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Physicochemical properties, composition and pollen spectrum of ling heather (*Calluna vulgaris* (L) Hull) honey produced in Spain

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Summary — The palynological and physicochemical properties of 28 samples of commercially produced Spanish ling heather honey were defined. On the basis of the melissopalynological analysis, 5 samples were excluded as they were of different botanical origin; 101 different pollen types were identified in the remaining samples. The relative richness of pollen from *Calluna* was between 10–33%. The high incidence of *Erica* spp pollen (usually > 10%), makes ling heather honey characterization difficult. The sugar spectrum showed low percentages of glucose (25.6 g/100 g), high levels of disaccharides, and traces of sucrose and trisaccharides. Enzymatic activity was higher (51.89 units on the Gothe scale) than that found in other unifloral Spanish honeys. The total acidity (45.5 meq/kg) exceeds the legal limit established for honey in the EEC. The mineral elements show a predominance of potassium, sodium and calcium. The different fluidity curves were determined using a 4-speed (16, 40, 80 and 160 rpm) concentric cylinder rotary viscometer. The thixotropical behaviour of this honey was determined as the crumbling index at the maximum tangential tension that could be generated by the viscometer used.

honey / *Calluna vulgaris* / pollen analysis / physicochemical properties / Spain

INTRODUCTION

Although *Calluna* is found throughout the Iberian peninsula, it is basically predominant in the area where the provinces of Soria and La Rioja meet. There are also the heathers *Erica aragonensis* Wilk, *Erica vagans* L, *Erica scoparia* L and *Erica arborea* L spread extensively over the Ibero-Sorian highlands at the NE limit of the central plateau. These highlands consist of the typical European transitional scrubland, where *Erica arborea* appears next to *Erica scoparia*, growing together with the maquis type comprising *Arbutus*, *Cistus*,

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Genista, *Buxus*, *Viburnum*, *Lavandula*, *Ulex*, *Myrtus*, *Thymus*, elements of *Quercetum sessiflorae*, *Quercetum tozae* and, in certain cases, *Quercetum ilicis*, and in which *Calluna* features as a principal characteristic (Tarazona Lafarga, 1984; Serra Bonvehí and Mundo Elias, 1988). These communities have the following characteristics: they are very frugal, siliceous and acidulous, they are well adapted to the poor soil conditions of the Ibero-Sorian Highlands, and to a climate which is not especially prone to drought or extreme temperatures. In this area, there are some enclaves where *Calluna* is predominant, although the other heathers do reappear with varying frequency. Therefore it is interesting to determine the pollen spectrum and examine the influence of the presence of *Erica* spp on *Calluna* honey, because they have the same flowering period. There are only a few published studies on the composition and characteristic features of ling heather and heather honey. Of these, the most important are the studies by Pryce-Jones (1936; 1944; 1952; 1953), Louveaux (1966, 1977), Pourtallier and Taliercio (1970), Fitó and Rodriguez (1981), Spettoli *et al* (1982), Henderson (1984), Accorti *et al* (1986), Speer and Montag (1986), Persano Oddo *et al* (1988), and Tan *et al* (1989), although they only determine a few characteristic features. Most of these studies make note of the fact that ling heather honey has thixotropical properties, which make its extraction by centrifugation impossible. Hence, the need to use a "loosener" on the combs. This study attemps to be more complete, in that, apart from the pollen spectrum, we determine the most common features of the honey, such as: water content; colour; electrical conductivity; sugar spectrum; mineral elements; hydroxymethylfurfural; enzymatic activity; true protein content; viscosity; and crumbling index of the thixotropical structure.

MATERIAL AND METHODS

Twenty-eight samples of commercially produced ling heather honey were taken over 2 successive years from the stores of 2 commercial entities; 5 of the samples were rejected on the basis of pollen spectra. All samples came from lots destined for sale on the market, and had been collected in 1985 and 1986 in the area where the provinces of Soria and La Rioja meet (Spain). For each of the samples, a questionnaire was filled in with data about its handling by the producer, extraction date, type of bee-hive and nomadic route. The samples were preserved at 0–5°C in a cold-storage room and analysed as soon as they arrived in the laboratory.

Melissopalynological analysis

The analysis was carried out in accordance with the methods of the International Commission of Bee Botany (ICBB) of the International Union of Biological Sciences (IUBS), described by Louveaux *et al* (1978). The grain count was performed following the method suggested by Vergeron (1964) (1 200 grains counted).

The pollens identified were classified according to their frequency. There were 4 classes of pollen: predominant (> 45%) = D; secondary (16–45%) = S; important minor (3–15%) = s; minor (< 3%) = r. For the absolute number of pollen grains, there are 5 groups: group I = honeys low in pollen (PK/10 g < 20 000); group II = normal honeys (PK/10 g 20 000–100 000); group III = honeys rich in pollen (PK/10 g 100 000–500 000); group IV = honeys extremely rich in pollen (PK/10 g 500 000–1 000 000); group V = pressed honeys (PK/10 g > 1 000 000).

Physical and chemical analysis

The sugar spectrum was determined in accordance with Serra Bonvehí and Bosch Callis (1988), on a Sigma 2 gas chromatograph and quantified on a Sigma 15 (Perkin–Elmer) microprocessor.

The electrical conductivity was measured in a solution at 20% dry weight and 20°C, in a Crison

model 332 conductimeter, using continuous flow immersion cells.

The enzymatic activity followed the method of White and Pairent (1959), established by the AOAC (1980), on a 260 Shimadzu UV–visible spectrophotometer at 660 nm.

Humidity was determined following Chataway (1932) and Wedmore (1955), a method established by the FAO/WHO (1969). We used an Atago model 8326 Abbe-type refractometer.

The colour was determined using tristimulary methodology (Aubert and Gonnet, 1983) on a 260 Shimadzu UV–visible spectrophotometer with a path-length of 1 cm.

The free and lactone acidity was evaluated by the method of White *et al* (1958), and the pH was measured in a 10% solution in an Expandable ion Analyzer EA 920 (Crion Research) pH-metre.

The activity of water in the honey (a_w) was determined *via* a Humidat-IC (Novasina) hygrometer at 20 ± 0.5°C.

The nitrogen content (protein + amino acids) was measured according to White *et al* (1962) on a Bloc Digest using a Dosi-Gen S-511 (Selecta) (N x 6.25) automatic distiller. Hydroxymethylfurfural was determined by the method of White (1979).

To determine mineral elements, 5 g honey was reduced to ashes at 500–550°C and dissolved in 2 ml and 2 N HCl, made up to 50 ml with distilled water at 40°C, and Cl_3La and ClCs were added (Sanui and Pace, 1968; De Ruig, 1986). The K, Na, Mg, Ca, Fe, Zn, Cr, Cu and Pb contents were evaluated using a model 703 atomic absorption spectrophotometer (Perkin–Elmer). Pb was determined in 15 g honey/25 ml distilled water.

The viscosity of the honey at 20–20.5°C was determined using a 4-speed (16, 40, 80 and 160 rpm) concentric cylinder rotary viscometer, type Searle–Couette, model RN, VEB–MLW, Prüfärate, Werk Medingen (Germany). The RN measuring mechanism consisted of a bell-shaped rotor and a inner cylinder inside a measuring glass, both of which provide 2 shearing surfaces (rotor diameter, 8.57 mm; glass diameter, 15 mm). First the speeds of deformation (§, s^{-1}) were calculated, and, with the results read from the scale on the viscometer, shear stress (Þ, dynes/cm^2) and apparent viscosity (n, cP) were determined. The results are represented graphically by a system of cartesian coordinates (Þ,§) to yield the fluidity curve, from which it is possible to work out an equation that describes the rheological behaviour of the fluid under study (Prentice, 1984). The ascendent and descendent values were gradually obtained by varying the rotation speed of the cylinder from the highest to the lowest, and *vice-versa*. During the deformation speed test, values were taken every 20 s, with the aim of seeing the variation that the apparent viscosity underwent throughout the testing time. With these values, one can determine the crumbling index of the thixotropic structure (B) (De Kée and Turcotte, 1980). For the calculation of (B), the following formula was used:

$$B = \frac{n_2 - n_1}{\ln t_2/t_1}$$

RESULTS AND DISCUSSION

Table I shows data from the pollen analysis, and tables II–V give values of chemical and physical parameters for the characterization, and provide estimates of their variability.

Five of the 28 samples studied were rejected because they presented a different botanic origin, being considered multiflower honey in which there was a predominance of *Erica* spp, *Centaurea cyanus, Vicia* sp and *Eucalyptus* sp.

In the 23 samples accepted 101 different pollen types were identified with an average of 40 per sample, which exceeds that of the principle monofloral Spanish

Table I. Pollenic richness, number of pollen types, percentage of *Erica* ssp and *Calluna* pollen.

Sample no	*Pollen types*	*Groups*	*% pollen* Erica	*% pollen* Calluna
$\bar{X}$	40	III/IV	16	17
V_{max}	46	V	33	33
V_{min}	33	III	2	10

Table II. Carbohydrates (g/100 g dry matter), crystallization index, water content and water activity.

Sample no	*Parameter*														
	F	*G*	*S*	*T*	*Iso*	*M*	*K*	*Me*	*R*	*Mel*	*W*	a_w	*G/W*	*F/G*	*G–W/F*
V_{max}	47.50	34.40	0.37	2.32	4.83	13.70	1.54	2.46	0.37	0.37	19.80	0.558	1.90	1.51	0.50
V_{min}	38.20	27.00	tr	0.50	2.11	6.21	0.31	0.50	tr	tr	14.40	0.522	1.16	1.29	0.10
$\bar{X}$	43.30	31.00	0.16	1.32	3.60	10.60	0.76	1.34	0.12	0.13	17.40	0.540	1.49	1.40	0.23
SD	2.01	2.13	0.08	0.42	0.71	2.02	0.29	0.46	0.25	0.15	2.05	0.009	0.23	0.07	0.08
Confidence limits	44.19	31.94	0.20	1.51	3.91	11.49	0.89	1.54	0.23	0.20	18.31	0.544	1.59	1.43	0.27
($\alpha = 0.05$)	42.41	30.06	0.13	1.13	3.29	9.71	0.63	1.14	0.01	0.06	16.49	0.536	1.39	1.37	0.20

F: fructose; G: glucose; S: sucrose; T: trehalose; Iso: isomaltose; M: maltose; K: kojibiose; Me: melibiose; R: raffinose; Mel, melezitose; (W): water content; a_w: water activity; tr: traces.

Table III. Physical and chemical characteristics and composition.

Sample no	*Parameters*																
	ID	*CE*	*N x 6.25*	*Colour*	*HMF*	*Acid*	*Ash*	*Ca*	*Mg*	*K*	*Na*	*Fe*	*Cu*	*Cr*	*Pb*	*Zn*	*pH*
V_{max}	81.10	12.17	1.10	x = 0.63 y = 0.52	12.30	52.18 7.95 60.13	0.77	374.90	165.70	1438.6	389.30	25.00	4.50	0.31	tr	17.10	4.33
V_{min}	26.10	5.88	0.50	x = 0.45 y = 0.37	4.79	28.96 0.48 30.89	0.24	142.30	34.90	569.90	180.20	2.88	0.16	tr	tr	1.21	3.67
$\bar{X}$	51.89	8.13	0.68	x = 0.55 y = 0.43	8.70	42.25 3.28 45.50	0.45	265.10	91.90	936.80	309.70	9.70	1.53	0.19	tr	4.40	4.07
SD	14.66	1.61	0.13	x = 0.03 y = 0.03	2.05	6.22 2.16 6.87	0.17	75.30	28.50	227.10	53.20	5.70	1.15	0.06	tr	3.98	0.19
Confidence limits (α = 0.05)	58.20	8.82	0.74	x = 0.57 x = 0.53 y = 0.44 y = 0.42	9.61	44.90 4.20 48.50 39.56 2.40	0.52	297.60	104.20	1035.0	332.70	12.20	2.03	0.22	tr	6.10	4.15
	45.50	7.44	0.62		7.80	42.50	0.38	232.60	79.60	838.60	286.70	7.30	1.03	0.16	tr	2.70	3.99

ID = diastase activity (Gothe scale); CE = electrical conductivity (10^{-4} S•cm^{-1}, 20°C); HMF = hydroxymethylfurfural (ppm); Acid = Acidity: free, lactone, total (meq/kg); Ash = (%); mineral elements = (ppm); tr = traces.

Table IV. Apparent viscosities and applied tangential tensions.

Sample no	*Speed 16, 40, 80 and 160 rpm cylinder rotary viscometer*					
	Tangential tension (dynes/cm²)			*Apparent viscosity (cP) (20–20.5°C)*		
	20 s	*40 s*	*60 s*	*20 s*	*40 s*	*60 s*
	1 176	995	–	23 511	19 892	–
	2 424	2 237	–	19 384	17 890	–
V_{max}	4 457	4 209	3 838	17 820	16 380	15 346
	8 666	8 104	7 861	17 325	16 201	15 516
	248	240	–	4 958	4 798	–
	495	460	–	3 960	3 500	–
V_{min}	1 310	1 114	990	5 238	4 455	3 960
	2 600	2 414	2 221	5 198	4 826	4 455
	584	460	–	11 676	9 140	–
	1 387	1 198	–	11 172	9 724	–
$\bar{X}$	2 748	2 468	2 188	11 073	9 963	8 995
	5 234	4 907	4 665	10 453	9 878	9 323
	217	175	–	4 332	3 512	–
	481	470	–	3 869	3 797	–
SD	779	735	746	3 153	2 968	2 962
	1 334	1 242	1 212	2 663	2 472	2 401

honeys (table I) (Serra Bonvehí *et al*, 1987; Serra Bonvehí, 1988; Serra Bonvehí and Cañas Lloria, 1988). About half of the samples (52%) had a minimum of 39 taxons and 30% had less than 37 taxons. Most of the samples belonged to groups III (52%) and IV (43%) (table I). The percentage of *Calluna* pollen was not high ($\bar{X}$ = 17%), with only 13% of the samples being over 25%. As shown in table I, 52% of the accepted samples contain 16–33% *Erica* spp ($\bar{X}$ = 24%); in the rest of the samples the presence varies from 2 to 16% ($\bar{X}$ = 8%). Unfortunately, this high *Erica* spp content makes it difficult to identify ling heather honey through a melissopalynological analysis. According to Accorti *et al* (1986) heather honeys should contain 45% *Erica* spp pollen as a minimum. Under these circumstances, the only feasible alternative is to limit its presence to such a value that its interactions do not modify the physicochemical characteristics of ling heather honey. Approximately 50% of the identified taxons appear in forms as important minor (s) and minor pollen (r). As dominant pollen (D), only *Eucalyptus* sp was detected, with *Calluna vulgaris* and *Erica* spp as secondary (S). *Onobrychis viciifolia* and *Medicago sativa* stand out among the forms of pollen belonging to cultivated plants. Four taxons were outstanding in their different frequencies (*Eucalyptus* sp, *Citrus* sp, *Helianthus annuus* and *Echium* sp) although they do not belong to the phytosociological communities of the collection area, appearing as floral remains from other zones in Spain that find their way to *Callu-*

Table V. Crumbling index of the thixotropical structure (B).

Sample no	*Speed 160 rpm cylinder rotary viscometer*		
	Apparent viscosity		*Crumbling index (B)*
	20 s	*60 s*	
01	10 148	9 158	330.00
02	10 643	8 374	756.30
03	17 325	15 716	536.30
04	11 261	10 148	371.00
05	11 145	10 096	350.00
06	9 652	8 663	329.70
07	8 178	7 549	209.70
08	10 643	9 405	412.70
09	11 138	9 900	412.70
10	7 625	6 311	438.00
11	10 024	9 281	247.70
12	13 365	10 390	991.70
13	11 138	9 034	701.30
14	8 663	8 168	165.00
15	12 499	12 128	123.70
16	11 138	10 766	123.70
17	5 198	4 455	247.70
18	5 940	5 475	155.00
19	9 404	8 956	149.30
20	12 004	10 024	660.00
21	10 643	10 024	206.30
22	14 726	13 118	536.00
23	7 920	7 278	214.00
24 *	10 420	10 397	7.00
25 *	7 809	7 814	–
26 *	12 400	12 392	2.77
27 *	6 823	6 817	2.00
28 *	8 034	8 047	–

Viscosity and crumbling index: cP (20–20.5°C); * samples refused based on their pollen spectra.

na. Among the most characteristic forms identified in this honey were spontaneous and subspontaneous adventitious plants, coming from other crops such as Ranunculaceae, Umbelliferae and *Rumex* sp.

Pollen forms that were not identified with certainty as belonging to a particular species or genus were grouped under what appear to be the most frequent forms (type *Achillea*, type *Carduus*, type C *(Centaurea cyanus)*, type H *(Helianthus annuus)*, type R 22–25 μ (*Brassica* sp), or per group (*Prunus* Gr, *Pyrus* Gr).

The taxons most frequently detected in at least 50% of the samples were: *Calluna vulgaris* (100%); *Erica* spp (*Erica aragonensis*, *Erica vagans*, *Erica scoparia*) (100%); *Quercus* sp (100%); *Salix* sp (100%); *Rubus ulmifolius* (100%); *Cistus* sp (96%); Cruciferae type R 22–25 μ (*Brassica* sp) (96%); *Hypecoum imberbe* (96%); *Thymus* sp (96%); *Trifolium repens* (96%); *Lavandula* sp (96%); *Melitotus* sp (91%); type *Campanula* (78%); *Ligustrum* sp (78%); type *Genista* (78%); *Lotus* sp (78%); *Onobrychis viciifolia* (78%); *Centaurea cyanus* (74%); *Prunus* Gr (74%); *Helianthemum* sp (70%); type *Carduus* (65%); *Taraxacum officinale* (61%); *Hypericum* sp (61%); *Satureia montana* (57%); type *Vicia* (57%); and *Castanea sativa* (48%). All the plants detected were also nectariferous, with exception of Caryophyllaceae, *Quercus* sp, Cistaceae, Pinaceae, Cupressaceae, Gramineae, *Papaver rhoeas*, *Rumex* sp and Ulmaceae.

As table II shows, ling heather honey presented lower percentages of glucose, similar to fructose, isomaltose, kojibiose and melibiose, with the presence of maltose standing out as significantly different ($P = 0.01$) from other unifloral honeys (Espada Herrero, 1984; Accorti *et al,* 1986; Serra Bonvehí *et al,* 1987; Serra Bonvehí, 1988; Bogdanov and Baumann, 1988; Serra Bonvehí and Cañas Lloria, 1988; Sabatini *et al,* 1989). The trisaccharide, sucrose and F/G index results coincide with findings of Pourtallier and Taliercio (1970) and Mateo Castro and Bosch Reig (1984). The F/G index and the respective interval (1.29–1.51) allow for a clear differentiation from *Erica* spp honey 0.95–1.29 (Espada Herrero, 1984); 0.95–1.25 (Accorti *et al,* 1986); 0.99–1.25 (Sabatini *et al,* 1989).

The electrical conductivity gave an average value of 8.13 x 10^{-4} S•cm^{-1}, placing it between flower honey and honeydew, as reported by Pourtallier and Taliercio (1970) (table III).

Ling heather honey presented high levels of diastasic activity, with only 13% of the samples giving values of less than 40 Gothe units. However, as heather honeys have low levels of diastasic activity, with average values recorded at about 10 Gothe units (Accorti *et al,* 1986), it could be possible for this parameter to be used as a differentiating element between the 2 honeys.

The average water content value came out at 17.40%. However, 43% of the samples had humidity values over 19%. The samples collected in 1985 had an average humidity of 15.70%. The same was not true for samples of year 1986, which reflected an average content of 19.31%, which we attribute to different climatic conditions prevailing in the 2 years of collection. The colour was very similar to *Erica* spp honey and the honeydew of *Quercus* sp (Rodriguez López, 1983; Accorti *et al,* 1986), having an average value of $\bar{X}$ = 0.55 (table III), which corresponds to the results of Aubert and Gonnet (1983). There were no indications of fermentation in any of the samples, and the values of activity of water (a_w) were less than 0.70 (table II), which makes the growth of yeasts impossible (Alcalá Aiguilera, 1977). The results in table III evidence the existence of high acidities, exceeding the legal limits (Boe, 1983). These values are essentially consequences of the percentages of gluconic acid and gluconolactone which may be present in the honey (Hadorn and Zürcher, 1963). The pH values are similar to those detected by Pourtallier and Taliercio (1970). The N x 6.25 content oscillates between 0.50 and 1.10%, with an average content of 0.68% (table III), which clearly differentiates the samples from the 5 refused samples and in general from other honeys, which present average values of 0.17% (White *et al,* 1962). The hydroxymethylfurfural values obtained (HMF) are typical of unprocessed honeys, with only 6 samples (26%) giving values higher than 10 ppm.

Ashing gave an average mineral content of 0.45%, which is similar to other heather honeys (Espada Herrero, 1984; Accorti *et al,* 1986). The presence of 9 chemical elements was determined (table III), with a net predominance of K and Na (77% of the total), followed by Ca (16%), Mg, Fe, Cu, Cr and Zn. With respect to other unifloral honeys studied (Serra Bonvehí *et al,* 1987; Serra Bonvehí, 1988; Serra Bonvehí and Cañas Lloria, 1988), K was detected in larger proportions, without becoming useful as a differentiating element (P = 0.05). Although most honeys behave like Newtonian liquids, ling heather honey is more like a non-Newtonian liquid. If the gradient of deformation is maintained as constant (§), the tangential tension (}) and the viscosity (n) diminish with the time (table IV). This phenomenon is known as thixotropy, which, in ling heather honey, we may attribute to the presence of protein (Pryce-Jones, 1953). In contrast, the rejected samples did not show thixotropy, demonstrating a Newtonian behaviour between tangential tension, apparent viscosity and measuring time. Passage from a gel-sol-gel stage was relatively rapid. Having agitated the honey for 5 minutes, we noticed a progressive decrease in viscosity. Once agitation had ceased, the honey did not completely recover its gel state, but behaved as if it was a non-Newtonian fluid. So long as ling heather honey is not subject to thermal treatment above 70°C (Lavie and Gonnet, 1970), thixotropy will be one of the best parameters for its characterization. This may be described by a rheogram, so long as we fix the variables that operate on the measurements in the fol-

lowing ways: through the ascending and descending curves of the rheogram; by the areas of the fluidity curves, in which the thixotropy is proportional to the area; and *via* the positioning of the fluidity curve. All of these require the use of expensive apparatus, and so we used a simpler Searle-Couette viscosimeter. The different fluidity curves were determined at different speeds with different values of (§), as constant throughout the measurement stage. Table IV shows the apparent viscosities and the applied tangential tensions.

Table V illustrates the different values of the crumbling index of the thixotropic structure (B); the data obtained is best described by Burgers model (Scott-Blair, 1970). To establish the smallest thixotropic variation that ling heather honey should require, we determined the crumbling index at the maximum tangential tension that could be generated by the viscosimeter used (table V). These data may vary a great deal, for example, Pourtallier and Taliercio (1970) gave a value of 40 cP, by applying a cylinder rotation speed of 1 rpm. To demonstrate the thixotropical behaviour of our honey, and therefore typify it as a uniflower ling heather honey, a variation in the crumbling index of a minimum of 120 cP at 20–20.5°C was necessary when the corresponding tangential tensions were applied at a rotation speed of the cylinder of 160 rpm for 60 s.

Résumé — Propriétés physicochimiques, composition et spectre pollinique du miel de callune (*Calluna vulgaris* (L) Hull) produit en Espagne. Les caractéristiques polliniques et physicochimiques de 28 échantillons de miels de callune du commerce produits en Espagne ont été étudiées. Sur la base de l'analyse mélissopalynologique (méthodes de l'UISB, Louveaux *et al,* 1978), 5 échantillons (18%) ont été éliminés pour avoir une origine botanique différente. Dans les autres échantillons, 101 types polliniques ont été identifiés, avec une moyenne de 40 par échantillon (tableau I). La teneur en pollen est élevée (100 000 à 500 000 PK/10 g). La richesse relative en pollen de *Calluna* se situe entre 10 et 33% (tableau I). La forte présence de pollens du genre *Erica* (en général > 10%) rend la caractérisation du miel de callune difficile. Le spectre des sucres présente de faibles pourcentages de glucose (25,6 g/100 g), des teneurs élevées en disaccharides et des traces de saccharose et de trisaccharides (tableau II). L'activité enzymatique (51,89 unités sur l'échelle de Gothe) est plus forte que dans les autres miels monofloraux espagnols. L'acidité totale (45,5 meq/kg) dépasse la limite légale établie par la CEE pour les miels. Il n'y a pas de signes de fermentation et l'activité de l'eau a_w est < 0.70. L'analyse minérale montre une prédominance du potassium, du sodium et du calcium. Les diverses courbes de fluidité ont été déterminées à l'aide d'un viscosimètre rotatif à cylindre concentrique aux 4 vitesses suivantes : 16, 40, 80 et 160 rpm (tableau IV). Le comportement thixotrope du miel de callune a été déterminé par l'indice de désagrégation (*crumbling index,* De Kée and Turcotte, 1980) calculé à la tension tangentielle maximum produite par le viscosimètre utilisé (tableau V).

miel / *Calluna* / caractéristique physicochimique / analyse pollinique / Espagne

Zusammenfassung — Zusammensetzung, physikalisch-chemische Eigenschaften und Pollenspektrum im spanischen Heidehonig (*Calluna vulgaris* L). Pollenspektrum und physikalisch-chemische Eingeschaften von 28 Heidehonigproben kommerzieller spanischer Honigerzeuger wurden analysiert. Nach der melissopalynologischen Analyse (Methodik der UISB, Louveaux *et al,* 1978)

waren 5 Proben abweichender botanischer Herkunft und wurden zurückgewiesen. In den übrigen Proben wurden 101 Pollenarten gefunden, im Durchschnitt enthielt eine Probe 40 verschiedene Pollenarten (Tabelle I). Der Pollengehalt war hoch (100 000–500 000 PK/10 g). Der relative Anteil an *Calluna* Pollen betrug zwischen 10 und 33% (Tabelle I), und der hohe Anteil an *Erica* spp (> 10% im allgemeinen) Pollen stellt ein Problem für die Charakterisierung dar. Das Zuckerspektrum zeigte hohe Anteile an Disacchariden, geringen Gehalt von Glukose (25,6 g/100 g), und Spuren von Saccharose und Trisacchariden (Tabelle II). Die enzymatische Aktivität (Gothe-Zahl 51.9) war höher als in anderen spanischen unifloralen Honigen. Der durchschnittliche Säuregrad (45.5 meq/kg) lag höher als die von der EEG für Honig erlaubten Grenzen. An mineralischen Bestandteilen überwogen Natrium-, Kalium- und Kalziumsalze. Es gab keine Gärungsanzeichen und die Wasseraktivität, a_w, war < 0.70. Das thixotropische Verhalten wurde mit einem Viskosimeter bei 4 Umdrehungsgeschwindigkeiten (16, 40, 80 und 160 rpm) des Zylinders charakterisiert (Tabelle IV, V).

Honig / *Calluna* / physikalisch-chemische Eigenschaft / Pollenanalyse / Spanien

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