EFFECT OF α_{s1}-CASEIN GENOTYPE ON YIELD, COMPOSITION AND CHEESE MAKING PROPERTIES OF MILK IN THE MALAGUEÑA BREED OF GOATS.

A. Sánchez[2], C. Angulo[1], M. Amills[2], J.L.Ares[3] and J.M. Serradilla[1]

[1]Dep. de Producción Animal, ETSIAM, Univ. de Córdoba, 14080 Córdoba, Spain.
[2] Genètica i Millora Animal, Fac.de Veterinaria, U.A.B., 08193 Bellaterra (Barcelona), Spain.
[3]Centro de Capacitación y Experimentación Agraria. Consejería de Agricultura y Pesca. Junta de Andalucía. Carretera de El Viso, Km. 2. 14270 Hinojosa del Duque (Córdoba), Spain.

SUMMARY

The effect of the α_{s1}-casein polymorphism on protein, fat and dry matter contents in milk, rheological parameters (coagulation time, K_{20}, A_{30} and curd yield capacity), measured with a Formagraph©, and cheese yield, have been studied in a Spanish breed (Malagueña). Other factors (herd, age, kidding season, lactation number) and covariables (days in lactation, pH and somatic cell counts) have been taken into account. The effect of the α_{s1}-casein polymorphism was significant for protein and effective dry matter (protein plus fat) contents in milk. It also showed an influence on curd yield capacity, which is a parameter very related to cheese yield. Results are compared with those observed in French Alpina and Saanen and they are discussed in relation with the differences of allele frequencies and environmental conditions between these breeds.

Keywords: Malagueña goats, caseins, rheology, cheese.

INTRODUCTION

The Malagueña is a breed of dairy goats widely distributed in the South of Spain. The number of milked does in 1995 was 161,880 (BIAP 1995). It is well adapted to semi-extensive semi-arid conditions, where it has good milk yield (347 Kg per lactation) and protein concentration (37.8 g/Kg). Its milk is fully used in cheese industry, partly to make fresh cheese, traditional in this region. Cheese industry and goats breeders need to improve the efficiency of cheese making processes and to increase the farm incomes. The α_{s1}-casein gene has been shown to have an extensive polymorphism (Boulanger *et al.* 1984) with an important effect on protein concentration on milk, as well as on cheese yields and other rheological parameters, in French Alpina and Saanen breeds (Barbieri *et al.* 1995). This effects have been observed using goats with known genotypes for α_{s1}-casein locus under rather controlled conditions in experimental farms. Spanish breeds of goats have lower average milk yields and the frequencies of α_{s1}-casein genotypes are somewhat different from French ones (Jordana *et al.* 1996). These two circumstances might determine a difference (at least quantitative) on the influence of α_{s1}-casein polymorphism on these parameters, as it has been shown in some previous studies on the influence of casein polymorphism on Spanish breeds (Diaz-Carrillo 1993). The purpose of the work presented here is to study the effect of the α_{s1}-casein genotypes on milk yield, main milk constituents contents and rheological characteristics of milk in this Spanish breeds of goats, under its usual managing and environmental conditions.

MATERIAL AND METHODS

A number of 195 goats of Malagueña breed in two private herds were genotyped for the α_{s1}-casein gene. Genotypic frequencies found were:

Genotype	AA	BB	AB	AE	BE	EE	AF	BF	EF	FF	00	Total
n	2	30	11	12	56	37	4	17	20	5	1	195

All goats, except those with genotypes AA, AF, FF and 00, with very small sample size, were milk recorded monthly during one year (from September 1995 to August 1996). Milk samples taken each test day were analysed for protein, fat and dry matter contents, using a near infrared spectrophotometer previously calibrated for these parameters (Diaz *et al.* 1993). Effective dry matter content (EDM) was computed as the addition of fat and protein contents.

All milk produced in one day was collected separately from each goat between two to four times during the year. Measures of somatic cells counts (SCC), obtained with a Fossomatic (Foss Electric), pH and some rheological parameters, obtained with a Formagraph© (Foss Electric) following the methodology described by Angulo *et al.* (1996), were taken for each of these samples. Formagraph© parameters measured were:

Clotting time (CT): It is the value obtained in minutes by measuring in the Formagraph© graph the distance from the origin to the point where the baselines have a separation of about 1 mm width, which is the moment when coagulation of milk takes place. **Curd firming rate** (K20): A measure of firmness of the curd adequate for cutting of cheese curd. It is the time in minutes between CT and a width of 20 mm in the Formagraph© graph. **Curd firmness at 30 minutes** (A30): It is the width of the Formagraph© graph 30 minutes after the process started. **Curd yielding capacity** (CY): It is the ratio of total milk weight to solid curd weight, expressed as a percentage, after one hour clotting. Cheeses were made with these samples of milk collected from each individual goat, following the traditional protocol used to make fresh goat cheese in Malaga (Ares 1995). Cheese yield (ChY), ratio of cheese to milk weight expressed in percentage, was measured, among other parameters, inmediately after cheese elaboration. Data were analysed with GLM procedure of SAS statistical programs (SAS 1992) with the following model:

$$Y_{ijklmnopq}=\mu+H_i+Ge_j+GA_k+KS_l+SK_m+KB_n+LN_o+An_p(H_i+Ge_j+GA_k+KS_l+SK_m+KB_n+LN_o)+b_1Day_q++b_2lSCC_q+b_3pH_q+\varepsilon_{ijklmnpq}$$

Where: $Y_{ijklmnopq}$ is the variable to analyse, μ is a general term, H_i is herd factor (two herds), Ge_j is the α_{s1}-casein genotype (7 genotypes), GA_k is the age of the goat (from 1 to 8 years), KS_l is the season of kidding (4 seasons), SK_m is the number of kids suckling to the goat the day that milk was recorded and sampled (from 0 to 4), KB_n is the number of kids born (from 1 to 4), LN_o is the number of lactation (from 1 to 8), An_p is the goat nested to all other factors (from 10 to 127 levels depending on the variable analysed), covariable Day_q is the number of days from parturition to the day when milk record and sample was taken, $lSCC_q$ is the logarithm of the number of somatic cell count in milk sample, pH_q is the pH measured in milk sample, and $\varepsilon_{ijklmnpq}$ is the error term. Not all covariables were considered for all variables studied. Table 1 shows the covariables included in the model in each case.

RESULTS AND DISCUSSION

Table 1 shows the level of significance (probabilities of values larger than the F value) found for each factor in the analyses of variance of each of the variables studied. This table also shows the number of samples (n) analysed for each variable, their average value and coefficient of variation (CV) and the coefficient of determination of the model (R^2). Most factors considered did not have any influence on the variables analysed, exception made of test day milk yield which was affected by some of the most usual effects (herd, goat's age, number of kids suckling). No differences were found, however, among levels of other factors, like kidding season and lactation number, which were found significant in other studies of the same breed (Hernández 1991; Diaz 1993). The same occur to other variables, like fat and protein content, which are normally affected by these factors. A possible explanation is that most observations correspond to kiddings from the same season (autumn) and very few observations (58) correspond to first lactations, which is the one with more different values. Animal is a highly significant factor of variation for most variables, meaning that genetic and intrinsic environmental factors, others than those considered explicitly in the model, are influencing the variables. It is of particular importance to have this factor in the model to account for genetic sources of variation other than the α_{s1}-casein genotype. Differences due to the different stages of the lactation period are corrected by means of the covariable *days*, which has a significant regression with most of the variables studied. It is interesting to observe that there is not a significant regression of the logarithm of somatic cell counts with any variable. Only with cheese yield, this regression has a nearly significant value ((P>F)=0,08). However, this is only true when SCC is smaller than $2x10^6$. Larger values impair the clotting process, giving soft curds and introducing a large variation in most rheological parameters.

Genotype for the α_{s1}-casein gene has a significant influence on protein content, effective dry matter and curd yield capacity. We have not found a significant effect of α_{s1}-casein genotype on test day milk yield. This agrees with results reported by Barbieri *et al.* (1995) in French Alpina and Saanen goats. On the contrary, our results do not agree with those of French breeds with respect to the influence of the α_{s1}-casein gene on fat content. Mahé *et al.* (1993) and Vassal *et al.* (1994) found significant differences of milk fat content between carriers of alleles A (high) and E (intermediate) and F (low)., To explain the difference between our results and the French ones it could be argued, that fat content is a parameter highly influenced by environmental factors. French experiments have been made under environmental conditions rather more homogeneous and controlled than ours. This larger environmental variability might overlay possible small influences of the α_{s1}-casein genotype. Curd yield capacity is significantly affected by α_{s1}-casein genotype. Although this parameter has been measure of curd yield obtained with a small sample of milk, it is correlated (r=0.68) with cheese yield. Under the other hand, no effect of the α_{s1}-casein genotype on cheese yield has been observed, as a consequence of the negative effect of the high levels of somatic cell counts on the clotting process. A larger number of cheeses should be made in order to detect genotype differences.

Table 1. Significance levels (Pr > F) of factors and covariables considered in the analysis of variance of milk constituent contents, rheological variables and cheese yield.

(1)	Day yield (Kg)	Protein content (%)	Fat content (%)	e.d.m. content (%)	Curd yield (%)	CT (minutes)	K_{20} (mm)	A_{30} (mm)	Cheese yield (%)
Herd	0,0001	0,40	0,49	0,40	0,98	0,08	0,63	0,08	0,19
Genotype	0,09	0,001	0,19	0,03	0,0001	0,06	0,63	0,97	0,62
Age	0,01	0,10	0,46	0,59	0,81	0,21	0,69	0,48	0,24
Season	0,37	0,09	0,05	0,51	0,56	0,13	0,57	0,29	0,94
Suc. kids	0,0001	0,22	0,09	0,07	0,16	0,54	0,39	0,67	0,25
Kids born	0,36	0,80	0,58	0,58	0,61	0,19	0,87	0,42	0,20
Lactation	0,42	0,25	0,60	0,71	0,83	0,07	0,30	0,18	0,22
Animal (2)	0,0001	0,001	0,0001	0,0002	0,61	0,93	0,05	0,75	0,35
b_1 days	0,0001	0,69	0,0001	0,001	0,001	0,55	0,05	0,56	0,59
b_2 pH	-	-	-	-	0,05	0,47	0,05	0,29	0,69
b_3 lscc	-	-	-	-	-	0,27	0,28	0,30	0,08
n	365	355	351	341	338	50	44	37	88
R^2	0,74	0,59	0,54	0,54	0,49	0,85	0,97	0,94	0,77
Mean	1,42	2,80	5,16	7,98	22.57	25.12	6.05	31.0	20.46
CV (%)	30,04	18,98	22,89	19,35	10.96	47.09	17.0	80.1	11.39

(1) See material and methods for description of variables analysed and factors.

(2) Animal is nested to all other factors.

REFERENCES

Angulo, C., Analla, M., Jiménez, I., Muñoz, A., Alonso, A. and Serradilla, J.M. (1996) In "Near Infrared Spectroscopy: The Future Waves", p. 604-610, editors A.M.C. Davis and P. Williams, NIR Publications. Chichester, West Sussex, U.K.

Ares, J.L. (1995) PhD Thesis, University of Córdoba. (Spain).

Barbieri, M.E., E. Manfredi, J.M.Elsen, G. Ricordeau, J. Bouillon, F. Grosclaude, M.F. Mahé, B.Bibé. (1995) *Genet Sel Evo.* **27**:437-450.

BIAP (1995) Consejería de Agricultura y Pesca., Junta de Andalucía, Sevilla (Spain).

Boulanger, A., F. Groscalude, M-F. Mahé. (1984) *Génét Sél Evol.* **16**:157-176

Díaz-Carrillo E. (1993) PhD Thesis, University of Córdoba, Spain.

Diaz-Carrillo, E., A. Muñoz-Serrano, A., Alonso-Moraga and J.M. Serradilla-Manrique. (1993) *J. Near Infrared Spectrosc.* **1**:141-146.

Hernández, D. (1991) PhD Thesis, University of Córdoba., Spain.

Jordana, J.; M. Amills, E. Díaz, C. Angulo, J.M. Serradilla and A. Sánchez. (1996) *Small Ruminant Research* **20**:215-221.

Mahé, M.F., Manfredi, E., Ricordeau, G. Piacere, A. y Groscalude, F. (1993) *Génét. Sél. Evol.* **26(2)**:151-157.

SAS (1992) SAS/STAT. User's guide Volume 1 Ver. 6 4th ed. SAS Institute Inc Cary USA.

Vassal L., Delacroix-Buchet A., Bouillon, J. (1994) *Lait* **74**: 89-103.