Safety assessment of traditional Plaisentif cheese

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Abstract

Traditional foods are gaining more and more market due to consumers’ increasing willingness to buy products linked to national cultures: among these products, cheese plays an important role. Plaisentif is a traditional Piedmont cheese, only made during violets blooming season. The aim of this work is to evaluate the safety of this cheese, taking into account the EU Regulations. Microbiological hazards as well chemical, biogenic amines and mycotoxins, analysis were investigated. Salmonella spp. and Listeria monocytogenes were never detected in cheeses after ripening. Biogenic amines were present in very low quantities. Ochratoxin A was never detected and patulin was detected in over one cheese during the two years of sampling. This is the first attempt to characterize traditional Plaisentif cheese from a safety point of view. All the information acquired can be held as a necessary basis for reinforcing the culture of traditional products, for economic opportunities in mountainous regions and for safeguarding traditions and cultural identities.

Introduction

Traditional products are, according to consumers, food that is handmade in a particular way, following a long-established tradition, sourced within a certain local area and among these products, cheese is included (Montel et al., 2014). For this kind of cheese, the producer usually uses raw or thermized instead of pasteurized milk. For this reason, the natural flora persists in the product determining the typical flavor and aroma. On the other side the natural microflora might result in safety issues. Currently information about safety and benefits of many traditional cheeses are missing and for this reason in deep studies are necessary (Montel et al., 2014).

The ancient Italian dairy tradition is expressed in a wide variety of traditional cheeses; in addition to protected designation of origin (PDO), Italian cheesemakers also produce so-called “historical cheeses”. These dairy products have made by fewer manufacturers located in a specific area within a region, are produced with non-standardized processes and results in small amount of finals forms, thus representing “niche products”. Plaisentif cheese can be considered among them even without being a PDO product, nor a protected geographical indication (PGI). Chronicles from the 1500 already mentioned it, milk and cheese factories are located between 1400 m and 1800 m above the sea level. Another noteworthy characteristic is that this cheese is produced only from June to July, corresponding to violets blooming season, lending it a peculiar flavor. This is the reason why it is called “formaggio delle viole”.

Plaisentif cheese is produced by mixing the morning milk to the one of the previous evenings, at a temperature of 33-36°C. Following the addition of rennet, the cheese maker evaluates the clotting time visually (normally an hour). The cheese must then age for 60 days after a salting phase (dry salt or brine). Temperature and humidity are not specified in the disciplinary. Finally, the cheese forms are marked (logo, producer, and printing data) and sold (Figure 1).

Raw milk can be a source of pathogens in cheese and traditional cheese-making factories may not always provide good hygienic conditions during the process. For these reasons, the aim of this work, after a previous evaluation of the lactic cheese microbiota (Dalmasso et al., 2016), was to investigate the presence of pathogens in the microflora, quantifying the content of biogenic amines (BAs) and of two common mycotoxins (ochratoxin A and patulin) that could have contaminated the cheese during ripening (Manca et al., 2020; Kokkonen et al., 2007) in not strictly controlled conditions.

Materials and methods

Milk and cheese samples

Samples of milk (n=18) and of the corresponding cheese, after a maturation period of 80 days were collected from nine producers over two years. Milk was collected refrigerated (4°C) and immediately bacteriologically analyzed. At the end of ripening, and in the same temperature conditions, a whole form was taken, refrigerated and immediately analyzed in aseptic conditions in the microbiological laboratory. Cheese samples were collected from the soft edible part and stored at -20°C awaiting chemical analysis.

Aw and pH analysis

For the determination a Medilor Basic 20 pHmeter (Crison Instruments SA, Alella, Barcelona, Spain) and a AquaLab3 TE (Degagon Devices Inc., Pullman, Washington, USA) were used.

Microbiological analysis

The analysis were conducted according to certified protocols. In particular for the enumeration of Enterobacteriaceae we used the AFNOR V08-‘54 method; for the enumeration of Coagulase positive Staphylococci, we used the AFNOR V08-14 with Baird Parker Agar added with RPF for highlighting Coagulase Active strains (Lioiphicem, Italy). For the detection of Salmonella and of Listeria monocytogenes...
were used respectively the ISO 6579-2002 and the ISO 11290-1/Am1 1:2004E protocols. The reagents were produced by Oxoid (Thermoscientific, Basingstoke, UK).

Mycotoxins analysis

**Extraction of mycotoxins**

Glassware was treated according to Pattono et al. (2013). In order to prevent loss of Patulin or salt formation Ochratoxin A. Analyses were done in twice.

To extract patulin, a modification of the extraction protocol proposed by Kokkonen et al. (2005) was used. The first phase was an extraction repeated three times with 10 mL of acetonitrile acidified with 0.1% formic acid. Subsequently, the sample was shaken (Ika-Vibrax, Staufen, Germany) for 5 minutes (600 strokes/min). Defatting was achieved by shaking an aliquot (15 mL) of the extracted acetonitrile three times with exane at the condition written above. The final step was the evaporation of one mL at 60°C. Ahead of the chromatographic analysis, 1 mL of mobile phase was used to dissolve the sample.

To extract ochratoxin A the protocol proposed by Pattono et al. (2013) was adopted. Briefly samples were homogenized in acetonitrile and sulphuric acid for acidification, shaken and the defatted always with exane. Both extracted were filtered with cellulose filters and evaporated to dryness until analysis.

**HPLC analysis**

For Ochratoxin A and Patulin the method by Pattono et al. (2013) was applied. The standards were: Patulin in acetonitrile (Fluka, Buchs, Switzerland) and Ochratoxin A in a benzene:acetic acid (99:1) solution (Supelco, Bellefonte, USA) stored at −40°C.

All solvents were HPLC grade (Merck, Darmstadt, Germany). The distilled water (resistivity value = 18.2 mΩ) was produced by a MilliQ system using a (Millipore, Billerica, MA, USA). The HPLC system (Merck, Darmstadt, Germany) was: L-7100 pump, L-7614 vacuum membrane degasser, Rheodyne 7725i injection valve with a 50 μL loop, a column end-capped PuroSpher Star RP-18 endcapped (250 × 4 mm × 5 μm) (Merck, Darmstadt, Germany) and the detectors (Merck, Darmstadt, Germany) were: for Patulin L-7400 UV detector set at 273 nm wavelength, for Ochratoxin A L-7480 fluorescence detector set at 333nm (excitation) and 460 nm (emission). The mobile phases were: for Patulin H2O:acetonitrile (90:10) at a flow rate of 0.8 mL/min; for Ochratoxin A: H2O:acetonitrile:acetic acid (49.5:49.5:1) at a flow rate of 1.0 mL/min.

**Confirmation of mycotoxins**

For Patulin it was used the protocol proposed by Cunha et al. (2009).

**Determination of biogenic amines**

**Extraction and derivatization of biogenic amines**

The extraction method was used, as reported for the hard cheese Toma Piemontese (Gennaro et al. 2013). Biogenic amines were extracted with HCl M 0.1 and for the derivatization a saturated solution of NaHCO3, and 1 mL dansylchloride solution (5 mg/ml) were added.

**HPLC analysis**

For the quantification of Biogenic Amines, it was used the protocol by Moret & Conte (1996). The HPLC apparatus was the same described for patulin. Also, solvents and water were the same previously described. Amines, aminoacids and dansyl-chloride were Sigma (St Louis, MO). The mobile phase was a water/ACN mixture in the following gradient elution: 0–5 min water/ACN 35:65, 5–20 min water/ACN 25:75. The flow-rate was 0.8 ml/min and UV detection at 254 nm.

**Table 1. pH and A<sub>s</sub> of milk and cheese (mean ± SD).**

| Sample     | pH      | A<sub>s</sub> | A<sub>s</sub> |
|------------|---------|--------------|--------------|
| Milk       | 6.78±0.05       | 6.58±0.15   | -            | -            |
| Cheese     | 5.39±0.19       | 5.53±0.22   | 0.96±0.008   | 0.95±0.01    |

**Results and Discussion**

Plaisentif cheese is a very peculiar cheese. It is a semi-hard cheese only manufactured three months a year, when a specific pasture is available. pH and A<sub>s</sub> values of milk and cheese for both years are showed in Table 1. Comparing to other traditional Cheese (“Toma Piemontese DOP” and Montasio cheese), pH of milk was aligned with the values recorded, considering the variability seen within different producers in our and other studies (Astegiano et al., 2014; Maifreni et al., 2013). A<sub>s</sub> and pH of cheese forms at the same aging time were aligned with Toma Piemontese but A<sub>s</sub> was lower than Montasio Cheese (Astegiano et al., 2014; Maifreni et al., 2013).

Salmonella spp and Listeria monocytogenes, were never detected in cheese although Listeria monocytogenes was detected once in milk in the first year of sampling. For the other bacterial species considered, a great variability was noteworthy (Tables 2 and 3). This fact was not surprising, if we consider the differences among the cheesemakers involved. Astegiano et al. (2014) and Maifreni et al.
Microbial counts, have to be proposed. Improving artisanal establishments have been the reason for some high conditions of some cheese factories, located in the second year. Coagulase-positive Staphylococci ranged between $<100$ to $1.4\times10^6$ CFU/ml (mean: $1.8\times10^4$) for milk and among $<100$ to $5\times10^5$ CFU/g (mean: $8.8\times10^3$) in cheese in the first year and between $<100$ to $4.9\times10^4$ CFU/ml (mean: $6.3\times10^3$) in milk and from $<100$ to $2.0\times10^6$ CFU/g (mean: $3.3\times10^3$) in cheese in the second year. The hygienic criteria over the process could be considered quite satisfactory, in relation to those permitted by the European Regulations (EC, 2007) and considering both the setting and the low amount of cheese produced every year. The level of $10^5$ at which the production of toxins might occur was never reached. However, coagulase positive Staphylococci were present in high counts: for this reason, control measures are strongly advised.

Even if we did not find any pathogens, a high number of Enterobacteriaceae were still present. Other authors reported lower counts, but not for all the samples of milk and cheese in Toma Piemontese (Astegiano et al., 2014); while for Montasio, milk and cheese at the same ripening time had lower counts (Maifreni et al., 2013). The hygienic conditions of some cheese factories, located at high altitude with possible contamination of water, environment, and supplies, could have been the reason for some high microbiological counts (Bhatt et al., 2012; Coton et al., 2012). Actions aimed at improving artisanal establishments conditions and training Food Business Operators (FBO), in order to decrease the microbial counts, have to be proposed.

Biogenic Amines (BAs) have been evaluated as a newly emerging risk in recent years (Ruiz-Capillas & Herrera, 2019; Moller et al., 2020; Pluta-Kubicza et al., 2020). The analysis of BAs was focused on Histamine (HIM) and Tyramine (TYR), as responsible for food intoxication, and on Cadaverine (CAD) and Putrescine (PUT) as responsible for the enhancement of the toxicity of the previous ones. For all of them, we observed a high variability for both years (Table 4). The two BAs responsible for food intoxication, histamine (HIM) and tyramine (TYR), were present in very low levels for both years with the exception of one produced during the first year (38.9 ppm). In the first year, they ranged between 0.2 and 38.9 ppm (mean value 8.3) for HIM, and between 0.1 and 2.6 ppm (mean value 1.5 ppm) for TYR. In the second year, they ranged between 0.3 and 18.4 ppm (mean

| Sample | Putrescine Mean±SD | Cadaverine Mean±SD | Histamine Mean±SD | Tyramine Mean±SD |
|--------|---------------------|---------------------|-------------------|-------------------|
| 1      | 0.6±0.4c             | 2.4±0.2c            | 0.3±0.2c          | 5.4±1.0cd         |
| 2      | 0.8±0.3c             | 0.4±0.1d            | 0.2±0.07c         | 4.9±1.8de         |
| 3      | 1.1±0.4bc            | 4.3±0.4ac           | 1.4±0.01c         | 3.5±0.6            |
| 4      | 0.8±0.3c             | 7.2±2.3a            | 1.1±0.6c          | 38.9±1.1a         |
| 5      | 12.0±0.8b            | 0.4±0.1d            | 7.2±3.0b          | 0.5±0.3f          |
| 6      | 0.2±0.01c            | 1.6±0.8bcd          | 0.2±0.03c         | 0.2±0.01f         |
| 7      | 25.0±3.7a            | 0.8±0.2cd           | 31.4±2.4a         | 1.5±1.0cd         |
| 8      | 0.7±0.2c             | 4.6±0.1ab           | 0.2±0.01c         | 1.2±0.04f         |
| 9      | 0.7±0.2c             | 0.4±0.1d            | 1.7±0.5c          | 6.1±0.1c          |

Different letters for different p-values.
value 4.5 ppm) for HIM, and between 0.4 and 8.5 ppm (mean value 2.8 ppm) for TYR. The quantity we found was within the levels considered safe for both BAs (Manca et al., 2020).

Putrescine ranged between 0.2 and 25.0 ppm (5.8 ppm mean value) and between 0.4 and 7.2 ppm (2.4 ppm mean value), respectively. Cadaverine ranged between 0.2 and 31.4 ppm (4.8 ppm mean value) and between 0.2 and 3.5 ppm (1.2 ppm mean value), respectively.

Overall, the total amount of BAs, ranged between 0.7 to 58 ppm (20.4 ppm mean value) in the first year, and from 2.3 to 21.4 ppm (10.9 ppm mean value) in the second year. Even in this case, as stated above for the two BAs separately, the total amount of BAs never reached the warning amount set for food (Manca et al., 2020); this threshold may be precautionary and, as stressed by many authors, lacks in reliability given the few data available about food consumption (Combarros-Fuertes et al., 2016; EFSA, 2011). This threshold was stated at 900 mg/kg, in absence of co-factors, and 100 mg/Kg if this consumption was associated to co-factors, such as pharmacological treatments with amine oxidase inhibiting substances, pathological status of gastrointestinal apparatus or alcohol (Manca et al., 2020; Reinholds et al., 2020).

Cheese has been considered suitable for the presence of mycotoxins, due to the presence of aflatoxins in milk, and the possibility of developing toxigenic molds in storage rooms and on the cheese crust (Decontardi et al., 2018; Kalinina et al., 2018; Moller et al., 2020; Kadakal et al., 2020). Another way of contamination was identified in the dairy tools used in the cheese-making process (Casquete et al., 2018). Among them, Penicilli and Aspergilli were the most detected (Montel et al., 2014; Casquete et al., 2018; Decontardi et al., 2018).

We carried analysis regarding the presence of Ochratoxin A and Patulin (Paterno et al. 2013; Ioi et al. 2017; Camaldo Leggieri et al. 2020).

Ochratoxin A was never detected in the examined samples, while patulin was detected in one sample at level of 10.0 ± 1.2 μg/kg. This situation was also confirmed by other studies, considering other traditional cheeses (Anelli et al., 2019; Kadakal et al., 2020).

For this reason, we might say that safety is assured for the considered mycotoxin (Reinholds et al., 2020). More investigation has to be performed to confirm the present results, and to detect other mycotoxins, even if regarding Aflatoxin M1 its presence is unlikely, given the way grazing animals are fed during the production period (June-July) (Rojas-Marin et al. 2018; Ráduy et al., 2020).

The detected levels were far from the toxic dose established for patulin by the European Union (25 μg/Kg), even if considering the one settled for solid products (Ioi et al., 2017).

The reason for such low quantities could be explained by many factors, influencing molds growth and mycotoxins productions: small quantity of carbohydrates, available in these ripened cheeses, strong bacteria antagonism, and a not optimal extrinsic factors for the mycotoxins production (Casquete et al., 2018; Camaldo Leggieri et al., 2020). In our opinion, temperature might have been a very important factor for the low quantity of this mycotoxin we observed (Camaldo Leggieri et al., 2020).

Conclusions

Traditional food answers to many consumers’ needs at multiple levels. First, it has been recognized as an important tool to create an added value production among the EU member states (Balogh et al., 2016); the EU itself encourages this policy, recognizing specific regulations such as PGI and PDO, or the corresponding national specifications. Second, it provides an answer to consumers in order to hinder globalization, promoting the local food culture and being an alternative to the intensive production which are less sustainable from the environmental point of view (Fernández–Ferrín et al. 2018). Lastly but not least, local food production represents a strong connection to tradition, local identity, culture, and an improved employment opportunity for rural areas, where the economy is relatively weak. Traditional food producers and, in particular traditional cheese producers must manage safety issues following a day-by-day empirically based (Montel et al., 2014). Nonetheless the results of this study did not show significant risk for human health due to consumption of Plaisentif cheese.

This was the first attempt to evaluate and assess the food safety of Plaisentif. All data will be a valuable starting point for the implementation of a hygienic criteria based production in mountainous cheese-making factories. All the improvements will lead to a new identity of such products and a valuable help in order to provide effective certification and regulatory systems that are vital to achieve higher standards of quality while protecting the integrity of traditional food products.

References

Anelli P, Haidukiwski M, Epifani F, Cimmerarusti, AT, Moretti A, Logrieo A, Susca A, 2019. Fungal mycobiota and mycotoxin risk for traditional artisanal Italian cave cheese. Food Microbiol 78:62–72.

Astegiano S, Bellio A, Adriano D, Bianchi D M, Gallina S, Gorlier A, Gramaggia M, Lombardi G, Macori G, Zuccon F, Decastelli L, 2014. Evaluation of hygiene and safety criteria in the production of a traditional Piedmont cheese. Ital J Food Saf 1705:160–163.

Balogh P, Békési D, Gortin M, Popp J, Lengyel P, 2016. Consumer willingness to pay for traditional food products. Food Policy, 61:176–184.

Bhatt VD, Ahir VB, Koringa PG, Jakharesa DN, Rank DN, Naurial, DS, Kunjada AP, Joshi CG 2012. Milk microbiome signatures of subclinical mastitis affected cattle analysed by shotgun sequencing. J App Microbiol 112:639–50.

Camaldo Leggieri M, Pietri A, Battilani P 2020. Modeling fungal growth, mycotoxin production and release in Grana cheese. Microorganisms 8:69.

Casquete R, Benito MI, De Guía Cordoba M, Ruiz-Moyano S, Galván, AI, Martin A 2018. Physicochemical factors affecting the growth and mycotoxin production of Penicillum strains in a synthetic cheese medium. Lebensm Wiss Technol 89:179–185.

European Commission, 2007. Regulation of the European Commission of 5 December 2007 (EC) amending Regulation No 2073/2005 on microbiological criteria for foodstuffs, 1441/2007/CE. In: Official Journal, L322/12, 7/12/2007.

Combarros-Fuertes P, Fernández D, Arenas R, Diezhandino I, Tornadijo, MA, Fresno JM 2016. Biogenic amines in Zamorano cheese: factors involved in their accumulation. J Sci Food Agric 96:295–305.

Coton M, Delbés-Paus C, Irleringer F, Desmasures N, Le Fleche A, Stahl V, Montel MC, Coton E, 2012. Diversity and assessment of potential risk factors of gram-negative isolates associated with French cheeses. Food Microbiol 29:88–98.

Cunha SC, Faria MA, Fernandes JO, 2009. Determination of patulin in apple and quince products by GC–MS using 13C5–7 patulin as internal standard. Food Chem 115:352-9.

Dalmasso A, Soto del Rio, MD, Civera T, Pattono D, Cardazzo B, Bottero MT,
2016. Characterization of microbiota in Plaisentif cheese by high-throughput sequencing. Food Sci Technol-Leb 69:490–6.

Decontardi S, Soares C, Lima N, Battilani P, 2018. Polyphasic identification of Penicillia and Aspergilli isolated from Italian Grana cheese. Food Microbiol 73:137–49.

EFSA Panel on Biological Hazards (BIOHAZ), 2011. Scientific opinion on risk-based control of biogenic amines formation in fermented food. EFSA J 9:2393.

Fernández-Férrín P, Calvo-Turrientes A, Bande B, Artaraz-Miñón M, Galán-Ladero MM 2018. The evaluation and purchase of food products that combine local, regional and traditional features: The influence of consumer ethnocentrism. Food Qual Prefer 64:138–147.

Gennaro MC, Gianotti V, Marengo E, Pattno D, Grosso A, Stocco PP, Pazzi M, 2013. Survey of the presence of patulin and ochratoxin A in traditional semi-hard cheeses. Food Control 33:54–57.

Ioi DJ, Zhou T, Tsao R, Marcone MF, 2017. Mitigation of patulin in fresh and processed foods and beverages. Toxins 9:157.

Kalinina SA, Jagels A, Hickert S, Mauriz Marques LM, Cramer B, Humphf, HU 2018. Detection of the cytotoxic penitrem A-F in cheese from the European market by HPLC-MS/MS. J Agr Food Chem 66:1264-9.

Kokkonen M, Jestoi M, Rizzo A, 2005. Determination of selected mycotoxins in mould cheeses with liquid chromatography coupled to tandem mass spectrometry. Food Add Contam 22:449e456.

Maiereni M, Frigo F, Bartoloceti I, Innocente N, Biasiutti M, Marino M, 2013. Identification of the Enterobacteriaceae in Montasio cheese and assessment of their amino acid decarboxylase activity. J Dairy Res 80:122-127.

Manca G, Ru A, Siddi G, Mocci AM, Muritru G, De Santis PL, 2020. Biogenic amines content in Fiore Sardo cheese in relation to free amino acids and physicochemical characteristics. Ital J Food Saf 9:48–53.

Møller COA, Ücok EF, Rattay FP, 2020. Histamine forming behavior of bacterial isolated from aged cheese. Food Res Int 128:108719.

Montel MC, Buchin S, Mallet A, Delbes-Paus C, Vuition DA, Desmasures N, Berthier F, 2014. Traditional Cheeses: rich and diverse microbiota with associated benefits. Int J Food Microbiol 177:136–54.

Moret S, Conte LS, 1996. High-performance liquid chromatographic evaluation of biogenic amines in foods. An analysis of different methods of sample preparation in relation to food characteristics. J Chromatogr A 729:363–9.

Pattno D, Grosso A, Stocco PP, Pazzi M, Zeppa G, 2013. Survey of the presence of patulin and ochratoxin A in traditional semi-hard cheeses. Food Control 33:54–57.

Ráduly Z, Szabó L, Madar A, Pócsi I, Csernoch L, 2020. Toxicological and medical aspects of Aspergillus-derived mycotoxins entering the feed and food chain. Front Microbiol 10:2908.

Reinholds I, Rusko J, Pugajea I, Berzina Z, Jansons M, Kirilina-Gutmante O, Tihomirova, K, Bartkekevics, V 2020. The occurrence and dietary exposure assessment of mycotoxins, biogenic amines, and heavy metals in mould-ripened blue cheeses. Foods 9:93.

Rojas-Marín V, Carvajal-Moreno M, González-Villaseñor MC, García-Hernández EA, González-Mendoza A 2018. Presence of Aflatoxin carcinogens in fresh and mature cheeses. Pharm Anal Acta 9:100058.

Ruiz-Capillas, C, Herrero AM 2019. Impact of biogenic amines on food quality and safety. Foods 8:62.