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IDENTIFICATION OF THE MOST RELEVANT QUALITY PARAMETERS FOR BERRIES - A REVIEW

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Abstract

Fresh fruit jointly to vegetables are an essential component of a healthy diet, able to decrease the risk of cardiovascular diseases and cancer. In the last years, their consumption has continued to grow rapidly linked to the increased public awareness of their health benefits, even if it remains below the recommended daily intake in many countries, due to barriers such as complacency and lack of willpower to change the diet. The attributes of berries, like chemical-physical and nutritional characteristics, microbial contamination, chemical contaminants as well as sensorial properties represent some very important quality parameters that must be determined in order to establish the quality of berries after ripening and during storage, until they reach their final destination (consumer). The aim of this study was to perform a literature review in order to determine the most relevant quality parameters of berries and to describe methods for their determination.

Key words*: berries, determination methods, quality parameters.*

INTRODUCTION

Fruits, especially berries, have been found to possess pharmacological and biochemical properties that are caused mainly by the anti-oxidant activity of their diversified compositions (Jia et al., 2012). Berry fruits have been widely recognized as an excellent source of bioactive phenolic compounds including flavonoids, phenolic acids, and tannins, that both individually and synergistically may help protect against cardiovascular disease, cancer, inflammation, obesity, diabetes, and other chronic diseases (Wu et al., 2010).

Mulberry is grown wild or cultivated in many countries for its foliage, which is a primary source of food for silkworms. Mulberry fruit is rich in carotene, vitamins B1, B2 and C, glucose, sucrose, morin, tartaric acid and succinic acid (Wang et al., 2013). Mulberry fruit is a highly perishable fruit, with short shelf life due to its soft texture and high sensitivity to fungal attack (Wang et al., 2013).

Strawberry is a popular and attractive fruit due to its high visual appeal and desirable flavour (Aday & Caner, 2014). Strawberries are rich in phytonutrients (amino acids, vitamins, and anthocyanins), high visual appeal, and desirable flavour, but are highly perishable and have relatively high physiological activity after harvest. Such behaviour results in a rapid deterioration in quality such as softening and shrinkage, discoloration, off-flavours, and finally fungal decay, resulting in short storage life (Wang et al., 2014; Wang & Gao, 2013).

Blueberries are recognized for their contribution to a healthy diet with different beneficial bioactive compounds such as flavonoids, anthocyanins, and others, which helps to avoid important diseases including different cancers (Concha-Meyer et al., 2015). Fresh berries are highly valued for their high antioxidant and vitamin content. Many bioactive compounds in berries have been shown to provide significant health benefits (Huang and Chen, 2014).

Raspberries are a high-value crop due to their unique flavour, exacting climatic requirements, high costs of production and perishability. Raspberry fruits contain small amounts of vitamins; only vitamin C is present at a significant level (Oduse and Cullen, 2012).

Cranberry is highly valued for its nutritional and medicinal properties. It prevents many aliments, which include scurvy and bladder infections in elderly women. Bringing this high-value crop to market is plagued by fruit rot, which is caused by a number of fungal and bacterial microorganisms (Palanimuthu et al., 2009).

Black currant have a high anthocyanin content. Many studies have demonstrated the excellent antioxidant activity of black currant extract (BCE) and its health benefits, including anticarcinogenic activity (Jia et al., 2012). They are considered to be a rich source of ascorbic acid, citric acid, malic and tartaric acids with plenty minerals, such as potassium, calcium and magnesium. Moreover, currants contain polyphenolic compounds such as anthocyanins, vanillic acid, caffeic, gallic and p-coumaric acids and quercetin (Kostarelou et al., 2014).

Blackberry is an aggregate fruit, composed of small drupelets, belonging to the *Rosaceae* family. They are rich in functional components, which are mainly represented by polyphenols such as anthocyanins and flavonoids, which are strong natural antioxidants (Azofeifa et al., 2015).

Goji berry grows in China, Tibet and other parts of Asia and its fruits are 1-2 cm-long, bright orange-red ellipsoid berries. Concentrated extracts and infusions prepared from the berries have a history of use as ingredients in various soft or alcoholic drinks that were marketed for their benefits to anti-aging, vision, kidney and liver functions cytoprotection (Amagase and Farnsworth, 2011; Donno et al., 2015a).

Seabuckthorn has been recognised as a versatile nutraceutical crop with diverse uses, from controlling soil erosion to being a source of horse fodder, nutritious foods, drugs and skin-care products. All parts of this plant are considered to be a good source of a large number of bioactive compounds, including carotenoids, tocopherols, sterols, flavonoids, lipids, vitamins, tannins, minerals etc. which contribute to its wide usage as a natural antioxidant (Maheshwari et al., 2011; Kumar et al., 2013).

Gooseberry has many cultivars from different regions and countries and is differentiated by size, colour, taste, flower shape, plant height and plant size (Bravo and Osorio, 2016). Gooseberries are popular fruits known for their organoleptic properties (flavour, odour, and colour), nutritional value (vitamins A and C, potassium, phosphorous, and calcium), and health benefits (Vasquez-Parra et al., 2013).

The fruits of **European elder** are a rich source of bioactive compounds like anthocyanins. Elderberries contain a high phenolic content and antioxidant activity when compared with other fruits and even with other berries (Seabra et al., 2010).

Black chokeberry (*Aronia melanocarpa*) belongs to the *Rosaceae* family, which is native to North America. The health beneficial effects of chokeberry have been suggested to be attributed to polyphenols, as the chokeberry contains a large amount of polyphenols (Lee et al., 2014).

QUALITY PARAMETERS AND METHODS OF THEIR DETERMINATION

1. Physical-chemical analysis methods

1.1. pH determination

In general, the pH is determined using specific instruments, like pH-meters. For this determination the glass electrode is connected at the apparatus and it is washed with distilled water before being introduced into the sample. The electrode is introduced into the sample in vertical position, such as the membrane glass electrode to be entirely in contact with the sample and kept until stabilization of the pH value on the screen. This method was used in this research to determine the pH of mulberries (Jiang and Nie, 2015), strawberries (Kartal et al., 2012; Aday and Caner, 2013), cranberries (Caminiti et al., 2011), blackberries (Wu et al., 2010), seabuckthorn (Gunenc et al., 2016) or goji berry (Donno et al., 2015a).

1.2. Determination of total titratable acidity

Total acidity is the sum of organic acids and their salts, titratable acid neutralization determined by their parties titratable acid with an alkaline solution (usually 0.1 NaOH). Determination of total acidity can be done by the following methods: by potentiometric titration method or electro titrimetric: the titration method in the presence of indicators such as phenolphthalein and bromothymol blue, which are inserted into the glass titration instead of phenol red by drops put on a white tile which paraffin is turn control. The result is expressed conventionally prevailing in the product acid (malic acid, tartaric acid or citric acid).This method was used in this research to determine the total titratable acidity mulberries (Jiang and Nie, 2015), strawberries (Wang et al., 2014; Ozkaya et al., 2009), raspberries (Stavang et al., 2015),blackberries (Wu et al., 2010), seabuckthorn (Gunenc et al., 2016), or gooseberries (Wójcik and Filipczak, 2015).

1.3. Determination of dry soluble matter (Brix)

Using this method is evaluated the content of reducing and non-reducing sugars (total sugar) of the samples by measuring the percentage of the solutes or index refractor. In general, the refractive index is measured with a refractometer and correlated to the amount of soluble solids (expressed as the concentration of sucrose), using the conversion table by direct reading on the scale of the refractometer. This method was used within the researches for determination of dry soluble matter of mulberries (Jiang and Nie, 2015), strawberries (Wang et al., 2014; Ozkaya et al., 2009; Aday and Caner, 2013), blueberries (Diaz et al., 2011), raspberry (Stavang et al., 2015; Giovanelli et al., 2014), cranberries (Caminiti et al., 2011), currants (Pantelidis et al., 2007; Jensen et al., 2010), blackberries (Wu et al., 2010), goji berry (Donno et al., 2015a) or gooseberries (Pantelidis et al., 2007; Wójcik and Filipczak, 2015).

1.4. Determination of water activity (a_w)

The index a_w s a measure of the energy state of the water in the system, showing how the water is bound tightly, structurally or chemically, into a substance. It is the relative humidity in equilibrium with a sample in a closed measuring chamber. The concept of water activity is of particular importance in determining the quality and safety of food. The index a_w influences the colour, aroma, texture and shelf life of food. In addition, based on the values of a_w, can evaluate the safety and stability of food in conjunction with the microbial growth, the speed of the chemical and biochemical reactions, and with the physical properties.

1.5. Determination of total dry matter (D.M.%)

Determination of dry matter using thermo balance is a quick and reliable method for determining the moisture content using the thermo gravimetric principle. Thermo gravimetry consists in weighing the sample before and after heating it, to determine the moisture content by difference. Conventional oven-drying technique works on the same principle, but the measurements takes more time.

2. Methods for analyzing nutritional properties

2.1. Determination of vitamin C

To determine the content of vitamin C is usually used titrimetric 2.6 diclorfenolindofenol method. This method was used to determine the level of vitamin C of cranberries (Rudy et al., 2015) or currants (Pantelidis et al., 2007).
Jiang and Nie (2015) used this method for determination of vitamin C content of mulberries, using the following working protocol: the EDTA solution, acetic acid solution, and fast blue B salt solution were respectively added into homogenised samples and diluted with water. The mixture was placed at room temperature for 3 min and detected at 420 nm using a UV spectrophotometer. The content of ascorbic acid was calculated according to the ascorbic acid standard curve (Jiang and Nie, 2015). This method was used also for the determination of ascorbic acid content of gooseberries (Pantelidis et al., 2007; Vasquez-Parra et al., 2013).Another method used to determine the content of vitamin C in the berries is using HPLC analysis of samples. Giovanelli et al. (2014) described this method for the determination of vitamin C content of raspberry as it follows: 4 g of homogenate were extracted with 16 mL of diluted meta-phosphoric acid (0.001%), which was prepared daily. The mixture was stirred for 20 min and centrifuged at 11,000 × g for 10 min at 10°C. The clear supernatant was injected in the HPLC apparatus and analyzed (Giovanelli et al., 2014; Mikulic-Petkovsek et al., 2013).

2.2. Determination of total phenolic compounds

To determine the total phenolic content, the most used method is the method of Folin-Ciocalteu. Therefore, for the extraction of polyphenolic compounds, samples were placed in 50 ml test tubes, and 25 ml of extraction solution was subsequently added to the weighed samples; after 60 min in the dark, the extracts were homogenized for about 1 min and then centrifuged for 15 min. This is based on Folin–Ciocalteu phenol reagent and spectrophotometric determination at 765 nm. The standard calibration curve was plotted using gallic acid at concentrations of 0.02–0.1 mg•ml^{-1}. The results were expressed as mg of gallic acid equivalents (GAE) per 100 g of fresh weight (FW) (Donno et al., 2015b). This method is frequently found in the literature for the determination of total phenolic content from mulberry (Donno et al., 2015b; Sánchez-Salcedo et al., 2015), blueberries (Pertuzatti et al., 2014; Ketata et al., 2013), raspberry (Cekic and Ozgen, 2010; Jin et al., 2012; Bobinaite et al., 2016; Chanjirakul et al., 2006; Giovanelli et al., 2014; Zhang et al., 2010), cranberry (Chiang et al., 2014; Chen et al., 2015a; Chen et al., 2015b; Vu et al., 2012), gooseberry (Pantelidis et al., 2007; Chiou et al., 2014; Vagiri et al., 2015; Mikulic-Petkovsek et al., 2013), blackberries (Ramos-Solano et al., 2015; Wu et al., 2010; Azofeifa et al., 2015; Barba et al., 2015; Da Fonseca Machado et al., 2014), goji berry (Donno et al, 2015a), seabuckthorn (Saggu et al., 2007; Kumar et al., 2013; Maheshwari et al., 2011), gooseberry (Pantelidis et al., 2007; Bochi et al., 2014; Vega-Gálvez et al., 2014, Vega-Gálvez et al., 2016), elderberry (Seabra et al., 2010; Duymus et al., 2014),aronia (Cujic et al., 2016; Jakobek et al., 2012; Samoticha et al., 2016; d'Alessandro et al., 2012).

2.3. Total anthocyanins content

The total anthocyanin content (TAC) in the fruit extracts is usually directly determined using the pH-differential method. The extracts for TAC analysis were prepared using the method described for quantification of total polyphenols. Anthocyanins demonstrate maximum absorbance at 515 nm at pH 1.0 and also at 700 nm at pH 4.5. The coloured oxonium form of anthocyanin predominates at pH 1.0, and the colourless hemiketal form at pH 4.5. The pH-differential method is based on the reaction producing oxonium forms. This method allows an accurate and rapid measurement of the total monomeric anthocyanins. Absorbance was measured at 515 and 700 nm and the results, considered as the monomeric anthocyanin pigment, was expressed as milligrams of cyanidin-3-O-glucoside (C3G) (Donno et al., 2015b). This method was used for the determination of total anthocyanin content of mulberries (Chen et al., 2016; Jiang and Nie, 2015), blueberries (Pertuzatti et al., 2014;Ketata et al., 2013), raspberries (Zhang et al., 2010; Bobinaite et al., 2016; Cekic and Ozgen, 2010; Jin et al., 2012; Chanjirakul et al., 2006; Giovanelli et al., 2014), cranberries (Caminiti et al., 2011; Rudy et al., 2015), currants (Chiou et al., 2014; Jia et al., 2012; Pantelidis et al., 2007; Bakowska-Barczak and Kolodziejczyk, 2011), blackberries (Wu et al., 2010; Barba et al., 2015; Da Fonseca Machado et al., 2014), gooseberries(Pantelidis et al., 2007; Bochi et al., 2014), elderberry(Duymus et al., 2014), aronia (Cujic et al., 2016).

2.4. Determination of antioxidant capacity

The determination of the antioxidant capacity of berries can be performed by different methods such as:

A. *DPPH radical scavenging activity*

To apply this method, different samples are dissolved in deionised water to obtain various concentrations. Then the DPPH is mixed in ethanol with the sample (in various concentrations). The mixture is then shacked and kept in the dark for 30 min at room temperature and absorbance is measured at 517 nm. This method was applied for the determination of antioxidant activity of mulberry (Chen et al., 2015; Sanchez-Salcedo et al., 2015), raspberry (Bobinaite et al., 2016; Jin et al., 2012; Zhang et al., 2010), cranberry (Chen et al., 2015a), currants (Chiou et al., 2007; Chiou et al., 2014; Jia et al., 2012; Bakowska-Barczak and Kolodziejczyk, 2011), blackberry (Azofeifa et al., 2015; Da Fonseca Machado et al., 2014; Wu et al., 2010), goji berry (Florino et al., 2016), seabuckthorn (Kumar et al., 2011; Kumar et al., 2013; Gunenc et al., 2016; Ting et al., 2011), gooseberry (Vega-Gálvez et al., 2014; Vega-Gálvez et al., 2016), elderberry (Seabra et al., 2010; Duymus et al., 2014), aronia (Lee et al., 2014; Jakobek et al., 2012; Gironés-Vilaplana et al., 2012; d'Alessandro et al., 2012).

B. *Ferric reducing antioxidant power (FRAP)*
This method is based on the reduction of the ferric (Fe^{3+}) TPTZ (2,4,6-tripyridyl-S-triazine) complex to its ferrous form (Fe^{2+}). Absorbance at 595 nm is recorded with a UV/Vis spectrophotometer. The standard curve can be obtained using $FeSO_4 \cdot 7H_2O$ (concentration range: 100–1000 μmol•L^{-1}), and results are expressed as millimoles of Fe^{2+} equivalents per kilogram (solid food) of FW. This method was applied for the determination of antioxidant activity of mulberry (Donno et al., 2015a), blueberry (Pertuzatti et al., 2014), raspberry (Cekic and Ozgen, 2010; Giovanelli et al., 2014), cranberry (Chen et al., 2015b), currants (Jia et al., 2012; Pantelidis et al., 2007), blackberry (Wu et al., 2010), goji berry (Donno et al., 2015b), seabuckthorn (Kumar et al., 2011; Kumar et al., 2013; Ting et al., 2011), gooseberry (Pantelidis et al., 2007; Vega-Gálvez et al., 2014; Vega-Gálvez et al., 2016).

C. *Hydroxyl radical scavenging activity (OH; HOSC)*
Briefly, the solution of $FeSO_4$, together with H_2O_2, salicylic acid and the tested sample in different concentrations are mixed well and incubated together at 37°C for 1 h. The absorbance of the mixture is then measured at 562 nm, while using ascorbic acid as positive control. This method can be adapted depending on the analyzed sample (different concentrations, different wavelengths, different control). This method was applied for the determination of antioxidant activity of mulberry (Chen et al., 2015), strawberry (Wang and Gao, 2013), raspberry (Jin et al., 2012).

D. *Oxygen radical absorbance capacity (ORAC)*
Sample solution is diluted with phosphate buffer (pH 7.4). Then the sample is mixed with Trolox standard at different concentration, followed by the addition of fluoresce in sodium salt. The mixture is shaken for 10 s and preincubated for 25 min at 37°C. Finally, the fluorescence intensity is measured at excitation of 485 nm and emission of 538 nm. Final ORAC value is expressed as mean μMol Trolox equivalent (TE) per g of dry weight (DW).This method was applied for the determination of antioxidant activity of mulberry (Chen et al., 2015), blueberry (Pertuzatti et al., 2014), raspberry (Jin et al., 2012; Chanjirakul et al., 2006; Zhang et al., 2010), cranberry (Chen et al., 2015a; Chen et al., 2015b), blackberry (Wu et al., 2010; Azofeifa et al., 2015), seabuckthorn (Gunenc et al., 2016), gooseberries (Vega-Gálvez et al., 2014), elderberry (Duymus et al., 2014).

E. *Free radical capture (ABTS)*
A stock solution of ABTS in potassium sulphate is realized and it is stored refrigerated in the dark. Prior to doing the analyses, this was diluted in ethanol until the absorbance at 734 nm was 0.70 ± 0.02. Then the tested sample is mixed with the realized solution and it is incubated at 30 °C for 25 minutes. Than the absorbance was read and compared to that of Trolox. Results are expressed as Trolox equivalents per g of dry weight, or TE/g DW.This method was applied for the determination of antioxidant activity of blueberry (Pertuzatti et al., 2014), raspberry (Cekic and Ozgen, 2010), currants (Jia et al., 2012; Bakowska-Barczak and Kolodziejczyk, 2011), blackberry (Sanchez et al., 2014; Da Fonseca Machado et al., 2014),aronia (Jakobek et al., 2012).

F. *Nitric oxide-scavenging activity (NO)*
Nitric oxide (NO) was generated from sodium nitroprusside. Then Griess reagent is added, the absorbance was read at 540 nm and compared to the absorbance of standard solutions of sodium nitrite. This method was described and used for determination of antioxidant properties of blackberries by Azofeifa et al. (2015) and seabuckthorn (Kumar et al., 2013).

3. Methods for determination of berries contaminants

3.1. Microbial contaminants (yeasts, moulds, bacteria)

A. *Determination of total mesophilic aerobic count*
Mesophilic aerobic total germ can be determined according to the standard SR EN ISO 4833:2003. From each sample are taken 10 g and introduced into Erlenmeyer glasses with 90 ml of sterile distilled water. The samples obtained are taken into 9 ml sterile distilled

water, thereby producing for each sample dilution 1. From these solutions, dilutions have been realized by the decimal dilutions method, the number of dilutions depending on the sample. From each dilution 1 ml is seeded in duplicate on nutrient agar plates. Petri dishes are then incubated aerobically for 72 hours at 30 °C and then the grown colonies were counted on each plate.

B. *Determination of yeasts and moulds*
The number of yeasts and moulds can be determined according to SR ISO 21527-1:2009. The analysis method comprises the following steps: From each sample are taken 10 g and introduced into Erlenmeyer glasses with 90 ml of sterile distilled water. The samples obtained are taken into 9 ml sterile distilled water, thereby producing for each sample dilution 1. From these solutions, dilutions have been realized by the decimal dilutions method, the number of dilutions depending on the sample. From each dilution 1 ml is seeded in duplicate on nutrient agar plates. Petri dishes are then incubated at 25 °C. After 3 days yeast colonies are counted and after 5 days the moulds colonies are counted.
In Table 1 is presented the situation of the frequency with which various yeasts and moulds are meet on berries.

Table 1. The frequency with which various yeasts and moulds are meet on berries (Tournas and Katsoudas, 2005)

Microorganism	Contaminated samples (%)	The level of contamination * (area)
Blackberries		
Botrytis cinerea	78	0-100
Cladosporium	33	0-80
Fusarium	22	0-100
Penicillium	22	0-50
Rhizopus	11	0-50
Blueberries		
Botrytis cinerea	55	0-100
Alternaria	46	0-75
Fusarium	13	0-25
Penicillium	9	0-50
Aureobasidium pullulans	5	0-40
Cladosporium	5	0-20
Trichoderma	5	0-30
Yeasts	5	0-60
Raspberry		
Botrytis cinerea	75	0-100
Fusarium	25	0-50
Cladosporium	20	0-65
Penicillium	15	0-50
Rhizopus	10	0-90
Yeasts	5	0-65
Strawberries		
Botrytis cinerea	77	0-100
Rhizopus	23	0-100
Penicillium	10	0-67
Fusarium	8	0-75
Alternaria	8	0-67
Cladosporium	5	0-60
Trichoderma	3	0-50
Yeasts	3	0-75

* Percentage of contaminated products (per sample)

3.2. Chemical contaminants (mycotoxins)
As moulds grow in a commodity, it does not create the putrefactive degradation associated with bacteria, and therefore the foods is sometimes eaten even though infected, which can result in ingestion of toxins. The fungi

themselves are not toxic, but their secondary metabolites can sometimes be hazardous substances. These are mycotoxins such as aflatoxins, ochratoxin A,penitrem A, sterigmatocystein, roquefortin C, PR toxin and cyclopiazonic acid. Yeasts are not known to produce mycotoxins. There are hundreds of known mycotoxins produced by a large number of mould species. For production of toxins the demands on the substrate, as well as on the environmental factors, is different than for growth. Toxin production often requires a higher aw than growth, as well as more available oxygen. Less favourable conditions can also result in less potent or stable toxins, or limited production. The chemistry of the substrate can also affect production of toxins. For example production of aflatoxins is stimulated by the presence of fatty acids, specific amino acids and zinc. Other microorganisms can also inhibit growth and formation of toxins (Eklöf, 2013).

The mycotoxins most commonly found in fruits and their processed products are aflatoxins, ochratoxin A, patulin and *Alternaria* toxins (Fernández-Cruz et al., 2010).

Aflatoxins (AF) are a group of closely related metabolites produced by *Aspergillus flavus* and *Aspergillus parasiticus*. They are difuranocoumarin derivatives and the main components of this group are aflatoxin B1, B2, G1 and G2, based on their fluorescence under UV light (blue or green) and their relative chromatographic mobility. Aflatoxins are classified by the International Agency for Research on Cancer (IARC) as being carcinogenic to humans (group 1).

Alternaria fungi are commonly parasitic on plants and may cause spoilage of fruits and vegetables during transport and storage. *Alternaria alternata* produces a number of mycotoxins, including the dibenzo-pyrones alternariol (AOH), alternariol monomethyl ether (AME) and altenuene (ALT), altertoxin I and II (ATX-I and -II) and tenuazonic acid (TeA) a tetramic acid.

Ochratoxin A (OTA) was originally isolated from Aspergillus ochraceus in 1965. Several different ochratoxins exist, but ochratoxin A is the most common.

Patulin (PAT) is a toxic metabolite produced by several species of *Penicillium* and *Aspergillus*. The most important producer of PAT is the apple-rotting fungus *Penicillium expansum*. The IARC has classified PAT as category 3, not classifiable regarding its carcinogenicity to humans.

In Table 2 is presented the occurrence of mycotoxins in fruits and their processed products.

4. Sensory analysis

Sensory analysis involves assessing the sensory quality of food, using previously checked senses (sight, taste, smell, sound, touch), using methods and qualified people in this field, under certain conditions that ensure objectivity, fairness and the opportunity to reproduce the outcomes (Miteluț et al., 2007). To determine the quality of berries at different times after harvesting, sensory analysis was performed with the help of expert groups (panellists) for mulberries (Wang et al., 2013), strawberries (Wang et al., 2014; Aday and Caner, 2013), raspberry (Stavang et al., 2015; Bobinaite et al., 2016; Junqueira-Goncalves et al., 2016), cranberries (Caminiti et al., 2011).

5. Determination of colour of berries

From the literature, the most widely used method for determining the colour of both fresh fruit and those subjected to various processes of preservation (like refrigeration, freezing, freeze-drying), is the colorimetric method, resulting in the three critical factors L * (lightness), a * (chromaticity on an axis of the green (-) to red (+)) and b * (chromaticity on an axis of blue (-) to yellow (+)).Therefore, many researchers have studied the original colour and its evolution over time or after subjecting the fruit to various technological processes, of mulberries (Wang et al., 2013), strawberries (Ozakaya et al., 2009; Kartal et al., 2012; Aday and Caner, 2013; Wang et al., 2014), blueberries (Yemmireddy et al., 2013), raspberry (Bobinaite et al., 2016; Giovanelli et al., 2014), cranberries (Rudy et al., 2015), gooseberries (Vasquez-Parra et al., 2013; Vega-Galvez et al., 2014) and aronia (Samoticha et al., 2016).

Table 2. The occurrence of mycotoxins in fruits and their processed products (Fernández-Cruz et al., 2010)

Commodities	Positives/Total	Toxins	Maximum concentration	Concentration range
Oranges	8/25	AFB1/AF	52/120 μg/kg	-
Apple rotten areas	30/30	AF	350 μg/kg	-
Apple remainders	0/30	-	-	-
Apple juice	5/5	B1, G1	-	μg/L
Musts	19/47	AF B1	-	0.01 – 0.46 μg/L
Dried raisins	-	AF	-	Max. 2 – 550 μg/kg
Dried figs	-	AF	-	Max. 10 – 325 μg/kg
	7/8	AOH	59000 μg/kg	-
	8/8	AME	2300 μg/kg	-
Rotten apples	8/8	TEA	500 μg/kg	-
Apples	1/22	AOH	160 μg/kg	-
	1/22	AME	250 μg/kg	-
Rotten mandarins	2/2	AOH	-	1000 – 5200 μg/kg
	-	AME	-	500 – 1400 μg/kg
	-	TEA	-	21000 – 87200 μg/kg
Tangerine flavedo	6/8	AOH	-	2.5 – 17.4 μg/kg
	-	AME	-	0.9 – 3.5 μg/kg
Apple juice concentrate	17/32	AOH	-	1.35 – 5.42 μg/L
	1/32	AME	1.71 μg/L	-
Apple juice	11/11	AOH	-	0.04 – 2.40 μg/L
	10/11	AME	-	0.03 – 0.43 μg/L
Red grape juices	5/10	AOH	-	0.03 – 0.46 μg/L
	-	AME	-	0.01 – 39.5 μg/L
Red wine	20/25	AOH	-	0.03 – 7.41 μg/L
	-	AME	-	0.01 – 0.23 μg/L
Peaches	21/56	OTA	-	0.21 μg/kg
Cherries	6/6	OTA	-	2.71 μg/kg
Strawberry	4/10	OTA	-	1.44 μg/kg
Apple	2/4	OTA	-	0.41 μg/kg
Red wine	40 – 87 %	OTA	Average 0.30 μg/L	0.01 – 15.6 μg/kg
White wine	10 %	OTA	Average 0.18 μg/L	0.05 – 1.13 μg/L
Special wines	20 – 45 %	OTA	Average 4.47 μg/L	0.09 – 15.25 μg/L
Grape juice	29 – 85 %	OTA	Average 0.15 – 0.48 μg/L	0.010 – 5.3 μg/L
Vinegar	50 – 100 %	OTA	-	0.22 – 6.4 μg/L
Raisins	60 – 98 %	OTA	Average 1.4 – 9.2 μg/kg	Max 26 – 250 μg/kg
Dried figs	3 – 100 %	OTA	Average< 0.12 μg/kg	< 0.12 - 6900 μg/kg
Apple rotten areas	30/30	PAT	1000 μg/kg	2 – 11,3000 μg/kg
Apples, remainders	30/30	PAT	300 μg/kg	-
Blueberries	1/12	PAT	21 μg/kg	-
Cherries	9/10	PAT	113 μg/kg	-
Strawberries	8/10	PAT	145 μg/kg	-
Raspberry	3/5	PAT	746 μg/kg	-
Apple juice	3 – 100 %	PAT	Average 1 – 140 μg/L	0.5 – 1150 μg/L
Apple juice concentrated	78 – 100 %	PAT	-	7 – 376 μg/L
Cider mills	19 %	PAT	36.9 μg/L	4.6 – 467.4 μg/L
Retail cider	28 %	PAT	24.2 μg/L	15.3 – 35.2 μg/L
Apple puree	4/8	PAT	Average 63.2 μg/kg	4 – 221 μg/kg
Apple marmalade	6/26	PAT	Average 8.4 μg/kg	3 – 39 μg/kg
Pear marmalade	1/6	PAT	Average 4.8 μg/kg	2 – 25 μg/kg

6. Determination of texture of berries

The texture is a basic quality of fresh berries. Thus, it can be determined by means of laboratory apparatus generally called texturometre; this method being applied for the determination of texture of strawberries (Ozakaya et al., 2009; Wang et al., 2014; Kartal et al., 2012; Aday and Caner, 2013),blueberries (Yemmireddy et al., 2013; Zielinska et al., 2015; Diaz et al., 2011) and raspberry (Giovanelli et al., 2014).

CONCLUSIONS

After the literature review, a series of parameters that are determined in order to establish the quality of berries resulted. These parameters are presented in the table below (Table3).

Table 3. Quality parameters determined for berries

No.	Quality parameters
	Chemical-physical parameters
1.	pH
2.	total titratable acidity
3.	soluble solids (Brix)
	Nutritional parameters
4.	the content of ascorbic acid (vitamin C) (titrimetric method, HPLC)
5.	total phenolic content
6.	total anthocyanin content
7.	antioxidant capacity (DPPH, FRAP, HOSC, ORAC, ABTS, NO)
	Microbial contamination
8.	yeasts and moulds
9.	mesophilic aerobic total germ
	Chemical contaminants
10.	aflatoxins (AF)
11.	toxins produced by *Alternariasp*.
12.	ochratoxin A (OTA)
13.	patulin (PAT)
	Sensorial analysis
14.	sensory attributes (panel - taste, aroma, texture, color, appearance)
15.	colour - colorimetric
16.	texture - texturometre

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