Nutrients | 中国城市母亲母乳中的类胡萝卜素和生育酚含量及其与母体特征之间的关系：一项横断面研究

本文关键字：母乳、类胡萝卜素、生育酚、初乳、哺乳阶段、横断面研究

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母乳成分依然是婴儿需要量的最佳估计标准。本研究旨在量化中国健康母亲母乳中的类胡萝卜素和生育酚，并探讨它们与哺乳阶段、地理位置、社会经济、分娩方式及膳食摄入之间的关系。

研究从 509 名健康母亲中获得母乳，同时利用超高效液相色谱分析法对类胡萝卜素和生育酚的含量进行了分析。通过一次 24 小时膳食回顾法评估了母亲的社会经济和分娩方式及膳食摄入情况。产后 0-4 天、5-11 天、12-30 天、31-60 天、61-120 天以及 121-240 天各组分含量均值（μg/100 mL）如下：β-胡萝卜素：8.0、 2.8、 2.1、1.7、1.9、 1.8；β-隐黄素：6.2、 3.4、 2.4、 1.7、 1.8、2.1； 叶黄素： 5.7、 7.0、 2.2、2.9、 2.8、 3.7；番茄红素：6.3、 2.5、1.8、 1.4、 1.4、 1.5；玉米黄质： 1.0、1.4、0.8、 0.8、1.0、 1.1； α-生育酚：645、 382、 239、 206、 212、 211； γ-生育酚： 68、 63、 70、 73、 68、 88。

这些组分的浓度在不同哺乳阶段呈现显著差异，且呈现出地理位置差异。在多变量分析中，发现类胡萝卜素的含量与母亲教育水平、分娩方式以及当前的体质指数之间具有相关性。

这些结果表明，哺乳阶段、地理位置、社会经济及分娩方式与中国健康母亲母乳中的类胡萝卜素及生育酚含量之间具有相关性。

参考文献：Xue Y,et al. Nutrients. 2017 Nov 9;9(11). pii: E1229.

文献链接：https://www.ncbi.nlm.nih.gov/pubmed/29120377

Table 1. Demographic characteristics of lactating mothers according to different lactating stages.

	0–4 Days (*n* = 77)	5–11 Days (*n* = 89)	12–30 Days (*n* = 73)	31–60 Days (*n* = 90)	61–120 Days (*n* = 90)	121–240 Days (*n* = 90)	*p*-Value
Age, years [1]							0.097
<25	22 (28.6)	27 (30.3)	26 (35.6)	18 (20.0)	26 (28.9)	36 (40.0)	
25–30	35 (45.5)	41 (46.1)	29 (39.7)	44 (48.9)	50 (55.6)	39 (43.3)	
>30	20 (26.0)	21 (23.6)	18 (24.7)	28 (31.1)	14 (15.6)	15 (16.7)	
Offspring gender [1]							0.158
Male	35 (45.5)	51 (57.3)	39 (53.4)	48 (53.3)	54 (60.0)	43 (47.8)	
Female	42 (54.5)	38 (42.7)	31 (42.5)	39 (43.3)	36 (40.0)	44 (48.9)	
Education [1]							0.003 *
Middle school or below	17 (22.1)	12 (13.5)	16 (21.9)	26 (28.9)	22 (24.4)	39 (43.3)	
High school	23 (29.9)	31 (34.8)	27 (37.0)	22 (24.4)	25 (27.8)	23 (25.6)	
College or above	36 (46.8)	45 (50.6)	29 (39.7)	42 (46.7)	41 (45.6)	26 (28.9)	
Family's per capita income, Yuan/month [1]							0.140
<2000	16 (20.8)	19 (21.3)	16 (21.9)	24 (26.7)	26 (28.9)	31 (34.4)	
2000–4000	30 (39.0)	37 (41.6)	34 (46.6)	41 (45.6)	40 (44.4)	41 (45.6)	
>4000	27 (35.1)	30 (33.7)	17 (23.3)	23 (25.6)	22 (24.4)	18 (20.0)	
Unclear	4 (5.2)	3 (3.4)	6 (8.2)	2 (2.2)	2 (2.2)	0 (0.0)	
Delivery mode [1]							0.002 *
Vaginal delivery	29 (37.7)	50 (56.2)	35 (47.9)	37 (41.1)	55 (61.1)	55 (61.1)	
Cesarean delivery	48 (62.3)	37 (41.6)	38 (52.1)	53 (58.9)	35 (38.9)	34 (37.8)	
Present BMI [1]							0.075
Underweight	1 (1.3)	5 (5.6)	2 (2.7)	2 (2.2)	4 (4.4)	8 (8.9)	
Normal	48 (62.3)	54 (60.7)	47 (64.4)	57 (63.3)	69 (76.7)	65 (72.2)	
Overweight	24 (31.2)	26 (29.2)	23 (31.5)	26 (28.9)	16 (17.8)	16 (17.8)	
Obesity	4 (5.2)	3 (3.4)	1 (1.4)	5 (5.6)	1 (1.1)	1 (1.1)	

Table 1. *Cont.*

	0–4 Days (*n* = 77)	5–11 Days (*n* = 89)	12–30 Days (*n* = 73)	31–60 Days (*n* = 90)	61–120 Days (*n* = 90)	121–240 Days (*n* = 90)	*p*-Value
Gestational weight gain [1]							0.300
Inadequate	17 (22.1)	11 (12.4)	14 (19.2)	17 (18.9)	19 (21.1)	26 (28.9)	
Adequate	27 (35.1)	29 (32.6)	28 (38.4)	32 (35.6)	36 (40.0)	25 (27.8)	
Excessive	33 (42.9)	48 (53.9)	29 (39.7)	41 (45.6)	34 (37.8)	39 (43.3)	
Dietary supplements intake [1]							0.028 *
Yes	5 (6.5)	13 (14.6)	17 (23.3)	17 (18.9)	22 (24.4)	13 (14.4)	
No	72 (93.5)	76 (85.4)	56 (76.7)	73 (81.1)	68 (75.6)	77 (85.6)	
Pregnancy duration, weeks [2]	39 (38–40)	39 (39–40)	39 (38–40)	39 (38–40)	39.5 (39–40)	40 (39–40)	0.332

BMI, body mass index, was calculated as body weight by height squared (kg/m^2). Data are expressed as medians (interquartile ranges) for continuous variables and count (percentage) for categorical variables. * Indicates a significant difference among six stages of lactating period ($p < 0.05$). [1] Compared by Kruskal–Wallis test; [2] Compared by chi-square test.

Table 2. Carotenoids and tocopherols concentrations in human milk at different lactation stages (μg/100 mL).

	0–4 Days (*n* = 77)	5–11 Days (*n* = 89)	12–30 Days (*n* = 73)	31–60 Days (*n* = 90)	61–120 Days (*n* = 90)	121–240 Days (*n* = 90)	*p*-Value [1]	*Post hoc* Test [2]
β-carotene	8.0 (4.7–15.2)	2.8 (2.0–4.4)	2.1 (1.4–3.1)	1.7 (1.3–3.0)	1.9 (1.4–2.7)	1.8 (1.4–2.6)	<0.001 *	P1 > P2 > P3 = P4 = P5 = P6
β-cryptoxanthin	6.2 (2.4–12.9)	3.4 (1.7–5.7)	2.4 (1.1–3.9)	1.7 (1.1–2.6)	1.8 (1.0–4.0)	2.1 (1.1–3.7)	<0.001 *	P1 > P2 > P3 = P4 = P5 = P6
Lutein	5.7 (2.9–10.2)	7.0 (4.6–10.3)	2.2 (1.2–6.3)	2.9 (0.9–5.9)	2.8 (1.2–6.5)	3.7 (2.4–5.9)	<0.001 *	P1 = P2 > P3 =P4 = P5 = P6
Lycopene	6.3 (4.0–9.9)	2.5 (1.7–4.3)	1.8 (1.2–2.6)	1.4 (1.1–2.0)	1.4 (1.0–2.0)	1.5 (1.3–2.0)	<0.001 *	P1 > P2 > P3 = P4 = P5 = P6
Zeaxanthin	1.0 (0.6–1.5)	1.4 (1.0–2.2)	0.8 (0.4–1.5)	0.8 (0.4–1.4)	1.0 (0.4–1.4)	1.1 (0.8–1.4)	<0.001 *	P2 > P1 = P3 = P4 = P5 = P6
α-tocopherol	645 (388–1176)	382 (236–551)	239 (145–396)	206 (126–345)	212 (112–300)	211 (135–326)	<0.001 *	P1 > P2 > P3 = P4 = P5 = P6
γ-tocopherol	68 (48–121)	63 (43–103)	70 (39–104)	73 (41–120)	68 (39–112)	88 (56–137)	<0.033 *	P2 = P3 < P6; P1 = P4 = P5 = P6

Data are obtained from all three cities and presented as the medians (interquartile ranges). * Indicates a significant difference among the six periods ($p < 0.05$). [1] Compared by Kruskal–Wallis test; [2] Compared by Mann–Whitney U test with adjusted alpha value ($\alpha' = 0.01$). P1: 0–4 days *postpartum*; P2: 5–11 days *postpartum*; P3: 12–30 days *postpartum*; P4: 31–60 days *postpartum*; P5: 61–120 days *postpartum*; P6: 121–240 days *postpartum*.

Table 3. Carotenoids and tocopherols concentration of human milk from different cities (Beijing, Suzhou, and Guangzhou cities) (μg/100 mL).

	Beijing (n = 151)	Suzhou (n = 180)	Guangzhou (n = 178)	p-Value [1]	*Post hoc* Test [2]
B-carotene	1.7 (1.3–3.2)	2.4 (1.7–4.3)	2.7 (1.7–5.0)	<0.001 *	C1 < C2 = C3
β-cryptoxanthin	1.1 (0.8–2.0)	3.6 (2.1–7.7)	2.8 (1.7–5.2)	<0.001 *	C1 < C3 < C2
Lutein	2.2 (1.0–4.1)	4.9 (2.6–7.9)	5.8 (2.9–8.7)	<0.001 *	C1 < C2 = C3
Lycopene	1.7 (1.3–2.8)	1.7 (1.3–2.7)	2.1 (1.4–3.8)	0.006 *	C1 = C2 < C3
Zeaxanthin	0.8 (0.4–1.4)	1.1 (0.7–2.0)	1.1 (0.7–1.5)	<0.001 *	C1 < C2 = C3
α-tocopherol	215 (117–333)	296 (208–478)	285 (148–479)	<0.001 *	C1 < C2 = C3
γ-tocopherol	71 (48–107)	94 (59–148)	53 (31–88)	<0.001 *	C3 < C1 < C2

Data are obtained from all six lactation stages and presented as the medians (interquartile ranges). * Indicates a significant difference among the three cities ($p < 0.05$). [1] Compared by Kruskal–Wallis test; [2] Compared by Mann–Whitney U test with adjusted alpha value ($\alpha' = 0.01$). C1: Beijing; C2: Suzhou; C3: Guangzhou.

Table 4. Comparisons of the carotenoids concentration in human milk by the characteristics of lactating women.

	β-carotene		β-cryptoxanthin		Lutein		Zeaxanthin	
	Adjusted [1] β (95% CI)	SEM	Adjusted [1] β (95% CI)	SEM	Adjusted [1] β (95% CI)	SEM	Adjusted [1] β (95% CI)	SEM
Age, years								
<25	−0.05 (−0.18, 0.08)	0.07	0.11 (−0.06, 0.28)	0.09	−0.13 (−0.35, 0.08)	0.11	−0.01 (−0.14, 0.15)	0.07
25–30	Reference		Reference		Reference		Reference	
>30	0.10 (−0.03, 0.23)	0.07	0.11 (−0.07, 0.29)	0.09	−0.03 (−0.15, 0.19)	0.11	0.12 (−0.03, 0.27)	0.08
Education								
Middle school or below	Reference		Reference		Reference		Reference	
High school	0.03 (−0.11, 0.17)	0.07	−0.18 (−0.36, 0.01)	0.09	0.12 (−0.11, 0.35)	0.12	−0.14 (−0.30, 0.02)	0.08
College or above	0.09 (−0.04, 0.23)	0.07	−0.12 (−0.30, 0.06)	0.09	0.08 (−0.14, 0.31)	0.11	−0.15 (−0.31, −0.00) *	0.08
Delivery mode					0			
Vaginal delivery	0.04 (−0.07, 0.15)	0.05	0.03 (−0.11, 0.17)	0.07	0.14 (−0.04, 0.31)	0.09	0.13 (0.02, 0.25) *	0.06
Cesarean delivery	Reference		Reference		Reference		Reference	
Current BMI					0			
Underweight	0.01 (−0.25, 0.26)	0.13	−0.02 (−0.35, 0.32)	0.17	0.32 (−0.09, 0.74)	0.21	0.29 (0.01, 0.57) *	0.14
Normal	Reference		Reference		Reference		Reference	
Overweight	−0.17 (−0.29, −0.05) *	0.06	−0.16 (−0.32, 0.00)	0.08	−0.11 (−0.31, 0.09)	0.10	−0.07 (−0.21, 0.07)	0.07
Obesity	−0.24 (−0.54, 0.07)	0.16	−0.16 (−0.57, 0.24)	0.21	0.16 (−0.34, 0.66)	0.26	−0.18 (−0.52, 0.16)	0.17

CI, confidence interval; SEM, standard error of mean. Multivariate linear regression model considering carotenoids in breast milk as the dependent variable and the other variables studies as independent variables. [1] Adjusted for periods of lactation (0–4 days, 5–11 days, 12–30 days, 31–60 days, 61–120 days, and 121–240 days *postpartum*), cities (Beijing, Suzhou, and Guangzhou cities), and other independent influencing factors listed above. * Indicates a significant difference when compared with the reference ($p < 0.05$). β-carotene: $R^2 = 0.482$, $p < 0.001$; β-cryptoxanthin: $R^2 = 0.366$, $p < 0.001$; Lutein: $R^2 = 0.282$, $p < 0.001$; Zeaxanthin: $R^2 = 0.124$, $p < 0.001$.

Table 5. The associations between vitamins intake and concentrations of carotenoids and tocopherols in breast milk.

		β-carotene	β-cryptoxanthin	Lutein	Lycopene	Zeaxanthin	α-tocopherol	γ-tocopherol
Dietary intake of vitamin A	R	0.022	0.026	0.027	−0.007	0.075	-	-
	p [1]	0.618	0.562	0.537	0.881	0.093	-	-
Dietary intake of total carotenoids	R	0.055	0.002	0.007	−0.038	0.003	-	-
	p [1]	0.220	0.963	0.880	0.398	0.948	-	-
Dietary intake of vitamin E	R	-	-	-	-	-	−0.083	0.006
	p [1]	-	-	-	-	-	0.063	0.885
Dietary intake of α-tocopherol	R	-	-	-	-	-	−0.033	−0.084
	p [1]	-	-	-	-	-	0.456	0.058

[1] Partial correlation was performed to analyze the correlations adjusted with cities (Beijing, Suzhou, and Guangzhou cities) and periods of lactating (0–4 days, 5–11 days, 12–30 days, 31–60 days, 61–120 days, and 121–240 days emphpostpartum).