CHAPTER

FRUIT BRANDIES

10

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1. INTRODUCTION

1.1 BRIEF HISTORY OF DISTILLATION

Distillation was a technique already used by ancient cultures in China (3000 BC), India (2500 BC), Egypt (2000 BC), Greece (1000 years BC), and Rome (200 BC). Initially, all these cultures produced a distilled liquid, later called alcohol by the Arabs, for the preparation of medicines and perfumes. In the 7th century, Arabs began the invasion of Europe, introducing the technique of distillation there. Later, in Christian Europe, the doctor and theologian Arnau de Vilanova (Valencia, 1238?–1311) published the book *Liber Aqua Vitae*, a treatise on wines and spirits, which was a manual of the period for the production of distillates. In about the year 1520, Theophrastus Paracelsus, professor of chemistry at Basle, developed many liqueurs, which he called the *grand arcanurn* and, among others, the famous *elixir proprietatis*. Initially, these spirits and liqueurs were used as medicines; however, later they were consumed to stimulate the appetite and aid digestion (Paracelsus, Theophrastus Philippus Aureolus Bombastus von Hohenheim, 2008).

1.2 ALCOHOLIC BEVERAGES

Alcoholic beverages are products that have been traditionally obtained, depending on the raw materials and the production area. For example, barley and peat are used in Scotland to produce whiskey; wine is used to produce brandy in the Mediterranean zone; and barley, corn, and rye are used to produce gin in Holland and bourbon in America. In addition, Scandinavians use potato, Mexicans use agave, and the Caribbean countries use sugarcane (Small and Couturier, 2011). The name brandy, used alone, generally refers to the grape product; brandies made from wines or fermented mashes of other fruits are commonly identified by the specific fruit name. With the exception of certain fruit types, known as white types, brandies are usually aged. Fruit brandy usually contains 40–45% ABV (80–90 US proof). It is often colorless (Brandy, 2015).

1.3 IMPORTANCE OF DISTILLED BEVERAGES

From an economic point of view, distillates have always had an important contribution in agro-food zones of production, either by the direct use of agricultural products as raw materials to obtain

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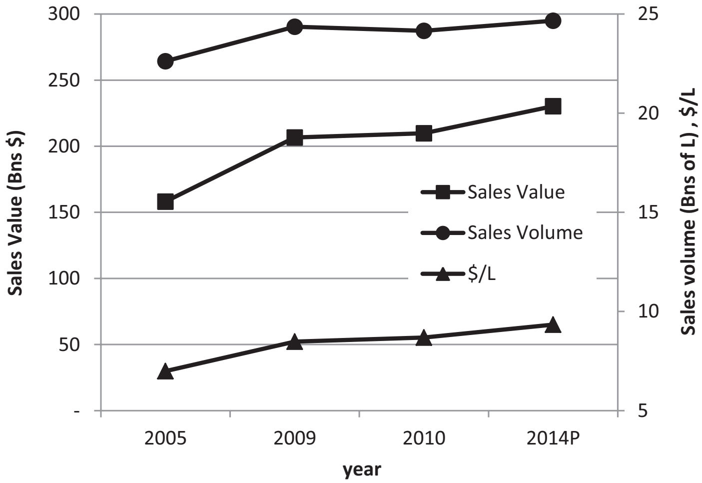

FIGURE 10.1

Global spirit market. Sales volume and sales value during period 2005–2014.

Adapted from Winchester Capital Research, 2015. The Spirits Industry 2015. http://winchestercapital.com/wp-content/uploads/2014/09/WC-Spirits-Industry-Report_2015-Final.pdf.

distillates, or by profiting from surplus production or residues from the processing of these raw materials. The spirits industry is likely to remain on the steady course of growth shown since 2011 and is poised to capture further market share from wine and beer. Fig. 10.1 shows the increase of sales during the period 2005–2014. The increase of sales volume was 9% while the sales value increased 45%, indicating a higher mean quality of the distillates (Winchester Capital Research, 2015). Leading spirits companies are seeking innovative products and emerging markets for growth. This has the potential to fuel further mergers and acquisitions in 2012. The market will continue to grow for two reasons. First, the spirits-consuming population is growing worldwide as middle classes are expanding in developing nations. Second, it is based upon the expectation that spirits will continue to penetrate the wine and beer markets in developing economies (Winchester Capital Research, 2012). Despite the large variety of spirits, only a few are highly consumed; the greatest economic impact is presented by whiskey, rum, gin, vodka, sake, and brandy (grape origin). Global distilled spirits marketing is also highly concentrated. The 10 largest marketers (by volume) have, since 1991, been responsible consistently for more than half the volume of globalized distilled spirits sold, and the market share of the two largest companies has increased by 65% (Jernigan, 2009).

1.4 CLASSIFICATION OF FRUIT ALCOHOLIC BEVERAGES

The large variety of available fruits and elaboration techniques to produce alcoholic beverages makes their classification extremely complex. In addition, the names of these products are sometimes confusing because a given name refers to different spirits in different countries. For example, the English term cherry brandy can mean either a cherry spirit or more likely a liqueur made by infusing cherries in sweetened brandy. Another confusing name is schnapps, derived from the German Schnapps.

Table 10.1 Legal Restrictions of Main Types of Fruit Spirit Drinks in Europe According to the Definitions Laid Down in Annex II of Regulation (EC) No 110/2008

Spirit Drink Parameter	Fruit Spirits	Macerated Fruit Spirit	Liqueurs	Crèmes
Main characteristic	Can be produced only by the alcoholic fermentation and distillation of fleshy fruit or must of such fruit	Produced by maceration of fruit, whether partially fermented or unfermented	Produced by flavoring, sweetening, and addition of fruits in ethyl alcohol of agricultural origin	Produced as liqueurs with a minimum sugar content of 250 g/L
Alcoholic strength	Distilled at less than 86 vol%	Distilled at less than 86 vol%	–	–
Volatile substances	>200 g/hL pa			
Hydrocyanic acid content (stone fruits)	<7 g/hL pa			
The maximum methanol content	1000 g/hL pa some exceptions			
The minimum alcoholic strength	37.5%	37.5%	15%	15%
Addition alcohol	No	Addition of a maximum of 20 L of ethyl alcohol per 100 kg of fermented fruit	–	–
Flavoring	No	No	Only natural flavoring substances (some exceptions)	Only natural flavoring substances and (some exceptions)
Sugar addition	No	No	>100 g/L exceptions	>250 g/L

In Germany, schnapps is an unsweetened fruit spirit, whereas in the United States, schnapps refers to sweetened spirits flavored with fruit or fruit extracts. These drinks (sometimes known as cordials) are more akin to fruit liqueurs (Buglass et al., 2011b). Nevertheless, these products are normally perfectly defined from a legal point of view through legislation. The spirit drinks in Europe are classified into categories according to the definitions laid down in Annex II of Regulation (EC) No 110/2008. In this Annex, the spirit drinks obtained from fruits are defined from a point of view of the final product; we can distinguish four major groups, and a summary of main legal restrictions are detailed in Table 10.1.

Fruit distillates, normally called brandies, are produced exclusively by the alcoholic fermentation and distillation of fleshy fruit or the must of such fruit, berry, or vegetable, with or without stones and distilled at less than 86% v/v. Macerated fruit spirits are obtained by maceration of authorized fruit or berries, whether partially fermented or unfermented, followed by distillation at less than 86% v/v. Liqueurs, including fruits types, are spirit drinks having minimum sugar content, expressed as invert sugar, of 100 g/L; with a few exceptions. Crèmes are liqueurs, excluding milk products, with a minimum sugar content of 250 g/L. The rules on flavoring substances and preparations are the same of liqueurs. Within the categories of liqueurs and crèmes, the EC regulations also define other fruit sprits drinks, such as Crème de cassis, Guignolet (cherries), Sloe gin, and Maraschino, etc.

1.5 FACTORS AFFECTING THE QUALITY OF THE BRANDIES

Brandies differ widely in quality and composition, depending on the raw material used and the processing procedures. They are especially rich in volatiles in comparison with other types of spirits due to high amount of alcohols and esters.

The quality of distillates is mainly defined by the aroma compounds, which can be classified into four groups: primary aromatic compounds, whose entire aroma appears exactly as in the fruit during ripening; secondary aromatic components, formed during alcoholic fermentation; tertiary aromatic compounds, formed during the distillation process; and quaternary aromatic compounds, formed during the maturation process (Tesevic et al., 2005).

A first condition to obtain quality distillates is that the fruits present adequate characteristics; they must have the correct sugar contents, possess the typical aromas, and be healthy. These characteristics do not have to match the fruits of direct consumption (Tanner and Brunner, 1982; Pischl, 2011). The second is the production process, which consists of four basic stages (Tanner and Brunner, 1982; Claus and Berglund, 2005): fruit preparation (mashing), fermentation, distillation, and storage. The fruit is crushed by mechanical means to extract the juice, but in the case of stone fruits, the cracked stone fruit pits increase the amount of undesirable compounds, such as benzaldehyde (Tanner and Brunner, 1982). The resulting mash is usually fermented in a stirred and cooled fermenter at a controlled temperature. Next the fermented mash is distilled in batch distillation equipment. The clear spirits are stored at high alcoholic strength a minimum of three months prior to alcoholic adjustment with water and bottling.

According to the raw material, three main types of brandies can be distinguished: distillates obtained with pome fruits, of which apples and pears are the most common; those obtained with stone fruits, mainly sweet cherries, sour cherries, plums, apricots, and peaches; and finally the distillates obtained from berries.

While the distillates with pome fruits are those traditionally obtained from pears and apples, new brandies with other fruits are also being developed to valorize surpluses.

2. DISTILLATION SYSTEMS

Distillation is a process of physically separating a mixture into two or more products that have different boiling points, by preferentially boiling the more volatile components out of the mixture. When a liquid mixture of two volatile components is heated, the vapor that comes off will have a higher concentration of the more volatile (i.e., lower boiling point) material than the liquid from which it was evolved. Conversely, if a vapor is cooled, the less volatile (i.e., higher boiling point) material has a tendency to condense in a greater proportion than the more volatile material (Kister, 1992).

2.1 DISCONTINUOUS DISTILLATION

Fig. 10.2 shows the two types of distillation equipment that are commonly used for the production of fruit spirits in batch operations: copper Charentais alembic (French style) and batch distillation columns (German style). Both distillation methods are based on the same theoretical principles, i.e., mass and energy balances, heat and mass transfer, and vapor–liquid equilibrium (Garcia-Llobodanin et al., 2011).

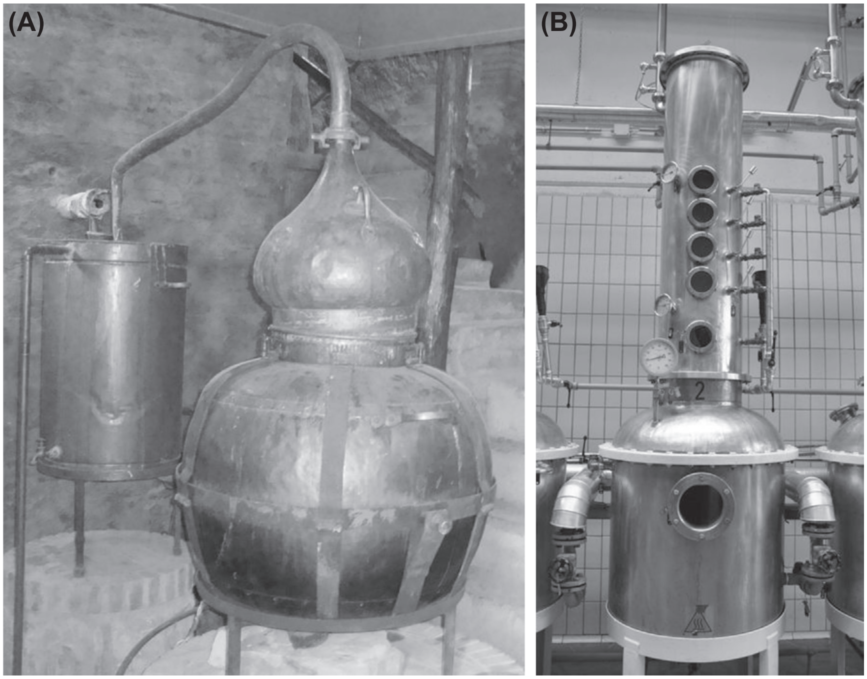

FIGURE 10.2

Typical distillation equipment used for the production of fruit spirits: (A) copper Charentais alembic (French style); (B) batch distillation column (German style).

Both methods differ in their operational principles. Copper pot still distillation presents an almost constant reflux rate, basically determined by the condensation in the swan neck, which in turn is defined by the ambient temperature. In the case of batch column distillation, the reflux rate varies over a wide range. If the column has total and partial condensers, the reflux rate is varied by changing the cooling rate in the partial condenser. If the column has a total condenser only, the flux rate is varied by changing the flow rate of the condensate stream that is returned to the column. In addition, the many equilibrium stages in the rectification column favor the separation, reducing the need for high reflux rates. However, in principle, if a large enough reflux rate can be established in a pot still, the level of separation can be the same as in a distillation column.

The raw materials used to obtain distillates are fermented from agricultural products which acquire a complexity of compounds in the fermentation process. Together, raw material and fermentation compounds will define the aromatic profile of the distillates. In addition, during the distillation, the heat applied in the kettle can produce chemical reactions between the existing compounds, forming other compounds that can increase the complexity of the final distillate. These minority compounds, also known as congeners, may have a different impact on the final product, since there are compounds that are not pleasant, some may even be toxic, and of course, there are compounds that give a positive character. Therefore, by identifying key congeners it will be possible to minimize and remove negative aromas and enhance positive ones. The art of distillation is to obtain distillates with an adequate alcoholic strength and at the same time a pleasant aroma.

In batch distillations, a mixture is heated to its boiling temperature in the boiler, then the vapors pass through the rectification system whether it is a hat in the case of the traditional alembic or a fractionation column. These vapors are then condensed giving rise to the distillate with an alcoholic strength depending on the rectification system. The early fraction of the distillate contains high levels of toxic and unpleasant substances that must be removed. That is why the first fraction collected (head) is rejected. The second fraction collected (heart) contains high levels of the desired aromatic compounds and possesses a high alcoholic strength. When the alcohol content of the distillate begins to decrease (tail fraction), its aromatic quality reduces significantly; the less volatile congeners that have unpleasant tastes are now beginning to distill. The commercial product is elaborated with the heart fraction after adjusting its alcoholic strength.

2.2 CONTINUOUS DISTILLATION

Fig. 10.3 shows the schema of a continuous distillation system. The ferment is fed to the distillation column C from tank F, being previously preheated in the heat exchanger E1 with the vapors obtained (distillate) in the column C, which can be total or partially condensed. Part of the condensate is returned to the column to generate reflux in the zone above the feeding plate and to control the alcoholic degree of the distillate. Next, the distillate passes through the heat exchanger E2, where it is finally cooled with

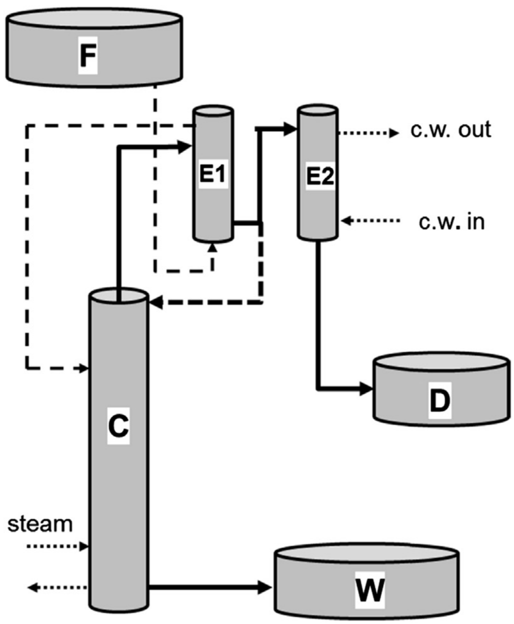

FIGURE 10.3

Schema of a continuous distillation column. *F*, ferment tank; *C*, column; *E1*, preheater ferment heat exchanger; *E2*, distillate condenser; *W*, waste tank; *D*, distillate tank; *C* and *W*, cooling water.

cooling water and sent to distillate tank D. The ferment is fractionated in the column by plates or special packaging, which contacts the falling liquid with the ascending vapor. The vapor is generated in the bottom of the column that is normally heated with steam. The waste (low alcohol content) is extracted from the bottom of the column and sent to tank W. The stability of the system is maintained by controlling the steam inlet, the ferment feed, and the waste removal.

Continuous distillation is faster and achieves higher concentrations of alcohol in the distillate compared with discontinuous distillation (Buglass et al., 2011a). Consequently, the distillate can be produced at lower costs. The main disadvantage of continuous distillation in spirits production is that the distillate is not entirely free of potentially harmful highly volatile components, such as methanol and acetaldehyde, although this situation can be improved by taking the ethanol from just below the top of the rectifier. In this case, most of the acetaldehyde and methanol is taken from the top of the column. Like batch column stills, continuous column stills yield a relatively pure spirit of high ethanolic strength (up to 95.6% ABV, i.e., the strength of the azeotropic mixture) and low in flavor compounds (congeners: acids, higher alcohols, and esters, for example). This is particularly the case with tall-column continuous stills, which are able to supply the highest degree of rectification. However, in the production of many distilled beverages; regulations require the spirit to be of considerably lower ethanolic strength than that of the azeotropic mixture. For example, the EU stipulates that the distillation of fruit spirits must occur at less than 86% ABV, so that the spirit retains some character of the fruit from which it is derived (Regulation (EC) No 110/2008).

3. POME FRUIT BRANDY

The distillates with pome fruits are those traditionally obtained from pears and apples; however, recent studies considered other fruits to valorize surpluses and to develop new brandies.

3.1 PEAR BRANDY

Even though there are many table and juice pear varieties suitable for the production of distillates, two varieties have outstanding distilling qualities: Seckel Sugar pear and Williams or Bartlett pear (Pischl, 2011). Bartlett pear distillates are considered to be the best, because of their pleasant aromas, mainly due to esters (Nikićević, 2005; Buglass et al., 2011b). Willner et al. (2013) have characterized 26 aroma-active compounds in the volatile fraction of Bartlett pear brandy. Sensorial analysis unveiled that ethyl 2-trans, 4-cis decadienoate, and ethyl trans-2-trans-4-decadienoate are key congeners in the overall aroma of Bartlett pear brandies. However, these odorants alone are not able to mimic the overall aroma of a Bartlett pear brandy and, thus, cannot serve as single quality markers. If Bartlett pear spirit is stored in colorless bottles, the 2-trans-4-cis isomers partially isomerize to the 2-cis-4-trans and 2-trans-4-trans isomers, all of which have much less pronounced pear-like odors, so the flavor quality of the spirit decreases. No such isomerization was noted for pear spirit stored in green bottles (Cigic and Zupancic-Kralj, 1999).

The possibility to obtain pear brandies with varieties different from Bartlett has been studied. García-Llobodanin et al. (2007) fermented Blanquilla pear juice concentrate previously diluted to 18° Brix. The pear wine was distilled with and without its lees using three different types of equipment: a glass alembic (a glass pot still coupled to a glass column), a copper alembic, and a glass alembic with the addition of copper shavings to the pot still. The results indicated that methanol, ethyl acetate, and furfural either decreased or showed no change in their concentrations when distilled in the presence of lees and in the copper alembic (see Fig. 10.4). Other compounds (ethyl decanoate and ethyl-2-trans-4-cisdecadienoate) showed increased concentrations in the presence of lees in all equipment tested (see Fig. 10.5).

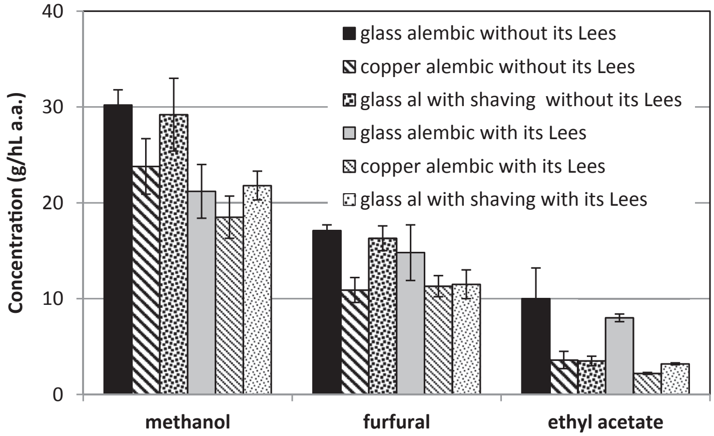

FIGURE 10.4

Effect of the presence of lees and copper in methanol, furfural, and ethyl acetate content for pear distillates.

Adapted from García-Llobodanin, L., Achaerandio, I., Ferrando, M., Güell, C., López, F., 2007. Pear distillates from pear juice concentrate: effect of lees in the aromatic composition. Journal of Agricultural and Food Chemistry 55, 3462–3468.

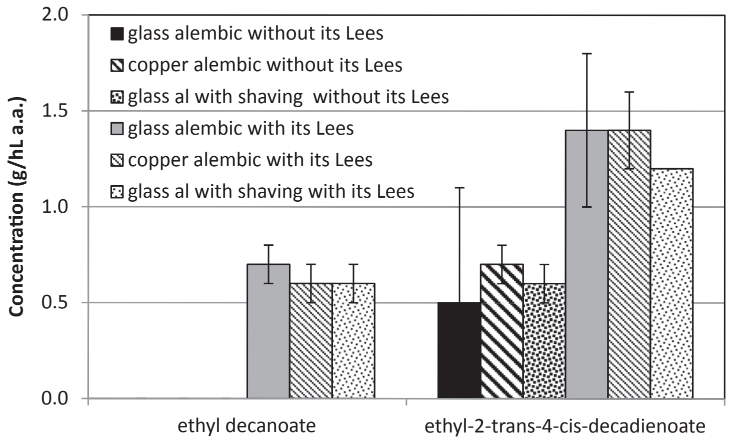

FIGURE 10.5

Effect of the presence of lees and copper in ethyl decanoate and ethyl-2-trans-4-cis-decadienoate content for pear distillates.

Adapted from García-Llobodanin, L., Achaerandio, I., Ferrando, M., Güell, C., López, F., 2007. Pear distillates from pear juice concentrate: effect of lees in the aromatic composition. Journal of Agricultural and Food Chemistry 55, 3462–3468.

It was assumed that the distillation of pear wine in the presence of the lees led to better product quality. García-Llobodanin et al. (2010) studied the pH effect on fermenting Blanquilla diluted pear concentrate. They made two sets of experiments using different fermentation yeasts and different distillation equipment. The results showed, in both experimental sets, that reducing the fermentation pH significantly increased the concentration of most of the higher alcohols and decreased the concentration of ethyl acetate in the spirits. Moreover, pear distillates obtained with the rectification column showed significantly higher concentrations of most of the long-chain ethyl esters (C6–C12) compared to those obtained in the alembic. García-Llobodanin et al. (2011) used Conference pear juice to obtain a pear wine, which was distilled by alembic in double distillation and with a packed column. Pear wine distillations with a packed column produced higher alcoholic degree spirits in just one distillation, compared with two consecutive alembic distillations. In addition, column distillation produced hearts with a lower concentration of toxic compounds such as acetaldehyde and methanol. Furthermore, spirits from column distillations contained significantly more esters and higher alcohols.

Versini et al. (2012) have studied the aroma fraction of Italian distillates of wild (*Pyrus amygdaliformis*, Vill., namely "Pirastru") and cultivated (*Pyrus communis*, L. cvs. "Coscia," "Precoce di Fiorano," and "Butirru de Austu") pear varieties grown in the northern part of the island of Sardinia. They found a wide range of volatile compounds in the distillates, with each varietal product having a specific aromatic profile. Taking into account what has been reported in the literature, the aromatic profiles of these products proved different from the most well-known Bartlett pear distillates: only Coscia distillates are rich in methyl and ethyl unsaturated decanoates, the typical Bartlett pear aroma compounds. Other compounds, such as fatty acid ethyl esters, from hexanoate to decanoate, are also usually at medium-low levels if compared with raw distillates of Bartlett pears. These ethyl esters present differences related to the year of production.

Arrieta-Garay et al. (2013) make a chemical and sensorial comparative examination of pear distillates from the three main varieties grown in Spain (Bartlett, Blanquilla, and Conference) using two distillation systems (copper Charentais alembic and packed column). The Bartlett distillates from both distillation systems possessed higher ethyl ester and acetate and lower cis-3-hexen-1-ol and 1-hexanol concentrations. Despite these differences, a sensory analysis panel could distinguish only the Bartlett alembic distillate from the alembic distillates of the other varieties. In contrast, the panel rated the packed-column distillates equally. Therefore, less aromatic pear varieties can be used to produce distillates with aromatic characteristics similar to those of the Bartlett variety if a suitable distillation process is used.

3.2 APPLE BRANDY

Apple brandy is a spirit obtained by the distillation of cider or apple wine. The apples can be classified as table, commercial, or cider apples, but all are suitable for alcohol production (Pischl, 2011). The sugar content of the average quality fruit is between 8% and 12%. The best known apple brandy, Calvados, is an exception because is an aged product, and it is made by a combination of sweet, tart, and bitter apple varieties that are fermented to produce cider. The cider is doubled-distilled in either pot still, producing a complex brandy that ages well, or a column still, resulting in a fresh brandy with less complex flavors (Small and Couturier, 2011). Calvados is the most important cider spirit bearing the Appelation Controle (AOC) seal, featuring the following varieties: a general AOC Calvados, AOC Calvados du Pays d'Auge, and AOC Calvados Domfrontais; the latter is made from apples and pears, using single column distillation (Burglass et al., 2011). Apple brandies are produced in several other European locations, including northern Spain (especially Asturias), northern Italy (especially Alto Adige and Trentino), Germany, and England, from a wide range of apple varieties—not solely from classic cider varieties that are grown in the major cider manufacturing areas (Vidrih and Hribar, 1999).

The volatile components of freshly distilled Calvados and Cognac have been extensively investigated (Ledauphin et al., 2004), and 331 compounds, of which 162 can be considered as trace compounds, were characterized. Of these, 39 are common to both spirits; 30 are specific to Cognac with numerous hexenyl esters and norisoprenoidic derivatives, whereas 93 are specific to Calvados with compounds such as unsaturated alcohols, phenolic derivatives, and unsaturated aldehydes.

The aroma quality of apple brandy is influenced by the cider maturation (Rodríguez-Madrera et al., 2010). It was found that the most mature cider gave a distillate of superior aroma (with more sweet and spicy character), with higher levels of ethyl acetate, ethyl lactate, and ethyl succinate, and volatiles derived from bacterial metabolism (which is more prevalent in extensively matured cider), such as 2-butanol, 4-ethylguaiacol, eugenol, and 2-propen-1-ol. Moreover, using different yeast species allows the production of spirits with important differences in their aromatic composition, which is certainly interesting from a commercial point of view (Rodríguez-Madrera et al., 2013).

Versini et al. (2009) were able to show that apple distillates made from native Sardinian varieties can be distinguished from those produced from locally grown apple varieties in the traditional cider brandy provinces of Trentino, using similar fermentation and distillation methods. Compounds such as ethyl octanoate, hexyl 2-methylbutanoate, 1-hexanol, benzaldehyde and furfural correlated well with apple varieties (see Fig. 10.6). Ethyl octanoate may be indicative of a more or less favorable yeast activity, while

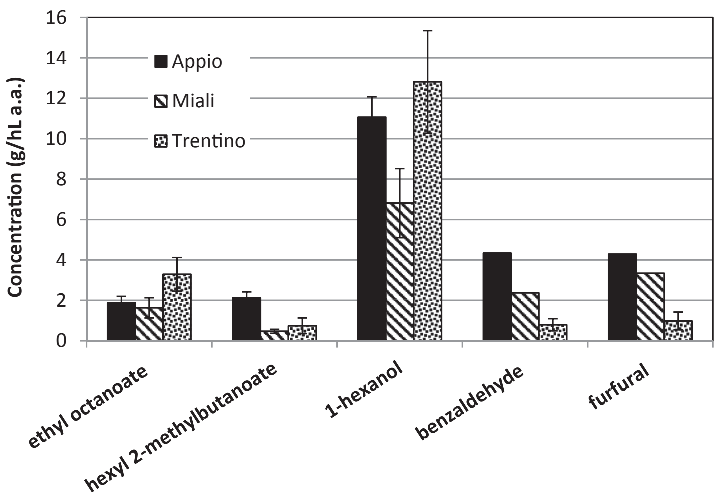

FIGURE 10.6

Comparison of composition of ethyl octanoate, hexyl 2-methylbutanoate, 1-hexanol, benzaldehyde, and furfural for native Sardinian varieties (Appio and Miali) versus Trentino varieties.

Adapted from Versini, G., Franco, M.A., Moser, S., Barchetti, P., Manca G., 2009. Characterisation of apple distillates from native varieties of Sardinia island and comparison with other Italian products. Food Chemistry 113, 1176–1183.

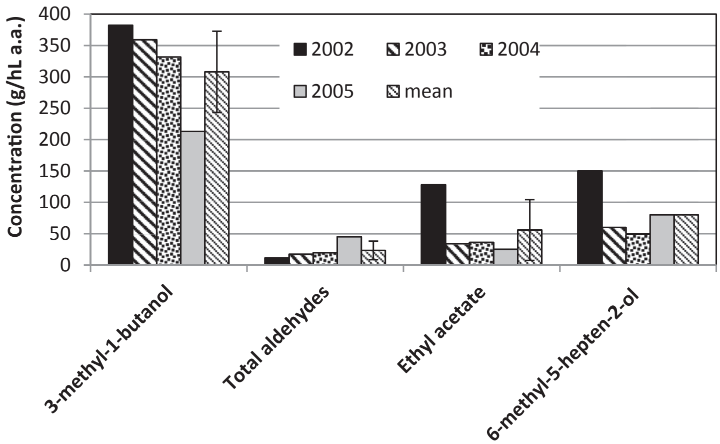

FIGURE 10.7

Effect of year for apple native Sardinian varieties in the volatile composition.

Adapted from Versini, G., Franco, M.A., Moser, S., Barchetti, P., Manca G., 2009. Characterisation of apple distillates from native varieties of Sardinia island and comparison with other Italian products. Food Chemistry 113, 1176–1183.

furfural may be linked to distillation and sugar residues. 3-methyl-1-butanol, total aldehydes, ethyl acetate, and 6-methyl-5-hepten-2-ol are dependent of the year of production (see Fig. 10.7).

Apple pomace (the solid residue generated after juice extraction) is composed of peel, pulp, and seeds, and represents about 25% of the processed apple. Fruit pomaces are usually employed as raw material in the production of spirits following traditional methods, which yields quality products of recognized prestige. Fruit marc spirits, as defined by the European Regulation, are drinks with an alcoholic strength higher than 37.5% (v/v), and a minimum quantity of volatile substances of 200 g/hL pa (EC 110/2008). Due to the seasonality of the raw material, large distillation facilities are required. The use of dry pomace to make apple pomace spirit is a possibility studied by Rodríguez-Madrera et al. (2013). The results of this study show that the treatment with enzymes with pectin methylesterase activity led to excessive levels of distilled methanol, and hence its use is not advisable. In contrast, the indigenous yeasts produced lower concentrations of methanol (see Fig. 10.8). Similar results were obtained by Zhang et al. (2011) in a study with apple mash, juice, and pomace of Crispin apples, which were treated with pectinase. Methanol, ethanol, n-propanol, isobutanol, and isoamyl alcohol were identified as the major alcohols in all the apple spirits.

4. STONE FRUIT BRANDY

Stone fruits such as cherry (Kirschwasser, Cherry, Kirsch), plum (Zwetschgenwasser, Slivovitz), yellow plum, and apricots are used to produce distilled spirits, not only in many regions of Europe, but also in many other parts of the world. Rakia, or rakija, is a brandy, obtained by distillation of fermented fruit, traditionally in Serbia, Slovenia, Croatia, Bosnia, Romania, Czech Republic, Slovakia, Poland, Hungary, and Bulgaria. In the Balkans is called rakia, while in Hungary pálinka; in Czech Republic and

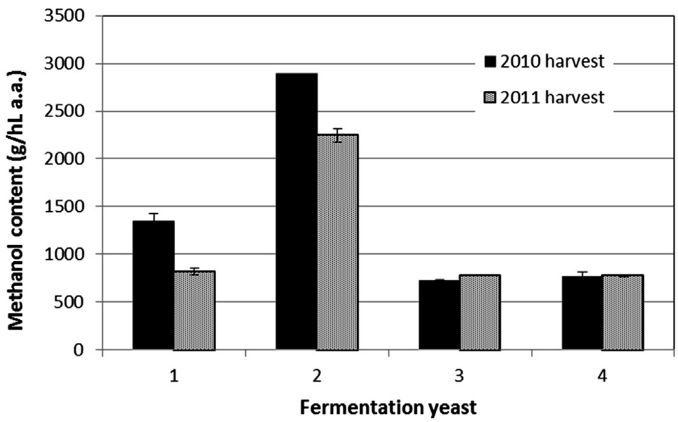

FIGURE 10.8

Methanol content for different fermentation yeasts and enzyme treatment effect. 1, Levuline CHP commercial yeast; 2, Levuline+ β-glucosidase; 3, S.c. 3′ indigenous yeast; 4, H.u. 283 indigenous yeast.

Adapted from Rodríguez-Madrera, R., Pando-Bedriñana, R., García-Hevia, A., Bueno-Arce, M., Suárez-Valles, B., 2013. Production of spirits from dry apple pomace and selected yeasts. Food and Bioproducts Processing 9, 623–631.

Slovakia pálenka. Slivovitz is the most common rakia made from plums. Other stone fruits used to produce rakia are peaches and apricots. The flavor of stone fruit spirits is mostly affected by the aroma compound benzaldehyde, which originates from the enzymatic degradation of amygdalin in the stones of the fruits, passing into the mash during fermentation and later into the distillate at rather high levels. Fermented fruit and beverages frequently contain ethyl carbamate (EC), a potentially carcinogenic compound that can be formed by the reaction of urea with ethanol. It has been regulated in several countries (Lachenmeier, 2005); special care should be taken in the case of stone fruits, since they may contain higher amounts of EC. Some pome fruit brandies, such as quince, may have high EC concentrations as well (Déak et al., 2010). Stone fruit distillates are produced by the yeast *Saccharomyces cerevisiae*, with ethanol as the major product of hexose fermentation and urea as a byproduct in arginine catabolism. In spirit production, EC can also be derived from cyanide found in the stone of the fruit (Schehl et al., 2007). Schehl et al. (2005) studied the influence of the stones on the quality of spirits, cherry, and plum mashes. Although mashes retaining the stones could be clearly distinguished from those where the stones had been removed, no significant preference could be attributed to either spirit, indicating that the aromatic characteristics added by the presence of stones during fermentation are largely a matter of personal taste.

4.1 CHERRY BRANDY

Cherries are classified into sweet cherries (*Prunus avium*) and sour cherries (*Prunus cerasus*). Well-ripened dark-sweet varieties are especially suitable to produce a good brandy. Sour cherries are also a good distilling fruit but not as ideal as sweet cherries (Pischl, 2011). Cherry brandies (kirsch) are produced across the world. Nevertheless, brandies under the name of Kirschwasser are mainly produced in southern Germany, France, and Switzerland by crushing different kinds of sweet cherries, and

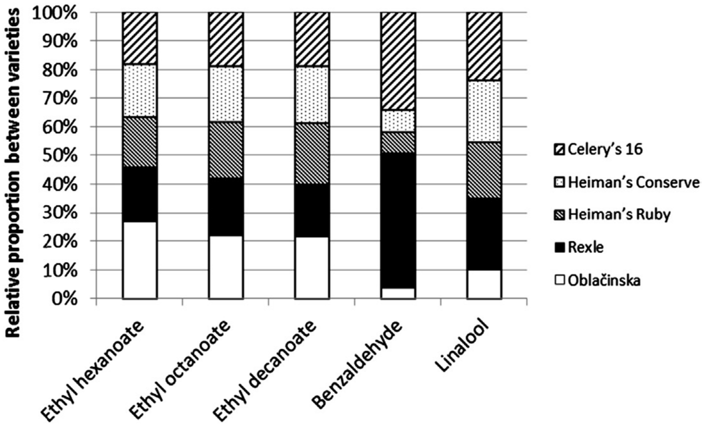

FIGURE 10.9

Relative proportion of volatile compounds in brandies obtained from different cherry cultivars.

Adapted from Nikićević, N., Veličković, M., Jadranin, M., Vučković, I., Novakovi , M., Vujisić, L., Stanković, M., Urošević, I., Tešević, V., 2011. The effects of the cherry variety on the chemical and sensorial characteristics of cherry brandy. Journal of the Serbian Chemical Society 76, 1219–1228.

leaving the mashed mass to ferment for several weeks. The fermented mash is then distilled in copper stills on open fire or vapor, where the head and tails are removed. The resulting distillate has an alcohol content of 60 vol% or more and is sold as a clear and colorless fruit spirit with an alcohol content of 40–50 vol%. Kirschwasser is also used as an additive for different liqueurs (e.g., Curacao, Cherry Brandy, Maraschino, etc.). In Serbia the production of sour cherry brandy has a long tradition. Favorable microclimatic conditions and pedological properties of Serbian soil resulted in Serbia holding fourth place in Europe for the production of this fruit (Nikićević et al., 2011).

Nikićević et al. (2011) studied different varieties of cherries for brandy production, evaluating both their chemical and sensory characteristics. They identified 32 components, including esters, benzaldehyde, terpenes, and acids. Ethyl esters were the most abundant in all samples. All the investigated cultivars yielded brandies of very good to excellent quality. The brandies of two cultivars, Celery's 16 and Rexle, were preferred. These were characterized by high contents of benzaldehyde and linalool (see Fig. 10.9) and significant amounts of aromatic organic acids and esters. In addition, these aromas were present in harmonious proportions.

4.2 PLUM BRANDY

Plum brandies are produced in different areas of Central and Eastern Europe, using different varieties, which are given specific names. In Eastern and Central Europe, plum brandies (slivovitz) matured under appropriate conditions are the most popular fruit brandies prepared from fresh Wegierka plums. This beverage originated in the Balkan Peninsula and the most popular brandy is from Bosnia and Herzegovina (Spaho et al., 2013); it is also quite well-known in Central Europe (Hungary, Poland, Czech Republic, Slovakia, and Romania) and, to a lesser extent, in France (eau de-vie de prunes), Germany (Zwetschgenwasser), and Switzerland (Pflumliwasser; Satora and Tuszynki, 2008). Plum brandy

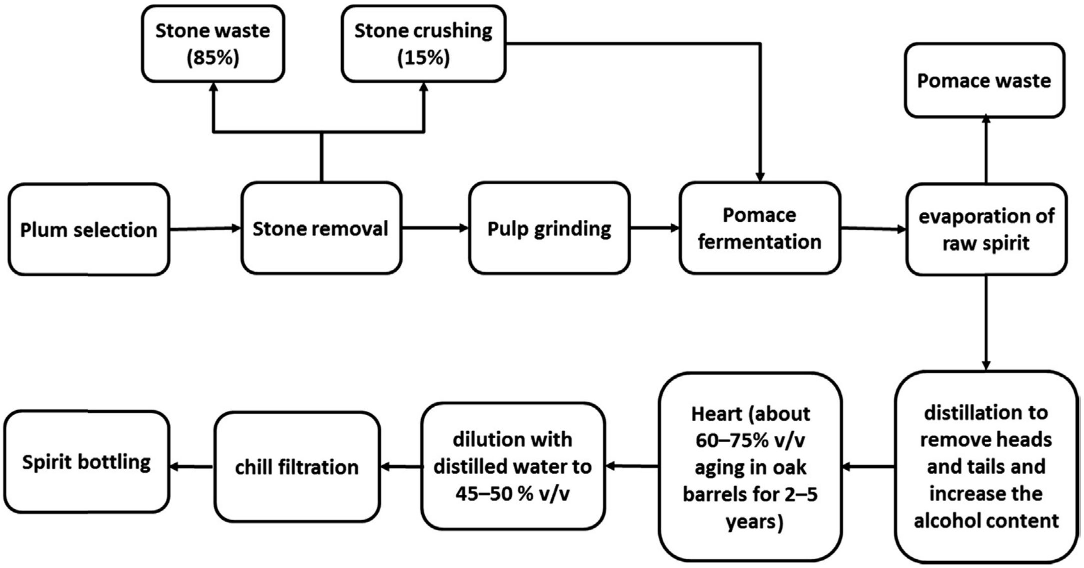

FIGURE 10.10

Traditional plum spirit (Slivovitz) process flow diagram.

is characterized by an intense fruit aroma. They often present a distinctive pungent flavor owing to its artisanal production (Spaho et al., 2013).

Slivovitz production (see Fig. 10.10) includes mill grinding of previously sorted plums (crushing about 15% of the stones), pomace fermentation, evaporation of the raw spirit and, most often, fractional distillation (fractionation) to remove heads and tails and increase the alcohol content. The main fraction of about 60–75% v/v is then subjected to maturation in oak barrels for 2–5 years and, if necessary, diluted with water to reach its consumption strength of 45–50% v/v. The described procedure results in products with various aroma profiles. Apart from its numerous valued components, plum brandy can also contain undesirable ingredients such as hydrocyanic acid (HCN), methanol, and EC (Tesevic et al., 2005). Nevertheless, the fermentation of mashes with selected yeast can reduce the formation of HCN. Balcerek and Szopa (2012), have observed that spontaneous fermentation of fruit pulp resulted in much higher amounts of HCN in the spirits obtained (10.5 mg/L of plum spirit 40%, v/v), in relation to the contents observed in the distillates from the mashes fermented with the addition of *Saccharomyces bayanus* wine yeast (2.80 mg/L of plum spirit 40%, v/v). Satora and Tuszynski (2010) compared spontaneously fermenting plum musts (*Kloeckera apiculata* and *S. cerevisiae*) with musts fermented with different yeasts isolated from fresh blue plum fruits (*Aureobasidium* sp.) and with musts fermented with commercial wine and distillery strains. After spontaneous fermentation, distillates were distinguished by a high content of acetoin, ethyl acetate, and total esters, accompanied by a low level of methanol and fusel alcohols (see Table 10.2). Non-*Saccharomyces* yeasts were responsible for higher concentrations of esters and methanol, while *S. cerevisiae* strains resulted in increased levels of higher alcohols. It was also found that isolated indigenous strains of *S. cerevisiae* synthesized relatively low amounts of higher alcohols compared to commercial cultures. Samples obtained using the distillery

Table 10.2 Chemical Composition of Analyzed Plum Spirit

Sample	Ethanol (% v/v)	SD	Methanol g/hL aa	SD	Total Fusels g/hL aa	SD	Ethylacetate g/hL aa	SD	Total Esters g/hL aa	SD	Acetoin g/hL aa	SD
Distillery, *Saccharomyces cerevisiae*	69.6	0.6	963.4	29.5	458.5	24.5	46.2	1.1	62.6	0.6	0.0	0.0
Wine, *S. cerevisiae*	69.5	4.2	760.0	13.5	509.2	38.6	27.7	1.0	39.4	0.8	0.8	0.2
Indigenous, *S. cerevisiae*	71.0	0.6	893.6	36.7	353.8	5.0	118.3	2.5	138.0	3.0	0.9	0.1
Aureobasidium sp.	69.6	0.0	963.2	67.5	309.7	34.8	85.8	0.9	92.2	1.0	1.0	0.3
Kloeckera apiculata	66.3	0.6	974.4	8.0	250.3	6.1	165.5	3.3	182.9	1.7	0.7	0.2
Spontaneous fermentation	74.3	1.4	755.0	37.8	183.0	13.0	192.5	10.7	247.0	25.6	2.0	0.1
Sig.	**		***		***		***		***		*	

,,*** display the significance at 5%, 1%, and 0.1% respectively, by least significant difference.*
Adapted from Satora, P., Tuszynski, T., 2010. Influence of indigenous yeasts on the fermentation and volatile profile of plum brandies. Food Microbiology 27, 418–424.

strain of *S. cerevisiae* received the highest score (18.2) during sensory analysis and were characterized by a well-harmonized taste and aroma.

Balcerek et al. (2013) studied the use of intermediate products of plum processing (pulp, concentrate and syrup left after candied fruits processing) as potential raw materials for distillates production. They also studied the supplementation of mashes with sucrose. The resulting distillates presented volatile compounds exceeding 2000 mg/L aa and low content of methanol and HCN. The good taste and aroma make the intermediate products of plum processing very attractive as raw materials for the plum distillates production.

4.3 APRICOT BRANDY

Like many stone fruits, apricots [*Prunus armeniaca* (L.)] are appreciated by consumers all over the world and, consequently, have gained great economic importance. The fruits are presently cultivated in all Mediterranean countries and in South Africa as well as in South and North America, mainly in California. The crop is either marketed fresh, used as canned and dried fruit, or is manufactured into juice (Greger and Schieberle, 2007). Apricot quality consists of a balance of sugar and acidity as well as a strong and characteristic aroma. A significant amount of apricot fruits is processed into brandy, a distillate of apricot fermented must (Puskas et al., 2013).

Genovese et al. (2004) compared aroma compounds in distillates obtained from Pellecchiella apricot (*Prunus armeniaca*, L. cv. Pellecchiella) and Annurca apple (*Malus pumila* L. cv. Annurca). Fifty and 45 volatiles were identified in the apricot and apple distillates, respectively. The aroma volatiles of the apricot distillate were characterized by a high concentration of alcohols and by a specific terpene profile that included linalool, ocimenol, alpha-terpineol, nerol, geraniol, cis-, and translinalool oxide. Gamma-decalactone, gamma-dodecalactone, and ethyl cinnamate were also characteristic of the apricot distillate. Olfactometric analysis showed that volatile compounds, such as beta-damascenone, ethyl 2-methylbutanoate, linalool, methyl anthranilate, ethyl cinnamate, gamma-decalactone, and gamma-dodecalactone, which probably resulted from the original fruit, had a significant odor activity, while 2-phenylethanol was the main odor impact compound.

Urosevic et al. (2014) studied the influence of five commercial yeast strains of *S. cerevisiae* and *S. bayanus* (SB, Top Floral, Top 15, Aroma White, and Red Fruit) and two nutrients, diammonium phosphate and Nutriferm Arom, were examined for their influence on young apricot brandies. Analyses of the major and minor volatiles and sensory analysis of the apricot brandies showed important differences between the samples. The sensory qualities of the assessed apricot brandies indicated that the quality depended on the combination of yeast and nutrients. Nutriferm Arom, as a complex nutrient, gave in all combinations better results than diammonium phosphate, a simple nutrient. The exception was the yeast strain SB that with simple nutrients gave the lowest amounts of some compounds, such as esters and higher alcohols, in the distillate, with better sensory results than the other sample.

The best results were obtained with yeast strain SB with both nutrients and yeast strain Top 15 only with complex nutrients, which gave a high content of linalool. The control sample with no nutrients and selected yeast gave a distillate that was evaluated as having the worst quality with higher concentration of ethyl acetate, 1-butanol, 1-hexanol, and amyl alcohols.

Brandy can be also prepared from wild apricot fruits even with those having high acidity (Joshie et al., 1990; Joshi and Sharma, 2004). The pulp is diluted in a 1:1 ratio with water fortified with a 0.1% 3-Deoxy-D-arabinoheptulosonate 7-phosphate (DAHP) synthase and fermented to completion with total soluble solids of 25° Brix. The wine is then distilled to make brandy. The brandy made from 1:1 diluted pulp was superior to that from 1:2 dilution. The brandy so produced has an intense apricot flavor and high sensory acceptability. The product was treated with slightly roasted oak wood chips during maturation to impart color and flavor. Comparison of the methanol content of brandy made experimentally with that of a locally prepared brandy showed a considerable reduction in the quantity of this alcohol (Joshi and Sadhu, 2000).

4.4 OTHER STONE FRUIT BRANDIES

The interest in using tropical fruits to develop new fermented beverages has grown significantly in the past few years. Reddy and Reddy (2005) studied the viability of fermenting six varieties of mango (*Mangifera indica* L.) produced in India; they also compared the resulting products with fermented grape products. Ethanol concentrations ranged from 7% to 8.5%; the levels of methanol were slightly higher and the concentrations of the other volatile compounds were similar to those of fermented grapes. Alvarenga (2006) studied the effect of enzymatic treatment of mango pulp to increase the extraction efficiency of the juice and to reduce its viscosity in the production of mango spirits. Mango spirits produced under optimum hydrolysis and fermentation conditions showed good quality but presented levels of copper and higher alcohols exceeding those allowed by existing legislation.

Coelho et al. (2011) studied the elaboration of umbu liqueur by maceration of this fruit without stems during 30 days in four types of alcohols: cereals, tubers, grass, and deodorized grass; they tested preferences in relation to flavor, aroma, and purchase intention. After the addition of syrup, a 90-day maturation period was started. The liqueurs were bottled and labeled to perform the sensory analysis through quantitative and acceptance methods. In the analysis, the four kinds of alcohol were found to be suitable for the preparation of umbu liqueur, but the liqueur made with grass alcohol was preferred by the judges in all aspects analyzed, which is an advantage to the small producer because of its low-cost. The liqueur produced with tuber alcohol was less accepted.

Marula is one of the most consumed wild fruits in southern Africa, and since it is drought resistant, it has exceptional yield per tree and both the fruit and the nut are edible. Fundira et al. (2002) studied different enzyme treatments to increase the juice yield and terpenes' recovery in the final distillate. This fruit is also used to produce liqueurs and crèmes.

5. BERRY FRUIT BRANDY

Berries are numerous, both cultivated and wild; the most common are raspberries, blackberries, and blackcurrant. Cranberries and elderberries are rich in tannins and partially poor in nitrogen; hence, their fermentation needs the addition of nutrients (Tanner and Brunner, 1982). Berries are commonly used in the preparation of macerated fruit spirits, liqueurs, and crèmes and are regulated in Europe (Regulation (EC) No 110/2008). These fruits have a significant amount of phenolic compounds and high antioxidant activity (Gorjanović et al., 2010). However, berries are not as widely used for distillation as stone fruits or pome fruits. Cultivated berries possess a relatively low sugar content (4–8%) compared to wild berries (Tanner and Brunner, 1982), resulting in low yields and expensive distillates (Vulic et al., 2012). The diversity of berries allows a wide range of fruit brandies and fruit liqueurs. The production of so-called delicatessen fruit brandies is increasing worldwide. Usual fruits used in these brandies are quince, raspberry, blackberry, cornel berry, currant, and blueberry. If proper technology is applied, they are highly appreciated by the consumer (Vulic et al., 2012).

The suitability of wild fruits to develop new spirits has been explored in several studies. Production of alcoholic beverages from fruits of the forest presents limitations. Sometimes these fruits are not easily fermentable; hence, they should be macerated, leading to liquors with different qualities. In addition, artisanal fermentation using fruit juices, either spontaneous or inoculated, are not reproducible. Solid-state fermentation (SSF) is a good alternative to submerged liquid fermentation (SLF). Even though SLF requires less complicated control systems, SSF yields highly aromatic products, composed of original fruit aromas and those produced during the fermentation process (Alonso-Gonzalez et al., 2010; Santo et al., 2012).

Alonso-Gonzalez et al. (2010) studied the potential of black mulberry and black currant to be used as fermentation substrates for producing alcoholic beverages obtained by distillation of the previously fermented fruits. In the two distillates obtained, the volatile compounds that can pose health hazards are within the limits of acceptability fixed by the European Council (Regulation 110/2008) for fruit spirits. However, the amount of volatile substances in the black currant distillate (121.1 g/hL aa) was lower than the minimum limit (200 g/hL aa) fixed by the aforementioned regulation (see Table 10.3). The mean volatile composition of both distillates was different from other alcoholic beverages, showing the feasibility for obtaining distillates from fermented black mulberry and black currant, which have their own distinctive characteristics. The same authors (Alonso-Gonzalez et al., 2011) obtained two distilled alcoholic beverages from red raspberry and arbutus berry by SSF and subsequent distillation of the fermented fruits. The mean concentrations of ethanol and volatile substances in the distillates from red raspberry and arbutus berry were higher than the corresponding minimum limits fixed by the European Council (Regulation

Table 10.3 Chemical Composition of Analyzed Black Mulberry, Black Currant, Red Raspberry, and Arbutus Berry Spirits

No.	Compound	Black Mulberry		Blackcurrant		Red Raspberry		Arbutus Berry	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	Ethanol (% v/v)	48.3	1.7	38.5	1.2	41.3	1.4	44.3	1.3
2	Methanol	349.6	2.3	167.4	1.3	113.9	1.4	320.5	3.5
3	2-Butanol	nd		0.1	0.0	0.2	0.0	nd	
4	1-Propanol	44.7	0.4	38.2	0.5	36.2	0.2	41.0	0.9
5	1-Butanol	0.9	0.0	0.2	0.0	0.5	0.1	0.8	0.1
6	2-Methyl-1-propanol	39.2	1.3	17.6	0.5	33.4	0.7	36.0	1.9
7	2-Methyl-1-butanol	15.0	2.3	5.6	0.3	11.8	1.2	13.8	0.7
8	3-Methyl-1-butanol	85.9	2.1	33.5	1.2	67.9	1.4	78.7	1.8
9	Allyl alcohol	nd		0.9	0.1	0.0	0.0	nd	
10	1-Hexanol	1.3	0.1	0.1	0.0	1.1	0.0	1.2	0.2
11	Benzyl alcohol	1.5	0.1	3.7	0.2	2.5	0.1	1.4	0.1
12	2-Phenylethanol	nd		0.3	0.0	nd		nd	
13	Ethylacetate	144.7	2.3	7.7	0.4	37.8	0.3	40.7	3.2
14	Ethyl lactate	0.3	0.1	nd		0.3	0.1	0.3	0.1
15	Acetaldehyde	13.9	1.2	12.8	1.5	4.4	0.2	32.7	1.9
16	Acetal	nd		0.3	0.0	4.0	0.3	20.5	1.3
Total alcohol 3(-8)		185.8	2.7	95.3	1.6	150.0	3.5	170.3	5.3
Total volatile substances (3-16)		347.6	3.5	121.1	2.2	200.1	4.5	267.1	12.1

nd, *not detected.*
*Adapted from Alonso-Gonzalez, E., Torrado-Agrasar, A., Pastrana-Castro, L.M., Orriols-Fernandez, I., Pérez-Guerra, N., 2010. Production and characterization of distilled alcoholic beverages obtained by solid-state fermentation of black mulberry (*Morus nigra *L.) and black currant (*Ribes nigrum *L.). Journal of Agricultural and Food Chemistry 58, 2529–2535; Alonso-Gonzalez, E., Torrado-Agrasar, A., Pastrana-Castro, L.M., Orriols-Fernandez, I., Pérez-Guerra, N., 2011. Solid-state fermentation of red raspberry (*Rubus ideaus *L.) and arbutus berry (*Arbutus unedo, *L.) and characterization of their distillates. Food Research International 44, 1419–1426.*

110/2008) for fruit distillates. In addition, the mean concentrations of methanol in the two alcoholic beverages were much lower than the maximum levels of acceptability that the aforementioned regulation fixed for red raspberry and arbutus berry distillates (see Table 10.3). These results showed that both fruits could be used as fermentation substrates for producing high quality alcoholic beverages.

Aronia berries and chokeberries are excellent fruits to produce strong alcoholic beverages. Balcereck (2010) studied the effect of the quality of raw materials, processing methods, pH of mashes, and yeast strains on the concentration of carbonyl compounds in aronia distillates. Distillates derived from frozen aronia berries contained almost two times more acetaldehydes than those obtained from fresh fruits. An adjustment of pH of aronia mashes from 3.4 to 4.5 resulted in an increase in the concentration of carbonyl compounds (in particular of acetaldehyde). Thermal processing of fruit pulp decreased the concentration of butyraldehyde and increased the concentrations of valeric and isovaleric aldehydes. Spirits produced from mashes fermented by yeast *S. bayanus* contained approximately 43% more acetaldehyde than that obtained from mashes fermented by mixed strains: Burgundy, Bordeaux, and Steinberg.

Galego et al. (2011) studied the preparation of distinct aromatic liquors using deodorized and concentrated fruit distillates. The process was exemplified using fig fruit spirits to prepare myrtle berry liquors. The partial rectification and distillation of used low-quality raw fig spirits lead to an improved final product that kept most of its good aroma properties. This procedure showed high potential to improve other fruit spirits. These improved spirits can be used to prepare new distinctive and highly aromatic liquor drinks. The myrtle berry liquors prepared also showed high levels of polyphenols and anthocyanins.

In the scientific literature, there are some studies about distillates with unusual fruits such as jabuticaba (*Myrciaria jabuticaba*, Berg; Asquieri et al., 2009; Duarte et al., 2011). The quality of the spirits from fermented jabuticaba juice was compared to the parameters established by Brazilian legislation. Asquieri et al. (2009) found that jabuticaba spirits presented values compatible with the parameters established by legislation, with the exception of high ester concentrations (357 mg/100 mL aa). Duarte et al. (2011) concluded that the use of jabuticaba for the production of spirits is a viable alternative usage of this fruit, and showed the potential of jabuticaba spirit as a new product that may be appropriate for a particular niche market.

6. OTHER FRUIT BRANDY

6.1 KIWI BRANDY

Studies on obtaining alcoholic beverages using kiwi fruit are scarce in the literature. Soufleros et al. (2001) evaluated the composition of volatile compounds, organic acids, sugars, and glycerol in a wine of kiwi fruit. They found that kiwi wines had higher concentrations of methanol, lower concentrations of esters, and similar concentrations of higher alcohols than grape wines. Sensidoni et al. (1997) produced kiwi spirits by distilling fermented kiwi juice enriched with rectified grape must and added pectolytic enzymes. In their research, the distillation was performed at two different operating pressures: reduced and atmospheric. The distillates obtained at reduced pressure were aromatically better; however, the characteristic aroma of the kiwi fruit was not detected in either of the distillates. The kiwi aroma is a combination of different volatile compounds such as ethyl butanoate, unsaturated aldehydes, and alcohols of six carbon atoms. The aromatic profile varies with fruit maturity, which increases the fraction of esters. In general, the Hayward variety is aromatically characterized by C6 aldehydes and alcohols, with some esters produced upon ripening (Lopez-Vazquez et al., 2012).

Lopez-Vazquez et al. (2012) study the aromatic composition of kiwi spirits obtained from fermented kiwis of the Hayward variety grown in the southwest of Galicia (Spain); two different strains of *S. cerevisiae* were tested. The spirits obtained were compared with other fruit spirits, in terms of higher alcohols, minor alcohols, monoterpenols, and other minor compounds relevant to quality and taste (see Table 10.4). The yeast strain affected the aromatic profile of the spirits, but the ratio of trans-3-hexen-1-ol and cis-3-hexen-1-ol was unaffected; this ratio in kiwi spirits is different from that found in other fruit distillates. Arrieta-Garay et al. (2014) showed that kiwi spirits obtained with a packed column had the highest concentrations of esters C6–C10 and monoterpenols, while alembic spirits had the highest concentrations of ethyl acetate, methyl acetate, and higher alcohols. Kiwi spirits distilled with a packed column were preferred by consumers. The predominant sensory descriptors in the packed-column kiwi spirits were floral, fruity, and spicy, while burned, smoky, and pungent were the principal aroma descriptors in alembic spirits. Moreover, significantly higher ethanol yields and ethanol strengths were obtained with the packed-column distillation system.

Table 10.4 Content of Main Compounds Present in Kiwi Distillates

	L1	Yeast	L2	Yeast
	Mean	**SD**	**Mean**	**SD**
Ethanol (% v/v)	41.5	0.9	42.3	1.6
Methanol	1236.6	76.4	1137.3	47.4
Ethyl acetate	46.4	8.9	33.0	0.3
Acetaldehyde	153.9	38.0	212.2	41.6
Σ total higher alcohols[a]	317.30	4.37	374.06	28.91
Ethyl lactate[a]	6.48	2.45	1.86	0.67
1-Hexanol[a]	6.27	0.55	4.13	0.22
Σ acetates of higher alcohols	0.05	0.01	0.04	0.02
Σ ethyl esters C6—C12	2.14	1.06	2.04	1.00
Σ ethyl esters C14—C18	0.44	0.42	0.44	0.75
Trans-3-hexen-1-ol	0.03	0.01	0.02	0.01
Cis-3-hexen-1-ol[a]	0.14	0.02	0.08	0.02
Trans-2-hexen-1-ol	0.03	0.01	0.01	0.01
2-Phenylethanol	0.76	0.11	1.09	0.43
Σ minor alcohols[a]	0.46	0.03	0.30	0.40
Σ monoterpenols[a]	1.61	0.20	1.07	0.22

SD, *standard deviation.*
[a]*indicates significant differences* ($P < .05$) *between yeast used.*
Adapted from López-Vázquez, C., Garcia-Llobodanin, L., Perez-Correa, J.R., Lopez, F., Blanco, P., Orriols, I., 2012. Aromatic characterization of pot distilled kiwi spirits. Journal of Agricultural and Food Chemistry 60, 2242–2247.

6.2 MELON BRANDY

Hernández-Gómez et al. (2003) used melon fruits (*Cucumis melo*) to develop a new melon spirit drink. They studied the influence of raw material to ferment (total mash, mash without skin and juice) and the distillation system used (column and copper pot). The melon wines were double distilled. The distillation methods resulted in differences, and the distillate obtained with the copper pot distillation was preferred. With regard to the type of substrate, the mash obtained with all the fruit gives a better yield in the process; it does not seem to be the ideal substrate due to the sluggish fermentation, high methanol content, and negative sensory characteristics; the one obtained from the melon juice was preferred. Nevertheless from an industrial standpoint, the distillate obtained from mash without skin substrate can be regarded as preferable, because it produces less waste with a lower environmental impact and it is not necessary to press the paste to obtain it (Hernández-Gómez et al., 2005a). Adjusting the pH brought about substantial decreases in the acetaldehyde and methanol content (see Fig. 10.11), a facet that will have to be taken into account in the case of methanol in view of the maximum limits set by the regulations (Hernández-Gómez et al., 2008). The maceration of the final double-distilled spirit did enhance the color and aroma attributes of the final product (Hernández-Gómez et al., 2005b; Briones et al., 2012).

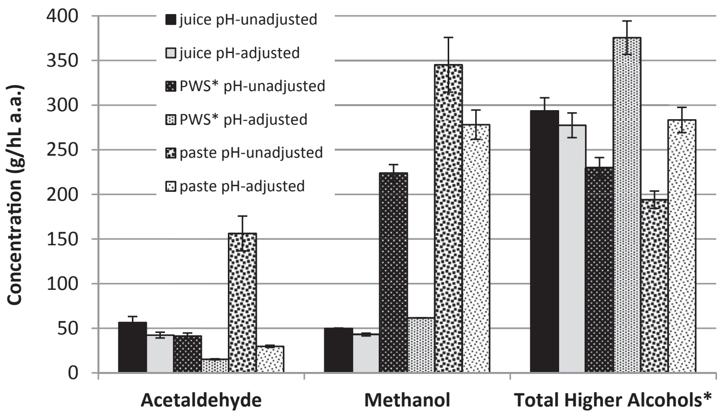

FIGURE 10.11

Effect of pH in acetaldehyde, methanol, and total higher alcohol content for different raw material fermented [juice, paste without skin (PWS), and paste].

*Adapted from Hernández-Gómez, L.F., Úbeda, J., Briones, A., 2008. Characterisation of wines and distilled spirits from melon (*Cucumis melo *L.). International Journal of Food Science and Technology 43, 644–650.*

6.3 ORANGE BRANDY

The high productivity of oranges, an appreciated fruit throughout the world, generates important postharvest losses. To reduce waste disposing costs and increase farmers' income, processed fruits can generate several industrial products such as jams, juices, wines, and spirits (Santos et al., 2013). Orange spirits have not been widely studied, except from some citrus-based drinks (Da Porto et al., 2002). The old study of Von Loesecke et al. (1936) described how to obtain orange and grapefruit spirits, as well as brandy, by distilling fermented orange and grapefruit juices. The brandies were subsequently aged in plain oak barrels. They also described how to obtain citrus liqueurs (citrus cordials) by adding citrus oils and sugar syrup to citrus spirits. Da Porto et al. (2002) characterized an orange brandy developed at industrial scale, using a distillation system formed by a boiler, a distillation column, and a rectification column. The system allowed working under reduced pressure, reaching a mean alcoholic strength of 50–60% v/v in the first distillation, and 75–80% v/v in the rectification column. Da Porto et al. (2006) studied the effect of the addition of different sweeteners in the aroma perception of orange spirits. They found that sucrose, glucose, and maple syrup, among the permitted sweeteners, and aspartame, among the unpermitted ones, increased the solubility of some important contributors to a desirable orange flavor. The increased solubility of such volatile compounds and their subsequent reduction in the headspace means that they will be less flavor-active in the aroma of orange spirits. Santos et al. (2013) found that a copper alembic distillate from orange wine had high concentrations of acetaldehyde, ethyl acetate, isoamyl alcohol, and 2-phenylethanol. Nevertheless, they showed that orange juice could be a good substrate for fermentation and distillation, and the sensory analysis performed revealed that the produced beverage had good acceptance by the tasters.

6.4 BANANA BRANDY

Banana (Guimarães-Filho, 2003) and Guava (Alves et al., 2008) have been used in Brazil to produce and characterize distillates, to reduce surpluses of these fruits. Guimarães-Filho (2003) analyzed the volatile organic compounds found in banana spirits that were generated during fermentation and distillation. High alcohols and methanol levels were above the maximum concentrations allowed by Brazilian legislation. Lara (2007) explored different pretreatments of banana pulp and fermentation conditions to decrease the viscosity of the must and reduce the formation of higher alcohols during the production of banana spirits; however, higher alcohols and total acidity continued to be outside the limits set by Brazilian legislation in the obtained banana spirits. Alvarenga et al. (2011) used different *S. cerevisiae* strains to ferment banana pulp, aiming to reduce the levels of methanol and higher alcohols. Teixeira et al. (2005) studied the conditions of banana pulp maceration to obtain liquors. Maceration times of two weeks with 95% v/v alcohol were appropriate to obtain 4 L of 18% v/v liquor, using 500 g of pulp and 350 g/L of sugar.

7. CONCLUSIONS

Alcoholic beverages derived from fruit present a wide research field, combining tradition with innovation, either using fruit not considered before or using traditional fruit in different ways. Better characterization and increased knowledge of so-called exotic fruit has already allowed the generation of aromatically appealing new products, especially liqueurs. In addition, through the incorporation of healthy compounds, the image of the alcoholic beverage products can be improved. Even though most exotic-fruit alcoholic beverages are consumed in the countries they are produced, globalization could boost their international trade, although it would be necessary to investigate how this trade would benefit developing countries.

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