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# Physicochemical attributes and pollen spectrum of Portuguese heather honeys

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**Abstract**

The qualities of selected honey samples of "Serra da Lousã" (Portugal) from three consecutive harvests (20 samples from each harvest) were evaluated by determing the pollen spectrum and physicochemical attributes. The following determinations were carried out: moisture, electrical conductivity, hydroxymethylfurfural, diastase activity, pH, acidity (free, lactone and total), formol number, reducing sugars, apparent sucrose, insoluble material and ash. The samples were found to meet all major national and international honey specifications. Honeys were considered to be monofloral whenever the dominant pollen was found to be over 45% of total pollen. From the 60 studied samples, 70% were monofloral honeys from *Erica* sp., 17% monofloral honeys from *Ericaceae* (*Erica* sp. and *Calluna vulgaris* (L.) Hull) and 13% multifloral honeys with a high percentage of *Erica* sp. 

## 1. Introduction

The botanical origin of honey is one of its main quality parameters, and its price is very often related to this floral origin. Some monofloral honeys are more appreciated than others due to their flavour and aromatic properties or due to their pharmacological attributes, and these are generally more costly to buy than multifloral honeys (Ferreres, Andrade, Gil, & Tomás-Barbéran, 1996).

Consumers in Portugal prefer honey produced from heather and they believe that this type of honey is superior to other types produced locally or imported from other countries around the world. Heather honey is produced in Portugal from *Erica* sp. (*Ericaceae*) (Andrade, 1995; Andrade, Ferreres, Gil & Tomás-Barbéran, 1997; Ferreres, Andrade & Tomás-Barbéran, 1994; Andrade, Ferreres, Andrade & Tomás-Barbéran, 1996) while, in Spain and France, heather honey comes from either *Calluna* or *Erica* species (Soler, Gil, Garcia-Viguera & Tomás-Barbéran, 1995). In New Zealand, *Calluna*-derived honeys are considered as heather (Tan, Wilkins, Holland & McGhie, 1989). This honey is characterized by its strong flavour and dark brown colour.

Therefore, the present study was conducted to investigate the most popular type of honey marketed in Portugal in terms of pollen spectrum and physicochemical analysis.

## 2. Materials and methods

### 2.1. Sample collection

The samples that were the object of our study had been claimed as "heather honey" by beekeepers on the basis of organoleptical characteristics. These samples were produced in the Serra da Lousã (Portugal) and provided and guaranteed by the Direcção da Circunscrição Florestal de Coimbra. Samples were stored at 0°C until analysis, which occurred no more than one month after extraction from the hives by beekeepers.

### 2.2. Sample floral-type identification

Pollen spectrum was obtained by a combination of the Erdtman (1966) and Louveaux, Maurizio, and Vorwhol

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(1978) studies. Briefly, a sample of 10 g of crude honey was dissolved in 50 ml of warm distilled water (around 40°C) and centrifuged twice (2500 x *g*) for 10 min. To the dry sediment 5 ml of glacial acetic acid was added. The solution was again centrifuged (2500 x g) for 10 min. To the obtained dry sediment, 10 ml of acetolysis solution (1 ml sulfuric acid +9 ml anhydrous acetic acid) was added, and the mixture was put in a warm bath (at 100°C) during 3 min. This solution was centrifuged and, to the resulting dry sediment 10 ml of glycerine (50%) was added. This solution was centrifuged and the dry sediment was placed in a stove (45°C) for 2 days. To the dry sediment, 0.5 ml of glycerine/gelatine was added and, after agitation in a vortex, 0.1 ml was then mounted on a slide. Slides were microscopically observed and compared with the reference for identification. Monofloral honeys were considered as such whenever the dominant pollen was found at over 45% of the total pollen.

### 2.3. Physicochemical analysis

The samples of honey were analysed according to the European Community (EC) (Official Codex Alimentarius Commission, 1969), Portuguese (NP 1307, 1309, Port. N 449/76), Spanish (BOE, 1986) and the AOAC (Herlich, 1990) methods in order to determine moisture, electrical conductivity, hydroxymethylfurfural (HMF), diastase activity, pH, acidity (free, lactone and total), formol number, reducing sugars, apparent sucrose and insoluble material. Total ash, soluble and insoluble ash, alkalinity of soluble, insoluble and total ash, and sulphated ash in honey were determined according to the Sancho, Muniategui, Huidobro and Simal (1992)

Table 1
Pollen analysis of Serra da Lousã honeys from 1991 harvest[a]

| Botanical name | Honey samples | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Boraginaceae *Echium* sp. | i[c] | i | m[d] | m | - | m | - | m | - | m | m | - | - | - | - | m | - | - | - | m |
| Campanulaceae Type *Campanula erinus* L. | - | m | m | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Caprifoliaceae *Sambucus nigra* L. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Caryophyllaceae | m | - | m | m | - | m | - | m | - | m | m | - | - | - | - | m | - | - | - | - |
| Cistaceae *Cistus ladanifer* L. | i | i | s | s | i | - | i | i | i | i | i | i | - | i | - | i | s | s | s | s |
| Compositae Liguliflorae Type *Lactuca serriola* L. | - | - | i | - | m | i | - | - | - | - | - | - | i | - | - | - | - | - | - | - |
| *Taraxacum* sp. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Tubiflorae | - | m | - | - | - | - | - | - | - | - | - | - | - | - | - | . | . | . | . | . |
| Ericaceae *Calluna vulgaris* (L.) Hull | m | i | i | m | - | m | - | i | i | - | m | m | m | - | m | - | - | - | - | m |
| *Erica* sp. | p | s[b] | s | s | p | p | p | p | p | p | p | p | p | p | p | p | p | p | p | p[a] |
| Fagaceae *Castanea sativa* Miller | i | i | i | i | i | i | i | i | - | - | i | - | i | - | i | - | s | s | i | i |
| Another species | i | i | i | i | i | - | i | i | - | - | i | - | - | - | i | - | i | i | i | m |
| Lamiaceae *Lavandula stoechas* L. | i | i | - | i | i | i | i | - | - | - | - | i | - | - | - | i | m | m | i | - |
| Mimosaceae *Acacia dealbata* Link | i | i | - | i | m | m | - | - | - | - | - | i | - | - | - | - | - | - | - | - |
| Myrtaceae *Eucalyptus globulus* L. | - | - | - | - | i | i | i | - | - | - | - | - | - | i | i | - | m | m | m | - |
| Leaceae *Ligustrum vulgare* L. | i | i | - | i | i | - | - | - | - | - | i | - | - | - | i | i | - | - | - | - |
| Onagraceae Type *Oenothera stricta* Link | m | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Papilionaceae *Cytisus* sp. | i | i | i | i | m | i | i | i | i | m | i | i | i | i | m | m | - | - | m | i |
| Plataginaceae *Platanus* sp. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Plantaginaceae *Plantago* sp. | m | i | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Resedaceae Type *Reseda luteola* L. | - | - | m | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Rhamnaceae *Frangula alnus* Miller | - | m | - | - | - | m | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Rosaceae | - | m | m | - | - | - | m | - | - | - | - | - | - | - | - | m | - | - | - | - |
| Salicaceae *Salix* sp. | - | m | m | - | - | m | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Saxifragaceae Type *Saxifraga globulifera* Desf. | - | m | - | - | - | - | - | m | - | - | - | - | - | - | - | - | - | - | - | - |
| Tiliaceae *Tilia* sp. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ulmaceae *Ulmus minor* Miller | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Umbelliferae | - | - | - | - | - | - | - | - | - | -. | - | - | - | - | - | - | - | - | - | - |
| Honeydew elements | n[e] | n | - | n | n | - | - | - | - | - | - | n | n | - | - | - | - | - | - | n |
| Number of pollenic types | 11 | 17 | 13 | 11 | 10 | 12 | 8 | 7 | 4 | 5 | 9 | 6 | 5 | 4 | 7 | 8 | 6 | 6 | 7 | 7 |

[a] This analysis was done according Louveaux et al. (1978) studies. p, predominant pollen (>45%).
[b] s, Secondary pollen (16–45%).
[c] i, Important minor pollen (3–15%).
[d] m, Minor pollen (<3%).
[e] n, Practically none.

method, using electrical conductivity measurements at 20°C.

## 3. Results and discussion

The results of the honey pollen analysis are shown in Tables 1, 2 and 3. This analysis was done according to the Louveaux et al. (1978) method.

In terms of melissopalinology, the honey samples of 1991 (Table 1) and 1993 (Table 3) show similar characteristics, distinct from the samples of 1992. These samples show a greater percentage of pollen grains from *Eucalyptus globulus* L. (present in 100% of samples) and a smaller percentage of pollen from *Ericaceae*. From the sixty studied samples, 70% were monofloral honeys from *Erica* sp., 17% monofloral honeys from *Ericaceae* (*Erica* sp. and *Calluna vulgaris* (L.) Hull) and 13% multifloral honeys with a high percentage of *Erica* sp. The palynological characteristics, which can be good markers of "Serra da Lousã" are: a high percentage of *Ericaceae*, the constant presence of *Erica* sp. and *Papilionaceae*, the combinations *Erica* sp.-*Calluna vulgaris* (L.) Hull-*Castanea sativa* Miller-*Papilionaceae* and *Erica* sp.-*Calluna vulgaris* (L.) Hull-*Castanea sativa* Miller-*Papilionaceae*-*Cistus ladanifer* L. (present in 80 and 60% of the honeys analysed, respectively).

A descriptive analysis of physicochemical parameters is given in Tables 4–9. The samples were found to meet all major national (NP 1307, 1309, Port. no 449/76) and international honey specifications [Codex Alimentarius Commission, 1969; BOE, 1986; AOAC, (Herlich, 1990) Methods]. The honey samples presented a moisture (Table 4) from 14.6 to 19.9%, with an average of

Table 2
Pollen analysis of Serra da Lousã honeys from the 1992 harvest[a]

| Botanical name | Honey samples | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 1 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Boraginaceae *Echium* sp. | - | m | i[c] | - | - | i | m[d] | - | - | - | - | m | i | m | - | i | m | - | m | - |
| Campanulaceae Type *Campanula erinus* L. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Caprifoliaceae *Sambucus nigra* L. | m | - | m | - | - | - | - | - | - | - | - | - | m | m | - | - | - | - | - | - |
| Caryophyllaceae | - | m | - | - | - | - | m | - | - | m | m | - | - | m | - | m | - | m | m | - |
| Cistaceae *Cistus ladanifer* L. | i | m | i | - | - | - | i | i | - | i | i | i | i | m | - | - | - | m | m | - |
| Compositae liguliflorae Type *Lactuca serriola* | - | - | m | s | - | - | i | m | i | m | m | - | m | m | m | - | - | m | m | - |
| *Taraxacum* sp. | - | - | m | - | - | m | - | m | - | - | m | m | - | - | - | - | - | m | - | - |
| Tubiflorae | - | m | m | - | - | - | m | m | - | - | - | - | m | m | m | - | - | - | - | - |
| Ericaceae *Calluna vulgaris* (L.) Hull | s[b] | i | i | - | i | i | i | i | i | i | i | i | i | i | i | i | i | i | i | i |
| *Erica* sp. | s | s | s | p[a] | p | s | s | s | s | p | p | s | s | s | s | p | p | p | p | s |
| Fagaceae *Castanea sativa* Miller | i | i | m | i | s | - | i | m | m | i | i | s | m | i | i | m | m | i | i | m |
| Another species | i | - | - | - | - | - | - | i | m | - | i | i | - | - | - | - | - | i | - | m |
| Lamiaceae *Lavandula stoechas* L. | m | m | - | m | i | m | m | m | - | i | - | - | m | i | - | m | - | - | i | - |
| Mimosaceae *Acacia dealbata* Link | m | - | m | - | - | - | m | - | - | - | - | - | - | - | m | - | - | - | m | - |
| Myrtaceae *Eucalyptus globulus* L. | m | s | i | i | i | s | i | s | s | i | m | s | i | i | s | s | s | m | i | i |
| Oleaceae *Ligustrum vulgare* L. | i | i | i | m | m | - | m | i | m | i | i | m | i | i | i | m | i | m | i | i |
| Onagraceae Type *Oenothera stricta* Link | m | - | - | - | - | m | - | - | - | - | m | - | - | - | - | - | - | - | | - |
| Papilionaceae *Cytisus* sp. | i | i | i | i | i | m | i | i | i | i | i | i | i | i | i | i | i | i | i | i |
| Plataginaceae *Platanus* sp. | - | - | - | - | - | m | - | m | - | - | - | - | m | - | - | - | - | - | - | - |
| Plantaginaceae *Plantago* sp. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Resedaceae Type *Reseda luteola* L. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | m | - | - | - | m |
| Rhamnaceae *Frangula alnus* Miller | - | m | m | i | - | - | m | - | - | i | - | - | m | m | i | - | - | - | - | - |
| Rosaceae | - | - | - | m | - | i | i | - | - | - | - | i | m | i | i | m | m | m | m | i |
| Salicaceae *Salix* sp. | - | - | i | i | - | m | i | - | i | - | - | - | i | - | - | i | m | - | - | m |
| Saxifragaceae Type *Saxifraga globulifera* Desf. | - | - | - | - | - | m | - | - | - | - | - | - | - | m | - | m | - | - | - | - |
| Tiliaceae *Tilia* sp. | - | - | - | - | - | m | - | - | - | m | - | - | - | - | - | - | m | m | - | m |
| Ulmaceae *Ulmus minor* Miller | - | - | - | - | - | - | - | m | - | - | m | - | - | - | m | - | - | - | m | - |
| Umbelliferae | - | - | - | i | - | - | m | - | i | - | - | - | - | - | - | - | - | - | - | - |
| Honeydew elements | n[e] | - | - | - | n | - | - | - | - | - | - | - | n | - | - | - | - | - | - | n |
| Number of pollenic types | 12 | 12 | 15 | 11 | 7 | 3 | 17 | 14 | 10 | 12 | 13 | 11 | 17 | 16 | 12 | 13 | 10 | 13 | 14 | 11 |

[a] This analysis was done according Louveaux et al. (1978) studies. p, predominant pollen (>45%).
[b] s, Secondary pollen (16–45%).
[c] i, Important minor pollen (3–15%).
[d] m, Minor pollen (<3%).
[e] n, Practically none.

Table 3
Pollen analysis of Serra da Lousã honeys from the 1993 harvest[a]

| Botanical name | Honey samples | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Boraginaceae *Echium* sp. | - | m[d] | - | m | m | - | - | - | i[c] | m | i | i | m | - | - | m | i | m | m | - |
| Campanulaceae Type *Campanula erinus* L. | - | - | - | m | - | - | - | - | - | - | - | m | - | - | - | - | - | - | - | - |
| Caprifoliaceae *Sambucus nigra* L. | m | m | - | m | - | - | - | m | - | - | m | - | - | m | m | - | - | - | - | - |
| Caryophyllaceae | - | - | m | - | - | - | m | m | - | - | - | m | - | - | - | - | - | m | - | m |
| Cistaceae *Cistus ladanifer* L. | m | i | m | - | i | i | i | i | i | m | i | - | - | i | i | m | i | i | m | m |
| Compositae liguliflorae Type *Lactuca serriola* L. | - | - | - | m | m | i | i | - | m | - | m | i | - | m | - | m | m | i | m | m |
| *Taraxacum* sp. | - | - | - | m | m | - | - | - | - | - | m | m | - | m | - | - | - | m | - | m |
| Tubiflorae | - | - | - | - | m | - | - | - | - | - | m | - | - | - | i | - | m | - | - | - |
| Ericaceae *Calluna vulgaris* (L.) Hull | i | i | i | m | m | i | i | i | i | i | i | i | i | i | m | i | i | i | i | i |
| *Erica* sp. | p[a] | p | p | p | p | p | p | p | p | p | p | s | p | s | p | p | p | p | s[b] | p |
| Fagaceae *Castanea sativa* Miller | m | i | m | m | m | m | i | m | m | i | m | i | i | m | m | m | - | i | m | m |
| Another species | m | - | m | - | - | - | - | m | i | - | - | m | - | - | - | - | - | - | - | - |
| Lamiaceae *Lavandula stoechas* L. | i | i | - | i | - | - | i | m | - | m | i | m | - | m | m | i | m | m | i | i |
| Mimosaceae *Acacia dealbata* Link | i | - | - | - | - | m | - | - | m | - | - | - | - | - | - | - | - | - | m | - |
| Myrtaceae *Eucalyptus globulus* L. | i | i | - | m | - | - | m | - | m | i | - | - | - | - | - | - | m | m | i | - |
| Oleaceae *Ligustrum vulgare* L. | m | m | - | m | m | m | i | m | i | i | i | i | - | - | - | m | m | i | i | i |
| Onagraceae Type *Oenothera stricta* Link | - | m | - | - | - | - | - | - | - | m | - | - | - | - | - | m | - | - | - | - |
| Papilionaceae *Cytisus* sp. | i | i | i | i | i | i | i | i | i | i | i | i | s | s | i | i | i | i | m | i |
| Plataginaceae *Platanus* sp. | - | - | - | m | - | m | - | - | - | m | - | - | - | m | - | - | - | - | - | - |
| Plantaginaceae *Plantago* sp. | - | - | i | i | i | - | - | m | m | - | m | m | - | i | i | - | i | i | m | - |
| Resedaceae Type *Reseda luteola* L. | - | - | - | m | m | m | - | m | m | m | - | - | - | - | - | - | m | - | - | - |
| Rhamnaceae *Frangula alnus* Miller | - | - | - | - | m | - | m | - | - | m | - | - | - | - | - | m | i | - | m | - |
| Rosaceae | - | - | m | - | i | i | - | m | i | i | - | - | i | - | - | m | - | - | - | - |
| Salicaceae *Salix* sp. | m | m | i | - | m | - | m | - | m | - | m | - | - | - | m | i | - | - | m | - |
| Saxifragaceae Type *Saxifraga globulifera* Desf. | m | i | i | m | m | i | i | m | m | m | i | m | m | m | m | i | i | m | i | i |
| Tiliaceae *Tilia* sp. | - | - | - | - | - | m | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ulmaceae *Ulmus minor* Miller | - | m | - | m | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Umbelliferae | i | i | - | i | i | m | i | i | - | m | i | i | i | m | i | i | - | m | m | i |
| Honeydew elements | n[e] | - | - | - | - | - | - | - | - | - | - | - | n | - | - | - | - | - | - | n |
| Number of pollenic types | 14 | 15 | 11 | 18 | 17 | 15 | 14 | 15 | 16 | 16 | 16 | 16 | 8 | 13 | 12 | 15 | 14 | 15 | 16 | 12 |

[a] This analysis was done according Louveaux et al. (1978) studies. p, predominant pollen (>45%).
[b] s, Secondary pollen (16–45%).
[c] i, Important minor pollen (3–15%).
[d] m, Minor pollen (<3%).
[e] n, Practically none.

17.83%, which means a proper degree of maturity, and agrees with the reported higher moisture in *Ericaceae* honeys (Crane, 1975, 1990). The insoluble material (Table 4) is likewise within limits (below 0.1%) (Codex Alimentarius Commission, 1969).

The reducing sugars (Table 5) were above 65% (the minimum limit set by EC regulations) in all samples, and the mean percentages of apparent sucrose (Table 5) were below or equal to 0.27 (5% is the maximum legal limit set by EC regulations). These two parameters confirm that the honey samples studied were floral honeys (NP 1307 and 1309, Port. no 449/76).

Honey samples showed an appropriate diastase number ranging from 13 to 51.1 (Gothe degrees) (Table 5), and their HMF content averaged 15.9 mg/kg (Table 5). Thus, all samples fell within the European Community regulations (Codex Alimentarius Commission., 1969) and presented a high degree of freshness. Electrical conductivity (Tables 6–8) average was 5.22 ($10^{-4}$ S $cm^{-1}$), which indicates that the samples studied were floral honeys (NP 1307, 1309, Port. no 449/76). The same conclusion can be drawn from the range of values for total ash content (0.04–0.52%) (Tables 6–8).

The total acidity (Table 9) was likewise within limits (below 40 meq/kg of honey), indicating absence of undesirable fermentation. The pH found (Table 9) in all samples (3.60–4.46) corresponded to that of floral honeys (Crane, 1990).

The honey samples studied had a formol number (Table 9) within the normal values set by the Manuel Suisse des Denrées Alimentaires (1974) (0.45–1.55 meq/100 g honey), with the exception of six samples which presented a formol number above 1.55 meq/100 g honey, indicating an artificial feed of bees with protein derivates.

Table 4
Analysis of moisture and insoluble material of Serra da Lousã honeys, from 1991 to 1993 harvests

| | Moisture (%) | | | Insoluble material (%) | | |
|---|---|---|---|---|---|---|
| | 1991 | 1992 | 1993 | 1991 | 1992 | 1993 |
| 1 | 16.32 | 16.70 | 18.70 | 0.01 | 0.03 | 0.09 |
| 2 | 17.84 | 17.72 | 17.70 | 0.03 | 0.02 | 0.02 |
| 3 | 15.84 | 16.48 | 19.70 | 0.01 | 0.03 | 0.02 |
| 4 | 15.12 | 16.32 | 19.50 | 0.01 | 0.02 | 0.02 |
| 5 | 17.24 | 18.40 | 18.90 | 0.02 | 0.04 | 0.01 |
| 6 | 18.92 | 18.00 | 19.90 | 0.03 | 0.02 | 0.02 |
| 7 | 16.68 | 16.68 | 19.30 | 0.01 | 0.03 | 0.02 |
| 8 | 17.84 | 17.40 | 18.70 | 0.01 | 0.01 | 0.02 |
| 9 | 17.00 | 18.08 | 19.80 | 0.02 | 0.01 | 0.03 |
| 10 | 18.04 | 18.71 | 19.90 | 0.04 | 0.08 | 0.01 |
| 11 | 18.44 | 17.60 | 19.70 | 0.03 | 0.10 | 0.01 |
| 12 | 18.24 | 17.52 | 18.91 | 0.06 | 0.04 | 0.07 |
| 13 | 15.88 | 16.80 | 18.50 | 0.05 | 0.01 | 0.03 |
| 14 | 17.84 | 16.16 | 18.70 | 0.02 | 0.03 | 0.02 |
| 15 | 17.32 | 17.20 | 17.60 | 0.03 | 0.03 | 0.05 |
| 16 | 16.80 | 17.88 | 19.30 | 0.01 | 0.06 | 0.03 |
| 17 | 17.64 | 16.44 | 19.50 | 0.01 | 0.08 | 0.05 |
| 18 | 16.68 | 17.08 | 14.60 | 0.02 | 0.04 | 0.04 |
| 19 | 18.76 | 18.00 | 19.50 | 0.03 | 0.04 | 0.01 |
| 20 | 17.72 | 17.20 | 18.70 | 0.01 | 0.06 | 0.03 |
| Mean | 17.31 | 17.32 | 18.86 | 0.01 | 0.04 | 0.03 |
| SD | 1.02 | 0.73 | 1.20 | 0.01 | 0.02 | 0.02 |
| $V_{min}$ | 15.12 | 16.16 | 14.60 | 0.01 | 0.01 | 0.01 |
| $V_{max}$ | 18.92 | 18.71 | 19.90 | 0.06 | 0.10 | 0.09 |

Table 5
Analysis of reducing sugars, apparent sucrose, diastase activity and hydroxymethylfurfural (HMF) of Serra da Lousã honeys, from 1991 to 1993 harvests

| | Reducing sugars (%) | | | Apparent sucrose (%) | | | Diastase activity (Gothe Scale) | | | HMF (mg/Kg of honey) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1991 | 1992 | 1993 | 1991 | 1992 | 1993 | 1991 | 1992 | 1993 | 1991 | 1992 | 1993 |
| 1 | 73.8 | 74.6 | 73.2 | 1.53 | 0.79 | 1.60 | 13.3 | 20.7 | 23.0 | 17.5 | 8.08 | 11.2 |
| 2 | 69.4 | 71.2 | 73.2 | 0.91 | 1.22 | 1.00 | 23.4 | 19.8 | 20.0 | 16.5 | 18.4 | 11.3 |
| 3 | 72.2 | 72.7 | 72.2 | 1.97 | 1.52 | 1.50 | 24.8 | 24.0 | 20.0 | 22.7 | 11.8 | 20.7 |
| 4 | 75.1 | 72.0 | 74.4 | 1.25 | 0.27 | 1.60 | 20.5 | 30.0 | 27.0 | 14.3 | 7.55 | 16.9 |
| 5 | 72.3 | 71.7 | 75.3 | 1.47 | 0.48 | 0.50 | 24.5 | 19.8 | 36.0 | 31.4 | 15.8 | 11.0 |
| 6 | 70.2 | 72.6 | 73.4 | 1.00 | 1.52 | 1.00 | 22.0 | 27.0 | 23.0 | 17.4 | 12.7 | 8.60 |
| 7 | 74.1 | 69.2 | 72.3 | 2.34 | 0.53 | 0.27 | 24.8 | 17.8 | 30.0 | 6.79 | 13.6 | 5.10 |
| 8 | 70.3 | 69.3 | 75.4 | 1.38 | 0.88 | 0.50 | 33.3 | 23.5 | 24.0 | 29.2 | 8.59 | 8.00 |
| 9 | 70.6 | 73.0 | 72.2 | 2.36 | 0.87 | 1.00 | 24.7 | 18.1 | 20.0 | 19.0 | 25.6 | 7.50 |
| 10 | 74.1 | 69.0 | 72.5 | 1.28 | 0.91 | 0.50 | 20.5 | 21.4 | 13.0 | 8.67 | 32.9 | 8.10 |
| 11 | 74.2 | 71.3 | 70.6 | 1.56 | 0.30 | 0.90 | 17.1 | 30.8 | 34.0 | 16.5 | 29.3 | 5.20 |
| 12 | 69.2 | 72.1 | 71.8 | 0.88 | 1.00 | 1.70 | 19.4 | 22.2 | 24.0 | 36.3 | 14.8 | 6.60 |
| 13 | 70.6 | 71.4 | 74.3 | 1.86 | 0.80 | 1.10 | 23.2 | 25.0 | 30.0 | 25.3 | 13.8 | 4.40 |
| 14 | 78.0 | 71.5 | 74.8 | 1.14 | 1.24 | 0.50 | 21.6 | 27.9 | 41.0 | 23.0 | 9.57 | 5.60 |
| 15 | 71.7 | 73.0 | 69.9 | 0.86 | 0.74 | 1.20 | 25.0 | 15.0 | 15.0 | 13.0 | 8.89 | 7.80 |
| 16 | 73.3 | 72.9 | 70.2 | 1.77 | 1.81 | 0.83 | 19.6 | 18.6 | 30.0 | 19.0 | 18.1 | 7.50 |
| 17 | 72.8 | 68.8 | 72.7 | 0.40 | 0.90 | 1.00 | 13.0 | 26.8 | 23.0 | 15.3 | 9.71 | 14.8 |
| 18 | 68.5 | 71.1 | 75.2 | 1.31 | 1.20 | 0.80 | 27.6 | 21.6 | 30.0 | 16.7 | 14.5 | 34.1 |
| 19 | 67.3 | 74.0 | 73.8 | 1.21 | 0.81 | 1.00 | 16.0 | 16.0 | 18.0 | 26.5 | 32.5 | 28.6 |
| 20 | 73.7 | 71.7 | 72.7 | 1.62 | 1.47 | 1.50 | 21.0 | 51.1 | 23.0 | 33.8 | 0.32 | 16.8 |
| Mean | 72.1 | 71.7 | 73.0 | 1.41 | 0.96 | 1.00 | 21.8 | 23.9 | 25.2 | 20.4 | 15.3 | 12.0 |
| SD | 2.59 | 1.62 | 1.63 | 0.50 | 0.42 | 0.42 | 4.78 | 7.80 | 7.06 | 7.98 | 8.70 | 8.01 |
| $V_{min}$ | 67.3 | 68.8 | 69.9 | 0.40 | 0.27 | 0.27 | 13.0 | 15.0 | 13.0 | 6.79 | 0.32 | 4.40 |
| $V_{max}$ | 78.0 | 74.6 | 75.4 | 2.36 | 1.81 | 1.70 | 33.3 | 51.1 | 41.0 | 36.3 | 32.9 | 34.1 |

Table 6
Analysis of electrical conductivity, ash (total, soluble and insoluble), sulphated ash and alkalinity of ash (total, soluble and insoluble) of Serra da Lousã honeys, from 1991 harvest

| | 1991 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Electrical conductivity ($10^{-4}$ S cm$^{-1}$) | Ash (%) | | | Sulphated Ash (%) | Alkalinity of ash (ml of acid N/100 g of honey) | | |
| | | Total | Soluble | Insoluble | | Total | Soluble | Insoluble |
| 1 | 2.90 | 0.15 | 0.11 | 0.04 | 0.25 | 2.04 | 1.47 | 0.57 |
| 2 | 5.21 | 0.34 | 0.26 | 0.08 | 0.53 | 4.51 | 3.25 | 1.26 |
| 3 | 4.97 | 0.32 | 0.24 | 0.08 | 0.51 | 4.30 | 3.10 | 1.20 |
| 4 | 7.41 | 0.52 | 0.39 | 0.13 | 0.80 | 6.88 | 4.95 | 1.93 |
| 5 | 4.93 | 0.31 | 0.23 | 0.08 | 0.50 | 4.49 | 3.02 | 1.17 |
| 6 | 5.47 | 0.36 | 0.27 | 0.09 | 0.57 | 4.84 | 3.48 | 1.36 |
| 7 | 5.74 | 0.38 | 0.29 | 0.09 | 0.59 | 5.05 | 3.64 | 1.41 |
| 8 | 5.00 | 0.32 | 0.24 | 0.08 | 0.51 | 4.30 | 3.10 | 1.20 |
| 9 | 5.52 | 0.36 | 0.27 | 0.09 | 0.57 | 4.84 | 3.48 | 1.36 |
| 10 | 7.10 | 0.50 | 0.38 | 0.12 | 0.76 | 6.56 | 4.72 | 1.84 |
| 11 | 4.47 | 0.28 | 0.21 | 0.07 | 0.45 | 3.76 | 2.71 | 1.05 |
| 12 | 6.44 | 0.44 | 0.33 | 0.11 | 0.68 | 5.80 | 4.18 | 1.62 |
| 13 | 4.81 | 0.31 | 0.23 | 0.08 | 0.48 | 4.08 | 2.94 | 1.14 |
| 14 | 5.57 | 0.37 | 0.28 | 0.09 | 0.58 | 4.94 | 3.56 | 1.38 |
| 15 | 5.62 | 0.37 | 0.28 | 0.09 | 0.58 | 4.94 | 3.56 | 1.38 |
| 16 | 5.53 | 0.36 | 0.27 | 0.09 | 0.57 | 4.84 | 3.48 | 1.36 |
| 17 | 3.58 | 0.21 | 0.16 | 0.05 | 0.34 | 2.79 | 2.01 | 0.78 |
| 18 | 6.46 | 0.45 | 0.34 | 0.11 | 0.69 | 5.91 | 4.26 | 1.65 |
| 19 | 5.47 | 0.36 | 0.27 | 0.09 | 0.57 | 4.84 | 3.48 | 1.36 |
| 20 | 6.54 | 0.45 | 0.34 | 0.11 | 0.69 | 5.91 | 4.26 | 1.65 |
| Mean | 5.44 | 0.36 | 0.27 | 0.09 | 0.56 | 4.78 | 3.43 | 1.33 |
| SD | 1.08 | 0.09 | 0.07 | 0.02 | 0.13 | 1.15 | 0.83 | 0.32 |
| $V_{min}$ | 2.90 | 0.15 | 0.11 | 0.04 | 0.25 | 2.04 | 1.47 | 0.57 |
| $V_{max}$ | 7.41 | 0.52 | 0.39 | 0.13 | 0.80 | 6.88 | 4.95 | 1.93 |

Table 7
Analysis of electrical conductivity, ash (total, soluble and insoluble), sulphated ash and alkalinity of ash (total, soluble and insoluble) of Serra da Lousã honeys, from 1992 harvest

| | 1992 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Electrical conductivity ($10^{-4}$ S cm$^{-1}$) | Ash (%) | | | Sulphated Ash (%) | Alkalinity of ash (ml of acid N/100 g of honey) | | |
| | | Total | Soluble | Insoluble | | Total | Soluble | Insoluble |
| 1 | 6.52 | 0.45 | 0.34 | 0.11 | 0.69 | 5.91 | 4.26 | 1.65 |
| 2 | 5.99 | 0.41 | 0.31 | 0.10 | 0.63 | 5.37 | 3.87 | 1.50 |
| 3 | 5.06 | 0.33 | 0.25 | 0.08 | 0.52 | 4.41 | 3.18 | 1.23 |
| 4 | 4.26 | 0.26 | 0.20 | 0.06 | 0.42 | 3.55 | 2.56 | 0.99 |
| 5 | 6.19 | 0.42 | 0.32 | 0.10 | 0.65 | 5.59 | 4.02 | 1.57 |
| 6 | 4.80 | 0.31 | 0.23 | 0.08 | 0.48 | 4.08 | 2.94 | 1.14 |
| 7 | 5.53 | 0.37 | 0.27 | 0.09 | 0.57 | 4.84 | 3.48 | 1.36 |
| 8 | 4.10 | 0.26 | 0.19 | 0.06 | 0.40 | 3.33 | 2.40 | 0.93 |
| 9 | 3.56 | 0.20 | 0.15 | 0.05 | 0.33 | 2.79 | 1.94 | 0.75 |
| 10 | 5.10 | 0.33 | 0.25 | 0.08 | 0.52 | 4.41 | 3.18 | 1.23 |
| 11 | 4.60 | 0.29 | 0.22 | 0.07 | 0.46 | 3.87 | 2.79 | 1.08 |
| 12 | 5.06 | 0.33 | 0.25 | 0.08 | 0.52 | 4.41 | 3.18 | 1.23 |
| 13 | 5.20 | 0.28 | 0.26 | 0.08 | 0.53 | 4.51 | 3.25 | 1.26 |
| 14 | 4.07 | 0.25 | 0.19 | 0.06 | 0.40 | 3.33 | 2.40 | 0.93 |
| 15 | 3.95 | 0.24 | 0.18 | 0.06 | 0.39 | 3.22 | 2.32 | 0.90 |
| 16 | 4.86 | 0.31 | 0.23 | 0.08 | 0.48 | 4.19 | 2.94 | 1.14 |
| 17 | 4.68 | 0.30 | 0.23 | 0.07 | 0.47 | 3.98 | 2.87 | 1.11 |
| 18 | 6.32 | 0.43 | 0.32 | 0.11 | 0.67 | 5.70 | 4.10 | 1.60 |
| 19 | 4.93 | 0.32 | 0.23 | 0.08 | 0.50 | 4.19 | 3.02 | 1.17 |
| 20 | 5.54 | 0.37 | 0.27 | 0.09 | 0.57 | 4.84 | 3.48 | 1.36 |
| Mean | 5.02 | 0.32 | 0.24 | 0.08 | 0.51 | 4.33 | 3.11 | 1.21 |
| SD | 0.82 | 0.07 | 0.05 | 0.02 | 0.10 | 0.87 | 0.63 | 0.25 |
| $V_{min}$ | 3.56 | 0.20 | 0.15 | 0.05 | 0.33 | 2.79 | 1.94 | 0.75 |
| $V_{máx}$ | 6.52 | 0.45 | 0.34 | 0.11 | 0.69 | 5.91 | 4.26 | 1.65 |

Table 8
Analysis of electrical conductivity, ash (total, soluble and insoluble), sulphated ash and alkalinity of ash (total, soluble and insoluble) of Serra da Lousã honeys, from 1993 harvest

| | 1993 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Electrical conductivity ($10^{-4}$ S cm$^{-1}$) | Ash (%) | | | Sulphated Ash (%) | Alkalinity of ash (ml of acid N/100 g of honey) | | |
| | | Total | Soluble | Insoluble | | Total | Soluble | Insoluble |
| 1 | 5.48 | 0.36 | 0.27 | 0.09 | 0.57 | 4.84 | 3.48 | 1.36 |
| 2 | 6.39 | 0.44 | 0.33 | 0.11 | 0.68 | 5.80 | 4.18 | 1.62 |
| 3 | 4.12 | 0.25 | 0.19 | 0.06 | 0.40 | 3.33 | 2.40 | 0.93 |
| 4 | 4.57 | 0.29 | 0.22 | 0.07 | 0.46 | 3.87 | 2.79 | 1.08 |
| 5 | 4.53 | 0.28 | 0.21 | 0.07 | 0.45 | 3.76 | 2.71 | 1.05 |
| 6 | 6.37 | 0.44 | 0.33 | 0.11 | 0.68 | 5.80 | 4.18 | 1.62 |
| 7 | 6.15 | 0.42 | 0.32 | 0.10 | 0.65 | 5.59 | 4.02 | 1.57 |
| 8 | 6.08 | 0.41 | 0.31 | 0.10 | 0.64 | 5.48 | 3.95 | 1.53 |
| 9 | 4.20 | 0.26 | 0.20 | 0.06 | 0.41 | 3.44 | 2.48 | 0.96 |
| 10 | 4.15 | 0.25 | 0.20 | 0.06 | 0.41 | 3.44 | 2.48 | 0.96 |
| 11 | 6.02 | 0.41 | 0.31 | 0.10 | 0.63 | 5.37 | 3.87 | 1.50 |
| 12 | 5.20 | 0.34 | 0.26 | 0.08 | 0.53 | 4.51 | 3.25 | 1.26 |
| 13 | 4.35 | 0.27 | 0.20 | 0.07 | 0.44 | 3.65 | 2.63 | 1.02 |
| 14 | 6.24 | 0.43 | 0.32 | 0.10 | 0.65 | 5.59 | 4.02 | 1.57 |
| 15 | 4.80 | 0.31 | 0.23 | 0.08 | 0.48 | 4.08 | 2.94 | 1.14 |
| 16 | 5.25 | 0.34 | 0.26 | 0.09 | 0.54 | 4.62 | 3.33 | 1.29 |
| 17 | 4.63 | 0.29 | 0.22 | 0.07 | 0.46 | 3.87 | 2.79 | 1.08 |
| 18 | 5.17 | 0.34 | 0.26 | 0.08 | 0.53 | 4.51 | 3.25 | 1.26 |
| 19 | 6.18 | 0.42 | 0.32 | 0.10 | 0.65 | 5.59 | 4.02 | 1.57 |
| 20 | 4.80 | 0.31 | 0.23 | 0.08 | 0.48 | 4.08 | 2.94 | 1.14 |
| Mean | 5.23 | 0.34 | 0.26 | 0.08 | 0.54 | 4.56 | 3.29 | 1.28 |
| SD | 0.82 | 0.07 | 0.05 | 0.02 | 0.10 | 0.88 | 0.63 | 0.25 |
| $V_{min}$ | 4.12 | 0.25 | 0.19 | 0.06 | 0.40 | 3.33 | 2.40 | 0.93 |
| $V_{máx}$ | 6.39 | 0.44 | 0.33 | 0.11 | 0.68 | 5.80 | 4.18 | 1.62 |

Table 9
Analysis of pH, acidity (free, lactone and total) and formol number of Serra da Lousã honeys, from 1991 to 1993 harvests

| | pH | | | Free acidity (meq/Kg of honey) | | | Lactone acidity (meq/Kg of honey) | | | Total acidity (meq/Kg of honey) | | | Formol number (meq/100g of honey) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1991 | 1992 | 1993 | 1991 | 1992 | 1993 | 1991 | 1992 | 1993 | 1991 | 1992 | 1993 | 1991 | 1992 | 1993 |
| 1 | 3.60 | 4.32 | 3.94 | 27.2 | 20.4 | 27.5 | 8.13 | 11.3 | 8.50 | 35.3 | 31.7 | 36.0 | 1.10 | 1.34 | 1.60 |
| 2 | 4.30 | 4.03 | 4.30 | 23.2 | 34.0 | 30.0 | 4.98 | 5.08 | 5.65 | 28.2 | 39.1 | 35.7 | 1.23 | 0.62 | 0.90 |
| 3 | 3.77 | 4.20 | 4.10 | 28.7 | 26.0 | 33.4 | 9.70 | 6.44 | 11.4 | 38.4 | 32.5 | 44.8 | 1.22 | 0.91 | 1.35 |
| 4 | 3.90 | 4.15 | 4.12 | 31.5 | 16.9 | 34.8 | 4.98 | 4.32 | 7.95 | 36.5 | 21.3 | 42.8 | 1.63 | 0.83 | 1.41 |
| 5 | 3.92 | 4.46 | 3.98 | 28.6 | 28.0 | 36.8 | 7.08 | 4.17 | 11.4 | 35.7 | 32.2 | 48.2 | 1.08 | 1.12 | 1.42 |
| 6 | 3.93 | 4.15 | 4.27 | 30.8 | 20.6 | 38.8 | 18.4 | 4.75 | 4.30 | 49.2 | 25.3 | 43.1 | 0.83 | 0.91 | 1.56 |
| 7 | 4.04 | 4.36 | 4.31 | 31.9 | 22.5 | 35.6 | 7.34 | 3.31 | 5.70 | 39.2 | 25.8 | 41.3 | 1.06 | 0.91 | 1.26 |
| 8 | 3.88 | 4.34 | 4.12 | 36.3 | 17.9 | 29.4 | 8.65 | 2.80 | 11.9 | 44.9 | 20.7 | 41.3 | 1.63 | 0.67 | 1.37 |
| 9 | 3.97 | 4.20 | 4.16 | 30.7 | 15.8 | 18.3 | 5.87 | 2.35 | 1.00 | 36.5 | 18.2 | 19.3 | 0.95 | 0.76 | 0.73 |
| 10 | 4.00 | 4.16 | 4.11 | 34.6 | 24.3 | 22.0 | 11.7 | 8.87 | 1.55 | 46.3 | 33.2 | 23.5 | 1.85 | 1.51 | 0.78 |
| 11 | 4.30 | 3.85 | 4.29 | 28.7 | 27.0 | 26.1 | 4.83 | 4.00 | 3.75 | 33.5 | 31.0 | 29.8 | 0.94 | 0.84 | 1.36 |
| 12 | 4.20 | 3.98 | 3.86 | 33.6 | 20.0 | 24.9 | 4.20 | 3.25 | 1.70 | 37.8 | 23.3 | 26.6 | 1.38 | 0.83 | 1.15 |
| 13 | 4.03 | 4.20 | 4.06 | 31.2 | 16.8 | 34.8 | 7.08 | 4.82 | 8.75 | 38.2 | 21.6 | 43.6 | 1.13 | 1.00 | 1.38 |
| 14 | 4.35 | 4.15 | 4.04 | 37.0 | 24.3 | 33.4 | 2.99 | 8.85 | 9.35 | 39.9 | 33.2 | 42.7 | 1.50 | 0.84 | 1.68 |
| 15 | 4.10 | 4.14 | 4.11 | 29.0 | 16.8 | 25.6 | 12.3 | 2.50 | 0.70 | 41.3 | 19.3 | 26.3 | 0.88 | 0.85 | 0.80 |
| 16 | 4.02 | 4.45 | 4.25 | 30.9 | 25.0 | 34.4 | 3.52 | 1.50 | 7.05 | 34.4 | 26.5 | 41.5 | 1.16 | 1.21 | 1.27 |
| 17 | 3.80 | 4.24 | 4.19 | 27.6 | 30.4 | 34.1 | 8.23 | 3.00 | 6.75 | 35.8 | 33.4 | 40.7 | 1.27 | 0.84 | 1.22 |
| 18 | 3.70 | 4.29 | 4.20 | 30.4 | 31.1 | 30.7 | 15.7 | 1.25 | 3.85 | 46.2 | 32.3 | 34.5 | 1.42 | 1.16 | 1.47 |
| 19 | 4.20 | 4.31 | 4.15 | 25.2 | 22.4 | 31.9 | 1.84 | 1.00 | 4.70 | 27.1 | 23.4 | 36.6 | 1.30 | 1.18 | 1.55 |
| 20 | 4.20 | 4.30 | 4.12 | 32.7 | 27.3 | 37.8 | 4.23 | 2.30 | 10.1 | 37.0 | 29.6 | 47.9 | 1.28 | 1.31 | 0.90 |
| Mean | 4.01 | 4.21 | 4.13 | 30.5 | 23.4 | 31.0 | 7.59 | 4.29 | 6.30 | 38.1 | 27.7 | 37.3 | 1.24 | 0.98 | 1.26 |
| SD | 0.21 | 0.15 | 0.12 | 3.42 | 5.27 | 5.50 | 4.27 | 2.72 | 3.58 | 5.60 | 5.87 | 8.27 | 0.27 | 0.24 | 0.29 |
| $V_{min}$ | 3.60 | 3.85 | 3.86 | 23.2 | 15.8 | 18.3 | 1.84 | 1.00 | 0.70 | 27.1 | 18.2 | 19.3 | 0.83 | 0.62 | 0.73 |
| $V_{max}$ | 4.35 | 4.46 | 4.31 | 37.0 | 34.0 | 38.8 | 18.4 | 11.3 | 11.9 | 49.2 | 39.1 | 48.2 | 1.85 | 1.51 | 1.68 |

In conclusion, the chemical characteristics of the heather honeys do not explain the preference of Portuguese consumers for this type of honey. The reason for this preference could be simply due to the taste and to the belief that this honey is naturally produced in the mountains and is able to cure many diseases, which is in accordance with the reasons why, for example, Saudi consumers prefer "Buck thorn" (*Zyziphus* sp.) (Abu-Tarboush, Al-Khatani, & El-Sarrage, 1993) and the Spanish prefer rosemary (*Rosmarinus officinalis* L.) honey (Perez-Arquillué, Conchello, Ariño, Jaun, & Herrera, 1994; 1995), as against other types of honey.

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