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# Effects of Smoking on Surface Colour and Texture of Traditional Goat Cheeses

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**Abstract:** Forty eight Canarian goat cheeses were smoked using six different materials; shell of the almond (*Prunus aulcis*), segmented prickly pear cactus (*Opuntia ficus indica*), pine needles and wood of canary pine (*Pinus canariensis*), rose rock wood *(Cistus monspeliensis*) and heather wood *(Erica arborea)*. Cheeses were smoked at two different ripening times: 4 and 10 days, samples of 20-days-old were analyzed. Surface cheese colour was measured using a colorimeter, measuring Lightness, Croma and Hue angle, while texture characteristics were determined using the Texture Profile Analysis (TPA) obtaining five parameters for texture: fracturability, hardness, cohesiveness, adhesiveness and elasticity. Only Lightness was affected by the age of cheese at smoking process. Cheeses smoked with *Erica arborea* wood and *Pinus canariensis* wood were statistically the darkest, while the ones smoked with *Pinus canariensis* needle were the lightest. Almond shell and *Pinus canariensis* wood produced cheeses with the highest intensive colour whereas the products smoked with *Erica arborea* wood and *Pinus canariensis* needles were the least intensive. When a smoke produced a darker colour, the Croma was high and the Hue angle was far from yellow axis. For texture characteristic, in compression test, cheeses smoked with 10-days-old were more fracturable and hardness and less elastic than others smoked with 4-days-old while the material used for smoking only affected cohesiveness.

**Key words:** Goat, cheese, smoking materials, colour, texture profile analysis, Canarian cheeses

## INTRODUCTION

Smoking is one of the oldest ways to preserve food, but modern techniques of the food industry have relegated these old preservation techniques to second place. These days, the main objective of the smoking process is to give to the food certain characteristics of colour, odour and flavour (Möhler, 1980). Sensory quality is one of the most important attributes for the successful marketing of smoked cheeses (Bárcenas *et al*., 1988) and it is without doubt that for consumers external aspects play an important role in food quality. The colour of smoked products is the first attribute used to judge acceptability of smoked products (Riha and Wendorff, 1993).

Rheological and fracture properties are of great importance for the producer, the market and the consumer. They affect the action of eating (perceived in the mouth), the use (cut, grating, spread and melted), the manipulation, packaging and formation of eyes. These properties differ depending on the type of cheese, the stage of maturation and also depending on the composition of the cheese and its content of water, fat, salt, pH, protein degradation and environmental factors such as temperature (Walstra and Peleg, 1991).

In the Canary Islands (Spain) there are some traditional hand-made cheeses that have been smoked in the same way since at least the XV century. The smoking process uses six different materials: The shell of the almond (*Prunus dulcis*), segmented prickly pear cactus (*Opuntia ficus indica*), pine needles and wood of canary pine (*Pinus canariensis*), rose rock wood *(Cistus monspeliensis*) and heather wood *(Erica arborea).* This old smoking procedure involves the production of smoking vapours by pyrolysis of the described materials. These vapours are absorbed at the surface of the products and produce the characteristic golden brown colour on the surface of the food as a result of the reaction between the smoke carbonyls and the amino groups of protein of the food (Hollenbeck *et al*., 1973).

Today, the Canarian farm-cheese makers are making a great effort to adapt their workshops to the new technologies, while trying to conserve all the specific characteristics of their cheeses (Fresno *et al*., 2005). This

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paper is included in a research project CAL02-075-C3-1 Characterisation of Gomero and Herreño cheeses, smoking effects and determination of specific indicators. Optimisation of the experimental smoked-design of the Palmero cheese. This project includes cheese making characterisation, chemical composition that includes polycyclic aromatic hydrocarbons (Guillin *et al*., 2003) sensorial properties and consumers preferences. Therefore, the objective of this paper is to study the effect of the smoking material on colour surface and texture parameters of the cheeses while avoiding all other considerations.

## MATERIALS AND METHODS

The present study was carried out in the Animal Production Unit of Canary Agronomic Science Institute (ICIA). Under experimental conditions, 48 cheeses were made using milk from the Canarian goat breeds. All cheeses were made with the same procedure and according traditional techniques (Fresno *et al*., 2005). Cheese weights were from 1-1.5 kg. The cheeses were made on the same day as the milking. Milk was not pasteurized and no starter culture was added. After heating to 30±1°C, animal rennet commonly used farmers (commercial rennin powder, Marshall® rennet power 50% quimosin and 50% pepsin) was added, according to the instructions of the manufacturer, in order to obtain a clotting within 30-35 min. After coagulation, all curds were cut to obtain grains the size of millet. The presses were the same for all cheeses: 4.9 KPa for 5 h. Afterwards, salting was achieved by rubbing dry salt into the surface of the cheeses.

Smoking process was carried out four and ten days after cheese were elaborated (cheese aging at smoking), as is usual in these products (Fresno *et al*., 2002) that are consumed quite fresh (Fresno, 2000). Smoking was made, in the same conditions for all cheeses, with a traditional kiln; the smoke was produced by the direct and incomplete thermal degradation of 6 different materials (smoking materials) that are commonly used by the local cheese producers. Smoke temperatures, in°C, (maximum, average and minimum) for the diverse material were the following: almond-shell (39.20, 36.70, 34.00); heather wood (53.50, 46.50, 35.80); rose rock wood (62.40, 45.70, 40.90); segmented prickly pear cactus (47.00, 38.90, 26.20) pine needles (48.20, 36.10, 48.20) and pine wood (68.00, 56.10, 32.10). Forty eight samples (4 cheeses×6 smoking materials×2 cheese-aging at smoking) were analyzed at 20 ripening days.

Each cheese sample was analysed three times by a near infrared spectroscopy (Instalab 600, Foss Electric, Slangerupgad, Denmark), with previous calibrations: Total solids by Standard IDF 4A (IDF, 1982), fat by Standard IDF 52 (1991) and total nitrogen by Standard IDF 220B (1993). The pH was measured at 20°C by introducing a penetrometric electrode into some cheese. pH value was determined at room temperature (20°C) using a pHímeter inoLab ph Level 1.

Surface colour was recorded using a portable MINOLTA spectrocolourimeter (Minolta CR-400). CIE Ligthness (L), Croma and Hue angle values were read from the surface of the cheeses. The L value ranges from 0-100 and was used as a measure of lightness. Colour intensity was recorded using the Croma value and Hue angle was used as a measure of colour tone. Each colour test were performed on nine replicated in the product surface.

To analyse the texture, a Texture Analyser XT2i was used with two different tests, a 50 mm cylindrical one for the compression and a 5 mm one for the penetration. 12 cylindrical samples were obtained from each cheese with the aid of a 40 mm stainless steel manual probe. Six cylinders were used for the compression tests and another six for the penetration. A Texture Profile Analysis (TPA) was performed for each sample which basically consisted of a double compression. The speed of descent of the head (head/top part) was 2 mm $sec^{-1}$ with a degree of compression of 75% and for the penetration test it descended 50% of the height of the sample. These tests gave five parameters: Fracturability, hardness, adhesiveness, cohesiveness and elasticity. Samples temperature was 22±1°C.

For chemical composition, colour and texture variables, effect of smoke type and ripening time was analysed using the ANOVA procedure (SPSS V. 11.0).

## RESULTS AND DISCUSSION

No statistical differences were founded for cheese rind chemical composition neither in pH values. Internal chemical composition of cheeses was affected by cheese aging at smoking; cheeses smoked with 10 days ripening presented less moisture and higher fat percentage values than 4 days cheeses (Table 1).

Results of smoke type effect on surface cheese colour are shown in Table 2. As has been frequently suggested (Ahmad, 1993) colour depends on the kind of the material used. In reference to lightness values, cheeses smoked with pine wood and heather wood were the darkest with similar values to the Swiss cheese (Riha and Wendorff, 1993b).That can be related with the smoke temperature as it was reported in other studies (Möhler, 1980; Riha and Wendorff, 1993a). Ruiter (1979) in his review, reported that the use of coniferous wood is

supposed to lead to darker products. Lightness external colour was for the cheeses smoked with pine needles. Differences were found in Croma values, the most intensive colour were for cheeses being smoked with almond shell and pine wood and products smoked with heather wood and pine needle were the least. No statistical differences were found for Hue Angle values.

In relation to ripening time smoking moment only in lightness values were found significant differences. Cheeses smoked four days after elaboration were lighter than chesses smoked 10 days after. Croma and Hue angle values were not affected by the moment of smoking.

A correlation trend between lightness, Croma and Hue angle was observed. When a smoke produced a darker colour, the Croma was high and the Hue angle was far from yellow axis. This correlation trend is supported by Pearson correlation index.

Table 3 contains mean values for textural characteristics on compression test. Cheese aging at smoking had higher effect on textural characteristics. Cheeses smoked with more ripening days presented higher values for hardness ($p<0.05$) and fracturability ($p<0.01$) but were less elastic ($p<0.01$), this can be related with the differences in fat composition as it was reported in other papers (Guinee, 2001; Kuckoner and Haque, 2003). Only cohesiveness was affected by the smoke type used, cheeses smoked with pine wood were the most cohesive while the ones smoked with rose rock wood were the least, as cheese chemical composition was not affected by the material used in smoking process it can associated with a higher temperature of the smoke.

For penetration test the two factors analysed had similar effects on textural parameters (Table 4). Cheeses smoked with more days aging continue presenting higher

Table 1: Chemical composition of smoked cheeses (internal and rind fractions)

| | LSM | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cheese aging at smoking (A)* | | Smoking material (M)** | | | | | | Effects | | | |
| | 1 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | RSD | A | M | A×M |
| ***iMoisture (%) | 45.59 | 44.38 | 45.38 | 44.37 | 44.77 | 45.02 | 45.35 | 44.68 | 0.22 | 0.006 | 0.853 | 0.012 |
| iProtein (%) | 22.76 | 22.63 | 22.80 | 23.07 | 22.28 | 22.47 | 22.41 | 23.13 | 0.25 | 0.824 | 0.931 | 0.886 |
| iFat (%) | 22.87 | 24.60 | 23.58 | 23.63 | 23.91 | 23.77 | 23.28 | 24.25 | 0.35 | 0.008 | 0.954 | 0.002 |
| iFat( %TS) | 41.98 | 41.81 | 43.08 | 35.53 | 43.17 | 43.23 | 42.57 | 43.78 | 1.11 | 0.945 | 0.516 | 0.954 |
| ****rMoisture (%) | 37.75 | 36.49 | 37.91 | 36.26 | 33.88 | 37.09 | 37.49 | 40.09 | 0.80 | 0.437 | 0.584 | 0.164 |
| rProtein (%) | 26.33 | 27.68 | 25.78 | 27.57 | 27.48 | 26.78 | 26.22 | 28.21 | 0.41 | 0.120 | 0.600 | 0.313 |
| rFat (%) | 30.58 | 32.86 | 29.92 | 31.47 | 35.61 | 30.89 | 30.38 | 32.05 | 0.70 | 0.087 | 0.157 | 0.171 |
| rFat( %TS) | 48.82 | 50.41 | 47.97 | 49.26 | 53.59 | 48.75 | 48.52 | 49.60 | 0.66 | 0.223 | 0.155 | 0.206 |

*1: Cheeses smoked 4 days after elabortion; 2: Cheeses smoked 10 days after elabortion, **1: Almond shell; 2: Heather wood; 3: Rose rock wood; 4:, segment prickly pear cactus; 5: Pine needles; 6: Pine wood ***i: Internal fraction ****r: Rind fraction LSM: Least Square Mean. RSD: Residual Standard Deviation

Table 2: Effects of the treatments on surface cheese colour

| | LSM | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cheese aging at smoking (A)* | | Smoking material (M)** | | | | | | Effects | | | | |
| | 1 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | RSD | A | M | AxM | L.P.C.I |
| Lightness | 79.94 | 75.58 | $76.65^{ab}$ | $75.88^{a}$ | $77.92^{ab}$ | $79.44^{ab}$ | $82.37^{b}$ | $74.37^{a}$ | 0.80 | 0.003 | 0.024 | 0.354 | --- |
| Croma | 28.09 | 29.27 | $31.66^{b}$ | $26.47^{a}$ | $27.68^{ab}$ | $29.14^{ab}$ | $25.27^{a}$ | $31.86^{b}$ | 0.55 | 0.198 | 0.000 | 0.291 | -0.661 |
| H. Angle | 85.81 | 85.46 | 84.84 | 84.32 | 85.72 | 87.39 | 88.22 | 83.33 | 0.54 | 0.743 | 0.091 | 0.679 | 0.751 |

* 1: Cheeses smoked 4 days after elaboration; 2: Cheeses smoked 10 days after elaboration, ** 1: Almond shell; 2: Heather wood; 3: Rose rock wood; 4:, Segment prickly bpear cactus; 5: Pine needles; 6: Pine wood, LSM: Least Square Mean. RSD: Residual Standard Deviation. L.P.C.I.: Lightness Pearson Correlation Index $^{a,b}$ Within a row, means marked with differ superscripts differ significantly ($p<0.05$)

Table 3: Effects of the treatments on compression textural characteristics

| | LSM | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cheese aging at smoking (A)* | | Smoking material (M)** | | | | | | Effects | | | |
| | 1 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | RSD | A | M | A×M |
| Fracturability | 22.34 | 40.74 | 20.11 | 27.64 | 24.87 | 31.75 | 21.70 | 33.17 | 3.30 | 0.002 | 0.073 | 0.030 |
| Hardness | 41.46 | 55.12 | 59.89 | 52.87 | 48.09 | 47.55 | 37.08 | 44.28 | 3.40 | 0.017 | 0.264 | 0.006 |
| Cohesiveness | 0.21 | 0.22 | $0.21^{abc}$ | $0.20^{ab}$ | $0.18^{a}$ | $0.23^{bc}$ | $0.23^{bc}$ | $0.24^{c}$ | 0.01 | 0.970 | 0.000 | 0.006 |
| Adhesiveness | 0.69 | 0.71 | 0.54 | 0.84 | 1.05 | 0.70 | 0.45 | 0.63 | 0.73 | 0.884 | 0.235 | 0.922 |
| Elasticity | 54.79 | 51.55 | 54.22 | 51.57 | 51.03 | 52.92 | 54.06 | 55.21 | 0.56 | 0.004 | 0.193 | 0.907 |

* 1: Cheeses smoked 4 days after elaboration; 2: Cheeses smoked 10 days after elaboration, ** 1: Almond shell; 2: Heather wood; 3: Rose rock wood; 4: Segment prickly pear cactus; 5: Pine needles; 6: Pine wood, LSM: Least Square Mean. RSD: Residual Standard Deviation. $^{a-c}$ Within a row, means marked with differ superscripts differ significantly ($p<0.05$)

Table 4: Effects of the treatments on penetration textural charcteristics

| | LSM | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cheese aging at smoking (A)* | | Smoking material (M)** | | | | | | Effects | | | |
| | 1 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | RSD | A | M | A×M |
| Penetrability | 2.72 | 2.53 | 3.19 | 3.50 | 2.83 | 3.09 | 2.87 | 3.29 | 0.21 | 0.045 | 0.901 | 0.018 |
| Hardness | 3.02 | 3.96 | 3.80 | 3.77 | 3.21 | 3.47 | 3.23 | 3.48 | 0.23 | 0.028 | 0.921 | 0.006 |
| Cohesiveness | 0.20 | 0.19 | $0.23^{c}$ | $0.13^{ab}$ | $0.11^{a}$ | $0.22^{c}$ | $0.21^{bc}$ | $0.24^{c}$ | 0.10 | 0.560 | 0.000 | 0.054 |
| Adhesiveness | 1.66 | 1.71 | 1.84 | 1.54 | 1.62 | 1.75 | 1.67 | 1.69 | 0.03 | 0.460 | 0.104 | 0.599 |
| Elasticity | 40.49 | 41.45 | $40.27^{ab}$ | $42.23^{ab}$ | $42.83^{b}$ | $40.65^{ab}$ | $40.46^{ab}$ | $39.37^{a}$ | 0.30 | 0.091 | 0.007 | 0.303 |

* 1: Cheeses smoked 4 days after elaboration; 2: Cheeses smoked 10 days after elaboration, ** 1: Almond shell; 2: Heather wood; 3: Rose rock wood; 4: Segment prickly pear cactus; 5: Pine needles; 6: Pine wood, LSM: Least Square Mean. RSD: Residual Standard Deviation. $^{a-c}$ Within a row, means marked with differ superscripts differ significantly ($p<0.05$)

values for hardness parameter but not for elasticity. Smoked increased its effect in comparison with compression test, because cohesiveness and elasticity were affected. Cheeses smoked with rose rock wood were the most elastic while the cheeses smoked with pine wood were the least. Cheeses smoked 10 days-aging presented higher values for penetrability. This fact could be due to less internal moisture of this kind of cheeses.

## CONCLUSION

Results suggest that smoked type and smoking process had a significant effect on the surface cheese colour and certain textural characteristics. These results can be used to characterize different smoked traditional cheeses and also to develop other new cheeses.

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