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# Occurrence of ochratoxin A in grapes, juices and wines and risk assessment related to this mycotoxin exposure

## Ocorrência de ocratoxina A em uvas, sucos e vinhos e avaliação de risco relacionada à exposição a essa micotoxina

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## — REVIEW —

**ABSTRACT**

*Ochratoxin A (OTA) is a mycotoxin with nephrotoxic, genotoxic, teratogenic and carcinogenic properties. The presence of this toxin in wines and juices occurs due to the development of toxigenic fungi in grapes. Studies have shown the presence of this toxic secondary metabolite in these beverages may results in economic losses to the winery as well as health problems for consumers. In Europe, several studies have been done in order to map the areas where the development of ochratoxigenic fungi is more favorable. However, in Brazil these studies are still incipient. The Joint Expert Committee on Food Additives of the World Health Organization (JECFA) established the safe tolerable intake of 112ng OTA per kg of body weight per week. To verify whether the population is exposed to OTA levels that pose a risk to health is necessary to compare the parameter of safe ingestion defined by JECFA with the levels of exposure to this toxin. Periodic monitoring of the OTA levels in food and beverage has been justified by some reasons including: (i) the toxic effects of this toxin, (ii) the recent publication of the Brazilian legislation establishing maximum limit for OTA, (iii) the introduction of grape juice in school meals and (iv) the recommendation of regular wine intake because of their functional properties.*

**Key words**: *mycotoxins, risk assessment, toxic compounds.*

**RESUMO**

*A ocratoxina A (OTA) é uma micotoxina que possui propriedades nefrotóxicas, genotóxicas, teratogênicas e carcinogênicas. A presença dessa toxina em vinhos e sucos ocorre devido à contaminação das uvas por fungos toxigênicos. Estudos têm mostrado a presença desse metabólito secundário tóxico nestas bebidas, o que pode significar perdas econômicas ao setor vitícola, bem como problemas à saúde dos consumidores. Na Europa, vários estudos têm sido realizados com o objetivo de mapear as áreas em que o desenvolvimento de fungos ocratoxigênicos é mais favorável. Entretanto, no Brasil estes estudos ainda são incipientes. O Comitê de Especialistas em Aditivos Alimentares da Organização Mundial da Saúde (JECFA) estabeleceu a ingestão tolerável segura de 112ng de OTA por quilo de peso corpóreo por semana. Para verificar se população está exposta a OTA em níveis que representam risco para à saúde, é necessário comparar o parâmetro de ingestão segura, definido pelo JECFA, com os níveis de exposição a esta toxina. O monitoramento periódico dos níveis de OTA em alimentos e bebidas é justificado por alguns motivos que incluem: (i) os efeitos tóxicos dessa toxina, (ii) a publicação recente da legislação brasileira que estabelece limite máximo para OTA, (iii) a introdução do suco de uva na merenda escolar; e (iv) a recomendação da ingestão regular de vinho/suco de uva devido as suas propriedades funcionais.*

**Palavras-chave**: *micotoxinas, avaliação de risco, compostos tóxicos.*

## INTRODUCTION

The grapes are subject to fungal contamination during cultivation, harvest, transport and/or storage. Mycotoxins are products of secondary metabolism of some filamentous fungi. Production of these toxic compounds is influenced by several factors, including humidity, temperature, substrate composition, water activity, pH and fungal strain (MARROQUÍN-CARDONA et al., 2014). Ochratoxin A (OTA) is a mycotoxin that has nephrotoxic, genotoxic, teratogenic and carcinogenic properties (ROCHA et al., 2014). In this way, the International Agency for Research on

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Cancer (IARC) has classified OTA in group 2B, ie, as a possible carcinogen to humans (IARC, 1993). Because of the toxicity of OTA, the maximum limit of 2ng $mL^{-1}$ was established for grape juice and wine by Brazilian legislation (ANVISA, 2011). This same limit is adopted in countries of the European Union (EUROPEAN COMISSION, 2006).

The use of grapes that contains OTA for the preparation of juices and wines may be a concern, since grape juices may be widely consumed by children and even are used in school meals in some Brazilian states, such as Rio Grande do Sul and Santa Catarina (RIO GRANDE DO SUL, 2009; SANTA CATARINA, 2009). The incentive to grape derivatives consumption occurs due to the presence of phenolic compounds and stilbene which reduce the risk of cardiovascular diseases and have antioxidant and anti-inflammatory properties (XIANG et al., 2014).

The objective of this review was to determine, based on research published in the literature, if the world population is exposed to OTA through the consumption of juices and wines at levels that pose risk to health. The factors related to the development ochratoxigenic fungi in grapes and occurrence of this mycotoxin in the juices and wines were reviewed. The databases used in this research were "Web of Science" and "Scopus" from September 2104 to March 2015. The keywords used for search data were "Ochratoxin wine" and "Ochratoxin juice".

## Occurrence and factors related to the incidence of OTA-producing fungi in grapes

The main OTA-producing fungi in grapes belong to the genus ***Aspergillus***. Two sections of ***Aspergillus*** are known as OTA-producing: ***Circumdati*** (group that belongs the ***A. ochraceus***) and ***Nigri*** (group in which are classified ***A. carbonarius*** and ***A. niger***). The contamination of grapes with ***Aspergillus*** may be minimized by cultivating grapes more resistant to pests and utilization of practices of harvesting and transportation that preserve the integrity of the grapes. The presence of OTA-producing fungi has been occurred in different countries with wine tradition in wine production, incuding Argentina (PONSONE et al., 2007; CHIOTTA et al., 2009), France (CLOUVEL et al., 2008), Italy (LUCCHETTA et al., 2010) and Tunisia (LASRAM et al., 2012).

The incidence of OTA-producing fungi in grapes of varieties Bonarda and Tempranillo produced in Argentina was verified by PONSONE et al. (2007). OTA was not found in grapes, however, several species of ***Aspergillus*** were isolated from grapes, including, ***A. japonicus*** (40%), ***A. niger*** (34%), ***A. awamori*** (15%), ***A. foetidus*** (4%), ***A. aculeatus*** (4%) and ***A. carbonarius*** (3%), of these, 24% were identified as OTA producers.

CHIOTTA et al. (2009) found 284 fungal isolates identified as ***Aspergillus*** section ***Nigri*** in grapes cultivated in Argentina. ***A. niger*** (81%), ***A. carbonarius*** (11%) and ***A. uniseriate*** (8%) were the species isolated from grapes, that included 32% of OTA-producers (69% of ***A. niger*** and 31% of ***A. carbonarius***).

CLOUVEL et al. (2008) observed that the presence of the ***Botrytis cinerea*** and ***Lobesia botrana*** incresead the contamination by ***A. carbonarius*** in grapes grown in southern France, achieving 5.8ng $mL^{-1}$ of OTA. These vectors damage the surface of the grapes and thus facilitate the colonization of ***A. carbonarius***. LUCCHETTA et al. (2010) evaluated the presence of OTA producing fungi in grapes grown in the northern, central and southern Italy. ***A. carbonarius*** was found mainly in grapes produced in the south region, while ***A. niger*** was predominant in Northern and Central region. The grapes from the south showed more frequent incidence (45%) and highest concentration of OTA (reaching of 9.2ng $mL^{-1}$ of OTA). The differences in fungal incidence and OTA levels of grapes grown in different regions may occur due to climatic factors of each region. In the southern region of Italy, for example, the climate is more humid and warm and in these conditions, the concentration of OTA in grapes can reach high levels.

LASRAM et al. (2012) evaluated the occurrence of toxigenic fungi and OTA in grapes grown in different regions of Tunisia. ***A. niger*** was the predominant specie isolated from grapes (75%), followed by ***A. carbonarius*** (22%). However, only 3% of A. niger showed potential to produce OTA, while 97% of ***A. carbonarius*** were OTA-producers. OTA was found in 38% of grapes in levels ranging from 0.05 a 5.85ng $mL^{-1}$.

The ochratoxigenic effect of ***A. carbonarius*** was evaluated in damage and undamage grapes by BELLÍ et al. (2007). These grapes were storage at 20 and 30ºC and humidaty of 80, 90 and 100%. The higher levels of OTA were found in damage grapes, storage at 30ºC and 100% of humidity.

## Occurrence of OTA in grape juice and wine

After cereals, juices and wines are the largest sources of exposure to OTA. Since OTA was first detected in these beverages sold in Switzerland (ZIMMERLI & DICK, 1996), several studies about the occurrence of OTA are found in the literature (Table 1 and 2). The concentration of OTA in juice

Table 1 - Occurrence of ochratoxin A in grape juices in different countries.

| Country | Incidence (%) | Range (ng $mL^{-1}$) | Estimated exposure "A" (ng $kg^{-1}$ bw $day^{-1}$)[a] | Estimated exposure "C" (ng $kg^{-1}$ bw $day^{-1}$)[b] | Reference |
|---|---|---|---|---|---|
| ----------Red juices---------- | | | | | |
| Germany | 78 | 0.02 - 6.72 | 0.05- 16.24[c] | 0.2 - 67.20[c] | WOESE, 2000 |
| | 11,1 | 0.008 - 0.104 | 0.02 - 0.25 | 0.08 - 1.04 | NG et al., 2004 |
| Brazil | 29,2 | 0.021 - 0.1 | 0.05 - 0.24 | 0.21 – 1.00 | ROSA et al,, 2004 |
| | ND[d] | <0.03 | <0.07 | <0.30 | SHUNDO et al., 2006 |
| | ND[d] | <0.01 | <0.02 | <0.10 | TERRA et al., 2012 |
| China | 30 | 0.26 - 0.54 | 0.63 - 1.31 | 2.60 - 5.40 | CAO et al., 2013 |
| Spain | ND[d] | <0.05 | <0.12 | <0.50 | BELLÍ et al., 2004 |
| Malaysia | 91 | <0.02 - 1.05 | <0.05 - 2.54 | 0.20 - 10.5 | LEE et al., 2012 |
| Switzerland | 100 | <0.003 - 0.311 | <0.007 - 0.75 | 0.03 - 3.11 | ZIMMERLI & DICK, 1996 |
| ----------White juices---------- | | | | | |
| Canada | 16 | 0.008 - 0.071 | 0.02 - 0.17 | 0.08 - 0.71 | NG et al., 2004 |

[a]Estimated exposure "A": Estimated exposure to OTA (ng $kg^{-1}$ bw $day^{-1}$) for adults (considering the body weight of 60kg) through the daily consumption of 145mL of juice, as established by the Consumer Expenditure Survey (IBGE, 2011).
[b]Estimated exposure "C": Estimated exposure to OTA (ng $kg^{-1}$ bw $day^{-1}$) for children (considering the body weight of 20kg) through the daily consumption of 200mL of juice in scholar meals.
[c]Estimated exposure to OTA may be greater than provisional tolerable intake for this mycotoxin (16ng $kg^{-1}$ bw $day^{-1}$) (JECFA, 2007), if these samples were consumed.
[d]ND: OTA were not detected.

and wine is often reported below of legislation limit (2ng $mL^{-1}$) (WOESE, 2000; NG et al., 2004; ROSA et al., 2004; SHUNDO et al., 2006; QUINTELA et al., 2012; CAO et al., 2013; LASRAM et al., 2013).

The maceration of the grapes is the main processing step that contributes to the OTA contamination of juice and wine, since the contact of grape skin during this stage facilitates the migration of toxin to must (WELKE et al., 2009). For this reason, in general, OTA levels are higher in red wines (in which maceration is necessarily done in contact with grape skin), followed by roses and whites wines (OTTENEDER & MAJERUS, 2000; CABANES et al., 2002). BRERA et al. (2008) confirmed this fact analyzing 1166 samples of wines from different regions of Italy. The maximum values were 7.50ng $mL^{-1}$ for red, 4.07ng $mL^{-1}$ for rosés, 1.95ng $mL^{-1}$ for whites. In addition, the wines produced in the southern region of Italy had higher values of OTA compared to the north. The authors suggest that the difference of latitude (from 46.8°N to 36.8°S) and climate between the north and south regions may influence the OTA levels.

Special wines such as fortified or dessert wines have high sugar concentration, thus, the probability of fungal contamination, including ochratoxigenic fungi, is increased in these wines. The late harvest (when the grapes have excessive degree of ripeness) may be used to concentrate more sugar in grapes used in winemaking. An alternative to the production of these more sweet wines consists in interrupting the fermentation by fortification with grape wine distillate. This procedure also provides that the characteristic alcohol level of this beverage is achieved, since the fermentation was terminated. In this way, enological practices influence the concentration of OTA (PIETRI et al., 2001; BELLI et al., 2004; RATOLA et al., 2005; CHIODINI et al., 2006). VALERO et al. (2008) found high levels of OTA in wines produced using grapes with excessive degree of ripeness (15.62ng $ml^{-1}$) and fortified wines (27.79ng $ml^{-1}$) elaborated with grape wine distillate.

Risk assessment related to OTA exposure through consumption of grape juice and wine

In 2001, The Joint FAO/WHO Expert Committee on Food Additives (JECFA) established a provisional tolerable weekly intake (PTWI) for OTA of 112ng $kg^{-1}$ body weight (bw), which corresponds to approximately 16ng $kg^{-1}$ pc per day (JECFA, 2007). The concept of provisional tolerable intake is based on the amount of a compound that can be consumed during the lifetime of an individual without causing damage to their health. In this way, the comparison of OTA exposure with PTWI may be used to evaluate the potential risks to human health. If the estimated

Table 2 - Occurrence of ochratoxin A in wines produced in different places and evaluation of the estimated exposure to this mycotoxin.

| Place | Incidence (%) [type][a] | Range (ng $mL^{-1}$) | Estimated exposure (ng $kg^{-1}$ bw $day^{-1}$)[c] | Reference |
|---|---|---|---|---|
| Africa | 100 [R] | 0.0844 - 0.455 | 0.21 - 1.14 | REMIRO et al., 2013 |
| South Africa | 100 [R] | <0.03 | <0.07 | SHUNDO et al., 2006 |
| Argentina | 17 [R] | <0.03 | <0.07 | SHUNDO et al., 2006 |
| | ND [R] | <0.20 | <0.50 | HOELTZ et al., 2012 |
| Australia | 50 [R] | <0.033 - 0.072 | <0.08 - 0.18 | QUINTELA et al., 2012 |
| Brazil | 3 [R] | <0.016 - 4.50 [3%][b] | <0.04 -11.25 | WELKE et al., 2010 |
| | 6 [R] | <0.80 - 0.84 | <2.00 - 2.10 | TEIXEIRA at al., 2011 |
| | 31 [R] | <0.10 - 1.33 | 0.25 – 3.32 | SHUNDO et al., 2006 |
| | ND [R] | <0.20 | <0.50 | HOELTZ et al., 2012 |
| | 75 [R] | <0.03 - 0.62 | 0.07 – 1.55 | TERRA et al., 2012 |
| | 14.3 [W] | <0.03 | <0.07 | TERRA et al., 2012 |
| Canada | 14 [W] | <0.004 - 0.156 | <0.01 - 0.39 | NG et al., 2004 |
| | 23 [R] | <0.008 - 0.393 | <0.02 - 0.98 | NG et al., 2004 |
| Chile | ND [R] | <0.20 | <0.50 | HOELTZ et al., 2012 |
| China | 10 [W] | <0.09 - 0.53 | <0.22 - 1.32 | WU et al., 2011 |
| | 29 [R] | <0.02 - 1.18 | <0.05 - 2.95 | WU et al., 2011 |
| | 57 [R] | <0.03 - 5.65 [39.5%][b] | <0.07 - 14.12 | ZHANG et al., 2013 |
| | 2,9 [W] | <0.03 - 0.07 | <0.07 - 0.17 | ZHANG et al., 2013 |
| | 25 [RO] | <0.03 - 0.22 | <0.07 - 0.55 | ZHANG et al., 2013 |
| | 28 [R] | <0.0028 - 0,0437 | <0.007 - 0.11 | MAO et al., 2013 |
| | 45 [R;W] | <0.01 - 0.98 | <0.025 - 2.45 | ZHONG et al., 2014 |
| Croatia | 100 [R] | 0.00003 - 0.0613 | 0.00007 -0.15 | REMIRO et al., 2013 |
| Spain | 80 | <0.11 - 1.3 | <0.27 - 3.25 | BELLÍ et al., 2004 |
| | 100 [RO] | 0.007 - 0.09 | 0.017 - 0.22 | CHIODINNI et al., 2006 |
| | 100 [R] | 0.064 - 0.138 | 0.16 - 0.35 | QUINTELA et al., 2012 |
| | 100 [R] | 0.07 - 0.2 | 0.175 - 0.50 | SHUNDO et al., 2006 |
| | 100 [R] | 0.001 - 0.104 | 0.002 - 0.26 | REMIRO et al., 2013 |
| | 100 [R] | 0.00049 - 0.0949 | 0.001 - 0.23 | REMIRO et al., 2012 |
| | 19[R] | <0.06 - 4.24 [4,3%][b] | <0.15 - 10.60 | BELLÍ et al., 2004 |
| Europe[e] | 91 [S] | <0.024 - 27.79 [55][b] | <0.06 - 69.50[d] | VALERO et al. (2008) |
| France | 93 [R] | <0.010 - 0.237 | <0.025 -0.60 | QUINTELA et al., 2012 |
| | 60 [R] | <0.20 - 0.29 | <0.5 - 0.72 | SHUNDO et al., 2006 |
| | 92 [R] | <0.0003 - 0.0883 | <0.0007 - 0.22 | REMIRO et al., 2013 |
| Greece | 89 [W] | <0.01 - 0.56 | <0.025 - 1.4 | SARIGIANNIS et al., 2014 |
| | 100 [RO] | 0.19 - 2.52 [50%][b] | 0.47 - 6.3 | SARIGIANNIS et al., 2014 |
| | 73 [R] | <0.01 - 0.71 | 0.025 - 1.78 | SARIGIANNIS et al., 2014 |
| | 100 [R] | 0.004 - 0.212 | 0.01 - 0.53 | REMIRO et al., 2013 |
| Italy | 94 [R] | <0.075 - 0.941 | <0.18 – 2.35 | GIOVANNOLI et al., 2014 |
| | 6.7 [R] | <0.12 - 2.69 [6.7%][b] | <0.3 - 6.72 | PRELLE et al., 2013 |
| | 100 [R] | 0.050 - 0.353 | 0.12 - 0.88 | QUINTELA et al., 2012 |
| | 95 [R] | <0.005 - 7.5 [2,8%][b] | <0.0125 - 18.75 | BRERA et al., 2008 |
| | 100 [R] | 0.03 - 0.33 | 0.075 - 0.82 | SHUNDO et al., 2006 |
| | 100 [R] | 0.0051 - 0.286 | 0.01 - 0.71 | REMIRO et al., 2013 |
| | 97.4 [R] | <0.01 - 7.63 | <0.025-19.01[d] | VISCONTI et al., 1999 |
| | 87.5 [RO] | <0.01 - 1.15 | <0.025 - 2.88 | VISCONTI et al., 1999 |
| | 44,4 [W] | <0.01 - 0.97 | 0.025 - 2.42 | VISCONTI et al., 1999 |
| Israel | 100 [R] | 0.0036 - 0.0654 | 0.009 - 0.16 | REMIRO et al., 2013 |
| Portugal | 100 [R] | 0.03 - 0.25 | 0.075 - 0.63 | SHUNDO et al., 2006 |
| | 25.7 [R] | <1.00 - 1.23 | 2.50 – 3.08 | PENA et al., 2010 |
| | 12 [W] | <1.00 - 2.40 [33%][b] | 2.50 – 6.00 | PENA et al., 2010 |
| | 6.7 [W;R] | <0.41 - 0.45 | 1.02 – 1.12 | FERNANDES et al. 2013 |
| Russia | 43 [R] | <1,80 – 4,40 [29%][b] | 4.50 - 11.00 | RUSANOVA et al., 2009 |
| Tunisia | 85 [R] | <0.09 - 1.50 | 0.225 - 3.75 | LASRAM et al., 2013 |
| Turkey | 100 [B] | 0.25 - 1.80 | 0.65 - 4.50 | ALTIOKKA et al., 2009 |
| | 100 [R] | 0.0029 - 0.101 | 0.005- 0.25 | REMIRO et al., 2013 |
| | 100 [R] | 0.39 - 7.96 [70%][b] | 0.97 - 19.90[d] | ALTIOKKA et al., 2009 |
| Uruguay | 33 [R] | <0.03 | <0.075 | SHUNDO et al., 2006 |
| | ND [R] | <0.2 | <0.50 | HOELTZ et al., 2012 |
| Chile, Spain and Australia | 13 [R;W;RO] | <0.03 - 0.26 | <0.075 - 0.65 | ALVARADO et al., 2013 |

[a]Analyzed samples: [W] white wine; [R] Red wine, [RO] Vinho rosé and [S] special wine.
[b]Percentage of samples with OTA concentration above 2ng $mL^{-1}$ (considering all samples evaluated by the authors).
[c]Estimated exposure to OTA (ng $Kkg^{-1}$ bw $day^{-1}$) for adults (considering the body weight of 60kg) through the daily consumption of 150mL of wine.
[d]Estimated exposure to OTA may be greater than the provisional tolerable intake for this mycotoxin (16ng $kg^{-1}$ bw $day^{-1}$) (JECFA, 2007), if these samples were consumed.
[e]Wines produced in various countries were evaluated including: Germany, Austria, Spain, France, Italy, Hungary and Portugal.

exposure to the toxin is higher than PTWI there is a risk related to the consume of products containing OTA. The OTA estimated exposure through the consumption of grape juice and wine may be calculated according to the equation:

$$EE = \frac{C \times OTA}{PC}$$ equation 1

where, EE: estimated exposure (ng $kg^{-1}$ bw $day^{-1}$), C: the consumption of juice and wine (mL $day^{-1}$), OTA: OTA level (ng $mL^{-1}$) and BW: body weight (60kg for adults and 20kg for children).

The OTA values found in grape juice (Table 1) and wine (Table 2) were used in calculation of estimated exposure to this toxin. Daily consumption of juice was estimated taking into consideration: (i) a cup (200mL) of grape juice consumed by children, since this beverage has been introduced in meals of public schools in the states of Rio Grande do Sul and Santa Catarina (RIO GRANDE DO SUL, 2009; SANTA CATARINA, 2009) and this amount has been daily consumed by children, (ii) 145mL of juice consumed by adults as established by the Consumer Expenditure Survey conducted by the Brazilian Institute of Geography and Statistics (IBGE, 2011) and (iii) a glass of wine (150mL) per day recommended by some searches due to the presence of polyphenolic compounds.

The studies focused on the incidence of OTA in juices are incipient in relation to research on the occurrence of this toxin in wine. Levels of OTA ranged from <0.003 to 6.72ng $mL^{-1}$ and 0.00003 to 27.79ng $mL^{-1}$, for juice and wine, respectively. According to table 1, only a paper published in the literature (WOESE, 2000) showed juice samples (marketed in Germany) with OTA levels above 2ng $mL^{-1}$ (the maximum limit adopted by European and Brazilian law). Thus, the consumption of these grape juices represents a risk situation, since the estimated exposure to OTA (16.24 and 67.20ng $kg^{-1}$ bw $day^{-1}$ for adults and children, respectively) was higher than the PTWI (16ng $kg^{-1}$ bw $day^{-1}$) defined as safe by JECFA.

OTA levels in juices were lower than 2ng $mL^{-1}$ in other studies cited in table 1, in which the occurrence of this mycotoxin was evaluated, including samples from Brazil (ROSA et al., 2004; SHUNDO et al., 2006), China (CAO et al., 2013), Spain (BELLI et al., 2004), Malaysia (LEE et al., 2012) and Switzerland (ZIMMERLI & DICK, 1996). In these cases, the OTA exposure through consumption of juice has not represented a health risk, since the estimated exposure to this toxin were lower than the value established as PTWI by JECFA (ZIMMERLI & DICK, 1996; ROSA et al., 2004; BELLI et al., 2004; SHUNDO et al., 2006; LEE et al., 2012; CAO et al., 2013).

In wines (Table 2), VISCONTI et al. (1999), VALERO et al. (2008), BRERA et al. (2008) and ALTIOKKA et al. (2009) presented samples in which the OTA exposure was noteworthy. In the evaluation of wines from Turkey, for example, 70% of the samples had levels greater than 2ng $mL^{-1}$ and exposure to OTA could reach 19.90ng $kg^{-1}$ bw $day^{-1}$ (ALTIOKKA et al., 2009). In Italian wines, similar estimated exposure (19,01 and 18,75ng $kg^{-1}$ bw $day^{-1}$) was observed by VISCONTI et al. (1999) and BRERA et al. (2008), respectively. OTA was found in these wines in concentration exceeding 2ng $mL^{-1}$ in 2.8% (VISCONTI et al., 1999) and 87% (BRERA et al., 2008) of samples.

Considering data of table 2, the highest estimated exposure to OTA (69.50ng $kg^{-1}$ bw day-1) was observed in special wines evaluated by VALERO et al. (2008). In these wines, the OTA levels reached 27.79ng $mL^{-1}$. The maximum limit established for OTA of 2ng $mL^{-1}$ is not applied for special wines. In this type of wine, the fermentation step is stopped by the addition of a given amount of grape distilled as mentioned above. This procedure is performed in order to obtain sweeter wines, as part of sugars was not consumed by yeast when the fermentation is stopped. Results obtained by VALERO et al. (2008) may indicate that fermentation is important role in the degradation of this mycotoxin.

Occurrence of OTA in wines at levels above 2ng $mL^{-1}$ (Table 2) was observed in several countries including Brazil (WELKE et al., 2010), China (ZHANG et al., 2013), Spain (BELLI et al., 2004), Greece (SARIGIANNIS et al., 2014), Italy (VISCONTI et al., 1999; BRERA et al., 2008; PRELLE et al., 2013), Portugal (PEN et al., 2010), Russia (RUSANOVA et al., 2009) and Turkey (ALTIOKKA et al., 2009). These results demonstrate that the OTA exposure through wine consumption may be a concern at these countries. In addition, samples containing high levels of OTA were detected in Italy (BRERA et al., 2008), Turkey (ALTIOKKA et al., 2009) and China (ZHANG et al., 2013), where the occurrence of OTA was verified in 95%, 85% and 57% of the samples, respectively. In other studies, despite the OTA has been found in wines from Africa (REMIRO et al., 2013), Spain (CHIODINI et al., 2006) and Israel (REMIRO et al., 2013) at low levels (0.0844 to 0.455, 0.007 to 0.009 and 0.003 to 0.0654, respectively), this toxin was found in 100% of the samples produced in these countries. In these cases,

the amount and frequency of wine consumption can be determining factors for exposure to OTA pose a risk to health.

## CONCLUSION

The OTA is present in several countries as a contaminant in grapes, juice and wine. In Europe, several studies have been conducted in order to map the areas where the development of mycotoxigenic fungi is more favorable, and consequently the production of OTA. In Brazil, these studies are still incipient.

***A. niger*** and ***A. carbonarius*** are mainly responsible for the fungic contamination of grapes. Moreover, these fungal species should be highlighted both for its high incidence and as for its great capacity to produce OTA. Factors that influence the OTA levels in juices and wines are well established in the literature. The grape variety used in winemaking, the presence of physical damage in surface of grapes and climatic conditions are frequently related to occurrence of OTA.

The estimation of OTA exposure through the consumption of juice and wine revealed that few studies showed samples in which the consumption could pose health risk. The estimated exposure to OTA was higher than the tolerable intake for this mycotoxin in rare cases. However, the frequency of occurrence of OTA was high. In addition, in some cases, the number of samples with OTA levels above the maximum limit established was significant in some countries.

Although the evaluations published in literature indicate that the OTA exposure through the consume of grape juice and wine poses risk to health in few cases, only the periodic survey on the levels of this toxin may ensure the security related to the consume of these products. The incidence of OTA in juices and wines must be constantly monitored due to the following factors: (i) toxic effects of OTA, (ii) evaluation of a reduced number of samples produced in Brazil, (iii) recent publication of Brazilian legislation establishing maximum limits for this mycotoxin, (iv) introduction of the grape juice in school meals and recommendation of regular intake of wine because of its functional properties.

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