly distributed in to the body by blood flow. The concentration of alcohol in the cells shows the level of intoxication. Frequent consumption of large quantities of alcohol can lead to deleterious health effects. The French paradox, on the other hand, has shown that the moderate consumption of red wine can lower the risk of coronary heart disease [11]. Daily red wine consumption can reduce coronary artery disease and atherosclerosis. Vilahur and Badimon [12] have established that inflammation and lipid status can be improved by consuming 150 ml/day (women) and 450 ml/day (men) red wine. Epidemiological studies focusing on the Mediterranean diet have concluded that the consumption of two glasses of wine daily improves health status and prolongs life expectancy [13]. Wine reportedly contains antioxidants and phenolic compounds [14]. Red wine has trihydroxystilbene (fig. 1a) and trihydroxystilbene-3-b-D-glucoside (fig. 1b) as its ingredients.

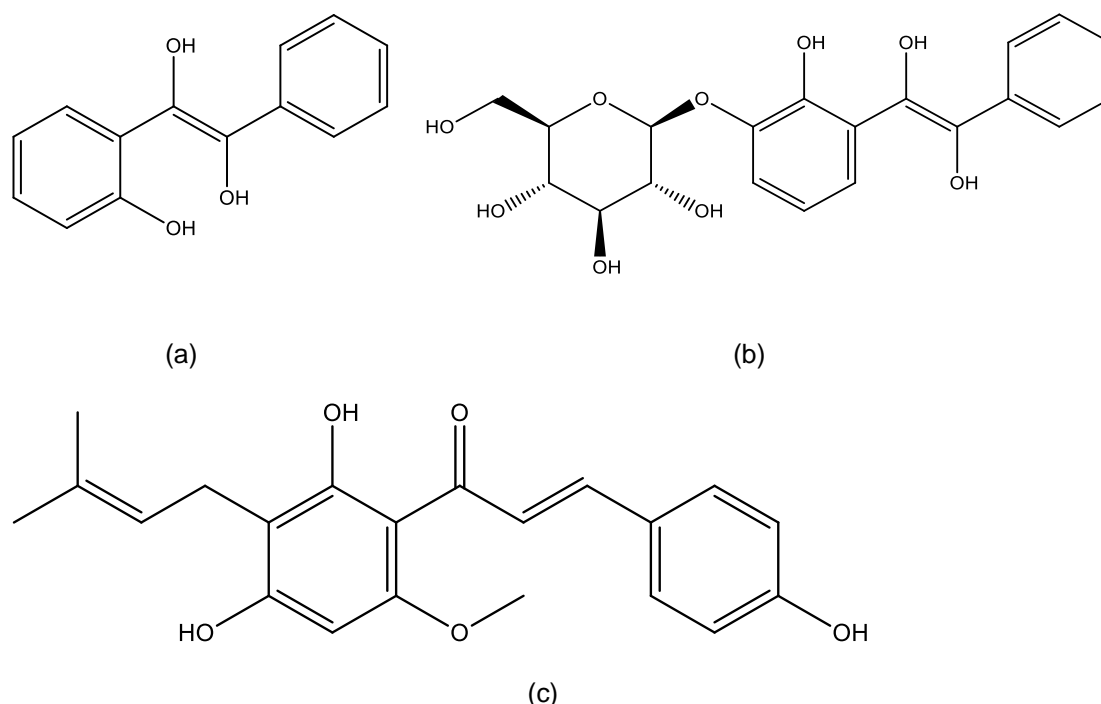


Fig. 1 Resveratrol (a), piceid (b), xanthohumol (c)

Resveratrol aids the cardiovascular system to oppose to oxidative stress by penetrating the brain barrier and protecting nerve cells; reducing the formation of blood clots [15]. These are only few of the secondary metabolites with potential health benefits. Phenolic compounds not only contribute to the sensory profile of wine (flavor, color, bitterness, etc.) but also possess health promoting properties i.e. antioxidant,

anti-inflammatory, and bactericidal. Beer is another alcoholic beverage with considerable beneficial properties. Beer contains important nutrients i.e. B-group vitamins, selenium, and potassium. About 30% of beer polyphenols are derived from hops. It has been discovered that hops contain 0.5mg/kg trans-resveratrol, and a number of piceid isomers. Xanthohumol (fig. 1c), the major flavonoid found in

beer, may prevent colonic carcinogenesis, and suppresses CYP1A2, a key enzyme involved in cancer progression.

Moderate consumption of alcoholic drinks affects indicators of atherosclerosis, such as improving lipid metabolism, increasing antioxidant activity, and improving coagulant status. Scientific evidence has

shown that ethanol and wine polyphenols can act synergistically against chronic cardiac disease [16].

III. USAGE IN CULINARY TECHNOLOGY

Alcohols are valuable cooking ingredients if used wisely. Depending on the time and technique, being used different percentage of alcohol is retained in the dish (fig.2).

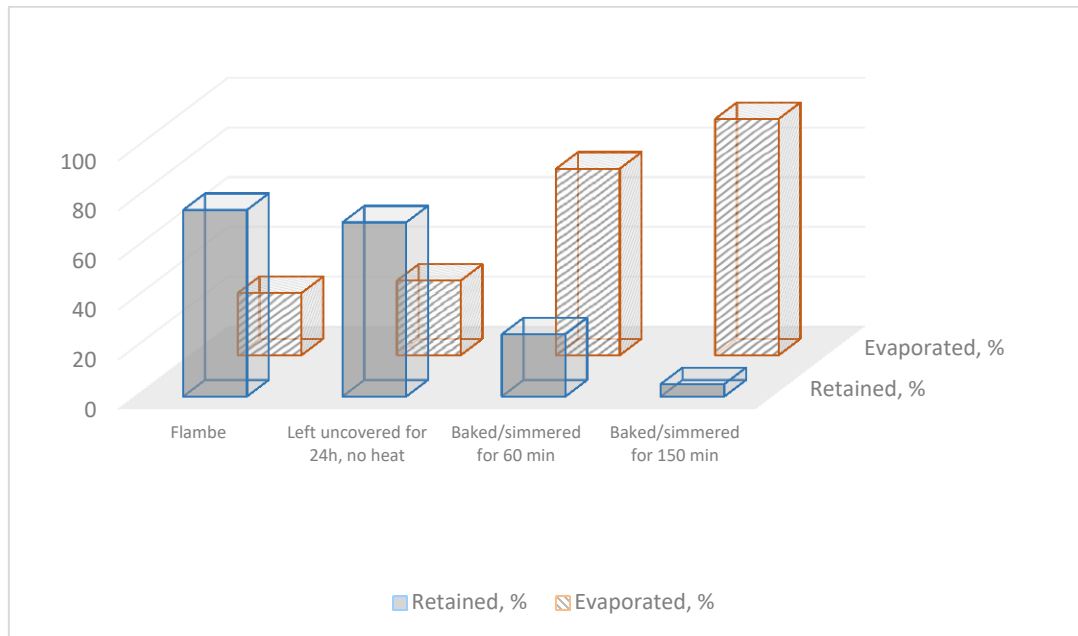


Fig. 2. Retained alcohol depending on technique used (Nutrient Data Lab, [17])

Alcoholic beverages bear some resemblance with the sugar molecule and thus have a slightly sweet taste. Spirits, wine and beer satisfy the body by leaving a warm sensation in the mouth and some aroma molecules in the air. Food itself nourishes the body and undergoes numerous changes in its chemistry before gaining its recognizable taste of a cooked dish. Processes such as caramelization, maillard browning, dextrinization, and hydration occur at different stages of the technological treatment.

The simplest browning reaction is the one of caramelization where in the event of heat sugar first melts into syrup and then progressively changes its color from yellow to dark brown. The chemical reaction is a result of many products i.e. organic acids, fragrant molecules, brown-colored polymers.

Sucrose forms the sweet taste in caramel goods, acetic acid - the sour, furans - the nutty, and acetaldehyde - the sherry-like. The typical flavor of caramel (sweet/bitter) depends on the time and temperature applied. Sucrose requires 170 °C to caramelize, while glucose needs 150 °C and fructose 105 °C [18]. This is due to their chemical structure.

Caramel's distinct flavor is due to alcohol, diacetyl, ethyl acetate, furan, benzene, maltol, etc. It has to be noted that sugar alcohols (polyols) do not have an aldehyde group in their structure to initiate browning reactions [19]. Sugar is responsible for the caramel

taste of flambé dishes. Examples of sugar alcohols are sorbitol and mannitol.

The Maillard reaction (described by Louis Maillard, 1912) is responsible for the cooked color and flavor of dark beers, chocolate, coffee beans, crusts, and roasted meats. Maillard flavors are more complex than caramel ones because of the involvement of amino acids. Maillard browning becomes first visible at around 120 °C [20]. This is the reason why techniques such as boiling, steaming and braising result in paler products compared to grilled, baked or fried ones. Maillard browning tastes can be sweet (furanones), earthy (pyrazines), nutty (pyrroles, oxazoles), meaty (furanones, thiophenes), etc.

Marinades can have an important role in the flavor of the ready dish. In the past, marinades consisted of a single alcoholic beverage, and today creative chefs marinate with cocktails. Tequilla-lime shrimp can now be found in many bars and restaurants. Vodka pairs well with pasta sauces and vodka tonic can be used to marinate chicken. Gin and whisky aid marinate a steak. Different product require different marination time [21]. Table 1 is revealing the time necessary for successfully marinating products of different origin.

TABLE 1. MARINATING DURATION FOR VARIOUS PRODUCTS

Product	Retention time in marinade
Vegetables (soft)	≤ 10 min
Vegetables (firm)	≤ 30 min
Fish, shellfish	30-60 min
Chicken	≤ 120 min
Beef	≤ 24 h
Pork	≤ 24 h
Tofu	≤ 24 h

The marinade affects the outside of the product meaning that the inside will not necessarily carry the flavor of the marinade. In order for the marinade to penetrate, cuts in the product have to be made. Alcohol marinades should be used for a limited period of time especially with tender meat like fish. If the alcohol percentage has to be eliminated from the marinade, it should simmer for around two hours. Marinades serve two purposes – enhance flavor and tender the product [22, 23]. Marinating requires direct contact. Marinades consist of acid, salt, organic flavors, herbs and spices. Each ingredient of the marinade serves a different purpose. The acid content in marinades breaks down proteins in the outer layer of connective tissue, making the surface texture of the meat softer. As the protein bonds break down, water is released and these shrunken bundles of connective tissue are easier to chew, giving the impression of tenderness [24]. Herbs and seasonings add flavor. Fat transfers fat-soluble flavors and retains moisture. Sugar sweetens up a marinade. The smaller the cut of the product, the less time it should spend in the marinade.

3.1. As an ingredient

Sherry: The range of sherry styles is very broad. Dry styles are excellent in soups or used to steam fish and shellfish; medium ones – for slow-cooking poultry and meat dishes, de-glazing cooking pans to make quick sauces; and sweet ones - for trifle and other desserts, while the very sweetest are used ice cream [25]. An Old English dessert - syllabub is prepared with whipped cream, sherry or white wine and sugar, and often infused with lemon. Varieties of trifle (dessert) are prepared with sherry or limoncello. Sherry is not only an ingredient to desserts. It is also used in main dishes, appetizers, dressing, etc. i.e. Forager's pie, caramelized sherry onions, pork stir-fry, sherry dressings, sherried mushroom sauce, and sheries shallots.

Wine: Wine (both red and white) can be a supplement to desserts, ingredient to stewed dishes, sauces, and marinades. The acidity has to be carefully

considered and tailored to mimic the acidity of vinegar/lemon. The wine should not overshadow the taste of the food. The choice of wine depends on the dish being prepared [26]. Salad dressings, pasta sauces pair well with dry white wine, and heavy meat with red wine. Wine has the ability to mask the unpleasant odor of fish and improve its taste. Red meat, marinades, and red sauces are advisably prepared with young dry red wines. Mature dry red wines, which are richer in tannins, are suitable for game meat. Dry white wine, on the other hand, is an excellent additive for chicken, fish and seafood, light white sauces and marinades. Desserts, syrups for swamps and confectionary bases, and sweet sauces benefit from semi-dry white wines. According to modern culinary masters, semi-dry and liqueur wines enrich the flavor to a variety of products - from seafood to duck/turkey meat. Reductions and sauces blend with a variety of dishes including meat, risotto, and shellfish. Adding wine to dishes is usually associated with the use of leftover wine so that the beverage does not do to waste. French cuisine benefits a lot from wine as an ingredient. A famous French recipe of chicken and vegetables is enriched with a Champagne reduction sauce. Coq au vin (chicken in wine) is another French recipe using wine as an ingredient. Variation of parfaits with wine exist in French cook books. Marinated steaks are a classical solution to add wine to a recipe. A tomato-based white wine fish soup is another alternative to incorporate wine in culinary technology. Mushroom red wine butter can be stored for two weeks in a refrigerator and used in a variation of dishes. Infused red wine can be served with variety of compotes. Another dessert where wine is an ingredient is pear pie with red wine. Chocolate cake can be glazed with red wine, and apricot sorbet is served in a bowl of champagne.

Beer: Beer is produced worldwide but with local grains. There are many types of beer but the technology is the same. The chosen grain (barley, wheat, etc.) is first malted, then cracked and mixed with water to convert the starch to sugar. The resulting liquid is boiled and flavor-giving hops are added. Yeast is also added to begin the fermentation. The finished beer is finally matured according to the producer's style. Beer adds lightness to batter used for deep frying fish or chicken. The basic principle is that the bubbles of carbon dioxide from the beer carbonate the mix, resulting in a crispier, lighter batter. A good beer sauce for roasted items can be prepared by deglazing the pan. Making a reduction is not advisable because of the extremely bitter taste that is going to form [27]. Beer can make an excellent addition to salad dressings and marinade. The beer with its acidity can replace the vinegar in a marinade. A beer soup cooked with egg yolk was a common breakfast staple in European countries to serve with bread during medieval times. Beer can be a valuable ingredient to baked good because alcohol inhibits gluten formation [29]. Baking with beer results in a tender, delicate crumb. Beer can very successfully be incorporated in starters, soups, main courses, desserts and bakery products. Beer cheese dip, which pairs well with pretzels, can be made with any type of beer, including nonalcoholic. The German variation is a beer cheese

spread. French cuisine also has the beer dipping sauce. The spicy beer mustard is combined with pretzels or used as a condiment for bratwurst. The famous beer can chicken is prepared with an opened beer can that is positioned inside the chicken so that the meat can infuse the beer flavor while cooking. Honey beer bread is very easy to prepare with only four necessary ingredients. The Swiss variation of beer bread includes cheese instead of honey. The containing banana bread is called beernana bread. The potato beer cheese soup, with its velvet texture, balances nicely the cheesy and beer flavors. Pressure-cooking with beer is also an option for beef and ham. The beer-braised roast with root vegetables is a dish prepared for St. Patrick's Day. Beer and pretzel caramels are nice bonbons with a combination of textures and flavors.

Rum: Most rum is made from molasses (a by-product of the sugar industry), which is first diluted with water, and then distilled. "Rum agricole" originates from the islands of Guadeloupe and Martinique and is made by fermenting sugar cane juice [30]. Cachaça is a colorless Brazilian rum distilled from sugar cane. Rum is a staple ingredient in both savory and sweet recipes [31]. Dark rum pairs well with beef stews and pork, while white rum with poultry and seafood. The easiest way to incorporate rum into cuisine is deglazing the pan after sautéing meat/fish, or marinating pork/chicken in an aged rum. Rum, because of its sweet taste is excellent with slow-cooked pork meat. Rum-infused butter can be added to desserts. Zabaione, a classic Italian dessert, has rum as an ingredient. Some of the other popular desserts containing rum are almond rum cake, rum balls, pecan pie and marble cake. A banana soufflé of pumpkin pie can enrich their flavor by adding 2 tbsp. of dark rum. Rum caramelizes well and is suitable for barbecue dishes. Rum with the combinations of caramel makes a distinguished dip or sauce. Raisins can be soaked in rum and afterwards used in culinary practice.

Rice alcohols: Rice alcohols can reach a concentration of 20%. Brewers use starch-digesting enzymes and yeasts to convert sugars to alcohol. Sake, with its different kinds, is vulnerable to light and high temperatures exposure [32]. Sake is characterized with its delicate flavors. Mirin and sake kasu are typical Japanese cooking alcohols. The alcohol fermentation takes place for about two months and the resulting liquid has around 14% alcohol. Sake lees is usually an ingredient for vegetable pickles, marinade for fish and soup.

Liqueurs and extracts bear similarities and only differ in their portion of sugar and alcohol, as well as flavoring concentration. Extracts are more frequently used in food industry and manufacturing, while liqueurs are effective flavor tools for chefs and home cooks [33]. Liqueurs and extracts' constituents explain these choices. Extracts are high in alcohol and low in sugar, while liqueurs are high in sugar and low in alcohol. This makes liqueurs more convenient for restaurant usage as it is less likely to overpower a flavor. Extracts are used in smaller quantities which makes them more useful for manufacturers.

Liqueurs: In the past, the terms liqueur and liquor were very easily distinguished. Liquors stand for vodka, gin, whisky, rum; and liqueurs for chartreuse, kahlua, benedictine, baileys and schnapps. Nowadays, they are considered the same and only one of the terms is used. By rule, liqueurs are sweet and lower in alcohol and liquors are not [34]. Liqueurs are often flavored and/or colored. Vegetables, herbs, flowers, leaves, skins, stones, pips and whole fruit can be used to flavor liqueurs. Liqueurs vary in quality and are geographically finite. Amaretto is a popular Italian liqueur used in cheesecake and macaroon cookie recipes. Frangelico can also be found in cheesecake and mousse contributing with its hazelnut flavor. Crème de Cassis is an excellent blend in chocolate recipes. Grand Marnier is a classic mixture of orange and brandy, which is used in mousses, crepes, soufflés, and to cook duck.

Extracts: Extracts are a derivative of the essential flavorings or oils of fruits, herbs or nuts. Pure alcohol best extracts essential oils, resins, alkaloids, glycosides, organic acids, chlorophyll, acid and bitter constituents [35]. The type of extract can be tincture or infusion. A tincture is an alcohol extract of a plant, made using varying alcohol percentages (20 to 98%). Wine is a traditional menstruum, though not often used today. It has a long shelf life and extracts as a dilute alcohol. A wine extraction is a medicine for the spirits as well as the body. An elixir is an extraction of an herb made from honey and alcohol (usually brandy). For years, extracts have been recognized almost exclusively as pharmaceutical products. After that, they are introduced in foods by homemakers and confectioners. They are widely used in culinary technology and depending on the desired results, various alcohol levels are being used. Extracts typically are used in very small amounts and most of the alcohol evaporates during the cooking process. The infusion time varies between 2 and 8 weeks. The vanilla extract is probably the most used flavoring ingredient in foods and beverages [36]. Natural vanilla flavoring is extracted from vanilla beans, the fruit pods of tropical vines that are part of the orchid family. Pure vanilla extract contains a defined level of natural vanilla and a minimum of 35% alcohol, by Food and Drug Administration (USA) and Food Safety Authority (EU) standards. Typical artificial vanilla flavorings contain synthetically produced vanillin, ethyl vanillin, guaiacol, vanillin mandelic acid, eugenol, and piperonal [37]. Other popular extracts are mint, banana, coffee, almond, hazelnut, orange, cinnamon, lemon, coconut, etc. Alcohol-free versions of such extracts are available on the market. They are usually made with glycerin as alcohol substituent.

3.2 Alcohol flavored food

Food producers are always seeking for launching new products on the market. A combination between food and alcohol offers opportunities for new tastes of food. Wine sorbet provides the most decadent dessert experience. Sorbet is made of fruit, and wine is fermented fruit. Sorbet also provides the great taste of a creamy dessert to those who cannot indulge in dairy products. Marmite is a by-product of beer brewing [38]. Several special editions of marmite have appeared

during the years. In 2007 a Guinness edition of marmite (30% Guinness yeast), resembling the Guinness beer flavor appeared on the market. The following year a champagne (0.3% added champagne) edition marmite was produced for Valentine's Day. Popcorn infused with alcohol can also be found in stores under the name pub corn with flavors like Pina colada, beer, and Irish cream. Alcohol is a popular ingredient/filling for bonbons. Manufacturers are currently using less traditional types of alcohol i.e. Malibu or Jack Daniels. In the past, rum or liqueurs were expected to be found in bonbons. In 2003, the Dutch market was introduced to the first ice cream with alcohol, containing around 5% and varying in flavor (Vodka, Tequila & lime, etc.).

3.3 As a cooking fuel

Alcohol fuels are increasing their popularity among culinary experts as modern eco-friendly fuel solutions. Ethanol and ethanol-based gels are convenient and cheap options especially in restaurants and catering service [39]. Heat is available initially after ignition and it burns at low temperatures. Ethanol gel is made from ethanol combined with a thickening agent to make it viscous. Ethanol gels have to be handled with care because of their ability to stick to various surfaces i.e. clothes and skin. This is both an advantage and a disadvantage, as fuel gels cannot be spilt but in order to extinguish such fire, a dry chemical extinguisher or sodium hydrogen carbonate (baking soda) should be used. To make the flame visible, manufacturers use small amounts of coloring and denaturing agents. In terms of health, ethanol can cause dryness to the skin and if being ingested, it causes intoxication and large quantities it can cause damage to the nervous system [40]. Methanol, on the other hand, is not so popular because it can have deleterious health effects if being ingested. All alcohol fuels should be stored in closed containers and bottles, mainly due to their combustible nature, as well as due to the possibility of evaporation.

3.4 Alcohol ingredient alternatives in culinary technology

Pomegranate juice is rich in polyphenols (gallic acid, ferulic acid, ellagic acid, etc.) Such polyphenols have the ability to inhibit free radicals and microbial growth, decrease the risk of cancer and cardio complications. In culinary technology, pomegranate juice can be consumed fresh, used as a marinade or ingredient of sauces. Sauces are very popular oil-in water emulsion products, which may vary in fat content and viscosity [41]. Topuz et al. [42] have described the ability of olive oil-pomegranate juice sauces to delay chemical changes, inhibit lipid oxidation, maintain the sensory attributes and extend the shelf life in addition to their desirable taste and flavor of fish marinades. Narsaiah et al. [43] have explored the possibility of using pomegranate fruit products for tendering goat meat. Pomegranate seed powder maybe considered mixed with other spices, to marinate goat meat mainly for its beneficial effects. Other alternatives to the common meat marinades can be vinegar (coconut, rice, malt, apple cider, etc.), ginger ale, lemon juice, etc.

IV. CONCLUSION

Culinary practice offers a great variety of technologies that contribute to a unique sensory characteristic of ready meals. Alcoholic beverages add up to the aroma and taste of dishes prepared with them. Special attention has to be paid to the percentage of alcohol left in the meal. Further research can help in the development of new recipes containing alcohol, as well as consider if alcohol used in culinary technology can lead to potential beneficial/harmful effects on the human body. Consumers' expectations continue to grow and cooks are constantly feeling the pressure of trying to develop new, sustainable, nutritious and well-designed dishes. The growth of food variety and innovations offers an opportunity for the manufacturers and food industry.

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