Chapter N 093

**The likely effect of the rise in global temperature on cheese safety.**

**Abstract:** Global warming is a current global concern affecting food safety since the rising temperature could influence microbial ecology, resulting in the growth and activity of certain bacterial strains producing toxic substances. Rising temperatures jeopardize the safety of fermented products such as cheese. During the cheese ripening, the amino acids liberated through the proteolytic phenomena are substrates for secondary catabolic reactions through bacteria, resulting in the release of substances with a potential negative impact on human health, such as biogenic amines. Therefore, the present work considered the content of biogenic amines in a sheep’s milk cheese produced during the winter and spring period to evaluate the effect of the increment of temperature on the production of these toxic compounds and obtain information on the potential impact of global warming on the safety of cheese. The results showed that the spring production had a content of biogenic amines higher than the winter ones. Given that the lengthening of the warm seasons due to the change in the climatic conditions is expected, producers should take action to ensure cheese safety and limit the adverse effect of the rising temperature.

**Keywords:** global warming, toxic compounds, cheese safety.

1. **Introduction**

The rise in global temperature, poses a risk to the food system. These severe weather conditions threaten food production worldwide with severe effects on food security and, in addition, food safety. The change in the weather conditions could cause, enhance, or modify the occurrence and intensity of some food-borne diseases since it affects the dominance and persistence of various parasites, fungi, and viruses, harmful to plant and animal health. The increment in temperature can promote the growth and activity of microorganisms or fungi producing toxic substances (Duchenne-Moutien & Neetoo, 2021). In this respect, several research highlighted that the increment in temperature and humidity could favor the production of the carcinogenic mycotoxins in cereal crops (Marroquín-Cardona et al., 2014). The change in the weather conditions might pose a risk also for fermented foods, such as cheese since the increment in temperature can promote the growth and activity of certain microorganisms producing biogenic amines (Loizzo et al., 2013). Therefore, this research aims to evaluate the variation in the free amino acids and biogenic amines content in sheep’s milk cheese during the winter and spring to provide insight into the effect of the temperature increment on this food.

#  Review of the literature

Biogenic amines at low concentrations are essential for natural metabolic and physiological functions in animals, plants, and microorganisms. Nevertheless, biogenic amines accumulation in food may have a toxicological effect and pose a food safety risk, especially for susceptible consumers. Though biogenic amines are usually detoxified by monoamine oxidase (MAO) and diamine oxidase (DAO) in the small intestine, toxic effects may arise through amine oxidase oversaturation due to high concentrations of biogenic amines or when detoxifying activity is impaired due to the use of monoamine oxidase inhibitors (MAOI), alcohol consumption or gastrointestinal disorders. Tyramine, histamine, tryptamine, β- phenylethylamine, putrescine, cadaverine, spermidine, and spermine are the most common biogenic amines in foods. Food rich in tyramine is associated with the "cheese syndrome" with symptoms such as hypertension, headaches, migraine, neurological disorders, and gastrointestinal symptoms (Özogul & Özogul, 2019). Likewise, consuming food with high histamine content can cause neurological, gastrointestinal, circulatory, respiratory disorders, flushing, rashes, and urticarial. Other amines, such as putrescine and cadaverine, are also precursors of carcinogens, e.g., N-nitrosamine. The biogenic amines could be in high content in sheep’s milk cheeses (Loizzo et al., 2013; Manca et al., 2015; Zazzu et al., 2019). These toxic compounds can be produced in fermented foods mainly by the decarboxylation of amino acids liberated through proteolysis by microorganisms with aminoacyl decarboxylase activity (Linares et al., 2012). In cheese, decarboxylase-producing strains could be provided by milk, some starter cultures, or microbial contamination. Proteolysis, with the consequent release of free amino acid precursors of biogenic amines, is affected by rennet and enzyme activity or microbial fermentation during cheese production and ripening.

Storage temperature is a risk factor for the formation and accumulation of biogenic amines in sheep’s milk cheese since the high temperature can favor the growth and activity of the decarboxylase-producing microorganisms and, as a result, the production of biogenic amines (Loizzo et al., 2013).

**3. Material and method**

*3.1 Sampling*

Sheep’s milk cheese samples were obtained from 3 farms located in Sardinia (Italy). The samples were collected after four months of ripening and produced in the winter and spring period.

*3.2* *Analyses of the free amino acids and biogenic amines*

The free amino acids and biogenic amines were determined by HPLC-FL (high-performance liquid chromatography with fluorescence detection). The method employed for the extraction and derivatization of the nitrogenous compounds considered as well as the chromatographic conditions utilized were described in previous work (Manca et al., 2020).

*3.3 statistical analysis*

The Anova method for analysis of variance was used to assess differences between means in relationship with the season of production. The Pearson correlation test was employed to analyse the correlation between the measured variables (p=0.01).

1. **Results and discussion**

From winter to spring, the level of the total biogenic amines significantly (p≤0.001) increased, reaching in the warm period a mean value (708.9±330.1 mg/Kg,) almost two times higher than that measured in the samples produced in the cold ones (table 1).

Table 1. Content of the biogenic amines and total free amino acids (mg/Kg) in cheese produced in winter and spring from three farms.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Producer** |  **Period of production** | **ANOVA** **(p value)** |
|  |  | **Winter** | **Spring** |  |
|  |  |  |  |  |
| Tryptamine | E | 7.5±10.4 | 6.7±5.2 |  |
|  | A | 5.5±5.0 | 8.33±4.1 |  |
|  | C | 21. 7±4.1 | 18.3±9.8 |  |
|  | Mean TOT | 11.7±10.4 | 11.1±8.3 | 0.703 |
|  |  |  |  |  |
| Phenylethylamine | E | 5.2±7.6 | 35.3±35.1 |  |
|  | A | 8.33±7.5 | 21.67±31.3 |  |
|  | C | 31.7±7.528 | 23.3±10.3 |  |
|  | Mean TOT | 13.9±14.6 | 19.4±18.6 | 0.100 |
|  |  |  |  |  |
| Putrescine | E | 70.0±38.2 | 258.3±123.0 |  |
|  | A | 26.67±15.1 | 120±32.9 |  |
|  | C | 278.3±82.3 | 303.3±104.4 |  |
|  | Mean TOT | 129.4±121.2 | 190.6±124.5 | 0.063 |
|  |  |  |  |  |
| Cadaverine | E | 20.4±16.0 | 50.0±21.9 |  |
|  | A | 20±6.3 | 43.33±23.4 |  |
|  | C | 50.0±31.6 | 50.0±31.6 |  |
|  | Mean TOT | 31.1±24.2 | 35.0±22.5 | 0.440 |
|  |  |  |  |  |
| Histamine | E | ND | 23.3±57.2 |  |
|  | A | ND | 18.3±29.9 |  |
|  | C | ND | 15.2±32.1 |  |
|  | Mean TOT | ND | 18.9±39.2 | 0.062 |
|  |  |  |  |  |
| Tyramine | E | 227.5±119.9 | 478.3±214.9 |  |
|  | A | 115.2±65.1 | 490.3±359.5 |  |
|  | C | 315.0±47.6 | 315.0±47.6 |  |
|  | Mean TOT | 203.9±109.7a | 433.9±223.5 | 0.000 |
|  |  |  |  |  |
| Total BA | E | 330.3±100.2 | 851.7±349.7 |  |
|  | A | 175.2±64.4 | 701.67±436.7 |  |
|  | C | 696.7±150.5 | 696.7±150.5 |  |
|  | Mean TOT | 390.0±250.6 | 708.9±330.1 | 0.001 |
|  |  |  |  |  |
| Total FAA | E | 8135.0±2517.9 | 10098.3±2417.5 |  |
|  | A | 5093.3±2606.6 | 12533.3±5494.3 |  |
|  | C | 7088.3±930.3 | 10668.33±1992.2 |  |
|  | Mean TOT | 6450.0±2119.5 | 10907.2±3545.4 | 0.000 |
|  |  |  |  |  |

ND= Not determined

The weather conditions could favour microbial growth and decarboxylase activity (Renes et al., 2020) during the ripening process. As found in other ewe’s milk cheeses (Schirone et al., 2012; Manca et al., 2015; Zazzu et al., 2019), tyramine was the main biogenic amine accounting for 52 % and 61 % of the total biogenic amines in winter and spring, respectively. Putrescine was the second most represented amine, while cadaverine, β-phenylethylamine, and tryptamine were observed in a low concentration or not found. Histamine was essentially detected in the samples produced in the warm period. Spermine and spermidine were not detectable in this cheese. Considering that biogenic amines are most often associated with food poisoning, threshold values for their content in food were suggested. Based on the limit of 900 mg/Kg proposed by Shalaby (1996) for the total content of biogenic amines in food, the mean levels of total biogenic amines in sheep’s milk cheese did not exceed this amount in the winter and spring productions. The samples produced during the spring season presented high biogenic amine contents, close to the suggested limit.

Table 2. Pearson correlation coefficients among the total free amino acids and biogenic amines measured in sheep’s milk cheese.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | Tot Total FAA1 | Total BA2 | Tryptamine | Phenyl-ethylamine | Putrescine | Cadaverine | Histamine | Tyramine |
| Total FAA | 1 | ,807\*\* | ,050 | ,465\*\* | ,416\*\* | ,531\*\* | ,573\*\* | ,856\*\* |
| Total BA | ,807\*\* | 1 | ,234 | ,735\*\* | ,725\*\* | ,587\*\* | ,61(\*\* | ,956\*\* |
| Tryptamine | ,050 | ,234 | 1 | ,117 | ,497\*\* | ,129 | -,155 | ,107 |
| Phenyl-Ethyl amine | ,465\*\* | ,735\*\* | ,117 | 1 | ,428\*\* | ,31(\* | ,358\*\* | ,737\*\* |
| Putrescine | ,416\*\* | ,725\*\* | ,497\*\* | ,428\*\* | 1 | ,373\*\* | ,139 | ,533\*\* |
| Cadaverine | ,531\*\* | ,587\*\* | ,129 | ,315\* | ,373\*\* | 1 | ,439\*\* | ,514\*\* |
| Histamine | ,57(\*\* | ,614\*\* | -,155 | ,358\*\* | ,139 | ,439\*\* | 1 | ,600\*\* |
| Tyramine | ,856\*\* | ,956\*\* | ,107 | ,737\*\* | ,533\*\* | ,514\*\* | ,600\*\* | 1 |
|   |  |  |  |  |  |  |  |  |

\*\* Correlation is significant at the P< 0.01. \* Correlation is significant at the P< 0.05.

1= Free amino acids; 2= Biogenic amines

The total content of free amino acids, considered an index of proteolysis, significantly increased (p≤0.000) as the seasons changed, reaching in the spring production the mean value of 16,356.5±3,588.7 mg/Kg, two and a half times higher than that found in winter. Renes (2021) confirmed this behaviour in Spanish sheep milk cheese, in which samples produced in spring after 100 days of ripening presented values of total free amino acids similar to the more mature winter products (180 days). As highlighted through the Pearson correlation test (table 2), the total biogenic amines, as well as the individual biogenic amine content, were significantly correlated with the total free amino acids (p≤0.01). This result confirmed an interrelationship between the availability of free amino acids and the production of biogenic amines (Loizzo et al., 2013; Manca et al., 2015; Manca et al., 2020). Glutamic acid, leucine, lysine, and valine, were the free amino acids most frequently recorded. The free amino acid profile in artisanal sheep’s milk cheese was similar to that discovered in other types of ewe’s milk cheese (Manca et al., 2015).

**5. Conclusions and future perspectives.**

During the warm period, the proteolysis phenomena and the microbial decarboxylase activity were more intense. Consequently, the rise in the biogenic amine content was observed. Considering that global warming is expected to affect the start, duration, and intensity of the warm season, thus, in the future, the weather conditions favourable for the development of biogenic amines in cheese might persist for periods of the year longer than the current ones. Further studies are needed to deepen the complex relationship between the intrinsic and extrinsic factors involved in the formation of the biogenic amine in cheese and to propose appropriate technological options to reduce the risk of the adverse impacts of the change in the weather conditions on the safety of the sheep’s milk cheese.

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