

Table 3-1 Intraday and interday analytical precision and accuracy of hesperidin in orange juice.

Conc. ($\mu\text{g/mL}$)	Intraday		Interday	
	Precision Mean \pm S.D. (C.V.%)	Accuracy (%)	Precision Mean \pm S.D. (C.V.%)	Accuracy (%)
50.0	50.5 \pm 0.4 (0.7)	1.1	50.4 \pm 0.4 (0.7)	0.9
25.0	24.0 \pm 0.1 (0.6)	-4.0	24.3 \pm 0.2 (1.0)	-3.0
12.5	12.0 \pm 0.1 (0.5)	-4.3	12.0 \pm 0.2 (1.8)	-4.2
6.3	7.0 \pm 0.1 (1.9)	11.2	6.9 \pm 0.0 (0.6)	10.3
3.1	3.2 \pm 0.0 (1.9)	0.8	3.2 \pm 0.0 (0.8)	1.2
1.6	1.6 \pm 0.0 (1.4)	5.0	1.6 \pm 0.0 (1.0)	3.5
0.8	0.9 \pm 0.0 (1.4)	19.1	0.9 \pm 0.0 (1.8)	16.1

Table 3-2 Intraday and interday analytical precision and accuracy of narirutin in orange juice.

Conc. ($\mu\text{g/mL}$)	Intraday		Interday	
	Precision Mean \pm S.D. (C.V.%)	Accuracy (%)	Precision Mean \pm S.D. (C.V.%)	Accuracy (%)
50.0	50.1 \pm 0.1 (0.2)	0.1	50.2 \pm 0.6 (1.2)	0.3
25.0	24.6 \pm 0.7 (3.0)	-1.0	24.6 \pm 0.4 (1.7)	-1.7
12.5	12.7 \pm 0.0 (0.3)	1.6	12.7 \pm 0.2 (1.6)	1.7
6.3	6.2 \pm 0.1 (0.8)	0.4	6.3 \pm 0.1 (1.5)	-0.1
3.1	3.1 \pm 0.1 (2.7)	-1.6	3.2 \pm 0.0 (1.3)	1.2
1.6	1.6 \pm 0.0 (1.5)	2.8	1.6 \pm 0.0 (0.8)	4.1
0.8	0.7 \pm 0.0 (4.0)	-5.7	0.7 \pm 0.0 (4.4)	-6.1

Table 3-3 Recovery (%) of hesperidin from orange juice.

Conc. Spiked ($\mu\text{g/mL}$)	a	b	c	Mean \pm S.D.
50.0	90.5	98.4	96.1	95.0 \pm 4.1
6.3	98.3	101.8	91.7	97.2 \pm 5.1
0.8	103.0	93.7	86.3	94.3 \pm 8.3

Table 3-4 Recovery (%) of narirutin from orange juice.

Conc. Spiked ($\mu\text{g/mL}$)	a	b	c	Mean \pm S.D.
50.0	98.6	97.0	99.1	98.2 \pm 1.1
6.3	101.5	104.5	106.8	104.3 \pm 2.7
0.8	104.6	102.4	91.6	99.5 \pm 7.0

Table 3-5 Intraday and interday analytical precision and accuracy of hesperetin in human urine.

Conc. ($\mu\text{g/mL}$)	Intraday		Interday	
	Precision Mean \pm S.D. (C.V.%)	Accuracy (%)	Precision Mean \pm S.D. (C.V.%)	Accuracy (%)
50.0	49.5 \pm 0.4 (0.7)	-1.0	49.6 \pm 0.3 (0.6)	-0.8
25.0	26.0 \pm 0.7 (2.8)	4.1	25.8 \pm 0.6 (2.3)	3.4
12.5	12.6 \pm 0.1 (0.7)	1.0	12.5 \pm 0.0 (0.3)	0.4
6.3	6.1 \pm 0.1 (1.6)	-2.2	6.2 \pm 0.0 (0.1)	-0.1
3.1	2.8 \pm 0.2 (7.5)	-9.6	3.0 \pm 0.1 (4.0)	-5.3
1.6	1.3 \pm 0.2 (8.4)	-13.8	1.4 \pm 0.1 (8.1)	-11.3
0.8	0.6 \pm 0.1 (9.3)	-17.2	0.7 \pm 0.1 (9.1)	-16.0

Table 3-6 Intraday and interday analytical precision and accuracy of naringenin in human urine.

Conc. ($\mu\text{g/mL}$)	Intraday		Interday	
	Precision Mean \pm S.D. (C.V.%)	Accuracy (%)	Precision Mean \pm S.D. (C.V.%)	Accuracy (%)
50.0	49.8 \pm 0.2 (0.3)	-0.4	49.9 \pm 0.1 (0.2)	-0.2
25.0	25.4 \pm 0.3 (1.1)	1.6	25.2 \pm 0.1 (0.4)	0.6
12.5	12.6 \pm 0.0 (0.3)	0.5	12.6 \pm 0.1 (0.6)	0.9
6.3	6.3 \pm 0.0 (0.4)	0.6	6.3 \pm 0.0 (0.7)	1.0
3.1	3.1 \pm 0.0 (1.3)	-1.9	3.1 \pm 0.0 (0.3)	-0.4
1.6	1.5 \pm 0.1 (3.9)	-5.3	1.5 \pm 0.0 (1.5)	-2.1
0.8	0.6 \pm 0.1 (9.4)	-17.8	0.7 \pm 0.1 (8.6)	-10.8

Table 3-7 Recovery (%) of hesperetin from human urine.

Conc. spiked ($\mu\text{g/mL}$)	a	b	c	Mean \pm S.D.
50.0	88.2	97.3	97.2	94.2 \pm 5.3
6.3	97.1	95.1	98.5	96.9 \pm 1.6
0.8	97.5	97.2	109.6	101.4 \pm 7.1

Table 3-8 Recovery (%) of naringenin from human urine.

Conc. spiked ($\mu\text{g/mL}$)	a	b	c	Mean \pm S.D.
50.0	97.1	101.2	103.9	100.8 \pm 3.4
6.3	96.2	91.3	103.9	97.1 \pm 6.4
0.8	97.8	103.1	85.5	95.5 \pm 9.0

Table 3-9 Recoveries of hesperetin sulfates (μmol) in urine after intake of orange juice in eleven volunteers.

Time (h)	1	2	3	4	5	6	7	8	9	10	11	Mean \pm S.E.
0-2	2.2	ND	0.1	0.1	ND	ND	0.1	0.4	ND	0.3	ND	0.3 \pm 0.2
2-4	7.3	0.6	1.2	0.4	0.9	0.4	2.3	1.5	0.1	1.4	0.9	1.5 \pm 0.6
4-6	16.0	8.7	4.2	1.2	11.8	1.8	15.9	1.7	5.7	1.5	2.9	6.5 \pm 1.7
6-8	1.9	8.6	0.6	2.4	6.1	2.1	7.6	4.1	3.4	0.2	0.2	3.4 \pm 0.9
8-10	1.9	2.7	0.5	2.6	1.3	12.1	4.3	1.1	1.4	0.1	0.1	2.6 \pm 1.0
10-12	0.5	2.0	0.1	-	-	-	5.0	0.9	2.0	0.5	0.1	1.0 \pm 0.5
12-24	0.4	ND	ND	0.4	0.3	0.6	3.1	0.4	0.4	0.2	0.2	0.5 \pm 0.3

ND: not detectable

Table 3-10 Recoveries of hesperetin glucuronides (μmol) in urine after intake of orange juice in eleven volunteers.

Time (h)	1	2	3	4	5	6	7	8	9	10	11	Mean \pm S.E.
0-2	0.9	ND	ND	ND	0.1	ND	ND	3.3	ND	ND	ND	0.4 \pm 0.3
2-4	1.8	ND	0.6	0.1	0.1	0.1	ND	1.7	ND	0.6	0.3	0.5 \pm 0.2
4-6	2.3	1.4	1.0	0.5	3.7	0.4	0.6	0.5	1.0	0.5	1.0	1.2 \pm 0.3
6-8	0.3	2.0	0.2	1.1	1.9	0.6	1.4	0.7	1.1	0.1	ND	0.9 \pm 0.2
8-10	0.7	0.6	0.1	1.0	0.4	1.2	1.4	0.7	0.6	0.1	ND	0.6 \pm 0.1
10-12	0.1	0.4	ND	-	-	-	0.8	0.6	0.4	0.1	ND	0.2 \pm 0.1
12-24	0.1	ND	ND	0.1	0.2	0.2	0.3	ND	0.1	ND	0.1	0.1 \pm 0.0

ND: not detectable

Table 3-11 Recoveries of naringenin sulfates (μmol) in urine after intake of orange juice in eleven volunteers.

Time (h)	1	2	3	4	5	6	7	8	9	10	11	Mean \pm S.E.
0-2	1.9	0.2	0.5	0.4	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.4 \pm 0.2
2-4	6.5	1.1	1.2	0.5	1.8	0.6	2.1	1.0	0.3	1.2	0.6	1.5 \pm 0.5
4-6	16.3	2.6	1.9	1.1	8.2	1.7	11.4	1.3	5.4	0.6	0.5	4.6 \pm 1.6
6-8	2.8	1.0	0.5	0.8	3.7	1.2	3.0	2.5	1.5	0.1	ND	1.6 \pm 0.4
8-10	2.0	0.5	0.5	0.7	0.7	4.1	1.4	0.6	0.6	ND	0.2	1.0 \pm 0.3
10-12	0.7	0.5	0.3	-	-	-	2.1	0.9	0.7	ND	0.2	0.5 \pm 0.2
12-24	0.6	0.2	0.2	0.5	0.4	0.3	0.2	0.1	0.3	ND	0.2	0.3 \pm 0.1

ND: not detectable

Table 3-12 Recoveries of naringenin glucuronides (μmol) in urine after intake of orange juice in eleven volunteers.

Time (h)	1	2	3	4	5	6	7	8	9	10	11	Mean \pm S.E.
0-2	1.4	ND	0.1	0.1	ND	0.1	ND	0.2	ND	0.2	ND	0.2 \pm 0.1
2-4	3.8	0.3	0.9	0.1	0.6	0.3	ND	1.2	0.1	1.0	0.4	0.8 \pm 0.3
4-6	7.9	1.2	1.4	0.8	2.7	1.1	0.9	0.8	2.5	0.7	0.8	1.9 \pm 0.6
6-8	2.7	0.6	ND	0.8	2.2	0.9	2.9	0.5	1.4	0.1	ND	1.1 \pm 0.3
8-10	1.9	0.2	ND	0.5	0.8	1.6	2.4	0.5	0.4	0.1	ND	0.8 \pm 0.3
10-12	0.1	0.2	0.1	-	-	-	1.0	0.4	0.6	0.2	ND	0.2 \pm 0.1
12-24	ND	ND	0.1	0.3	0.3	0.1	0.1	ND	0.1	0.1	ND	0.1 \pm 0.0

ND: not detectable

Table 3-13 Urine recoveries of hesperetin sulfates (% of dose/h) in eleven volunteers after intake of orange juice during each time interval.

Time (h)	1	2	3	4	5	6	7	8	9	10	11	Mean ± S.E.
0-2	4.6	ND	0.4	0.1	ND	ND	0.3	1.0	ND	0.8	ND	0.7 ± 0.4
2-4	10.1	0.6	2.6	1.1	0.4	0.4	1.6	2.0	ND	7.4	2.4	2.6 ± 1.0
4-6	7.0	6.6	5.7	0.2	2.7	2.3	6.6	1.2	4.7	5.7	3.9	4.2 ± 0.7
6-8	1.1	7.1	0.7	4.8	1.4	3.0	10.8	5.3	6.1	0.8	0.3	3.8 ± 1.0
8-10	1.4	2.8	0.8	4.0	0.6	4.5	ND	0.2	2.5	0.4	0.1	1.6 ± 0.5
10-12	0.1	0.2	ND	-	-	-	0.4	ND	0.3	0.2	ND	0.1 ± 0.0
12-24	0.1	ND	ND	0.4	0.1	0.3	1.6	0.2	0.2	0.3	0.1	0.3 ± 0.1

ND: not detectable

Table 3-14 Urine recoveries of hesperetin glucuronides (% of dose/h) in eleven volunteers after intake of orange juice during each time interval.

Time (h)	1	2	3	4	5	6	7	8	9	10	11	Mean ± S.E.
0-2	1.9	ND	0.2	ND	0.5	ND	ND	8.6	ND	0.1	ND	1.0 ± 0.8
2-4	2.4	0.0	1.2	0.3	0.1	0.1	ND	2.3	ND	3.1	0.8	0.9 ± 0.3
4-6	1.0	1.1	1.4	0.1	0.8	0.5	0.2	0.4	0.8	1.9	1.3	0.9 ± 0.2
6-8	0.2	1.6	0.3	2.1	0.4	0.9	2.0	0.9	1.9	0.3	0.1	1.0 ± 0.2
8-10	0.5	0.6	0.2	1.5	0.2	0.4	ND	0.2	1.0	0.2	ND	0.4 ± 0.1
10-12	ND	ND	ND	-	-	-	0.1	ND	0.1	ND	ND	0.0 ± 0.0
12-24	ND	ND	ND	0.1	0.1	0.1	0.2	ND	ND	ND	0.1	0.1 ± 0.0

ND: not detectable

Table 3-15 Urine recoveries of naringenin sulfates (% of dose/h) in eleven volunteers after intake of orange juice during each time interval.

Time (h)	1	2	3	4	5	6	7	8	9	10	11	Mean ± S.E.
0-2	1.7	0.2	0.9	0.3	0.4	0.6	0.4	0.2	0.4	0.3	0.3	0.5 ± 0.1
2-4	3.9	0.5	1.1	0.7	0.4	0.3	0.6	0.6	0.1	2.8	0.7	1.1 ± 0.4
4-6	3.1	0.9	1.2	0.9	0.8	1.0	2.1	0.4	2.0	1.0	0.3	1.2 ± 0.3
6-8	0.7	0.4	0.2	0.7	0.4	0.8	1.9	1.4	1.2	0.1	ND	0.7 ± 0.2
8-10	0.7	0.2	0.3	0.4	0.1	0.7	ND	0.1	0.4	ND	0.2	0.3 ± 0.1
10-12	ND	ND	ND	-	-	-	0.1	ND	ND	ND	ND	0.0 ± 0.0
12-24	0.1	0.1	0.1	0.2	0.1	0.1	ND	ND	ND	ND	0.1	0.1 ± 0.0

ND: not detectable

Table 3-16 Urine recoveries of naringenin glucuronides (% of dose/h) in eleven volunteers after intake of orange juice during each time interval.

Time (h)	1	2	3	4	5	6	7	8	9	10	11	Mean ± S.E.
0-2	1.3	ND	0.1	0.1	ND	0.2	ND	0.2	ND	0.3	ND	0.2 ± 0.1
2-4	2.3	0.2	0.9	0.2	0.1	0.2	ND	0.7	ND	2.4	0.5	0.7 ± 0.3
4-6	1.5	0.4	0.8	0.1	0.3	0.6	0.2	0.2	0.9	1.1	0.4	0.6 ± 0.1
6-8	0.7	0.2	ND	0.7	0.2	0.6	1.8	0.3	1.1	0.2	ND	0.5 ± 0.2
8-10	0.7	0.1	ND	0.3	0.2	0.3	ND	ND	0.3	0.1	ND	0.2 ± 0.1
10-12	0.1	ND	ND	-	-	-	ND	ND	ND	ND	ND	0.0 ± 0.0
12-24	ND	ND	ND	0.1	0.1	ND	ND	ND	ND	ND	ND	0.0 ± 0.0

ND: not detectable

Table 3-17 Half-life of conjugated metabolites of hesperetin and naringenin after oral administration of orange juice to eleven volunteers.

$t_{1/2}$ (h)	Hesperetin sulfates	Hesperetin glucuronides	Naringenin sulfates	Naringenin glucuronides
1	2.0	2.4	1.2	1.1
2	2.8	1.7	1.3	2.0
3	2.6	1.2	2.3	1.7
4	6.4	3.3	3.1	2.6
5	2.1	2.6	1.2	1.9
6	1.0	4.1	1.8	1.4
7	3.4	4.1	1.6	1.6
8	3.8	3.0	1.9	1.5
9	3.6	2.8	2.5	1.7
10	2.9	2.9	1.3	2.3
11	1.5	4.3	2.1	1.7
Mean \pm S.E.	2.9 \pm 0.4	2.9 \pm 0.3	1.8 \pm 0.2	1.8 \pm 0.1