Emir. J. Food Agric. 2013. 25 (6): 409-417
doi: 10.9755/ejfa.v25i6.12496
http://www.ejfa.info/

FOOD SCIENCE AND NUTRITION

Determination of the quality of cheese "Chihuahua" type: Sensory and physicochemical approaches

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Abstract

The physicochemical and sensory characteristics of eight formulations from Chihuahua cheese with differences in the number of maturation days were studied. There were significant differences in their (pH, internal temperature and color). Sensory characterizations were carried out by sorting task technique with a panel of 12 assessors. The sensory maps were analyzed by using Multidimensional Scaling (MDS) and Correspondence Analysis (CA) while a spatial comparison between configurations of physiochemical and sensory data were validated by the Multiple Factor Analysis (MFA) and *Rv coefficient*. A lexicon of 22 sensory attributes was generated by the assessors which further allowed them to discriminate cheese samples. The cheese eventually developed different attributes with respect to their maturation, especially in aspects of texture and aroma. A comparison of spatial configurations using Rv coefficients showed a moderate correlation between the methods of analysis. However, updates may be necessary for a complete sensory characterization by techniques such as QDA® for further study of Chihuahua cheese quality evaluation by consumers.

Key words: Chihuahua cheese, Physicochemical analysis, *Rv coefficient* and Sorting task

Introduction

Hispanic-style cheeses are cheeses developed in México, Latin America, and the Caribbean and are usually based on European cheese-making traditions but modified to accommodate local cheese-making conditions and consumer preferences (Van Hekken and Farkye, 2003). Although Chihuahua cheese is one of the major varieties of cheese consumed in northern Mexico and is usually consumed within one month after being manufactured, because after this time, the sensory characteristics perceived with great intensity in Chihuahua cheese, only a few papers have been published on its chemical and sensory properties (Van Hekken et al., 2008). In the Mexican state of Oaxaca, milk production is destined for the manufacture of different cheeses (López et al., 1997; Morales et al., 2003); the sensory attributes play an important role in the selection of a product by consumers (Issanchou et al., 1997) and at the same time, they are used for the sensory characterization (Ramón et al., 2011). The chemical and physical changes that occur during ripening cause the body of the freshly made cheese to lose its firmness and tough curd texture to become soft. Cheese ripening is a complex process involving many physicochemical changes such as pH changes and protein breakdown (Karoui and Dufour, 2003). Although research on sensory evaluation developed by Bárcenas et al., 2004; Drake et al., 2005; Ramón et al., 2011) have characterized different kinds of cheeses, there are currently few studies on the sensory quality of Chihuahua style cheese (Van Hekken et al., 2006; Van Hekken et al., 2008). However, this type of method, called sensory profile, is quite efficient but also very expensive and time consuming so most industries cannot routinely use this technique (Chollet et al., 2011). For this reason, it is necessary to develop other sensory methods in order to obtain sensory information about these products. As examples of new techniques for

Received 21 May 2012; Revised 15 October 2012; Accepted 02 January 2013; Published Online 02 April 2013

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sensory description we have free sorting task or categorization (Abdi et al., 2007). However, during a task of categorization, products groups are formed based on the dissimilarities/similarities between among them to give us information about the criteria used by each judge (Cadoret et al., 2011). According to Bécue and Le (2011) and Leliévre et al. (2008) the sorting task is a cognitive process consisting of asking assessors to group items depending on their resemblances. This long-term practice task is gaining importance in sensory analysis to evaluate products from a global point of view (holistic approaches) and to compare different types of assessors (such as trained or naïve). In the sensory domain, sorting tasks were used in description of products such as beers (Chollet and Valentin, 2001; Leliévre et al., 2008; Chollet et al., 2011), wines (Bécue and Le, 2011), olive oil (Santosa et al., 2010) and cheese (Tang and Heymann, 2002; Nestrud and Lawless, 2009). Multidimensional scaling (MDS) is a useful statistical technique for generating perceptual maps that can systematically represent the similarity/dissimilarity of products in a spatial map (Tang and Heymann, 2002; Nestrud and Lawless, 2009). Other statistical techniques used are DISTATIS, Multiple Correspondence Analysis (MCA) (Chollet and Valentin, 2001, Abdi et al., 2007; Leliévre et al., 2008; Cadoret et al., 2009; Cadoret et al., 2011) and Correspondence Analysis (CA) (Chollet and Valentin, 2001;Bécue and Le, 2011). The information on the two different types of tools, physicochemical and sensory data, is very important to establish the quality of cheeses. Due the above, the use of multi-varied techniques such as Multiple Factor Analysis (MFA) and *Rv* coefficient allow for the determination of the degree of correlation between data on physiochemical and sensorial nature (Pagès and Husson, 2001; Husson et al., 2001).

Consequently, for the purpose of this study it was decided to investigate the changes in the sensory properties that occur during maturation and correlation with physicochemical data.

Materials and Methods

Samples of cheeses

Eight Chihuahua type cheeses were manufactured with lactic cultures (*Lactococcus lactys + cremoris*) and matured over different periods of days (0, 8, 10, 18, 24, 31, 34 and 41 days) in ripening chamber model Sobrinox rus 230 at a controlled temperature of 10°C. For the production of Chihuahua type cheese, the lactic cultures *Lactococcus lactys + cremoris* were used. They were shown at a temperature between 32-37° C for 45 minutes. At 32-35°C the rennet was added and left to set for 45 minutes. The cheese were prepared with whole milk and came from a single cow is why it was not necessary standardization fat protein. On obtaining a solid consistency, it was cut. The cut was made in a space of 2 cm and was carefully stirred to avoid mixing. Later, the curds were heated between 35 and 37°C and were left to set for 20 minutes, 2.5% salt is added and then it is pressed. The cheeses were cut into cubes of 3.5 x 3.5 cm and were sensorially and physicochemical evaluated at a temperature of 25°C (Bárcenas et al., 2004; Drake et al., 2009a; Drake et al., 2009b). The cheeses were transported in Styrofoam coolers on ice. Upon receipt, the cheeses were stored at 5ºC in the dark until analysis.

Physicochemical analysis

pH

The pH was measured on cheese slurry prepared from 10 g of cheese and 10 g of distilled water using a potentiometer Hanna model HI 99163 (Hernández et al., 2010).

Internal cheese temperature

A Hanna model HI 99163 potentiometer/ thermometer with an insertion electrode was used according to Villegas de Gante (2004). The temperature and pH are two of the factors that can influence microorganism growth in the lactic cultures being those temperatures in the range of 15 and 20°C where the maturation of semi hard doughy cheeses such as the Chihuahua cheese occurs.

Color measurements

In order to determine the color of the Chihuahua cheese samples**,** cross sections were analyzed by using Hunter X-rite model HI SP60L colorimeter, registering the value of L* [brightness, from 0 (dark) to 100 (light)] and *b**[from -60 (blue) to +60 (yellow)]. Before taking the measurements, the instrument was calibrated with its white reference tile. The color was measured in the grated cheeses (15 g) within the test tubes (27 mm diameter, 250 mm length). Eight to ten readings were taken from each test tube and the average value was used. The L* (whiteness) and b* (yellow to blue) values were used to evaluate color changes for the samples (Hernández et al., 2010). The pH, internal temperature and color analyses were performed four times.

Sensory analysis

Sorting task procedure

The panel dedicated to the sorting was composed of 12 assessors (6 men and 6 women) aged from 20 to 28 were recruited students and personnel in the laboratory analysis and Food technology from the University of the Sea, Campus Puerto Angel, Oaxaca, Mexico. These assessors had previous experience in the evaluation of dairy products. The evaluation of cheese consisted of one single session. The sorting task procedure was realized according to Chollet and Valentin (2001), Leliévre et al. (2008) and Chollet et al. (2011). The assessors were presented with the entire set of cheese. The order of presentation of the samples was randomized prior to presentation and so it was different for each assessor. The assessors started by tasting all the cheeses, one at time. The assessors were free to make as many groups of cheeses between 2 and 7 (acoording to similar properties sensory) as they wanted and to put as many cheeses as they wanted into each group. Subjects are told that they must sort the samples into no fewer than two groups and into no more than 7, to ensure a group structure (Faye et al., 2004). After they had finished their sorting task, the assessors were asked to describe each group of cheese.

Data coding

Encoding free sorting data

For each assessor, the results are encoded in an individual similarity matrix (cheese x cheese), in which 1 stands for two samples set in the same group and 0 for two samples put in different groups. These individual matrices are added for all subjects or for sub-groups of subjects. The result co-occurrence matrix represents the global similarity matrix in which larger numbers indicate higher similarity between samples. The assumption underlying this method is that samples grouped together are more similar than samples sorted into different groups (Popper and Heymann, 1996).

Encoding terms

Each subject describes each group of products with words and expressions. For each subject, the terms given for a group of cheese are associated with each product from the group. The underlying assumption is that all the cheeses of the group are described by the terms in the same way. An occurrence matrix (Cheese x Attributes) is provided by the assessors. The global terms matrix is calculated by adding individual matrices. The resulting contingency table was then reduced and simplified (1) Attributes having similar meanings were grouped by the sensory analyst; (2) Only attributes having quotations for an attribute by the total possible number of quotations at a frequency higher or equal to 3 % are kept for the comparison of cheeses. This percentage was calculated by dividing the number of quotations for an attribute by the total possible number of quotations. Finally only the words whose frequency is at least 3 were left (Faye et al., 2004, 2006).

Statistical analysis

Sensory map of product and correlation physicochemical- sensory analysis

The resulting co-occurrence matrix was submitted to an MDS analysis in order to derive a spatial representation of cheese. The quality of fit was measured by the stress value, where the stress varies from 0 (perfect fit) to 1 (worst possible fit). A value below 0.2 is generally considered as a good agreement between the initial and final configuration (Chollet and Valentin, 2001; Leliévre et al., 2008; Chollet et al., 2011). The sensory map analyzed through CA offers a visualization of cheese, attributes and the associations between products and attributes (Perrin and Pagès, 2009; Bécue and Le, 2011). Sensory and physicochemical data were analyzed jointly using Multiple Factor Analysis (MFA) where the first step consists of performing a PCA per group of variables. Then, each variable is multiplied by the inverse of the first eigenvalue issued from the corresponding factor analysis. The internal configuration of each group is not modified. The second step consists of performing a PCA on the resulting data, yielding a configuration which takes into account all the weighed variables and measurements of the similarities between the date sensory and physicochemical given by the *Rv* coefficient (Lassoued et al., 2008). According to Cartier et al. (2006); Nestrud and Lawless (2008), an excellent agreement between configurations corresponds to a coefficient value close to 1 while Faye et al. (2004) concluded that there is a good agreement between two configurations at *Rv* values close to 0.67. MDS, CA, MFA and *Rv* coefficient were performed with the software XLSTAT, version 2009 (Addinsoft, New York, NY, USA).

Results and Discussion

In order to describe the cheese by sorting task, more than 20 attributes were generated by the assessors; however, other attributes such as fat odor, aroma of yoghurt, aged flavor, melts in the mouth were eliminated because of low frequency values. However, they were not statistically usable and they were not introduced in the CA. Figure 1 presents the 21 attributes which are used: acid, creamy, hard in the mouth, soft in the mouth, dry and yellow are included within the first more frequent words used by the assessors.

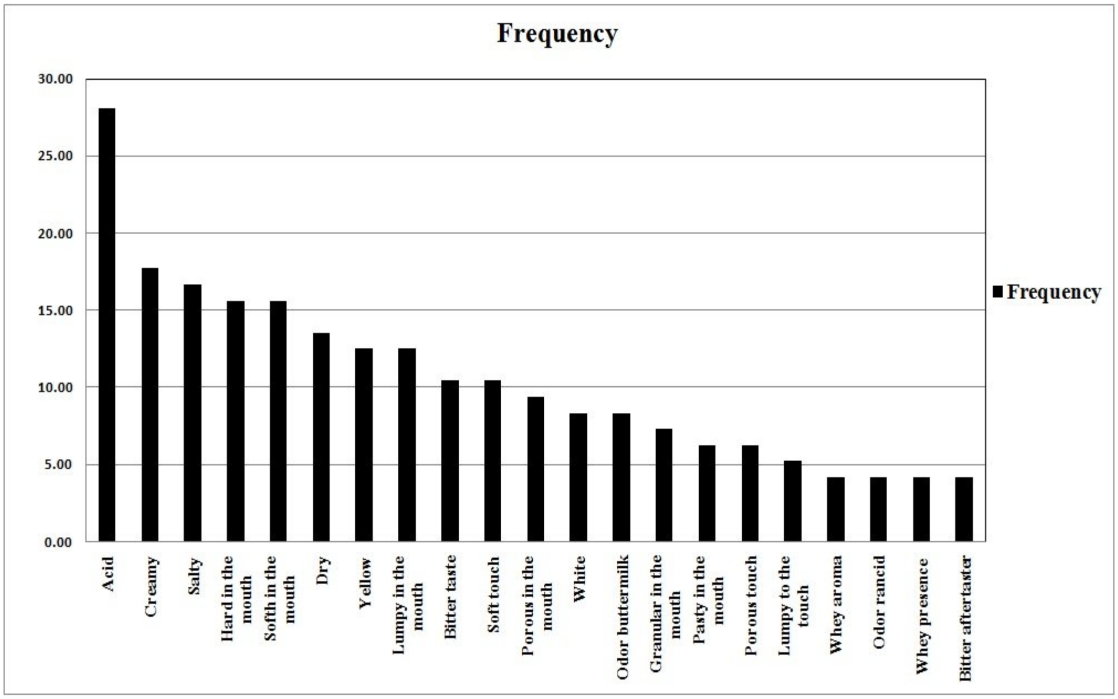


Figure 1. Glossaries of the most frequent word used.

Figure 2 shows the two-dimensional solution for multidimensional sorting data (Kruskal Stress= 0.14). This value confirmed the results obtained by Nestrud and Lawless (2010) who demonstrated the relative consistency of sorting data set of cheddar cheese (Kruskal Stress = 0.081). Tang and Heymann (2002) reported a Kruskal Stress value = as 0.12. The cheeses within the same general number of ripening days were plotted close together, especially in the cheeses with similar days of maturation. For example, the sensory map showed: cheeses H, A and D (group 1), cheese G and F (group 2), cheese E, B (group 3) and Cheese C (group 4). The CA was performed on the contingency table. Attributes having a quotation frequency higher or greater than 3 were introduced into the CA. The first factor of CA (see Figure 3) accounted for 82.60% of the total inertia and reveals that the cheese with 10 (A) and 18 (H) days maturation had a more acid intensity, bitter taste, soft to touch and mouthfeel. According to Hort et al. (1997) initially, that is within the first 7 to 14 days, residual coagulant enzymes are responsible for the relative rapid hydrolysis of the α_{s1}- casein to α_{s1}-l casein which reduces the rubbery texture of the cheese. This may be due to pH changes which are directly related to changes in the casein network. The cheese with 24 (F) and 31 (G) days respectively were classified as yellow, and salty. Aspects of texture were creamy and pasty mouthfeel. On the other hand, the cheeses B and E (34 and 41 days respectively) were described as hard and lumpy in the mouth. Hort et al. (1997) observed that the creamy character of the maturing cheddar cheese changes with time and shows a significant logarithmic relationship. However, the changes in the texture of the cheeses described above may be due to the result in the extent and type of protein–protein interactions in the protein network due to ripening (Karoui and Dufour, 2003). Where the increment in firmness and hardness could be attributed to the crystallization of the fat which will occur over time. Additionally, as proteolysis continues, less water is available which results in a harder, not as easily deformable cheese (Hort et al., 1997). Lawrence et al. (1987) observed that, during the second stage of maturation, the rate of proteolysis is considerably slower, with consequently less remarkable changes in the springiness and crumbliness attributes. Cheese texture may also change with the physical state of the fats depending on the storage temperature and time (Karoui and Dufour, 2003). The salt content of samples increased significantly until 30 days and then did not change statistically during the maturation period (Cambaztepe et al., 2009) as was occurred in the case of cheese G. On the other hand, the changes associated with aromas incremented with maturation time developing the attributes of bitter, acidic, buttermilk smell, rancid odor, and aroma of whey. Muir et al. (1996) observed the attributes of cheddar aroma, cheddar flavor and acid flavor that were generated during the course of cheddar cheese maturation.

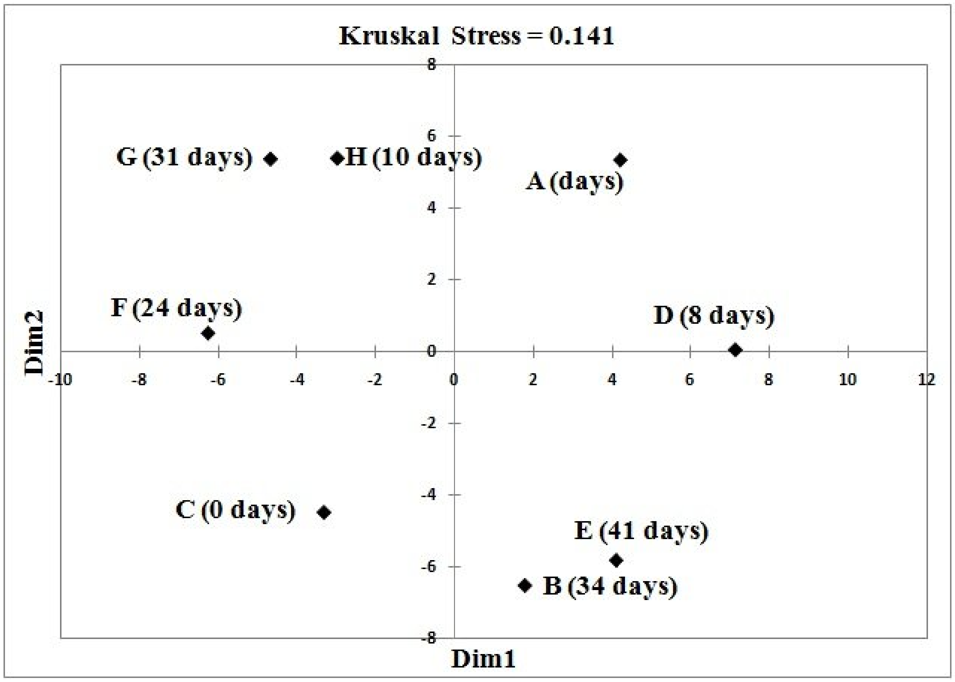


Figure 2. Perceptual space for cheese derived from multidimensional scaling for sorting data.

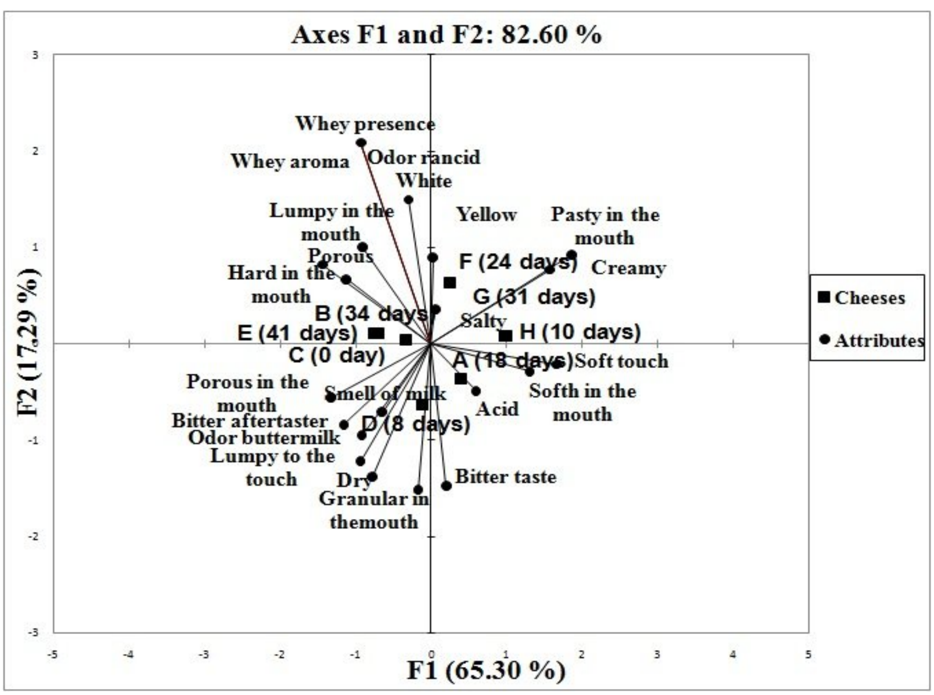
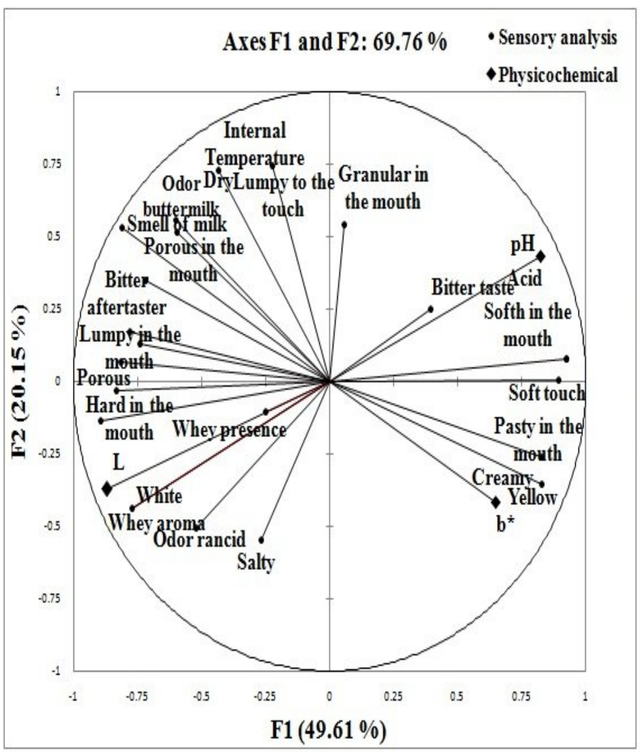


Figure 3. Cheeses and attributes projections on the first two dimensions of Correspondence Analysis.

Correlation of physicochemical and sensory analysis by MFA

The result of the first two principal axes of the MFA was 69.76% (see Figure 4). This value was higher than what was reported by Lassoued et al. (2008) at 51.42%, which noted similarities between the configurations of sensory description and instrumental data for the evaluation of bakery products using the flash profile. Figure 4 shows correlations between white and variable L* in the cheese C (0 days). On the contrary, variable b* is correlated with yellow (sensory), which is for the cheeses with more than 24 days of maturation (cheese F and G). According to Hernández et al. (2010), these differences in color were observed with increases in the yellowness at a greater ripening time. In other words, the L* value decreased significantly during ripening and increased the values b*, Pinho et al. (2004) observed this same effect during ripening (0 to 60 days) of “Terrincho” ewe cheese. The pH is correlated with acid and bitter taste which is attributed to acidification due to microbial growth (Hernández et al., 2010). According to Pinho et al. (2004) acidity increased slightly during ripening between 30 and 60 days. Internal temperature is correlated with attributes of dry, smell of milk and buttermilk odor.

The *Rv* coefficient provides a measure of similarity between the results of the methods of data collection and analysis. A high value of the coefficient would suggest that the methods were measuring the same underlying characteristics of the samples (King et al., 1998). The *Rv* coefficient for the physicochemical and sensory data were 0.51 which only reflected the differences between the two analysis methods for characterization of cheese A, B and G in which major differences between analysis for the evaluation of these cheeses, while in the cheeses C, D, E, F and H the distances between analysis were equidistant (see Figure 5).



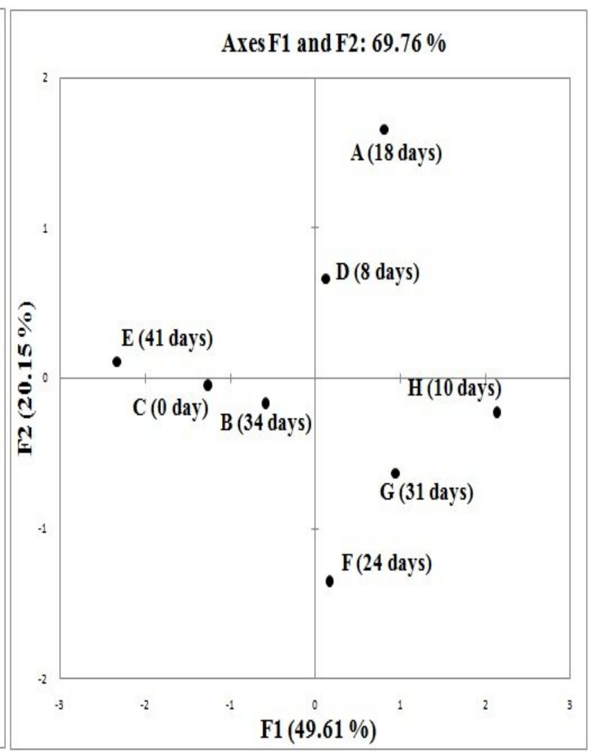


Figure 4. Correlation circle of Multiple Factor Analysis for physicochemical and sensory data.

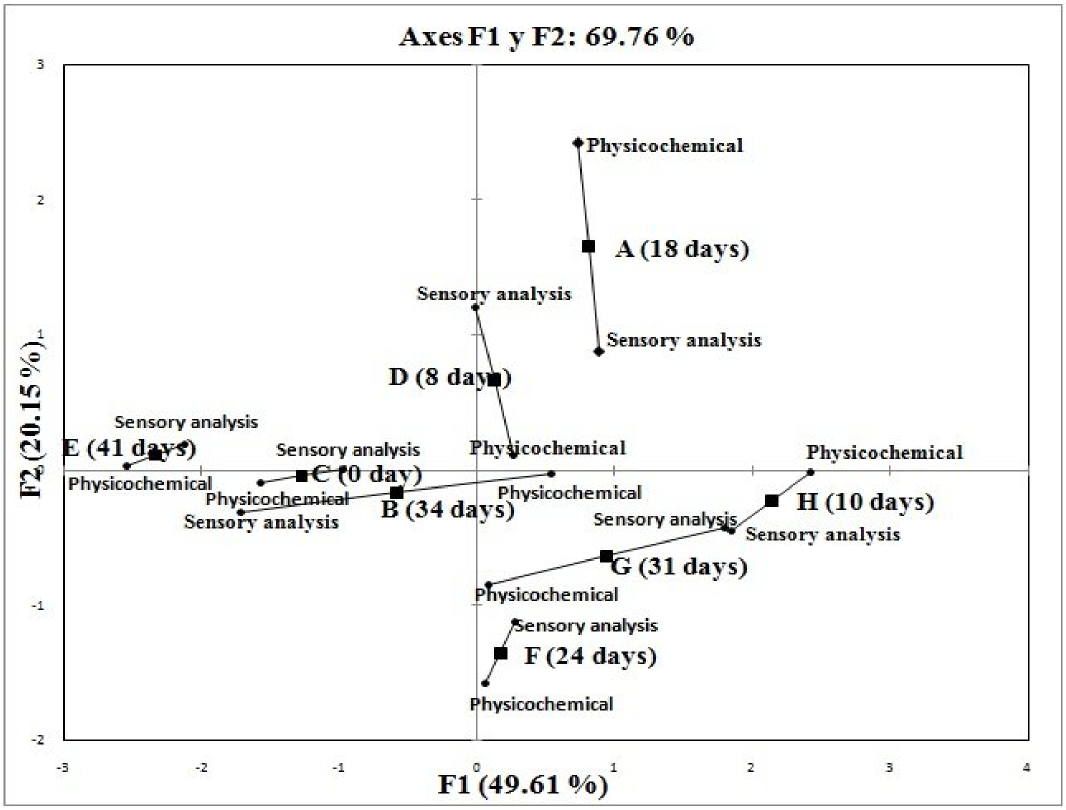


Figure 5. Multiple factor analysis on the table of the averages by the performed analysis.

Conclusion

It is clear from the preceding results that the main changes in physicochemical and sensory characters are associated with maturation. The combination procedures of sorting with multidimensional scaling analysis, correspondence analysis and multiple factor analysis showed in the perceptual map that the physicochemical and sensory properties are affected by biochemical processes such as proteolysis which caused changes in texture and aromas. However, updates may be necessary for a complete sensory characterization by techniques such as QDA® for further study of Chihuahua cheese quality evaluation by consumers.

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