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COMPOSITION OF HONEYS FROM SOME IMPORTANT HONEY SOURCES

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Data used

The *Directory of important world honey sources*[3], published earlier this year, gives data on 452 nectar sources and 15 honeydew sources of honey. In addition to information on the plants and the nectar (or honeydew) and pollen from them, data on the physical properties and the chemical composition of the honeys were included where available.

The chemical composition of honey in general has been reviewed by White[10]. The present paper is concerned with 101 honeys for which the *Directory* gives the content of two or more constituents. All are from nectar plants; honeydew honeys will be discussed in a subsequent paper. The *Directory* should be consulted for numerical results of individual chemical analyses, and for the publications from which they were taken. Many results were obtained by standard methods; however, some authors did not state their methods, and in some languages we were unable to ascertain them. A published chemical composition of certain honeys was omitted from the *Directory* if the samples were stated to have been aged or subjected to high temperatures, or to be granulated.

In the literature there are reports of analyses of many other honey samples that are identified only by place of origin, and such honeys are, of course, not represented in the *Directory*. Nor are honeys from mixed sources, for example some of the many USA honeys analysed by White[9].

Individual honey constituents

In 1983 a 'Proposed draft Codex standard for honey (world-wide standard)' was issued by the Joint FAO/WHO Food Standards Programme[1]. The present paper shows how the honeys whose composition was reported in the *Directory* match up to this proposed Codex.

Table 1 is derived from data in the *Directory,* and relates to 9 constituents of honey. Limits for six of them are given in the proposed Codex, and for one other (HMF) in an EEC Directive[4]. Table 1 also includes separate columns for the two main reducing sugars, glucose and fructose.

In compiling the *Directory,* honeys for which a chemical analysis was available were recorded as follows. The content of each constituent was quoted (usually % by weight of honey), and was assigned to one of two (or three) classes—low, (medium), high—and the class was entered on word-processor discs in code form so that programmed searches could subsequently be made. For the content of water, sucrose, ash and free acid, three classes were used, with the proposed Codex limit as the boundary between medium and high classes. We had no guidelines for boundaries between low and medium classes, nor for any boundaries for glucose and fructose, so these were set arbitrarily. For total reducing sugars, amylase (diastase) and HMF, two classes were used, separated by the proposed Codex or the EEC limit.

The plant sources of the honeys are listed in Table 1, with their families and entry numbers in the *Directory*. In the columns headed *W, R, . . . D, H,* symbols are used to indicate the class, i.e. the range within which the constituent is present in the honey. For instance, g = low glucose content (<31%), G = medium glucose content (31–40%), **G** = high glucose content (40% +). Any value outside the proposed limit is denoted by ⋆.

Boundaries set between classes were as follows:

	low	*boundary*	*medium*	*boundary*	*high*
water	w	16%	W	21%	⋆
glucose	g	31%	G	40%	**G**
fructose	f	35%	F	43%	**F**
sucrose	s	1%	S	5%	⋆
ash	a	0·1%	A	1·0%	⋆
free acid (meq/kg)	c	15	C	40	⋆

	low	*Codex or EEC limit*	*high*
reducing sugars	⋆	65%	R
amylase (Gothe scale)	⋆	3	D
HMF (ppm)	H	40	⋆

Water content

The water content of honey is most important in determining whether or not the honey is likely to suffer spoilage through fermentation. The presence of yeasts also affects the likelihood of fermentation, and so do the glucose and fructose contents through their relative solubilities in water.

Lochhead[6] and Stephen[7] investigated the relation between water content and fermentation in 319 and 700 Canadian honey samples, respectively. From their results it seems that honeys containing less than 16% water are virtually safe from fermentation regardless of yeast content. Of those containing more than 18% water (3% lower than the Codex limit) two-thirds of Stephen's samples fermented, and Lochhead considered such honeys safe only if their yeast count was low (less than 10/g); at above 20% water, honeys were regarded as 'always in danger'.

In Table 1 the class for the water content is given for 75 honeys; 13 of them contained more than 21% water, 54 contained 16–21%, and 8 less than 16%. Of the honeys with more than 21% water, 3 were produced in the tropics from *Apis cerana,* 2 were from Taiwan, and 8 from the north temperature zone. The honeys with a low water content (117, 158, 164, 176, 210, 290, 355, 426) can be identified from Table 1; all were probably produced in conditions of low atmospheric humidity.

For *Calluna vulgaris* the maximum water content in the proposed Codex is 23%, and some samples reported in the *Directory* exceeded this level. The same maximum of 23% is allowed for 'clover honey'. The water content was reported for four clovers (*Trifolium* spp.) listed in Table 1 and for *Melilotus alba* (sweet clover); none had more than 21% water except 2 out of 13 samples of *T. repens*; these contained 21·2% and 21·3% water.

TABLE 1. Composition of honeys from important world sources.

Column headings:

W = water	*F* = fructose	*C* = free acid
R = reducing sugars	*S* = sucrose	*D* = amylase (diastase)
G = glucose	*A* = ash	*H* = HMF

See text for explanation of symbols. Symbols in brackets refer to non-numerical data. Where x x x are entered in columns *G, F, S,* the only results available are as percentages of total sugars.

*Indicates that the honey analysed was probably from *Apis cerana.*

Entry no. and plant name	*W*	*R*	*G*	*F*	*S*	*A*	*C*	*D*	*H*	
014 *Acer pseudoplatanus* L.; Aceraceae	W					A				014
016 *Actinodaphne angustifolia* Nees; Lauraceae*	W		G	F		A	C			016
017 *Actinodaphne hookerii* Meissn.; Lauraceae*	W	R	G	F		A	C			017
021 *Aesculus turbinata* Bl.; Hippocastanaceae	W	R	G	f	S					021
023 *Aloe davyana* Schonl.; Liliaceae			G	F	S			D	H	023
031 *Anchusa officinalis* L.; Boraginaceae			x	x	x					031
033 *Angelica archangelica* L.; Umbelliferae			x	x	x					033
034 *Antigonon leptopus* Hook. & Arn.; Polygonaceae	W		g	f	s	A	⋆			034
035 *Asclepias syriaca* L.; Asclepiadaceae			x	x	x					035
036 *Astragalus sinicus* L.; Leguminosae	⋆	R	G	F	S	a	C	D		036
037 *Avicennia germinans* (L.) L.; Avicenniaceae	⋆		**G**							037
039 *Azadirachta indica* A. Juss.; Meliaceae*	⋆				⋆	a	C			039
047 *Borago officinalis* L.; Boraginaceae			x	x	x					047
054 *Brassica campestris* L.; Cruciferae	W		g	F	s	A	C	D		054
060 *Brassica napus* L. var. *oleifera* DC.; Cruciferae	W	R	G	F	s	a	C			060
072 *Calluna vulgaris* (L.) Hull; Ericaceae	⋆	R	G	F	S	A		D		072
077 *Carvia callosa* (Nees) Brem.; Acanthaceae*	W	R	G	F	⋆	A	C	D		077
080 *Castanea sativa* Mill.; Fagaceae	W	R	G	F	S	A	c	D	H	080
081 *Catunaregam spinosa* (Thunb.) Tirvengadum; Rubiaceae*	W	R	G	F		A	C			081
083 *Centaurea cyanus* L.; Compositae			x	x	x			D		083
090 *Citrus deliciosa* Ten.; Rutaceae	⋆		G	F	S					090
097 *Citrus sinensis* (L.) Osb.; Rutaceae	W		g	F	⋆	a	C	(d)	H	097
098 *Citrus unshiu* (Mak.) Marc.; Rutaceae			g	F	s					098
099 *Clethra alnifolia* L.; Clethraceae	W		G	F	s	A	C	D		099
114 *Coriandrum sativum* L.; Umbelliferae	W		x	x	s	A		D	H	114
117 *Cucumis melo* L.; Cucurbitaceae	w		G	F	S	A	C	D		117
122 *Dalbergia sissoo* DC.; Leguminosae*	W		G	F	S	A				122
135 *Dracocephalum moldavica* L.; Labiatae			x	x	x					135
140 *Echium vulgare* L.; Boraginaceae	W		G	F	S	a	c			140
144 *Epilobium angustifolium* L.; Onagraceae	W		g	F	s	A	C	D		144
145 *Erica arborea* L.; Ericaceae		R	x	x	s					145
146 *Erica cinerea* L.; Ericaceae	W						C		H	146

Entry no. and plant name	*W*	*R*	*G*	*F*	*S*	*A*	*C*	*D*	*H*	
152 *Eucalyptus albens* Benth.; Myrtaceae	W		g	F	S		C	D		152
156 *Eucalyptus camaldulensis* Dehnh.; Myrtaceae		R	G	F	S	A	C	D		156
158 *Eucalyptus cladocalyx* F. Muell.; Myrtaceae	w		g	F		A				158
164 *Eucalyptus fasciculosa* F. Muell.; Myrtaceae	w	R	g	**F**	s	a	c	D	H	164
172 *Eucalyptus leucoxylon* F. Muell.; Myrtaceae	W	R	G	F	S	A	c	D	H	172
174 *Eucalyptus macrorhyncha* F. Muell. ex Benth.; Myrtaceae								D		174
175 *Eucalyptus maculata* Hook.; Myrtaceae	W	R	G	**F**	s	A	C	D	H	175
176 *Eucalyptus melliodora* A. Cunn. ex Schauer; Myrtaceae	w	R	G	F	S	a	C	D	H	176
184 *Eucalyptus robusta* Smith; Myrtaceae	W					A				184
198 *Euphoria longan* (Lour.) Steud.; Sapindaceae	W		G	F	s	A	C			198
199 *Fagopyrum esculentum* Moench.; Polygonaceae	⋆	R	G	F	S	A	⋆			199
202 *Geranium pratense* L.; Geraniaceae			x	x	x					202
206 *Gliricidia sepium* (Jacq.) Walp.; Leguminosae*	⋆				⋆	A	C			206
210 *Gossypium hirsutum* L.; Malvaceae	w	R	G	F	S	A	C			210
220 *Hedysarum coronarium* L.; Leguminosae	W		x	x	S	a	C	D	H	220
221 *Helianthus annuus* L.; Compositae	W	R	G	F	S	a		D	H	221
223 *Hevea brasiliensis* Muell. Arg.; Euphorbiaceae*	⋆	R	**G**	f	⋆					223
229 *Hyssopus officinalis* L.; Labiatae			x	x	x					229
230 *Ilex glabra* (L.) A. Gray; Aquifoliaceae	W		g	F	s	A	C	D		230
237 *Ipomoea batatas* (L.) Lam.; Convolvulaceae	⋆		G	F	S		C			237
250 *Knightia excelsa* R.Br.; Proteaceae	W	R				A				250
252 *Lavandula angustifolia* Miller; Labiatae	(⋆)		G	F	(⋆)					252
256 *L. angustifolia* x *latifolia* Medicus; Labiatae			G	F						256
257 *Leonurus cardiaca* L.; Labiatae			x	x	x					257
259 *Leptospermum scoparium* J. & G. Forst.; Myrtaceae	W		G	F	s		C	D		259
265 *Lippia nodiflora* (L.) Michx.; Verbenaceae	⋆		G	F	s	A	C	D		265
267 *Liriodendron tulipifera* L.; Magnoliaceae	W		g	f	s	A	C	D		267
268 *Litchi chinensis* Sonner.; Sapindaceae	W							D		268
272 *Lotus corniculatus* L.; Leguminosae			x	x	x					272
274 *Lythrum salicaria* L.; Lythraceae	W		G	F	s	a	C			274
286 *Marrubium vulgare* L.; Labiatae			x	x	x					286
290 *Medicago sativa* L.; Leguminosae	w	R	G	F	S	a	c	D		290
296 *Melilotus alba* Desr.; Leguminosae	W		G	F	S	a	C	D		296
300 *Metrosideros umbellata* Cav.; Myrtaceae	W	R					⋆			300
309 *Nicotiana tabacum* L.; Solanaceae	W	R			s	A		D	H	309
311 *Nyssa ogeche* Bartram; Nyssaceae	W		g	**F**	S	A	C	D		311

Entry no. and plant name	*W*	*R*	*G*	*F*	*S*	*A*	*C*	*D*	*H*	
314 *Onobrychis viciifolia* Scop.; Leguminosae	W		x	x	x					314
316 *Oxydendron arboreum* (L.) DC.; Ericaceae	W		g	F	s	A	c	D		316
324 *Phacelia tanacetifolia* Benth.; Hydrophyllaceae			x	x	x					324
342 *Prunus x yedoensis* Matsum.; Rosaceae	W	R	**G**	F	s					342
347 *Rabdosia rugosa* (Wall. ex Benth.) Hara; Labiatae*	W		G	F	S	A	C			347
354 *Robinia pseudacacia* L.: Leguminosae	W		g	**F**	S	a	c	D	H	354
355 *Rosmarinus officinalis* L.; Labiatae	w	R	G	F	S	a	c	(D)		355
358 *Rubus idaeus* L.; Rosaceae	W		G	F	S	A		D		358
361 *Sabal palmetto* (Walt.) Lodd. ex Schultes; Palmae	⋆		G	F	s	a	C	D		361
369 *Salvia nemorosa* L.; Labiatae			x	x	x					369
370 *Salvia officinalis* L.; Labiatae			G	**F**	x	A				370
373 *Sapindus mukorossi* Gaertn.; Sapindaceae*	W		G	F	⋆	A	C			373
381 *Scrophularia nodosa* L.; Scrophulariaceae			x	x	x					381
382 *Serenoa repens* (Bartr.) Small; Palmae	W		g	F	s	A	C	D		382
395 *Syzygium cuminii* (L.) Skeels; Myrtaceae*	W		G	**F**		A				395
396 *Syzygium jambos* (L.) Alston; Myrtaceae*	W	R	G	F			c			396
398 *Taraxacum officinale* Weber; Compositae			x	x	x					398
401 *Terminalia chebula* Retz.; Combretaceae*	W	R	G	F		A	c			401
403 *Thelepaepale ixiocephala* (Benth.) Bremk.; Acanthaceae*	W	R	G	F		A	C			403
406 *Thymus serpyllum* L.; Labiatae	W	R	G	F	s	A	C			406
407 *Thymus vulgaris* L.; Labiatae		R	g	F	S	a	c			407
408 *Tilia americana* L.; Tiliaceae	W		g	F	s	a	C			408
410 *Tilia cordata* Mill.; Tiliaceae			g	F	S					410
411 *Tilia japonica* (Miq.) Simonk.; Tiliaceae	⋆		x	x	x					411
422 *Tournefortia argentea* L.f.; Boraginaceae	W		g	F	⋆					422
426 *Trifolium alexandrinum* L.; Leguminosae	w	R	G	F	S	a	C			426
428 *Trifolium hybridum* L.; Leguminosae	W		G	F	S	a	C	D		428
429 *Trifolium incarnatum* L.; Leguminosae	W		**G**	F	s	a	C	D		429
430 *Trifolium pratense* L.; Leguminosae			x	x	S					430
431 *Trifolium repens* L.; Leguminosae	W		g	F	S	A	C	D	H	431
434 *Turbina corymbosa* (L.) Raf.; Convolvulaceae	W	R			S	a				434
440 *Vicia villosa* Roth; Leguminosae	W		g	F	S	a	C	D		440
448 *Ziziphus mauritania* Lam.; Rhamnaceae	⋆		G	F	s	A	C			448

Reducing sugars

The percentage of reducing sugars was recorded for 31 honeys, and for all of them it was above the proposed Codex minimum of 65%. Amounts of the two main reducing sugars (glucose and fructose) vary according to the plant source, and affect granulation, hygroscopicity, sweetness and other characteristics of honey[2]. We therefore assigned classes for these sugars, using the boundaries set out above. Out of 69 honeys, the glucose

content was within the range 31–40% for 45, above it for 4, and below it for 20. Out of 68 honeys, the fructose content was within the range 35–43% for 58, above it for 6 and below it for 4.

Sucrose

Determination of the sucrose content of honey was important in the past, as a means of detecting adulteration of honey by the addition of sucrose. The sucrose content was recorded for 65 honeys, and 7 exceeded the proposed Codex limit (5%); 33 contained 1–5%, and 25 less than 1%. Five of the 7 honeys with a high sucrose content (039, 077, 206, 223, 373) were produced by *Apis cerana* in India or Sri Lanka, and one was produced by *Apis mellifera* from *Tournefortia argentea* on Wake Island in the Pacific.

The proposed Codex lists certain other honeys by common name, for which a higher sucrose content is allowable. Among those with a permitted 10% sucrose maximum are several in Table 1 which in fact contained less than 5%: *Citrus deliciosa, C. unshiu, Eucalyptus camaldulensis, Medicago sativa, Melilotus alba* and *Robinia pseudacacia.* Samples of freshly extracted *C. sinensis* honey in Israel contained 9·1–10·3% sucrose, but in two USA analyses of honey from this source, levels were below this.

Further studies should be carried out on honeys produced in the tropics and subtropics, including those from other *Apis* species than *mellifera,* to establish the extent to which their sucrose content differs from that of honeys produced by *A. mellifera* in temperate zones.

Ash

The ash content was recorded for 63 honeys, and for all of them it was below the proposed Codex maximum of 1·0%; 41 contained 0·1–1·0% and 22 contained less than 0·1%. Plants in the Leguminosae were notable as yielding honeys with a low ash content. The 63 honey sources included 12 Leguminosae, of which 9 gave honeys containing less than 0·1% ash, whereas only 13 of the 52 non-legume sources did so.

Free acid

Honeys with a high free acid content have a sharp or slightly acid flavour; those with a low content are likely to be less stable towards micro-organisms in the honey. The free acid content was recorded for 56 honeys, of which 3 exceeded the proposed Codex limit of 40 meq/kg. For 42 honeys the value was between 15 and 40 meq/kg, and for 11 it was below 15 meq/kg.

Amylase

Amylase (diastase) is an enzyme capable of breaking down starch. It is gradually destroyed on long storage of honey at any temperature, and it is heat sensitive, for instance half is destroyed if honey is heated to 80°C for 70 minutes. A low amylase content of honey is therefore used as an indicator of improper heating or of long storage of honey. It is measured by the 'diastase number' on the Gothe scale. Values were recorded for 38 honeys, and all were above the proposed Codex minimum of 3.

HMF

HMF (5-hydroxymethylfurfuraldehyde) is a breakdown product of certain sugar solutions, particularly those containing glucose and fructose, stored at high temperatures or for a long time. A high HMF content has been used as an indicator of improper heating of honey, or of adulteration of honey with invert sugar prepared by acid hydrolysis at high temperatures. The allowable maximum set by the EEC Directive[4] is 40 ppm, and the HMF value for all 14 honeys was below this limit.

Some other substances in honey

Whenever records were available, other constituents of honey samples were recorded in the *Directory*, although the content was not coded for programmed searches. These substances include: maltose, fructomaltose and several other sugars; 'bound' (i.e. not 'free') acid, and lactone; other enzymes, including sucrase, glucose oxidase; amino acids, nitrogen, protein; colloids; yeasts; vitamins.

In view of frequent references to vitamins in honey, details have been extracted from the *Directory* for inclusion here. It is not known how many of the honeys have been assessed for vitamin content with a negative result, but a positive quantified result was reported for six. Vitamin C (ascorbic acid) was found in *Calluna vulgaris* (40–52 ppm) and *Fagopyrum esculentum* (41–82 ppm) honeys in Poland, and *Carvia callosa* honey (113·5 ppm) in India. For comparison, contents quoted for vitamin C in some raw fruits are 200, 500 and 2000 ppm in tomato, orange and blackcurrant, respectively[8]. In India, vitamin B1 (thiamine) was found in *Catunaregam spinosa* honey (0·08 ppm). Wholemeal bread contains 2·4 ppm. Vitamin B5 (pantothenic acid) was present at 0·7–11·5 ppm in *Aesculus turbinata* honey in Japan. Beef liver contains 77, eggs 16, and avocado 10·7 ppm[5]. Honey from *Robinia pseudacacia* in Japan contained 260 ppm 'total' vitamins.

Substances not listed at the beginning of this section, but also recorded in the *Directory* in one or more of the honeys listed in Table 1, include the following.

The volatile compounds in the aromas of several honeys have been analysed: 060, 152, 176, 259, 290, 407, 411, 430, 431. Flavour and aroma are closely related, and 'compounds probably contributing to flavour' have been studied in some honeys: 036, 098 and 354.

Methyl anthranilate was first detected in 'orange' honey in 1930; its content (in honey presumed to be from *Citrus sinensis*) was reported to be 0·84–3·95 ppm. Traces of the compound have also been found in honeys from *Nyssa ogeche* (0·05 ppm), *Tilia americana* (0·04 ppm) and *Lavandula angustifolia* (amount unspecified).

Crystals of calcium oxalate were found in *Tilia cordata* honey; the compound originates from the nectar of the flowers in which it has also been identified. Oxalic acid was reported in honey from *Oxydendron arboreum*.

Of 10 samples of honey from *Fagopyrum esculentum*, 6 contained rutin and 4 quercetin; after 4 days only quercetin was present in all. Several pyrrolizidine alkaloids were found in honey from *Echium lycopsis*.

Conclusions and further information

Of the honeys discussed, all conformed with the proposed Codex (or the Directive) for content of total reducing sugars, ash, amylase (diastase) and HMF. For free acid, only 3

out of 56 honeys had more than the limit proposed. For sucrose 7 out of 65 contained more sucrose than the proposed 5% limit, of which most were produced in the tropics. For these constituents, almost all the honeys thus conformed to the proposed standard, except that a few tropical honeys contained excess sucrose. On the other hand 13 out of 75 honeys contained more water than the proposed maximum of 21%. This limit itself is higher than that considered by some scientists to provide security against fermentation.

The majority of the honeys discussed here were produced in temperate zones, but many important honeys from the tropics and subtropics still await analysis. A free leaflet is therefore being made available from IBRA, listing the honey sources in the *Directory* for which the honey composition seems to be unknown. IBRA would be glad to know of published (or unpublished) data for any of them, as well as additional data for the less well studied honeys in Table 1.

IBRA will shortly publish *Important honey sources: Satellite Directory 3. Composition of some honeys.* It will give printouts of the available data on the composition of the honeys listed in Table 1, together with lists of the plant sources of honey whose constituents exceed the several limits set in the proposed Codex. Further details can be obtained from IBRA. The physical properties of honey reported in the *Directory of important world honey sources* will be dealt with separately.

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*Water and sucrose contents of honey are discussed in relation to the proposed limits in ALINORM 85/20 and associated documents, which were received while this paper was in proof.