

**EFFECTS OF ARTIFICIAL SUGAR FEEDING  
ON SUGAR COMPOSITION OF ROYAL JELLY<sup>1</sup>**

Giulio SESTA\*, Livia PERSANO ODDO, Fabrizio NISI, Leonardo RICCI

C.R.A. - Istituto Sperimentale per la Zoologia Agraria, Sezione di Apicoltura

Via L. Rech 36

00156, Roma (Italy)

Tel: +39 06 86895456; fax: +39 06 86895463

e-mail [giulio.sesta@apicoltura.org](mailto:giulio.sesta@apicoltura.org)

**Short title:** Sugar composition of royal jelly

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**Abstract**

The aim of this research is to contribute to the knowledge of the Royal Jelly (RJ) sugar composition and to examine its possible dependence on artificial sugar feeding of bee colonies. For organic beekeeping artificial nutrition is not allowed, except in case of danger to the life of the colony. This restriction does not seem to be important for the production of RJ, which is a honeybee secretion and should not be directly affected by feeding. In this study the sugar content was determined in 95 RJ samples, partly obtained from colonies fed with different sugar syrups, partly purchased from commercial producers and importers. Results show that no correlation can be established between the RJ sugar content and the feeding regimes tested. The ranges (g/100g of fresh matter) found for the three main RJ sugars are 2.3-6.9 for fructose; 3.7-8.2 for glucose, <0.1-2.1 for sucrose and 6.9-16.0 for their sum. These values may represent a contribution in establishing a quality standard for RJ.

**Key words** : Royal jelly/sugar composition/organic beekeeping.

**1. Introduction**

Sugars are among the main components of royal jelly (RJ). Their determination may be a significant part of RJ quality control. Fructose, glucose and sucrose are by far the most important sugars in RJ. Their content was studied by several authors [4, 5, 6, 7, 8, 10, 12, 13], including the detection of possible adulteration with honey or sugars [9]. The European regulation on organic agriculture does not allow artificial nutrition of bee colonies, except in case of danger to the life of the colony [2]. However with beekeeping for RJ production, it is often necessary to

supply colonies with both sugar and protein nourishment. Currently, it would be virtually impossible to produce organic RJ commercially without such feeding. However, this restriction seems to be not so important for RJ, which is a honeybee secretion and should not be directly affected by feeding, as it may be for honey. In order to provide a further contribution to the knowledge of RJ sugar composition and to evaluate its possible dependence on sugar feeding, an investigation was conducted, analysing RJ samples obtained in different experimental conditions.

## ***2. Materials and methods***

In April 2004, 15 bee colonies were equipped for RJ production, and divided into 5 groups: one group (Group I, blank) was kept without any artificial nutrition, to verify the natural variability of sugar content, and the other 4 groups were fed with 4 different types of sugar nutrition:

*Group II* Honey-water solution 1:1

*Group III* Sugar syrup: sucrose-water solution 1:1

*Group IV* Cerestar: a commercial syrup containing glucose (33% on dry weight), fructose (25%), maltose (21%) and other oligo and polysaccharides

*Group V* Apiinvert: a commercial product containing fructose (39% on dry weight), glucose (31%) and sucrose (30%)

Once a week, during all the active season, from May to September, artificial royal cells containing one-day-old larvae were inserted in each colony and nutrition (1.5 L) was supplied according to the experimental scheme; on the third day after the insertion, the RJ samples were collected. In total 77 RJ samples were obtained (9

to 19 for each group). The experimental scheme and the sample distribution are shown in Table I.

Table I – Experimental scheme and samples collected.

Group (3 colonies each)	Feeding	Samples collected
I (blank)	No sugar nutrition	14
II	Honey	17
III	Sugar syrup	18
IV	Cerestar	19
V	Apiinvert	9
<b>Total samples</b>		<b>77</b>

In order to compare experimental and commercial samples, other RJ samples were purchased from Italian producers (13 samples) and importers (5 samples).

All the 95 RJ samples were analysed by an HPLC-RID method previously developed and validated [11] that allows the determination of the main RJ sugars: fructose, glucose, sucrose, and of maltose, with a detection limit of 0.06 g/100g.

### 3. Results and discussion

Results are reported in Table II and Fig. 1.

Table II – Sugar content in the RJ samples analysed (g/100 g of fresh product): average values (in bold)  $\pm$  standard deviation, minimum and maximum values .

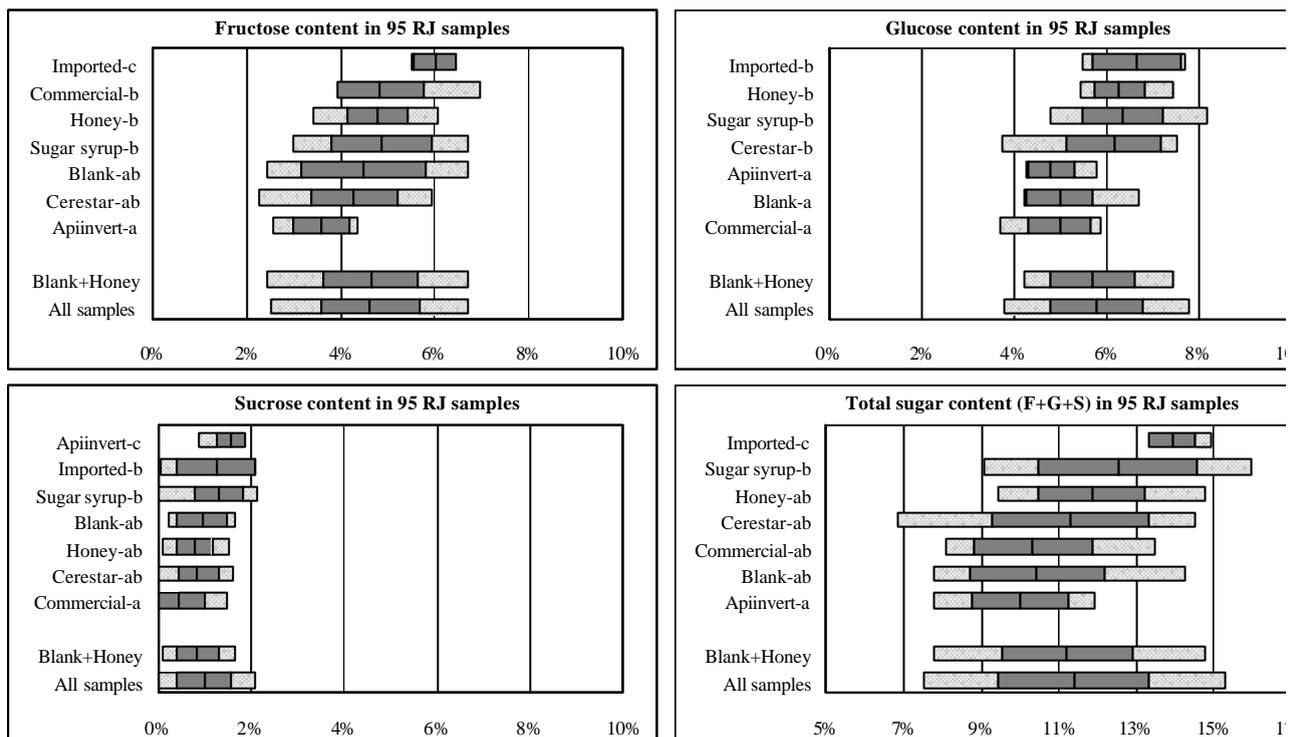
Groups (feeding)	Samples	Fructose	Glucose	Sucrose	Fr+Gl+Su	Maltose
I (blank)	14	<b>4.5</b> $\pm$ 1.3 2.4-6.7	<b>5.0</b> $\pm$ 0.7 4.3-6.7	<b>1.0</b> $\pm$ 0.6 0.2-1.7	<b>10.4</b> $\pm$ 1.7 7.8-14.3	<b>0.1</b> $\pm$ 0.1 nd-0.3
II (honey)	17	<b>4.8</b> $\pm$ 0.7 3.4-6.1	<b>6.3</b> $\pm$ 0.6 5.4-7.5	<b>0.8</b> $\pm$ 0.4 0.1-1.5	<b>11.9</b> $\pm$ 1.4 9.4-14.8	-
III (sugar syrup)	18	<b>4.9</b> $\pm$ 1.1 3.0-6.7	<b>6.4</b> $\pm$ 0.9 4.8-8.2	<b>1.3</b> $\pm$ 0.5 nd-2.1	<b>12.5</b> $\pm$ 2.1 9.1-16.0	-
IV (Cerestar)	19	<b>4.3</b> $\pm$ 0.9 2.3-5.9	<b>6.2</b> $\pm$ 1.0 3.8-7.5	<b>0.9</b> $\pm$ 0.4 nd-1.6	<b>11.3</b> $\pm$ 2.0 6.9-14.5	<b>0.4</b> $\pm$ 0.6 nd-2.2
V (Apiinvert)	9	<b>3.6</b> $\pm$ 0.6 2.6-4.4	<b>4.8</b> $\pm$ 0.5 4.3-5.8	<b>1.6</b> $\pm$ 0.3 0.9-1.9	<b>10.0</b> $\pm$ 1.2 7.8-11.9	<b>0.04</b> $\pm$ 0.04 nd-0.1
Commercial RJ	13	<b>4.9</b> $\pm$ 0.9 3.9-6.9	<b>5.0</b> $\pm$ 0.7 3.7-5.9	<b>0.5</b> $\pm$ 0.5 nd-1.5	<b>10.3</b> $\pm$ 1.5 8.1-13.5	<b>0.8</b> $\pm$ 0.9 nd-3.1
Imported RJ	5	<b>6.0</b> $\pm$ 0.5 5.5-6.5	<b>6.7</b> $\pm$ 1.0 5.5-7.7	<b>1.3</b> $\pm$ 0.2 0.1-2.1	<b>13.9</b> $\pm$ 0.6 13.3-14.9	-
All samples (confid. interv 95%)	95	<b>4.6</b> $\pm$ 1.0 2.5-6.7	<b>5.8</b> $\pm$ 1.0 3.8-7.8	<b>1.0</b> $\pm$ 0.6 nd-2.1	<b>11.4</b> $\pm$ 2.0 7.5-15.3	<b>0.3</b> $\pm$ 0.6 nd-1.6

nd = not detectable

The 3 main sugars, fructose, glucose and sucrose, and the sum of the 3, show some differences from one group to another, confirmed by the analysis of variance (Student-Newman-Keuls test), however, there is a wide overlap in the ranges. Considering the entire sampling, the 95% confidence intervals for the 3 main sugars (g/100 g of fresh product) were 2.5 – 6.7 for fructose; 3.8 – 7.8 for glucose and *nd* – 2.1 for sucrose; the sum of the 3 ranges from 7.5 to 15.3 (Table II). Most of this variability is accounted for by the groups I (blank) and II (fed with honey), that should represent the natural range (see also Fig.1, where the range of the whole sampling is compared to the one of the groups I and II).

Therefore, no correlation can be established between the RJ sugar content and the tested nourishments.

Figure 1 - Sugar content (g/100 g of fresh product) of the analysed RJ samples.



The dark area corresponds to average  $\pm$  standard deviation; the light area to minimum and maximum values. Different letters (a, b, c) correspond to significant differences (according to Student-Newman-Keuls test). In the lower part of the graphics the range of the whole sampling (confidence intervals at 95%) is compared to that of the groups I (blank) and II (fed with honey) plotted together.

The disaccharide maltose, even if mostly present at very low levels (less than 1%), seems to be higher in samples of group IV (fed with cerestar, which actually contains 20% maltose) and in commercial samples, where it occasionally reaches 2-3%. While in groups I (blank) and III (apiinvert), maltose is mostly under the

detection limit and does not rise above 0.3%. However, only 4 groups of RJ samples were analysed for maltose up to now (as maltose is less frequently found in RJ, and its determination started in a subsequent period with respect to the three main sugars), and these first results need to be confirmed through further analysis before drawing any conclusions. The total sugar content (fructose + glucose + sucrose) are in agreement with those reported by other authors (see Table III) with the exception of Serra Bonvehi [10], who reports rather higher values for fructose (6.0-12.3%) and, consequently, for the total sugar content.

Table III - Sugar composition of RJ (g/100 g of fresh product) as reported by different Authors.

Authors	Samples	Fr+Gl+Su
Pourtallier <i>et al.</i> , 1970 <sup>(1,2)</sup>	-	7.0 – 11.6
Tourn <i>et al.</i> , 1980	1	13.1
Takenaka and Echigo, 1980 <sup>(1,2)</sup>	-	6.0 – 15.8
Lercker <i>et al.</i> , 1982 <sup>(2)</sup>	5	7.3 – 15.9
Pourtallier <i>et al.</i> , 1990 <sup>(1,2)</sup>	-	12.9 – 14.6
Lercker <i>et al.</i> , 1992 <sup>(2)</sup>	30	6.8 – 18.0
Palma, 1992	3	11.4 – 11.5
Serra Bonvehi, 1992	15	11.9 – 22.5
this study	95	6.9 – 16.0

<sup>(1)</sup> Quoted by Lercker *et al.* [5].

<sup>(2)</sup> Data were expressed as percent on dry matter. Percent values on fresh product were calculated on the basis of the average water content reported for the same samples.

#### 4. Conclusions

The RJ marketed in Europe is mostly imported, but the interest of European beekeepers in its production as a valuable means to diversify their activity and improve their income is increasing. Additional revenue could be obtained through possible organic production of RJ. However currently according to EC regulation

[2], this is almost impossible because of the need for artificial feeding. From our investigation, the artificial sugar nutrition shows no or very little effect on RJ sugar composition. From RJ analysis it is not possible to determine the feed supplied (more studies are needed to determine the possible role of maltose). Therefore, the limitation of artificial feeding for the organic production of RJ appears unnecessary, at least with regard to the effect on sugar composition. Fructose, glucose and sucrose are among the main components of RJ, and a possible quality standard for this product will most likely include these three sugars among composition criteria as is the case for international honey standards [1, 3]. The values found from the analysis of 95 samples may represent a useful contribution to establish reference ranges for fructose, glucose and sucrose content.

### **References**

- [1] Codex Alimentarius Commission, Revised Codex Standard for honey, Codex Stan 12-1981, Rev.2 (2001), 7pp.
- [2] European Commission, Council Regulation (EC) N.1804/1999 supplementing Regulation (EEC) N.2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs to include livestock production (Annexe I, Section C), Official J. Eu. Communities (Aug 24<sup>th</sup> 1999), L222, 1-28.
- [3] European Commission, Council Directive 2001/110/CE concerning honey, Official J. Eu. Communities (Jan 12<sup>th</sup> 2002), L10, 47-52.

- [4] Lercker G., Capella P., Conte L.S., Ruini F., Giordani G., Components of royal jelly. II. The lipid fraction, hydrocarbons and sterols, *J. Apicult. Res.* 21 (1982), 178-184.
- [5] Lercker G., Caboni M.F., Vecchi M.A., Sabatini A.G., Nanetti A., Caratterizzazione dei principali costituenti della gelatina reale, *Apicoltura* 8 (1992), 27-37.
- [6] Palma M.S., Composition of freshly harvested Brazilian royal jelly: identification of carbohydrates from the sugar fraction, *J. Apicult. Res.* 31 (1992), 42-44.
- [7] Pourtallier J., Taliercio Y., Mussot J.M., Contrôle de la qualité de la gelée royale. Revue bibliographique des travaux sur la composition, les propriétés et les utilisation de la gelée royale, *Bull. Apic*, 13 (1970), 145-160.
- [8] Pourtallier J., Davico R., Rognone M.C., Les analyses dans le contrôle de pureté de la gelée royale, *L'abeille de France* 753 (1990), 405-407.
- [9] Serra Bonvehi J., Study of adulteration of royal jelly with other honey bee products and water, *Prod. Sanidad Anim.* 6 (1991), 99-111.
- [10] Serra Bonvehi J., Azucares, acidez y pH de la jalea real, *Anal. Bromatol.* 44 (1992), 65-69.
- [11] Sesta G., Determination of sugars in royal jelly by HPLC, *Apidologie* 37 (2006) 84-90.
- [12] Takenaka T., Echigo T., General chemical composition of the royal jelly, *Bull. of the faculty of Agriculture, Tamagawa University*, 20 (1980), 71-78.

- [13] Tourn M.L., Lombard A., Belliardo F., Buffa M., Quantitative analysis of carbohydrates and organic acids in honeydew, honey and royal jelly by enzymic methods, *J. Apicult. Res.* 19 (1980), 144-146.