

The $^{13}\text{C}/^{12}\text{C}$ pattern of honey from different countries and determining adulteration in commercially available honey from Taiwan

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Honey



Natural sweet product produced by honey bees from flower nectar or honeydew.



Honey is a valuable natural food commodity.



Honey mainly consists of carbohydrates such as fructose, glucose, reducing sugars and sucrose

Good honey = money




Pure honey 20%, HFCS 80%
Honey honey....money money



Tests take buzz out of manuka honey

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♥ Comment (7)  Print

MANUKA honey, an increasingly popular yet costly health supplement, is at the centre of an international food fraud investigation amid evidence that much of it is fake.

The Food Standards Agency (FSA) has issued a nationwide alert to all trading standards departments asking them to watch out for honey that has been labelled as manuka but is derived from other sources.

Manuka honey, which sells for up to £45 for a 500g jar, has been praised by sports stars and celebrities such as Katherine Jenkins, the classical singer, Scarlett Johansson, the actress, and Novak Djokovic, the world No 1 tennis player.

Tests carried out by the Food and Environment Research Agency (Fera), the scientific arm of Defra, the environment and food ministry, along with overseas studies suggest that much of the honey labelled as manuka has nothing to set it apart from ordinary honey — except the price.

Researchers say 75% of Taiwan's honey not pure 學者檢測 賣場蜂蜜七成五不純

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Are you consuming real honey or fake honey? After testing a dozen different honeys being sold at supermarkets, hypermarkets and fruit stands, Taiwan Apicultural Society president and National Ilan University Biotechnology and Animal Science Department director Chen Yue-wen found that 75 percent were not real honey. Pollen could not be extracted from six of the honeys and three were a mixture of both fake and real honey. However, all products marked with official certification were up to standard. The Consumers' Foundation has urged the government to require companies to be honest when listing the content of products.

Pure honey has no additives, Chen says, adding that much of the fake honey on the market is made up of high fructose corn syrup, caramel coloring and artificial flavoring. Many of the blended and synthetic honeys being sold on the market are actually a combination of pure and fake honey, and may meet the government's Chinese National Standards (CNS). Chen has come up with a new method for analyzing stable isotopes in integrated biochemical processes, allowing one to accurately differentiate real from fake honey, which he will be presenting at the International Apicultural Congress at the end of the month.

Miaoli District Agricultural Research and Extension Station researchers Sung I-hsin and Wu Heui-hu say that not enough domestic honey is being produced to meet market demand, especially since production was cut in half this year, making it highly difficult to find pure Taiwanese honey at hypermarkets and supermarkets. They say that purchasing it directly from beekeepers would be the best way to get it. Taiwan Beekeepers Association chairman Wu Chao-sheng also says that domestically produced honey with certified labels is only sold at the Matsusei grocery store chain. While in the past there were a lot of fake honeys being sold, now food processing companies are buying pure honey from beekeepers and adding other ingredients, but he says that they should label the contents accurately.

After reporters visited supermarkets and hypermarkets such as Pxmart, A.mart, RT-Mart and Carrefour, they found that none of the honey being sold at these stores had certified labels, and that all of the honey on sale, aside from two from Thailand, were from Taiwan. Carrefour and RT-Mart both add high-fructose corn syrup to their own brands of honey, which are marketed as "blended honey," while A.mart does not label its honey this way. Some companies label their product as longan honey, but when you look on the back you see that it is actually blended honey. Causing much confusion, some companies even place pictures of beekeepers on molasses products.

A.mart says that of their company's two longan honeys, one is 100 percent pure longan honey, while it is clearly labeled that the other one contains fructose and dextrose.

Tsai Shu-chen, chief of the Food and Drug Administration's (FDA) food division, says that companies selling honey are not legally required to clearly state the contents of the product in product names unless it is being marketed as "pure honey." But Consumers' Foundation secretary-general Lei Li-fen says that the FDA requires labeling for milk powder, fruit juice and rice flour to indicate that the contents do not meet official standards by writing flavored milk powder, juice from concentrate or flavored rice flour. The standard should be the same for all products, says Lei.

Nutrition Foundation of Taiwan chief executive officer Wu Ying-jung says that fake honey does not have the nutrients that natural honey does, adding that eating too much high-fructose corn syrup can cause obesity, fatty liver disease and hyperuricemia, so not labeling such products clearly poses a potential danger to people with diabetes or metabolic syndrome.

(Liberty Times, Translated by Kyle Jeffcoat)

C3 Plants vs C4 Plants



Nectar collected from C3 plants, $\delta^{13}\text{C}$ values $\approx -25\text{‰}$

Adulterated sugar (corn syrup, cane sugar) come from C4 plants,

$\delta^{13}\text{C}$ values $\approx -10\text{‰}$



AOAC Method 998.12: 1999; chap.44; 29



Detection of adulteration of Brazil commercial honey samples by the $^{13}\text{C}/^{12}\text{C}$ isotopic ratio (Padovan et al., 2003)








Detection of adulteration of Turkey commercially available honey samples by EA-IRMS (Simsek et al., 2012).



Detection of adulteration in honey samples added various sugar syrups with $^{13}\text{C}/^{12}\text{C}$ isotope ratio analysis method (Murat, 2013).

Methods

-  Extraction of protein from honey was performed by **AOAC Official method 998.12**
-  $\delta^{13}\text{C}$ values for **honey** and **protein** were determined by **Piccarro A0302 Combustion Module-Cavity Ring Down Spectroscopy (CRDS, Piccarro G2121-i)**
-  Protein content were determined by **Bradford**
-  Adulteration (%) =
$$\frac{(\delta^{‰} \text{protein} - \delta^{‰} \text{honey})}{(\delta^{‰} \text{protein} - \delta^{‰} \text{sweetener})} * 100$$
-  Honey is adulterated to an acceptable extent of **10%**

Honey samples

Group	<i>n</i>	Criteria	Source
1	40	Taiwan 2012 Award longan honey	Longan honey contest
2	40	Taiwan 2013 Award longan honey	Longan honey contest
3	19	2012 Thailand longan honey	Imported companies
4	17	2013 Thailand longan honey	Imported companies
5	20	2012 Taiwan multi-flower	Beekeepers
6	10	2013 Taiwan multi-flower, certificated by TBA	Taiwan Beekeepers Association
7	20	2011 China honey	Yangzhou University, China
8	12	2012 Commercial honey	Taiwan markets
9	30	2013 Commercial honey	Taiwan markets
Total	208		

Official Taiwan Longan honey Contest in each June for 20 years



Table 1. $\delta^{13}\text{C}$ values and protein content of **Taiwan 2012 Award longan honey** samples

No	$\delta^{13}\text{C}$ values for honey (‰)	$\delta^{13}\text{C}$ values for protein of honey (‰)	Differences in $\delta^{13}\text{C}$ (‰) values (protein-honey)	Bradford protein assay (mg/g)	Adulteration (%)	Honey quality
1	-27.43	-24.60	2.83	1.34	0	Pure
2	-27.08	-25.28	1.80	1.16	0	Pure
3	-27.22	-25.06	2.15	1.20	0	Pure
4	-25.46	-25.08	0.38	1.27	0	Pure
5	-25.69	-24.71	0.98	1.33	0	Pure
6	-25.55	-24.59	0.97	1.36	0	Pure
7	-26.81	-25.47	1.34	0.97	0	Pure
8	-26.89	-26.03	0.86	1.21	0	Pure
9	-25.78	-24.50	1.28	1.50	0	Pure
10	-26.86	-25.46	1.40	1.44	0	Pure
11	-26.76	-24.21	2.55	1.73	0	Pure
12	-26.06	-24.14	1.92	1.69	0	Pure
13	-27.05	-25.17	1.88	1.26	0	Pure
14	-26.64	-23.26	3.38	1.27	0	Pure
15	-26.60	-25.37	1.23	1.28	0	Pure
16	-26.49	-24.72	1.77	1.38	0	Pure
17	-25.78	-24.74	1.04	1.05	0	Pure
18	-26.64	-25.14	1.50	1.23	0	Pure
19	-26.36	-24.75	1.61	1.21	0	Pure
20	-26.17	-24.80	1.37	1.32	0	Pure
21	-25.22	-24.20	1.02	1.51	0	Pure
22	-25.85	-24.65	1.20	1.33	0	Pure
23	-26.16	-24.64	1.52	1.59	0	Pure
24	-26.67	-24.16	2.52	1.42	0	Pure
25	-26.04	-24.20	1.85	1.56	0	Pure
26	-25.29	-24.05	1.24	1.29	0	Pure
27	-26.44	-24.65	1.79	1.28	0	Pure
28	-25.42	-23.65	1.77	1.32	0	Pure
29	-24.24	-23.80	0.44	1.38	0	Pure
30	-26.46	-25.07	1.39	1.37	0	Pure
31	-24.45	-23.73	0.72	1.61	0	Pure
32	-26.84	-24.44	2.39	1.48	0	Pure
33	-25.51	-24.58	0.94	1.31	0	Pure
34	-26.10	-24.30	1.80	1.52	0	Pure
35	-26.22	-25.30	0.92	1.46	0	Pure
36	-26.20	-25.97	0.23	1.19	0	Pure
37	-26.51	-25.93	0.58	1.40	0	Pure
38	-26.88	-26.15	0.73	1.48	0	Pure
39	-26.41	-25.39	1.02	1.51	0	Pure
40	-25.65	-25.21	0.45	1.33	0	Pure
Average	-26.20 ± 0.71	-24.78 ± 0.67	1.42 ± 0.70	1.36 ± 0.16		



Table 2. $\delta^{13}\text{C}$ values and protein content of **Taiwan 2013 Award longan honey** samples

No	$\delta^{13}\text{C}$ values for honey (o/oo)	$\delta^{13}\text{C}$ values for protein of honey (o/oo)	Differences in $\delta^{13}\text{C}$ (o/oo) values (protein-honey)	Bradford protein assay (mg/g)	Adulteration (%)	Honey quality
1	-28.71	-28.07	0.64	1.35	0	Pure
2	-28.22	-27.28	0.94	1.47	0	Pure
3	-27.07	-26.70	0.37	1.47	0	Pure
4	-27.26	-26.47	0.79	1.44	0	Pure
5	-28.49	-26.81	1.68	1.32	0	Pure
6	-26.98	-25.88	1.10	1.61	0	Pure
7	-27.44	-25.80	1.64	1.56	0	Pure
8	-26.87	-26.26	0.61	1.36	0	Pure
9	-26.95	-26.21	0.74	1.20	0	Pure
10	-27.62	-26.35	1.27	1.69	0	Pure
11	-27.87	-26.56	1.31	1.49	0	Pure
12	-27.40	-26.27	1.13	1.42	0	Pure
13	-28.45	-26.51	1.94	1.12	0	Pure
14	-26.74	-26.10	0.64	1.46	0	Pure
15	-28.01	-26.49	1.52	1.35	0	Pure
16	-27.15	-26.04	1.11	1.52	0	Pure
17	-27.49	-26.50	0.99	1.37	0	Pure
18	-26.04	-24.27	1.77	1.63	0	Pure
19	-25.70	-24.34	1.36	1.55	0	Pure
20	-25.68	-24.42	1.26	1.44	0	Pure
21	-25.10	-24.32	0.78	1.38	0	Pure
22	-25.06	-24.17	0.89	1.33	0	Pure
23	-26.16	-24.52	1.64	1.70	0	Pure
24	-27.02	-25.24	1.78	1.34	0	Pure
25	-25.06	-24.42	0.64	1.44	0	Pure
26	-25.78	-24.18	1.60	1.52	0	Pure
27	-25.07	-24.31	0.76	1.51	0	Pure
28	-25.62	-24.43	1.19	1.33	0	Pure
29	-26.09	-24.78	1.31	1.38	0	Pure
30	-26.18	-25.26	0.92	1.35	0	Pure
31	-24.70	-23.79	0.91	0.87	0	Pure
32	-25.66	-23.91	1.75	1.40	0	Pure
33	-24.52	-23.73	0.79	1.43	0	Pure
34	-25.50	-24.15	1.35	1.46	0	Pure
35	-25.00	-23.74	1.26	1.13	0	Pure
36	-21.61	-22.82	-1.21	1.07	9.2	Pure
37	-25.19	-24.04	1.15	1.39	0	Pure
38	-26.18	-25.52	0.66	1.04	0	Pure
39	-26.12	-25.24	0.88	1.01	0	Pure
40	-26.65	-24.96	1.69	1.21	0	Pure
Average	-26.36 ± 1.37	-25.27 ± 1.20	1.09 ± 0.55	1.38 ± 0.18		



Table 3. $\delta^{13}\text{C}$ values and protein content of 2012 Thailand longan honey samples imported to Taiwan

No	$\delta^{13}\text{C}$ values for honey (o/oo)	$\delta^{13}\text{C}$ values for protein of honey (o/oo)	Differences in $\delta^{13}\text{C}$ (o/oo) values (protein-honey)	Bradford protein assay (mg/g)	Adulteration (%)	Honey quality
1	-24.65	-24.31	0.34	0.61	0	Pure
2	-24.66	-24.15	0.51	0.64	0	Pure
3	-24.06	-24.33	-0.27	0.64	1.8	Pure
4	-24.42	-24.38	0.04	0.63	0	Pure
5	-24.56	-24.36	0.20	0.59	0	Pure
6	-25.41	-24.59	0.82	0.67	0	Pure
7	-25.30	-24.67	0.62	0.55	0	Pure
8	-25.96	-24.45	1.51	0.58	0	Pure
9	-24.75	-24.98	-0.23	0.63	1	Pure
10	-24.54	-24.99	-0.45	0.55	2	Pure
11	-24.65	-24.15	0.50	0.48	0	Pure
12	-24.72	-24.09	0.63	0.68	0	Pure
13	-26.15	-23.42	2.73	0.66	0	Pure
14	-25.97	-25.20	0.77	0.63	0	Pure
15	-25.31	-24.14	1.17	0.68	0	Pure
16	-25.01	-24.24	0.76	0.71	0	Pure
17	-25.54	-24.93	0.61	0.89	0	Pure
18	-25.93	-24.76	1.17	0.66	0	Pure
19	-24.83	-23.46	1.37	0.73	0.	Pure
Average	-25.07 ± 0.61	-24.40 ± 0.47	0.67 ± 0.73	0.64 ± 0.08		



Table 4. $\delta^{13}\text{C}$ values and protein content of **2013 Thailand longan honey** samples imported to Taiwan

No	$\delta^{13}\text{C}$ values for honey (o/oo)	$\delta^{13}\text{C}$ values for protein of honey (o/oo)	Differences in $\delta^{13}\text{C}$ (o/oo) values (protein-honey)	Bradford protein assay (mg/g)	Adulteration (%)	Honey quality
1	-26.27	-25.53	0.74	0.85	0	Pure
2	-26.25	-25.49	0.76	0.85	0	Pure
3	-26.12	-25.40	0.72	0.84	0	Pure
4	-26.84	-25.38	1.46	0.74	0	Pure
5	-26.68	-25.63	1.05	0.79	0	Pure
6	-26.56	-26.13	0.43	0.72	0	Pure
7	-26.13	-25.59	0.54	0.75	0	Pure
8	-26.06	-25.85	0.21	0.77	0	Pure
9	-26.88	-25.92	0.96	0.77	0	Pure
10	-26.56	-26.09	0.47	0.80	0	Pure
11	-23.72	-24.36	-0.64	0.75	4.4	Pure
12	-27.73	-25.63	2.10	0.95	0	Pure
13	-21.83	-22.93	-1.10	0.62	8.3	Pure
14	-13.79	-	-	-	-	Adulterated
15	-27.87	-26.09	1.78	0.96	0	Pure
16	-27.54	-26.54	1.00	0.76	0	Pure
17	-27.33	-25.78	1.55	0.71	0	Pure
Average	-25.54 ± 3.37	-25.52 ± 0.84	1.52 ± 3.26	0.79 ± 0.21		

1 out of 17 samples adulterated with C₄ HFCS

Table 5. $\delta^{13}\text{C}$ values and protein content of **2012 Taiwan honey** samples obtained from **beekeepers**

No	$\delta^{13}\text{C}$ values for honey (o/oo)	$\delta^{13}\text{C}$ values for protein of honey (o/oo)	Differences in $\delta^{13}\text{C}$ (o/oo) values (protein-honey)	Bradford protein assay (mg/g)	Adulteration (%)	Honey quality	type
1	-27.88	-27.31	0.57	0.58	0	Pure	Beggarticks
2	-26.35	-24.77	1.59	0.31	0	Pure	Tallow
3	-23.22	-23.88	-0.66	0.66	4.6	Pure	Unknown
4	-26.48	-26.22	0.26	0.56	0	Pure	Cinnamon
5	-21.46	-24.61	-3.15	0.82	21.1	Adulterated	Avocado
6	-21.66	-24.29	-2.63	0.86	18.0	Adulterated	Litchi
7	-25.73	-26.52	-0.79	0.33	4.7	Pure	Beggarticks
8	-25.47	-27.52	-2.05	0.74	11.5	Adulterated	Unknown
9	-21.84	-23.60	-1.77	0.76	12.7	Adulterated	Unknown
10	-23.62	-24.91	-1.29	0.70	8.5	Pure	Unknown
11	-26.60	-26.23	0.38	0.64	0	Pure	Unknown
12	-24.82	-25.22	-0.40	0.69	2.6	Pure	Unknown
13	-26.80	-26.00	0.80	1.23	0	Pure	Unknown
14	-22.27	-25.41	-3.14	0.71	20.0	Adulterated	Unknown
15	-25.12	-24.99	0.13	0.55	0	Pure	Unknown
16	-23.95	-26.59	-2.63	1.38	15.6	Adulterated	Unknown
17	-23.62	-24.90	-1.29	0.84	8.5	Pure	Litchi
18	-26.77	-27.16	-0.40	0.71	2.3	Pure	Unknown
19	-24.26	-24.97	-0.71	0.87	4.7	Pure	Aglaia
20	-27.01	-26.61	0.40	0.71	0	Pure	Beggarticks
Average	-24.75 ± 1.98	-25.59 ± 1.15	-0.84 ± 1.38	0.73 ± 0.25			



6 out of 20 samples Contaminated with C_4 sugar syrup

Table 6. $\delta^{13}\text{C}$ values and protein content of **Taiwan honey** samples **certificated by Taiwan Beekeepers Association** in 2013

No	$\delta^{13}\text{C}$ values for honey (o/oo)	$\delta^{13}\text{C}$ values for protein of honey (o/oo)	Differences in $\delta^{13}\text{C}$ (o/oo) values (protein-honey)	Bradford protein assay (mg/g)	Adulteration (%)	Honey quality	type
1	-25.72	-25.46	0.26	0.76	0	Pure	Unknown
2	-23.77	-24.82	-1.05	0.93	6.9	Pure	Unknown
3	-25.41	-25.09	0.32	0.97	0	Pure	Unknown
4	-26.09	-25.69	0.4	1.09	0	Pure	Unknown
5	-26.00	-25.10	0.9	0.85	0	Pure	Unknown
6	-25.22	-25.34	-0.12	1.17	0.8	Pure	Unknown
7	-25.97	-25.53	0.44	0.96	0	Pure	Unknown
8	-26.54	-25.13	1.41	0.98	0	Pure	Unknown
9	-25.43	-25.76	-0.33	0.69	2.1	Pure	Unknown
10	-25.53	-24.68	0.85	1.06	0	Pure	Unknown
Average	-25.57 ± 0.74	-25.26 ± 0.36	0.31 ± 0.69	0.95 ± 0.15			



Table 7. $\delta^{13}\text{C}$ values and protein content of **China honey** samples in 2011 (from Yangzhou University, China)

No	$\delta^{13}\text{C}$ values for honey (o/oo)	$\delta^{13}\text{C}$ values for protein of honey (o/oo)	Differences in $\delta^{13}\text{C}$ (o/oo) values (protein-honey)	Bradford protein assay (mg/g)	Adulteration (%)	Honey quality	Locality-honey type
1	-25.58	-25.67	-0.09	0.08	0.6	Pure	Xinjiang-Lavender
2	-27.12	-25.95	1.18	0.16	0	Pure	Xinjiang-Unknown
3	-25.97	-25.45	0.52	0.46	0	Pure	Xinjiang-Unknown
4	-25.72	-25.63	0.09	0.32	0	Pure	Xinjiang-Unknown
5	-24.33	-23.63	0.70	0.37	0	Pure	Berberine
6	-25.26	-24.14	1.12	0.98	0	Pure	Longan
7	-24.67	-24.44	0.24	0.49	0	Pure	Xinjiang- Unknown
8	-27.03	-26.11	0.92	0.11	0	Pure	Hubei-Cole
9	-25.01	-25.42	-0.41	0.69	2.6	Pure	Guizhou-Cole
10	-27.27	-26.57	0.70	0.08	0	Pure	Jiangnan-Cole
11	-26.36	-25.72	0.63	0.14	0	Pure	Zhejiang-Cole
12	-22.90	-23.42	-0.52	0.09	3.8	Pure	Shandong-Purple
13	-23.17	-23.08	0.10	0.85	0	Pure	Binzhou Zaohua
14	-27.12	-26.94	0.18	0.01	0	Pure	Hubei-Cole
15	-26.99	-26.06	0.93	0.09	0	Pure	Hubei-Cole
16	-27.06	-26.29	0.77	0.08	0	Pure	Hubei-Cole
17	-27.05	-26.55	0.49	0.08	0	Pure	Hubei-Cole
18	-27.70	-27.09	0.61	0.16	0	Pure	Zhejiang-Cole
19	-29.42	-27.36	2.06	0.19	0	Pure	Zhejiang-Cole
20	-28.79	-27.09	1.70	0.12	0	Pure	Jiangxi-Cole
Average	-26.23 ± 1.68	-26.63 ± 1.27	0.60 ± 0.64	0.28 ± 0.28			



Table 8. $\delta^{13}\text{C}$ values and protein content of different types of honey samples

Type of honey	<i>n</i>	$\delta^{13}\text{C}$ values for honey (o/oo)	$\delta^{13}\text{C}$ values for protein of honey (o/oo)	Bradford protein assay (mg/g)
2012 Taiwan award longan honey	40	-26.20 ± 0.71 a*	-24.78 ± 0.67 c	1.36 ± 0.16 a
2013 Taiwan award longan honey	40	-26.36 ± 1.37 ab	-25.27 ± 1.20 a	1.38 ± 0.18 a
2012 Thailand longan honey	19	-25.07 ± 0.61 c	-24.40 ± 0.47 b	0.64 ± 0.08 d
2013 Thailand longan honey	16	-26.27 ± 1.52 ab	-25.52 ± 0.84 a	0.79 ± 0.09 c
2012 Taiwan honey from beekeepers	14	-25.59 ± 1.48 abc	-25.69 ± 1.02 a	0.67 ± 0.23 cd
2013 Certificated Taiwan longan honey	10	-25.57 ± 0.74 bc	-25.26 ± 0.36 a	0.95 ± 0.15 b
2011 China honey	20	-26.23 ± 1.68 ab	-25.63 ± 1.27 a	0.28 ± 0.28 e

*Means in the same column followed by a different letters are significantly different by the LSD-Test ($P < 0.05$)

Table 9. $\delta^{13}\text{C}$ values and protein content of **commercial honey** samples from Taiwan in 2012

No	Label	$\delta^{13}\text{C}$ values for honey (o/oo)	$\delta^{13}\text{C}$ values for protein of honey (o/oo)	Differences in $\delta^{13}\text{C}$ (o/oo) values (protein-honey)	Bradford protein assay (mg/g)	Adulteration (%)	Honey quality
1	Adulterated longan honey	-25.14	-	25.14	-	-	Adulterated
2	Pure honey	-25.61	-	25.61	-	-	Adulterated
3	Pure honey	-25.81	-	25.81	-	-	Adulterated
4	Pure honey	-15.52	-	15.52	-	-	Adulterated
5	Pure honey	-19.45	-25.66	-6.21	0.10	38.9	Adulterated
6	Pure honey	-24.58	-24.73	-0.15	0.11	1.0	Pure?
7	Pure honey	-20.36	-25.23	-4.87	0.14	31.3	Adulterated
8	Adulterated honey	-12.00	-	12.00	-	-	Adulterated
9	Adulterated honey	-23.05	-	23.05	-	-	Adulterated
10	Pure honey	-22.83	-22.23	0.60	0.58	0	Pure
11	Pure honey	-22.51	-22.57	-0.05	0.82	0.4	Pure
12	Adulterated honey	-13.95	-	13.95	-	-	Adulterated
Average		-20.90 ± 4.74	-24.08 ± 1.58	10.87 ± 12.47	0.35 ± 0.33		

Only 2 or 3 of 12 commercial honey were pure!

Table 10. $\delta^{13}\text{C}$ values and protein content of **commercial honey** samples from Taiwan in 2013

Sample Number	Lable	$\delta^{13}\text{C}$ values for honey (o/oo)	$\delta^{13}\text{C}$ values for protein of honey (o/oo)	Differences in $\delta^{13}\text{C}$ (o/oo) values (protein-honey)	Bradford protein assay (mg/g) (< 0.02)	Adulteration (%)	Honey quality
1	Pure honey	-24.36	-24.15	0.21	0.42	0	Pure
2	honey	-24.46	-24.48	-0.02	0.57	0.1	Pure
3	honey	-24.23	-24.24	-0.01	0.46	0.1	Pure
4	Pure longan honey	-24.65	-22.59	2.06	0.17	0	Pure?
5	Pure longan honey	-14.36	-25.25	-10.89	0.15	70.0	Adulterated
6	Pure honey	-22.60	-22.96	-0.36	0.42	2.7	Pure
7	Pure longan honey	-25.40	-24.58	0.82	0.79	0	Pure
8	honey	-22.63	-23.69	-1.06	0.46	7.6	Pure
9	Adulterated longan honey	-15.44	-	-	-	-	Adulterated
10	Pure longan honey	-15.26	-24.39	-9.13	0.31	62.2	Adulterated
11	Pure hetero honey	-25.09	-24.80	0.29	0.26	0	Pure
12	longan honey	-24.23	-23.89	0.34	0.87	0	Pure
13	Pure honey	-13.76	-23.21	-9.45	0.15	69.9	Adulterated
14	Pure honey	-24.58	-	-	-	-	Adulterated
15	honey	-25.04	-25.23	-0.19	0.59	1.2	Pure
16	longan honey	-24.71	-25.21	-0.5	0.52	3.2	Pure
17	Pure honey	-26.76	-25.20	1.56	0.71	0	Pure
18	Pure honey	-25.41	-26.51	-1.1	0.03	6.5	Pure?
19	Pure honey	-18.15	-25.64	-7.49	0.23	47.0	Adulterated
20	Pure honey	-25.95	-24.36	1.59	0.14	0	Pure?
21	Pure honey	-19.47	-26.46	-6.99	0.12	41.7	Adulterated
22	Pure longan honey	-26.78	-25.33	1.45	0.36	0	Pure
23	Adulterated honey	-14.51	-	-	-	-	Adulterated
24	Adulterated honey	-16.29	-	-	-	-	Adulterated
25	Adulterated apple honey	-23.53	-	-	-	-	Adulterated
26	Pure longan honey	-25.47	-25.35	0.12	0.37	0	Pure
27	Adulterated honey	-25.75	-	-	-	-	Adulterated
28	Pure longan honey	-25.68	-	-	-	-	Adulterated
29	Pure longan honey	-25.46	-	-	-	-	Adulterated
30	Pure longan honey	-26.24	-25.71	0.53	0.75	0	Pure
Average		-22.54 ± 4.29	-24.69 ± 11.14	-1.74 ± 3.54	0.40 ± 0.27		

50%
were
pure!

Discussion



All products (90 honey samples) marked with official certification and evaluation were up to standard.



Certification logo issued by
Taiwan Beekeepers Association




<http://www.honey.com.tw>

Taiwan award longan honey

Discussion



1 of 36 Thailand longan samples showed any trace of protein.

- It may probably adulterate with C4 sugars
-  that the $\delta^{13}\text{C}$ value was -13.79‰ .

Discussion



Taiwan honey (30 honey sample from beekeepers) that 6 of the samples may be contaminated with 12-21% adulterated sugar syrup by beekeepers themselves.



China honey, no adulteration was detected in any these honey samples (20 honey samples)

Discussion

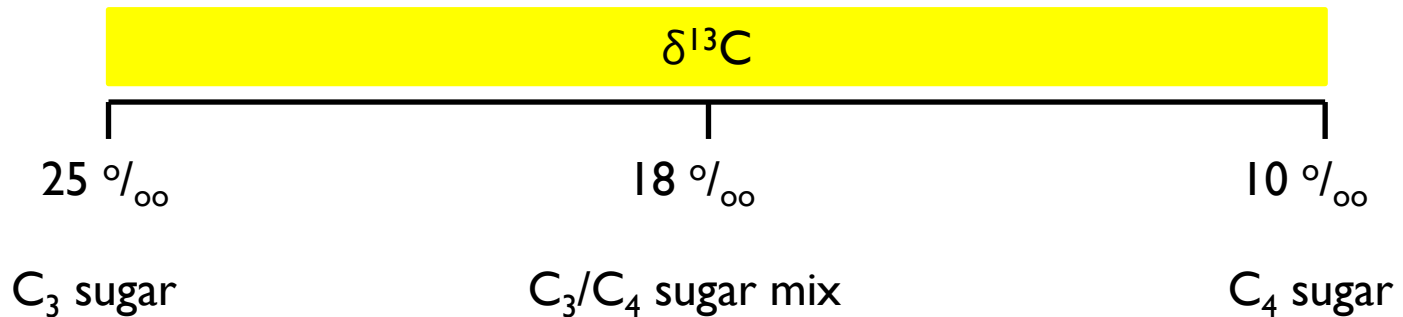


Commercial honey in Taiwan (42 honey samples, 2012-2013) :

- $24 / 42 = 57.1\%$ were adulterated
- 15 samples were no trace of protein
→ 100% artificial
- 9 sample were mixed with 31-70% adulterated C_4 sugars determined by $13C/12C$ pattern

Conclusion

- $^{13}\text{C}/^{12}\text{C}$ ratio of C_3 and C_4 change from **-23 to -28 ‰** and **-9 to -15 ‰** (Cabanero et al., 2006; Ruiz-Matute et al., 2010).
- Artificial syrup produce from C_4 or C_3 plant
- Natural honey produce from C_3 plant



Conclusion



Determination of adulteration of honey with C_3 sugar is still a problem.



Detect adulteration with C_3 sugar in a certain way including protein content, HMF, pH..., but it needs more bigger database.

Thanks for your attentions

