INFLUENCE OF CLIMATIC CONDITIONS ON YIELD AND PROFITABILITY OF QUINCE BRANDY PRODUCTION

Bojan Dimitrijević[1], Predrag Vukosavljević[1], Zoran Rajić[1], Ivana Karabegović[2]

[1]Faculty of Agriculture, University of Belgrade
[2]Faculty of Technology in Leskovac, University of Niš

Corresponding author: bojandi@agrif.bg.ac.rs

Abstract
The aim of this study was to show how climatic conditions could affect the yield and profitability of quince brandy production. The study was conducted using various methods such as content analysis, analytical methods, interview and direct observation. In addition, hypothetical-deductive method, statistical methods and descriptive methods were also used. Data were obtained from different sources i.e. the internal documentation of agricultural holding where the quince, as a raw material for production of brandy was produced, the internal documentation of distillery, as well as professional literature and the internet. The analysis was done for the period 2013 - 2016. The study showed that climatic conditions can affect the yield and profitability of quince brandy production, and the production of quince brandy in analyzed years was profitable.

Keywords: climate conditions, yield, profitability, quince brandy.

Introduction

Rakija is the national drink of Serbia. It is one of the most popular alcoholic drinks there. It is made of different fruit species. Quince is one of them. Rakija made of quince fruits is called Dunjevacha. It is a brandy with a characteristic fruity taste, preserved in the liquor due to the complex processing of the fruit and the distillation process. In addition the production of Dunjevacha can be a very profitable.

Material and methods

The study was conducted using various methods such as content analysis, analytical methods, interview and direct observation. In addition, hypothetical-deductive method, statistical and descriptive methods were also used. The data was obtained from different sources, ie the documentation from the agricultural holding where quince as a raw material for the production of brandy was produced, the documentation from the distiller, the professional literature and the internet. The analysis was done for the period 2013 - 2016.

Raw materials for the production of fruit distillates

For the production of fruit brandy, all fruit raw materials containing sugar can be used, from which during the process of alcoholic fermentation (ebullition), ethyl alcohol (ethanol) is formed. In the Republic of Serbia, stone fruits (plums, apricots, peaches, sour cherries and cherries), pome fruits (apples, pears and quinces), berries (raspberries and blackberries) are most often used for this purpose as well as the fruit of the vine. Top quality fruit brandy can be achieved only with the processing of quality fruits i.e. those that are healthy and at a stage of full technological maturity. Fruits that are unripe, rotten, moldy or insufficiently formed are not suitable for production (Pischl, 2011). The full technological maturity of the fruit is achieved when the maximum concentration of sugar and aromatic substances is reached in it. At this stage of ripening, the fruit is most suitable for any kind of processing, and also the production of fruit brandy. Most fruit varieties have characteristics of an aromatic substance, therefore the characteristic flavoring brandy is obtained by processing them.

Quince as a raw material for the production of brandy

Quince (Cydonia oblonga) is an old fruit species, as most of the group of pome fruits that it belongs to. It was grown 4,000 years ago, and most often as a subsidiary fruit species. It is believed to be originating from the Caucasus region, from where it spread to the east and south (to Asia Minor), and from there into ancient Greece. Before the beginning of Common Era, it was transferred from Greece to Rome, and then to other parts of the European continent (Mratinić, 2010). It is mostly cultivated in the Mediterranean region and in the wine-growing zone of moderate continental climate. Quince has never had economic significance as some other fruit species, such as plum, apple, apricot, peach, grapevines, and so on, and it grew most sporadically on individual agricultural households. In the total amount of fruit produced in the Republic of Serbia, quince has been represented for about 0.8 - 0.9% over the years (SORS, 2017). The quince trees are the most common in the valleys of the Zapadna Morava river and the Velika Morava river and in the Danube region. The variety of quince, compared to other fruit species, is rather modest. It is believed that there are about 500 varieties of quince, of which about 30 are in the wider production. What is important for industrial processing are the varieties of the correct shape, with fewer unevennesses, a smaller content of skeletal cells and with higher content of sugars and aromatic substances. The most recommended varieties for growing and processing are: Leskovačka, Vranjska, Constantinople and Champion. In Serbia, the most common varieties are Leskovačka and Vranjska. Quince starts to bear fruit in the fourth year, and the highest fertility is when it is between 15 and 20 years old. Yields are 40 - 200 kg per tree. Of the total weight of the fruit of the quince (depending on the variety: 150 - 1050 g) soft parts make up 85-90%. The content of certain substances that determine the quality of the quince fruit can range in a wide variety, most often: sugar 7 - 15%, dry matter 11.3 - 22%, total acids 0.6 - 1.8% and pectic substances 0.7 - 1.9% (Nikićević and Tešević, 2010). The fruit has a characteristic, beautiful and intense fragrance and represents a rich source of vitamin C and mineral substances (K, Na, Zn, Fe, Mn). It is used in the food industry for the production of compotes, canned fruit, jam, homemade marmalade, fruit juices and nectars, but first of all for the production of the quince fruit brandy so called 'dunjevača'. It is assumed that about 90% of the produced quince in Serbia is processed into the brandy 'dunjevača'. In the observed case, quince variety Leskovačka was used for the production of brandy (Picture 1).

Picture 1. Quince variety Leskovačka

Source: http://edenskivrt.hr/sadnice/dunja-leskovacka

The fruit of this variety is apple-shaped, medium-sized (290 - 400 gr), very juicy, with fine grain, without stone cells, with sweet-acid flavour and having a very pleasant smell. On average, there is 15

- 16% soluble dry matter, of which about 6 - 7% of total sugars and 0.8% of total acids. The scarf skin is even, smooth, of a very attractive appearance. For its cultivation, it requires favorable climatic conditions, fertile soil and sufficient humidity. It matures in the second half of October, and it is kept for a long time under normal conditions. It gives top quality brandy.

Production of quince brandy

Quince brandy ('dunjevača') is a fruit brandy produced by alcoholic fermentation and distillation and / or rectification of a fermented crushed fruit (fleshy fruit) or wider quince with or without seeds, up to a maximum of 86% vol. of ethanol, so that the distillate has the smell and taste of distilled raw materials. The quince brandy must contain volatile substances in the amount of at least 200 g/hl calculated on 100% vol. alcohol and the maximum amount of methanol of 1350 g/hl calculated on 100% vol. alcohol. The minimum alcoholic strength of quince brandy is 37.5% vol. As with any other fruit brandy, it is not allowed to add carbohydrate sugar and alcohol. Quince brandy cannot be flavored. From 100 kg of quince can be obtained 5 - 7 liters of brandy of 40% vol. or 2 - 3 liters of absolute alcohol. The technological process of the production of quince brandy includes 5 phases: fruit production; alcohol fermentation (ebullition) of crushed fruit ; distillation and / or rectification; maturation (aging) in wooden pots or maturing in inert pots; cold stabilization with correction, blending and adding permitted additives. The quince fruit is very sensitive to mechanical injuries. Even minor harm caused by pressure on the cells cause the appearance of black spots on the scarf skin. In these places, the molds develop rapidly and with their hyphae "pierce" the scarf skin, penetrate into the fruit and damage it. That is why the quince in the "bulk" must not be in the layer thicker than 1.2 m, and it is best to be kept in crates for apples that can hold 15 kg. One damaged moldy fruit can very quickly contaminate the entire basket of quince of 300 kg. Therefore, the production of quince brandy begins with the harvesting of fruits in full technological maturity. It is very important that the fruits remain on the branch for a full maturation as long as possible. Fruits achieve full technological maturity in the second half of October and early November. If it is harvested earlier, it is necessary to keep them for a shorter time for ripening. Insufficiently mature fruits have less sugar and aromas, and more acids and this will give less randman and poorer quality of brandy. It is extremely important for the quality of quince berry that the fruits of the quince are mature, healthy and clean, and that the process in the processing is appropriate. Quince is a climacteric fruit, so it is desirable to mature for a certain period of time, usually from 7 to 20 days, at a temperature of about 15°C before further processing. This enables the achievement of full phenol and technological maturity of the fruits. After the harvest, however, the fruits can not be stored for too long, because, due to various damages, they quickly fall under the influence of microorganisms. During storage, there is also a change in the structure of the fruit with the appearance of putridity which is manifested by the color change of the mesocarp, by darkening, by reducing the acidity and softening of the tissue, which is negatively reflected on the randman and the quality of the brandy. After a very good wash, which must be done by dipping and spraying the fruits, an inspection is carried out with the separation of other impurities, moldy and damaged fruits. Washing the quince fruit is very important, because the quince contains an extremely aromatic waxy coating that is rich in some undesirable multi-fatty acids, terpenes and norisoprenoidal compounds that smell on oil (petroleum). That is the reson the washing is sometimes done with strong wash sprays so that the wax coating is removed before further processing. Fruit disintegration can be done on choppers or hammer mills. On this occasion, the seeds should not be damaged, as this has a bad effect on the quality of brandy. Because of its solid structure, quince is practically very difficult to be mashed. Therefore, the inedible parts of the seeds loggia are not usually removed, but the whole crushed fruit is transferred to the fermenters for alcohol fermentation. Alcoholic fermentation, as it is the case with apple processing, can be applied to the chopped fruit of the quince or this mass can be subjected to squeezing, so only the juice is placed on ebullition, thus avoiding the negative impact of the seed of loggia. The quince brandy produced by the distillation of wine from the quince has a lower content of methanol, a smaller content of aromatic substances, but it is more drinkable,

"gentle" and of better quality because the fermentation and distillation does not include the seed in loggia. One ebullition is usually not sufficient to achieve a satisfactory randman, so the pulpy residue is extracted extensively with water or with enzymatic process with appropriate pectolytic enzymes. The quince is rich in polyphenolic compounds, and therefore is highly susceptible to oxidative changes. With these changes, the crushed fruit and juice get a dull-yellow color that degrades the aroma. In order to reduce these undesirable changes, the processing should be done quickly, without delay and trying to keep the crushed fruit or juice out of the air. In general, further processing of the quince fruit can be by the so-called cold or hot, with or without the separation of the seed in loggia. A better procedure is the cold one, with the separation of the seeds of loggia, since then there is no separation of a larger amount of norisoprenoid compounds (C_{12} atoms in the molecule), which are natural ingredients of the fruit of the quince, and they smell on oil (petroleum). The crushed fruit is, due to the presence of high concentrations of protopectins, very dense and difficult to process. Therefore, in order to liquidize the crushed fruit with the cold process without heating, and for the purpose of achieving greater randman, and prevention of germination during distillation, 60-100% of water from the quince mass is added to the crushed fruit. The water must be previously prepared and purified (reverse osmosis, softening with ion-exchange or distilled). Together with water, protopectinases and pectolytic enzymes are immediately added to the crushed fruits. It is necessary to maintain temperature of 20 - 50°C for their effect in the next 24 hours. Protopectinase decomposes protopectins to colloidal soluble pectinic and prectic acid fractions, while pectolytic enzymes continue further degradation of pectin substances to lower products (galacturonic acid, araban, etc.). In this way, the crushed fruit can be liquidized and subjected to alcohol fermentation and subsequent distillation without any problems. Adding enzymes also has an effect on the improvement of aroma in distillates, because they release some of the aromatic substances from their glucosides, which make them volatile and they are converted to distillates. The quince is a late fruit, and therefore it comes to alcoholic fermentation when cold weather has already arisen. For these reasons, it is recommended for manufacturers who do not have controlled fermentation conditions to add selected yeast, ammonia-phosphate, vitamin B1, complex nutrients and citric acids, or 5% H2SO4 to lower the pH of the crushed fruit under 3 in fermentation. The purpose of adding acid is to stop the reproduction of "wild" yeasts and bacteria. The crushed fruit is cooled to about 15-20°C, after which it is added the activated selected yeast, and as such it is transferred to the fermenter. During alcoholic fermentation the temperature should be 15-20°C, which is optimal for performing alcoholic fermentation with moderate intensity. When alcoholic fermentation begins, the created carbon dioxide raises the thick part of the hook to the upper part of the fermenter, and the liquid part remains below. It is desirable, at least once a day, to raise this dense part of the crushed fruit by hand, mixing it manually or by transferring the liquid part with the pump from the bottom to the top. It is mandatory that the fermenters are closed so that only carbon dioxide can be released, through spraying with water at the top. If the fermentors are open, they must be covered during fermentation to prevent the evaporation of ethanol and aromatic substances, the presence of air and acne flies that can cause unwanted acetic bacteria. After the alcoholic fermentation has been completed, which, depending on the temperature, takes place for 10 - 30 days, the obtained crushed fruit is subjected to distillation. If the distillation has to be postponed, the fermented crushed fruit must be protected from deterioration. Distillation of the wine from the quince, and also the fermented quince crushed fruit, especially if water and pectolytic enzymes are added to it before it is started, can be performed almost in all types of appliances and devices with intermittent or continuous operation. Distillation is most often performed on disposable devices with a shorter rectification column and a copper catalyst or standard two-way distillation on the batch apparatus. The advantage of a disposable distillation apparatus with a short rectification column and a copper catalyst is undeniable. Benefits are seen in obtaining aromatic and quality distillates, higher yields and easier, cheaper and simpler work. If the full amount of water is not added to the crushed fruit before ebullition, and it is thick, it is necessary to add about 10-20% of water in order to reduce the danger of heating. Regardless of the amount of water, it is necessary

for the mixer to work all the time during distillation. Regardless of which type of apparatus or device is used for distillation, it is necessary to separate the fractions. During the distillation, the fractions of the first, middle fractions ("heart") and the third part are separated. Separate side fractions may be returned to re-distillation together with the distillation of the fermented crushed fruit or separately. The concentration of ethanol in the middle fraction (heart) should be 60-65% vol. for batch two-fold distillation and 70-75% in single column distillation. Fruit distillates from quince are very suitable for maturation in wooden vessels. Primary aromatic ingredients from quince fruit, the secondary produced during fermentation and the tertial produced during distillation are highly compatible with quaternary aromatic ingredients that the ethanol-water mixture extracts from wooden vessels (usually oak). For these reasons, distillates of quince are often subjected to maturation (aging) in wooden, usually oak barrels and casks. It is necessary for the distillates to mature in wooden pots for at least two years. On the other hand, in some regions, the distillates do not go to aging (maturation), they only merge and harmonize themselves in neutral vessels of glass, stainless steel or food plastics. In order to harmonize the resulting quince distillate, it should be placed in an inert vessel for at least 6 months. The quince brandy is finalized and released to the market with an ethanol concentration of 40-43% vol. as colorless or with golden-yellow color of wooden vessels. Brandy is full, heavy, impressive with smell and taste, with specific aromatic properties.

Results and discussion

This paper analyses the data on the production of quince brandy for the years 2013-2016. During the analyzed period the brandy was produced from the Leskovachka Quince variety at the plantations in the Kosmaj mountain. The following was analyzed for each production year: the quantity of the quince harvested and the related waste, ie the fruits unsuitable for the production of brandy, as well as the fruit harvest and the processing dates. For each observed production year, the analysis also included the climatic conditions and whether any additional ripening process took place. Furthermore, the analysis included the quality of the harvested quince, the purchasing price and brix.

Table 1. Overview of the important parameters in the production of quince brandy for the period 2013-2016

Observed		Year			
parameter		2013	2014	2015	2016
Quince variety		leskovačka	leskovačka	leskovačka	leskovačka
The location of the orchard		Kosmaj	Kosmaj	Kosmaj	Kosmaj
Quantity of quince produced		18.992	42.085	45.500	33.154
Waste	(kg)	230	757	540	578
	(%)	1,21	1,8	1,18	1,74
Date of harvest of fruit		01.11.	01.10.	01.11.	13.10.
The date the processing started		03.11.	03.10.	08.11.	15.10.
Assessment of climatic conditions		favorable	unfavorable	favorable	unfavorable
Condition of the fruit		Large, nice, not juicy	Large, nice, juicy	not juicy	Large, nice, juicy
Additional ripening		no	no	7 days at 12-18°C	no
Price of quince fruit (din/kg)		45	50	30	40
Briks		16	14	15,8	13,7
The amount of brandy obtained (l)		1.600	2.950	3.450	3.580
Randman (%)		8,4	7	7,6	7,2
Alcohol content in brandy (%)		40	40	40	40
Sensory evaluation		18,1	17,2	18,1	17,8

Source: Internal documentation of agricultural holding, 2017.

Sugar was not added during the distillation process in any of the production years. Following the processing of the fruit, of the quantity of the produced quince brandy, the randman, and eventually the grades obtained from the sensory analysis of the produced quince brandy were also analyzed. The yield of quince varied from year to year, both in terms of quantity and quality, which had a direct impact on the both the quantity of the produced quince brandy and its quality. This is also indicated in the data taken for the analysis presented in Table 1.

Analysis of the quince brandy production costs and retail price

The second part of the study refers to the analysis of the quince brandy production costs and retail price. The cost of raw materials required for the production of 0.7 liters of brandy 40 vol. % is calculated from the quantity of raw materials required for the production of the said quantity of brandy and the retail price of the quince. However, in order to calculate the quantity of the raw material required for the production of 0.7 liters of brandy, the randman, which is indicated in Table 1, must be also considered. The result showed that the quantity of the raw material required in the observed years (2013-2016 was: 11.9; 14.3; 13.2 and 13.9 kg respectively. There was no variation in the retail price of quince brandy during the years covered in this study. The 0.7 l packaging was on the markets the Republic of Serbia was analysed. Considering that during the analysed years the technology of the production of the quince fruit, including its processing into brandy, was unchanged, it is an assumption that the variation in the quantity and quality of the quince, as well as the brandy produced from it, was a direct result of the climate. This ultimately influenced the profitability in the production of quince brandy.

Table 2. Overview of the cost for the production of 0.7 liters of quince brandy for each year in the period 2013-2016

Observed	Year			
Costs	2013	2014	2015	2016
The price of the raw material needed for 0,7 l of brandy [10]	535,7	715	396	556
Transportation of raw materials from plantation to factory (3 din/kg)[11]	35,7	42,9	39,6	41,7
Fermentation agents (din/0,7 l) (yeasts, enzymes, yeast feed, citric acid)	17,5	17,5	17,5	17,5
General expenses (din/0,7 l)	5,6	5,6	5,6	5,6
Aging in burials (maturation) (din/0,7 l/year)	14	14	14	14
Packaging	178,44	178,44	178,44	178,44
• Bottle 0,7 l (din/piece)	120	120	120	120
• Cap (din/piece)	12	12	12	12
• Front label (din/piece)	20	20	20	20
• Back label (din/piece)	3,25	3,25	3,25	3,25
• Excise stamps	0,95	0,95	0,95	0,95
• Box	22,24	22,24	22,24	22,24
General bottling Costs (din/piece)	5,6	5,6	5,6	5,6
Total costs	792,54	979,04	656,74	818,84
Earnings (Total costs : Earnings = 1 : 1)	792,54	979,04	656,74	818,84
Excise (125,98 din/l[12] x 0,7 l)	88,19	88,19	88,19	88,19
VAT (20%)	158,51	195,81	131,35	163,77
Selling price of the product (din/pieces)	1831,8	2242,07	1533,01	1889,63
The amount of quince brandy obtained (l)	1.600	2.950	3.450	3.580
Units produced (pieces 0,7 l)	2.285	4.214	4.929	5.114
Total income	4.186.912	9.448.740	7.555.569	9.664.128

Source: Internal documentation of distillery, 2017.

[10] Purchase price of the raw material (din/kg) x quantity of raw material needed for the production of 0.7 l of brandy (kg)

[11] The amount of raw material needed for 0,7 l of brandy x cost of transport per kg of raw material (3 din/kg)

[12] Law on excise, Official Gazette of the Republic of Serbia, http://www.paragraf.rs/propisi/zakon_o_akcizama.html

Conclusions

The aim of this study was to show how climatic conditions could affect the yield and profitability of quince brandy production. The analysis was done for the period 2013 - 2016. The study showed that climatic conditions can affect the yield and profitability of quince brandy production, and the production of quince brandy in analyzed years was profitable.

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