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Case review: food pattern effects on milk lipid profiles

Abstract

It has been shown that maternal food intake determines the levels of unsaturated fatty acids that are present in human milk. This case study compares the human milk lipid profiles the first two weeks of lactation from women consuming three food patterns: vegan, standard American diet, and Asian. Participants were matched for demographics. The milk samples were analyzed using gas chromatography to determine the lipid profile for each participant. The lipid profiles differed by food pattern ($p < 0.007$). Linoleic acid and alpha-linolenic acid levels were highest for the vegan food pattern. The ratios of omega-6 to omega-3 fatty acids were well above the suggested ratio considered to be optimal with the vegan pattern had the lowest omega-6 to omega-3 ratio and the highest level of docosahexaenoic acid, possibly indicating conversion of alpha-linolenic acid to docosahexaenoic acid. Further research is needed to determine the impact this may have on long-term infant health.

Keywords: food patterns, breastfeeding, fatty acid in human milk, maternal diet, docosahexaenoic acid, human milk composition, lactation, nutrition

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Introduction

For infants being exclusively breastfed, human milk is their only source of nutrients with the lipid component of human milk as major source of energy for breastfed infants. Lipids contribute approximately half of the total energy intake infants need.¹ In human milk during early infant development, these lipids are critical for growth and maturation² in both the short and long term.³ It is known that the essential fatty acids, linoleic acid (LA), an omega-6 fatty acid, and alpha-linolenic acid (ALA), an omega-3 fatty acid are reflective of food intake in the human body.⁴⁻⁶ While omega-6 and omega-3 fatty acids transfer to human milk based on maternal diet, very little is converted to longer chain fatty acids such as arachidonic acid (ARA) (converted from LA) and docosahexaenoic acid (DHA) (converted from ALA).⁷ It is unknown whether the fatty acids docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA), and arachidonic acid (AA) in human milk are reflective of maternal dietary pattern. Little information is available regarding the day-to-day changes in the lipid profile of human milk in the first few days postpartum with relation to different dietary patterns. The objective of this case study was to evaluate the lipid profile for three dietary patterns during the first two weeks postpartum: Vegan, Standard American, and Asian dietary patterns.

Methods

The participants were a convenience sample selected from a larger study of women attending prenatal breastfeeding classes. The participants were chosen based on their self-reported food patterns and matched in demographics to compare lipid profiles based on dietary considerations. All procedures were reviewed, approved, and monitored by the University Institutional Review Board. The participants were recruited during the third trimester of pregnancy. The participants were English speaking healthy women giving birth to healthy full-term infants who were planning to breastfeed their infants exclusively for 6 months. Each participant received lactation management prenatally and immediately postpartum from an

Internationally Board Certified Lactation Consultant to ensure that any breastfeeding challenges were addressed immediately. Each infant was weighed beginning on day 3 postpartum using a Tanita Baby-Weigh scale at each milk sample collection to verify appropriate weight gain and ensure non-inference with infant feeding. Three women fit the desired dietary profile: Vegan (VGN), standard American diet (SAD), and Asian (ASN). A food frequency questionnaire was completed for each participant during their pregnancy to identify the dietary pattern. A food recall was conducted during the first week postpartum to confirm the dietary pattern identified during pregnancy for each participant.

Beginning on Day 3 postpartum and continuing through Day 12, a milk sample of approximately 3 milliliters was collected from each participant daily using hand expression at the end of the feeding. The samples were collected at approximately the same time each day within a two-hour window. The milk sample was collected consistently from the right breast. Upon collection, the sample was placed in a foil-lined, insulated bag containing cold packs for transport to the laboratory. At the lab, the sample was divided into three 1-ml aliquots and stored at -80°C until analysis. Two of the aliquots of milk were analyzed using the gas chromatography (GC) analysis of fatty acid methyl esters (FAME) protocol detailed by Cruz-Hernandez et al.⁷ The FAME concentrations were calculated by multiplying the peak area of the fatty acid by its formula weight and by nmole of 19:0 internal standard present per unit area. The third aliquot of milk was analyzed for protein using the Lowry based method of the BioRad DC Assay to standardize the nmole of FAME in the sample to the milligrams of protein. The fatty acids of interest were linoleic acid, C18:2n-6 (LA); α -linolenic acid, C18:3n-3 (ALA); arachidonic acid, C20:4n-6 (ARA); eicosapentaenoic acid, C20:5n-3 (EPA); and Docosahexaenoic Acid C22:6n-3 (DHA). Oleic and Palmitoleic acids were included in the analysis.

Results

While the dietary patterns were different, the participants were in

good health, living within a 5-mile radius (in the same community with the same access to resources), were of the same socioeconomic status, married, had pre-pregnancy BMI of 24, gained between 25 to 30 pounds during their pregnancy, and were primiparas. All three women consumed the same brand of multi-vitamin and mineral prenatal supplement during their pregnancy and discontinued the supplement at the birth of their infant, except for the VGN who continued to take a B12 supplement. Additionally, they all intended to breastfeed their infants for at least six months. The VGN and SAD were Caucasian. The ASN was Korean. The VGN pattern was characterized by abstaining from the use of any animal products and consuming

foods that contain no animal products of any kind. The SAD had food patterns characterized by high intake of red meat, processed meat, prepared foods, saturated fats, fried foods, dairy products, high-fructose corn syrup, eggs, refined grain products, potatoes, and sweetened beverages. The ASN pattern was predominantly based on plant foods including rice, a wide variety of vegetables, and fresh fruit with small portions of lean meat and fish. The 24-hour food recall is summarized in Table 1. The daily values and means (\pm SD) for each fatty acid measured in the milk are shown for each food pattern in Table 2.

Table 1 24hour Food Recall

Food Pattern	Breakfast	Lunch	Snack	Dinner	Snack
VGN	Breakfast burrito (flour tortilla with pinto beans, rice, and vegetables in a mild Mexican sauce), a tangerine, and 1 cup low-fat non-dairy milk	Brown rice with vegetables and one cup of carrot sticks with ranch dressing.	$\frac{3}{4}$ ounce almonds and raisins	Black bean enchilada with a mixed salad with raspberry vinaigrette	Peach
SAD	Scrambled eggs with cheese and cranberry juice.	Hamburger on a bun with lettuce tomato, pickles, mayonnaise, and mustard. Coke	Yogurt with blueberries.	Macaroni and cheese with cooked broccoli.	Coke and potato chips
ASN	Pho soup, made of rice noodles, beef, and beef broth seasoned with star anise, cinnamon sticks, cloves and ginger. Served with sprouts, basil, other herbs, and lime wedges.	Chicken pot sticker, ginger soy dip, and stir fried spicy eggplant with brown rice	Spring rolls with chili-lime dip.	Seared salmon, fried rice, papaya salad with chili vinaigrette.	Edamame

Table 2 Daily concentration of fatty acids for day 3 through day 12 postpartum by food pattern

	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Mean(\pm SD)
VGN											
Palmitoleic Acid C16:1n-7	10.99	10.18	8.27	10.53	7.64	10.38	15.59	10.75	7.19	4.82	9.63(2.9)
Oleic Acid C18:1n-9	2.01	2.41	2.31	2.93	3.38	3.3	3.29	3.56	2.68	1.58	2.74(0.66)
Linoleic Acid C18:2n-6	33.57	36.9	27.99	20.72	23.27	26.49	25.29	40.93	31.94	24.51	29.16(6.47)
α -Linolenic Acid C18:3n-3	2.09	1.86	2.18	1.22	2.74	2.4	7.55	3.51	3.4	1.97	2.89(1.78)
Arachidonic Acid C20:4n-6	0.6	0.7	0.8	0.57	0.55	0.85	0.92	0.65	0.9	0.59	0.71(0.14)
Eicosapentaenoic Acid C20:5n-3	0.4	0.14	0.18	0.15	0.14	0.09	0.15	0.16	0.29	0.16	0.19(0.09)
Docosahexaenoic Acid C22:6n-3	0.64	0.54	0.58	0.54	0.5	0.55	0.59	0.36	0.62	0.47	0.54(0.08)
Total	50.3	52.73	42.3	36.67	38.22	44.04	53.37	59.92	47.01	34.09	45.87
SAD											
Palmitoleic Acid C16:1n-7	12.29	13.1	11.99	10.35	10.98	13.75	15.43	7.03	10.1	13.05	11.81(2.33)
Oleic Acid C18:1n-9	3.35	3.51	3.49	3.65	3.02	3.83	4.65	2.14	3.4	4.1	3.51(0.66)
Linoleic Acid C18:2n-6	15.74	21.48	14.48	17.66	19.12	22.03	15.85	15.39	27.66	27.24	19.66(4.83)
α -Linolenic Acid C18:3n-3	0.94	1.34	0.86	0.98	1.4	1.36	1.54	0.99	1.27	2.91	1.36(0.59)
Arachidonic Acid C20:4n-6	0.72	0.86	0.64	1.11	0.91	1.01	0.82	1.02	1.11	1.12	0.93(0.17)
Eicosapentaenoic Acid C20:5n-3	0.08	0.09	0.03	0.07	0.07	0.06	0.09	0.08	0.53	0.69	0.18(0.23)
Docosahexaenoic Acid C22:6n-3	0.26	0.34	0.26	0.44	0.32	0.37	0.32	0.24	0.44	0.31	0.33(0.07)
Total	33.37	40.72	31.75	34.27	35.81	42.4	38.69	26.88	44.52	49.41	37.78
ASN											
Palmitoleic Acid C16:1n-7	9.65	14.33	10.68	8.98	8.61	13.41	8.56	8.12	5.65	7.25	9.52(2.66)
Oleic Acid C18:1n-9	1.49	1.87	1.9	1.58	1.19	19.43	1.49	2.3	1.12	1.13	3.35(5.66)
Linoleic Acid C18:2n-6	11.71	10.61	12.58	9.19	11.96	18.28	13.25	16.32	9.46	16.73	13.01(3.14)
α -Linolenic Acid C18:3n-3	1.11	0.63	0.74	0.51	1.04	0.35	0.9	1.09	0.46	1	0.78(0.28)
Arachidonic Acid C20:4n-6	0.43	0.26	0.66	0.44	0.56	0.43	0.56	0.54	0.39	0.47	0.47(0.11)
Eicosapentaenoic Acid C20:5n-3	0.03	0.06	0.07	0.06	0.07	0.04	0.07	0.07	0.04	0.05	0.06(0.01)
Docosahexaenoic Acid C22:6n-3	0.4	1.58	0.42	0.31	0.4	0.08	0.4	0.23	0.22	0.13	0.42(0.43)
Total	24.82	29.34	27.04	21.06	23.82	52.01	25.24	28.66	17.35	26.77	27.61

The fatty acids in the milk of women with these different dietary patterns were significantly different for each pattern ($p < 0.007$). LA and ALA were highest for the VGN food pattern at 29.16 nmoles/mg protein and 2.89 nmoles/mg protein, respectively. The mean for LA in the SAD pattern was 19.66 nmoles/mg protein and ALA was 1.36 nmoles/mg protein. The ASN pattern had the lowest mean for LA at 13.01 nmoles/mg protein and the mean for ALA was 0.78 nmoles/mg protein. The VGN shows the overall highest concentration for omega-3 fatty acids (ALA, EPA, and DHA) over the first fourteen days. The SAD had the highest levels of ARA, while in general, ASN had the lowest levels of fatty acids. Figure 1 shows the mean proportions of LA, ALA, ARA, EPA, and DHA. When comparing the milk from the different food patterns we observed the following relationships between the VGN, SAD, ASN diets: LA made up 64%, 52%, and 47% of the profiles respectively.

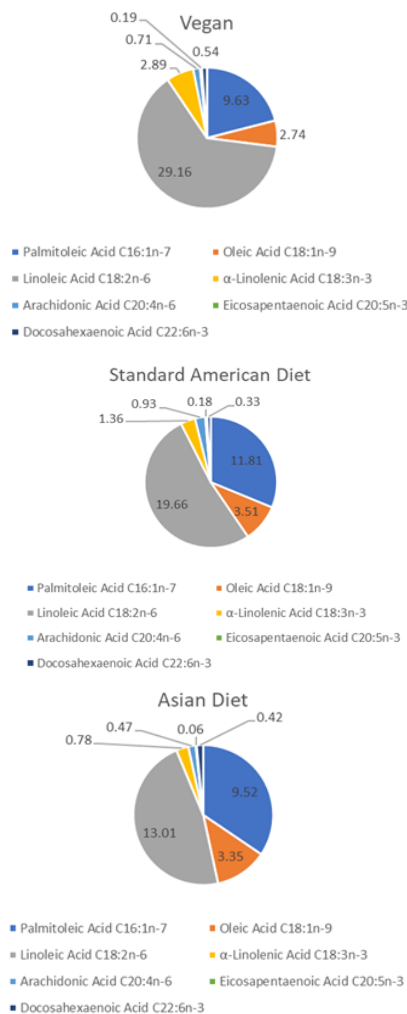


Figure 1 The lipid composition for VGN, SAD, and ASN food patterns shown in nmoles/mg protein.

The ratio between omega-6 and omega-3 fatty acids was 8.26:1 for the VGN based on the total of LA and ARA divided by the total of ALA, EPA and DHA. The SAD has an omega-6 to omega-3 ratio of 10.53:1 and the ASN ratio is 10.36:1. The omega-6 fatty acids compared to the omega-3 fatty acids are shown in Figure 2.

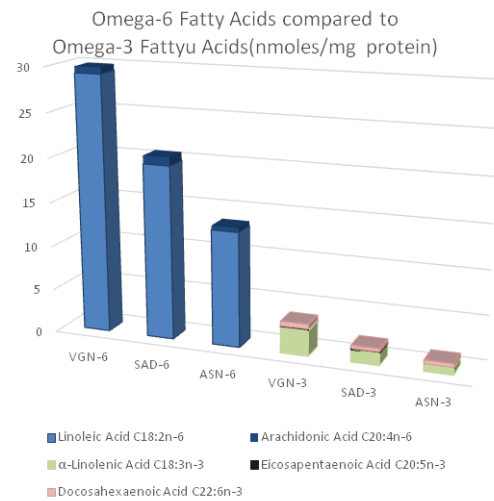


Figure 2 Omega-6 Fatty Acids compared to Omega-3 Fatty Acids (nmoles/mg protein).

Discussion

The typical Western diet is high in LA. High levels of LA intake are less healthful than ALA. While the VGN had the ratio closest to the suggested optimal ratio of 4:1,^{8,9} it was double what is suggested. The milk tested from the other two food patterns showed ratios more than double the suggested optimal level. It is unknown what impact these ratios have on the long-term health of the infant. It is interesting to note that although ALA can be converted to DHA, increased levels of LA can interfere with the conversion process in the human body. This seems to be affected by the ratio of LA to ALA rather than the level.¹⁰ This can be seen in the VGN who has the lowest ratio of LA to ALA and the highest level of DHA. It has been reported that fatty acid concentrations in human milk are reflective of maternal food intake.¹¹ The values we report are higher concentrations than those reported in the literature.

Conclusion

Linoleic (LA) and alpha-linolenic (ALA) acids cannot be made by the human body and must be acquired through the human diet. These essential fatty acids are precursors of long chain polyunsaturated fatty acids, such as arachidonic (AA, C20:4 n-6) and docosahexaenoic acid (DHA, C22:6 n-3), which are both present in human milk and crucial for infant development.¹² The effects on an infant containing a low omega-6 to omega-3 ratio or a high omega-6 to omega-3 ratio has not yet been studied in breastfed infants. However, it has been shown in adults that excessive amounts of omega-6 polyunsaturated fatty acids and a very high omega-6 to omega-3 ratio, as found in today's Western diets, promotes the pathogenesis of many diseases, including cardiovascular disease, cancer, and inflammatory and autoimmune diseases. However, increased levels of omega-3 polyunsaturated fatty acids, or a low omega-6 to omega-3 ratio in adults, may exert suppressive effects.⁸ As the components of human milk are related to maternal food intake,¹³ we believe that maternal food patterns are a preparation for infant food acceptance based on the foods the mother has available. Further studies are needed to explore factors that may be associated with changes in fatty acid composition and omega-6

to omega-3 ratios in human milk in relation to changes in maternal food patterns as there are no solid conclusions about the optimal lipid profile for long-term infants' health.¹⁴

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Conflicts of interest

Authors declare that there is no conflicts of interest.

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