Comparing the composition and trend of fatty acid in human milk with bovine milk and infant formula in northeast region of China

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**ABSTRACT**

The fatty acid (FA) composition in human milk, bovine milk and infant formula from the northeast region of China was analyzed by gas chromatography (GC). The content of linoleic acid (LA, C18:2n6) in bovine milk (2.53 %) was lower than human milk (25.58 %) and formula milk (20.56 %). The trends of LA and α-linolenic acid (ALA, C18:3n3) in human milk increased significantly throughout the lactation while a decreasing trend for LA was observed and the difference of ALA was not significant in both bovine and formula milks. The proportion of docosahexaenoic acid (DHA, C22:6n3) and arachidonic acid (ARA, 20:4n6) in human milk and formula were declining with the change of lactation or infant age. We suggest there should be more detailed distinction with reference to human milk in the infant formula in order to meet infant’s personalized nutrition, especially the FA composition in the 1st month after delivery.

**Comparativa de la composición y la tendencia de los ácidos grasos en la leche humana, la leche bovina y la fórmula infantil en la región noreste de China**

Se analizó la composición de los ácidos grasos (FA) en la leche humana, la leche bovina y la fórmula infantil en la región noreste de China mediante cromatografía de gases (GC). El contenido de ácido linoléico (LA, C18:2n6) en la leche bovina (253 %) fue menor que en la leche humana (25,58 %) y la fórmula infantil (20,56 %). Las tendencias de LA y el ácido linoléico α (ALA, C18:3n3) en la leche humana aumentaron significativamente durante la lactación mientras que se observó una tendencia de disminución para LA y la diferencia de ALA no fue significativa en la leche bovina ni en la fórmula infantil. La proporción de ácido docosahexaenoico (DHA, C22:6n3) y ácido araquidónico (ARA, 20:4n6) en la leche humana y la fórmula infantil fue en declive con el cambio de la lactación o la edad del bebé. Sugerimos que debería haber una distinción más detallada en lo que concierne a la leche humana en la fórmula infantil para responder a la nutrición personalizada de los bebés, especialmente la composición de FA en el 1er mes de vida.

1. Introduction

Human milk, a complex biological fluid containing different constituents, is ideally satisfied to the infant’s nutritional requirements in the first half of year of human life (Fuquay, Fox, & McSweeney, 2011). The lipid content is about 38 g/L in human milk, which not only contributes more than 50 % of the energy for the growth of the newborn but also provides essential polyunsaturated fatty acid (PUFA) for infant, such as DHA and ARA which play an important role in visual and cognitive development (Gunstone, Harwood, & Dijkstra, 2007; Tai, Wang, & Chen, 2013). However, there are only about 38 % of infants worldwide who are completely breast-fed in their first six months after birth (World Health Organization [WHO], 2010). In this case, infant formulas become an important nutritional source for them (WHO, 1992).

The composition and content of FA in human milk are dynamic and variable within a feeding, diurnally, over lactation, between mothers, and other factors (Chung, 2014). Among these factors, the stage of lactation is the primary factor which affect the FA composition in human milk (Yang et al., 2014). With the change of lactation, saturated fatty acids (SFA) tend to increase slightly and total monounsaturated FAs decreased and the oleic acid (OLA) was much at the part of the decrease in the major MUFA. However, there are no statistical significance (Ribeiro et al., 2008). Meanwhile, main n-6 and n-3 PUFA showed fluctuations from the 1st week up to 16th week of lactation, for example, ARA significantly dropped from transitional to mature period. This trend was also confirmed by Yu, Duchen, and Björkstén (1998). What’s more, Kovács, Funke, Marosvölgyi, Burus, and Decsi (2005) and Minda et al. (2004) analyzed the FA composition of human milk during the first 28 days and found that the FA composition even change from day to day. However, unlike the dynamic changes of the FA in human milk, all infant formulas are fortified to the same and they are one-size-fits-all based on authoritative criterion and standard including commission directive 2006/141/EC (European Communities(EC), 2006), code of federal regulations 21CFR107 (Food and Drug Administration [FDA], 2014), codex stan 72–1981 (Codex Alimentarius
Commission [CAC], 1981), codex stan 156–1987(CAC, 1987) and the national food safety standard such as GB 10765–2010 and GB 10767–2010 (Standardization Administration of the People’s Republic of China [SAC], 2010a, 2010b). Obviously, the fact cannot meet the personalized nutritional requirements of formula-fed infants.

Personalized nutrition is a conceptual simulation to personalized medicine and it emphasizes that the food products satisfy requirement or preference of specific consumer groups. At the same time, the personalized nutrition of specific consumer groups is affected with many factors such as taste and flavor preferences, cultural mores and life stages and so on (Dennis, et al. 2007; Kussmann & Fay, 2008). It is known that the nutritional status of different life stages have significant impact on the body’s health and development. Especially in the early stage of life, the growth and development of the body are primary biological purpose and vary rapidly for the infant. Therefore, the dietary requirements should be considered comprehensively. However, there are only a few studies, associated with the term infant who exclusively depend on the infant formula, in the field of personalized nutrition. Based on this situation, comparing the FA composition among the human, bovine and formula milks and validating whether the infant and follow-on formulas could meet the personalized nutritional requirements of infant in different life stages become necessary. Hence, we are particularly interested in analyzing the composition and content of FA in the milk of human, bovine and infant and follow-on formulas from the northeast region of China and looking forward to obtain a scientific basis to pose and vary rapidly for the infant. Therefore, the dietary requirements should be considered comprehensively. However, there are only a few studies, associated with the term infant who exclusively depend on the infant formula, in the field of personalized nutrition. Based on this situation, comparing the FA composition among the human, bovine and formula milks and validating whether the infant and follow-on formulas could meet the personalized nutritional requirements of infant in different life stages become necessary. Hence, we are particularly interested in analyzing the composition and content of FA in the milk of human, bovine and infant and follow-on formulas from the northeast region of China and looking forward to obtain a scientific basis to adjust the FA composition of infant and follow-on formula with reference to human milk.

2. Material and methods

2.1 Reagents

All reagents were of analytical or high performance liquid chromatography (HPLC) grade. Ammonia, ethanol, petrol- leum ether, ethyl ether, pyrogallic acid, potassium hydroxide, sodium chloride and methanol were purchased from Tianjin Kermel Chemical Reagent Co. Ltd. Boron trifluoride was purchased from Alfa Aesar (Tianjin) Chemical Co. Ltd. n-hexane was from Tianjin guangfu fine chemical research institute. The 37 component FAME mix was from Sigma-Aldrich (Bellefonte, USA).

2.2 Raw sample collection and store

The collection of human and bovine milk samples were reviewed and authorized by the scientific research ethics committee of Northeast Agricultural University (No. 20120624). All participants provided written informed consent. Seventy-three human milk samples were donated by volunteer mothers (30 ± 4 years old, with 40 ± 3 weeks of pregnancy) from Harbin (Heilongjiang Province, China), Qiqihar (Heilongjiang Province, China) and Changchun (Jilin Province, China), and their race is the Han nationality. The lactation of human is divided into three periods: colostrum (1 ~ 5 d), transition (6 ~ 21 d) and maturity lactation (after 21 d) and all of the samples were collected from the 1st to the 122nd day after delivery. Each sample was collected after full expression from one breast using a milk pump while the baby was fed on the other breast between 8:00 AM and 11:00 AM on each collection day. Then packed it in a 50 mL polypropylene tube and refrigerated rapidly. Finally, samples were sent to the laboratory and stored at – 80°C until analyses.

Forty-nine bovine milk samples were collected from the 1st day to the 120th day. Bovine milk is also divided into three periods which include colostrum (1 ~ 7 d), transition (8 ~ 35 d) and maturity lactation (after 36 d). The samples were collected by hand during 3:00 PM to 4:00 PM with the assistance of the professionals of pasture. Each collected sample was packed in a 50 mL polypropylene tube and refrigerated rapidly. Finally, all samples were sent to the laboratory and stored at – 80°C until analyses.

The infant (0 ~ 6 months), older infant (6 ~ 12 months) and young children (12 ~ 36 months) formulas were purchased from local markets (Harbin, Heilongjiang Province, China). All of the formulas are conformed to meet the national food safety standard of Infant formula (GB 10765–2010), older infants and young children formula (GB 10767–2010) in China. The origin of the fat fraction is composite vegetable oil and anhydrous cream and the average content of total fat is 2.8 g/100 mL. Finally, twenty-four formulas were stored at ventilated, cool and dry conditions until analyses.

2.3 Analytical methods

The extraction, derivatization of lipid were carried out according to the GB 5413.27–2010 (SAC, 2010c) with minor modifications and our research was conducted in key laboratory of dairy science, northeast agricultural university. Briefly, sample (1.0 mL) was added to a 10 mL test tube and mixed with 0.2 mL ammonia. Test tube was heated at 65 ± 1°C for 15 min, Taken out and slightly shaken. After cooling down to room temperature, ethanol (1.0 mL) was added and shaken. Then 2.0 mL ether and petroleum ether were added to the test tube respectively and the resulting mixture was shaken for 1 min. After standing and de mixing, the upper phase (approximately 4 mL) was moved to 10 mL test tube equipped with Teflon-lined screw caps. This process was repeated 3 times and 1 mL ether and petroleum ether respectively in the last time. Finally, all of the organic phases were pooled in screw glass tubes and dried via nitrogen blowing.

Pyrogallol-methanol (0.1 g/mL, 0.1 mL) was added to the crude lipid. After concentrated and dried, KOH-methanol (0.5 mol/L, 1.0 mL) was mixed in extract and put into water bath at 80 ± 1°C for 5 ~ 10 min. Then BF₃-methanol (14 %, 0.5 mL) was added and continued bathing 15 min and cooled down to room temperature. The solution in glass tube was transferred to 10 mL centrifuge tube and the glass tube was washed (1.0 mL each time) with saturated sodium chloride solution before all liquid was pooled in the same centrifuge tube. Put 2.0 mL n-hexane into the mixture, centrifuged (5000 rpm/min, 5 min) and the n-hexane phase was transferred into 1.5 mL sampling bottles by 1.0 mL sterile syringe through 0.22 filter membrane. Stored at –20 °C and waiting for analysis.

2.4 Instrumentation and analytical conditions

The analysis for the methyl esters of the FA was carried out by Agilent 7890A with a 7683 auto injector coupled to a
flame ionization detector (Agilent Technologies, Richardson, TX, USA). A SP-2560 capillary column was used for analysis (100 m × 0.25 mm ID 0.2 µm, Agilent Technologies). 1.0 µL aliquots were injected and the split ratio of 50:1 was used. Calefactive procedure of column as follows: the initial temperature was 140°C for 5 min, increased to 180°C at the speed of 5°C/min and stayed for 10 min then rose to 210°C at speed of 2°C/min and kept 15 min, finally, up to 240°C at speed of 10°C/min and hold the temperature for the 10 min. the temperature of injection port and detector were set at 240°C and 260°C respectively. The carrier gas was helium and the flux was 1.0 mL/min. The parameters were acceptable if the 37 components FAME Mix were separated ideally and the shape of all peaks were sharp and symmetrical. In addition, The peaks in samples were identified by comparison with the FAME standards and the result was expressed as mass percentage.

2.5 Statistical analysis

The results were provided by Agilent GC work station (normalization). The data were expressed as median (inter-quartile). Differences were significant at P-values < 0.05 at the 95 % confidence level by SPSS 13.0 software.

3. Results and discussion

3.1 FA compositions of the human milk in different lactation

FA compositions in the human milk, fluctuated with the change of lactation, is presented in Table 1. Pam, OLA and LA were the predominant FA during the colostrom, transition and mature lactation, accounted for 77.98 ~ 78.57 % of total FA. The contents of Pam, cis-11-eicosenoic acid (C20:1n9), erucic acid (C22:1n9), nervonic acid (C24:1n9), cis-11, 14-eicosadienoic acid (C20:2 n6) reduced with the change of lactation.

The content of LA and ALA increased from colostrom to mature (Figure 1). This trend were similar with the result of Ribeiro et al. (2008) and we reported higher content of them. The reason may be due to the Chinese people eat more soybean oil. Conversely, the contents of DHA and ARA decreased with the change of lactation, their contents were 0.52 % and 0.45 % in the colostrom period. From the transition to mature period, the contents of DHA and ARA decreased from 0.47 % and 0.45 % to 0.25 % and 0.29 % respectively (Figure 1). This trend were consistent with related literatures reported by Yu et al. (1998), Berenhauser, Prado, Silv, Gioielli, and Block (2012), Ribeiro et al. (2008), Kovacs et al. (2005) and Li et al. (2009). The cause of the changes of LA, ALA, DHA and ARA in human milk could be expounded as follows: 1) a competitive inhibition exists between the metabolism of n-3 and n-6 fatty acid families since the process that LA and ALA are converted to ARA and DHA respectively by diverse desaturase- and elongase-enzymes share the same series of enzymes (Salem, Wegher, Mena, & Uauy, 1996; Schmitz, Ecker, 2008). 2) Δ6- and Δ5-desaturase activities in human liver of neonates was lower than previously reported in adult humans (Poisson et al., 1993). With the growth of the infant, the enzyme system is more perfect. The ability of converting LA and ALA to ARA and DHA will be strong. Therefore, the LA and ALA in breast milk will increase while the content of ARA and DHA will decrease.

| FAs     | Colostrom (n = 25) | Transition (n = 24) | Mature (n = 24) | P-Value$^a$ |
|---------|--------------------|--------------------|----------------|------------|
| C8:0    | 0.04(0.06)*        | 0.16(0.08)         | 0.17(0.05)     | 0.000      |
| C10:0   | 0.79(0.42)         | 1.28(0.60)         | 1.20(0.24)     | 0.001      |
| C12:0   | 3.85(2.94)         | 4.79(2.18)         | 4.43(1.03)     | 0.079      |
| C14:0   | 4.19(3.68)         | 4.25(1.77)         | 3.29(0.92)     | 0.061      |
| C15:0   | 0.10(0.03)         | 0.09(0.01)         | 0.07(0.02)     | 0.000      |
| C16:0   | 23.97(1.19)        | 21.91(1.87)        | 19.43(2.89)    | 0.000      |
| C17:0   | 0.17(0.04)         | 0.20(0.06)         | 0.25(0.13)     | 0.007      |
| C18:0   | 5.34(1.19)         | 5.20(1.29)         | 4.90(1.14)     | 0.806      |
| C20:0   | 0.11(0.05)         | 0.11(0.03)         | 0.12(0.04)     | 0.183      |
| C22:0   | 0.08(0.04)         | 0.22(0.07)         | 0.13(0.09)     | 0.000      |
| C24:0   | 0.04(0.02)         | 0.04(0.02)         | 0.04(0.03)     | 0.899      |
| C15:1   | 0.12(0.09)         | 0.11(0.08)         | 0.09(0.07)     | 0.312      |
| C16:1   | 1.73(0.85)         | 2.01(1.00)         | 1.39(0.44)     | 0.033      |
| C17:1   | 0.11(0.03)         | 0.12(0.04)         | 0.10(0.05)     | 0.043      |
| C18:1t   | Nd                 | 0.00(0.01)         | 0.01(0.02)     | 0.000      |
| C18:1n9c | 33.00(3.32)       | 33.41(3.03)        | 33.56(5.55)    | 0.645      |
| C20:1n9 | 0.44(0.16)         | 0.35(0.11)         | 0.34(0.13)     | 0.003      |
| C22:1n9 | 0.09(0.03)         | 0.06(0.02)         | 0.04(0.01)     | 0.000      |
| C24:1n9 | 0.19(0.09)         | 0.11(0.05)         | 0.04(0.03)     | 0.000      |
| C18:2n6 | 21.01(6.55)        | 21.05(2.64)        | 25.58(2.88)    | 0.000      |
| C18:3n6 | 0.04(0.03)         | 0.07(0.05)         | 0.44(0.13)     | 0.000      |
| C20:3n6 | 0.96(0.40)         | 0.64(0.17)         | 0.11(0.03)     | 0.000      |
| C20:5n6 | 0.49(0.17)         | 0.44(0.16)         | 0.34(0.12)     | 0.000      |
| C22:6n3 | 0.45(0.11)         | 0.45(0.10)         | 0.29(0.11)     | 0.000      |
| C18:3n3 | 1.06(0.19)         | 1.09(0.56)         | 1.99(0.92)     | 0.000      |
| C20:5n3 | 0.10(0.04)         | 0.07(0.02)         | 0.04(0.02)     | 0.000      |
| C22:6n3 | 0.52(0.21)         | 0.47(0.21)         | 0.25(0.14)     | 0.000      |
| Σ5FA    | 39.63(8.06)        | 38.78(4.94)        | 33.12(15.26)   | 0.009      |
| ΣMUFA   | 35.81(3.22)        | 36.46(4.27)        | 36.47(8.78)    | 0.968      |
| ΣPUFA   | 24.57(6.53)        | 24.76(5.23)        | 30.72(9.28)    | 0.000      |
| LA/ALA  | 19.82(5.40)        | 19.31(16.16)       | 12.85(2.28)    | 0.000      |
| AR/A/PHA | 0.90(0.27)        | 0.92(0.26)         | 1.08(0.37)     | 0.010      |
| EPA/DHA | 0.18(0.09)         | 0.14(0.07)         | 0.13(0.05)     | 0.082      |
| n-6/n-3 | 13.66(3.32)        | 13.90(3.19)        | 11.74(1.77)    | 0.048      |

Table 1. Fatty acids of the human milk in colostrum, transition milk and mature lactation (% of total fatty acids)
3.3 FA compositions of the infant and follow-on (older infant and young children) formula

In the formulas, PAM, OLA and LA were the major FA and total of them accounting for 74.04 %, 67.4 % and 61.82 % in infant, older infant and young children formulas respectively. The percentage of LA, DHA and ARA in total FA decreased when the applicable groups changed from infant to young children (Table 3). Except for young children formula, the LA levels in infant and older formulas were similar with the content in human milk. DHA and ARA were only detected in infant formula (DHA: 0.16 %, ARA: 0.12 %) and older infant formula (DHA: 0.02 %, ARA: 0.05 %) and their contents were significantly lower than the contents of human milk (Table 3).

3.4 Comparison of FA compositions among the human milk, bovine milk and formula milk

There were 26, 28 and 29 kinds of FA in the human milk, purebred Holstein milk and formula milk (Table 4). Compared with other studies, the numbers of FA in human milk were lower than the results obtained by Chen et al. (1997) where 30 kinds FA were detected in Chinese human milk, however, the numbers of FA in Holstein milk was same with Czech Pied cattle Which contained 26 kinds FA (Pések, Samková, & Špíčka, 2006). As for FA profile, we specifically detected C8:0 and C23:0 in human milk, but did not find C22:4n-6, C22:5n-6, C22:5n-3 and trans fatty acid including C14:1t, C16:1t. In bovine milk, our result presented more SFA such as C12:0, C14:0 and 26, 26 and 28 kinds of FA (Pešek, Samková, & Špíčka, 2006). All of this requiring us to pay more attention to the process which produce the infant formula with Holstein milk as the main raw material.

C16:2n-4, C16:3n-4, C18:3n-4, C18:4n-3 in Czech Pied cattle. This situation can be improved by adding fish oil and sunflower oil to the bovine diet (Shingfield et al., 2006). This requiring us to pay more attention to the process which produce the infant formula with Holstein milk as the main raw material.

addition, DHA and EPA were not detected in Holstein milk and the percentage of ARA was trivial in whole lactation. This situation can be improved by adding fish oil and sunflower oil to the bovine diet (Shingfield et al., 2006).

Table 2. Fatty acid of the Holstein bovine milk in colostrum, transition milk and mature lactation (% of total fatty acid).

| FA          | Colostrum (n = 14) | Transition (n = 15) | Mature (n = 20) | P-Valuea |
|-------------|-------------------|---------------------|----------------|----------|
| C40         | 2.50(0.76)b       | 2.34(0.56)          | 2.45(0.76)     | 0.034    |
| C6:0        | 1.17(0.36)        | 1.61(0.34)          | 1.71(0.66)     | 0.059    |
| C8:0        | 0.67(0.15)        | 1.21(0.27)          | 1.67(0.56)     | 0.009    |
| C10:0       | 1.26(0.81)        | 1.88(1.20)          | 2.68(0.98)     | 0.001    |
| C12:0       | 0.14(0.17)        | 0.07(0.10)          | 0.29(0.18)     | 0.000    |
| C14:0       | 2.00(1.60)        | 2.34(1.15)          | 3.32(0.58)     | 0.002    |
| C16:0       | 0.00(0.00)        | 0.00(0.06)          | 0.16(0.22)     | 0.008    |
| C18:0       | 9.73(5.13)        | 8.44(1.03)          | 10.62(2.13)    | 0.002    |
| C18:1n9c    | 0.82(0.22)        | 0.70(0.28)          | 1.17(0.25)     | 0.002    |
| C18:1n9c    | 30.57(4.80)       | 30.24(4.34)         | 31.10(5.26)    | 0.382    |
| C17:0       | 1.20(0.38)        | 0.80(0.20)          | 0.61(0.36)     | 0.000    |
| C18:0       | 16.34(2.59)       | 17.12(3.32)         | 11.80(4.26)    | 0.003    |
| C20:0       | 0.18(0.21)        | 0.00(0.61)          | 0.17(0.18)     | 0.962    |
| C21:0       | 0.47(0.12)        | 0.61(0.41)          | 0.60(0.23)     | 0.067    |
| C22:0       | 0.00(0.02)        | 0.00(0.60)          | Nd             | 0.112    |
| C23:0       | 0.45(0.18)        | 0.20(0.44)          | 0.00(0.16)     | 0.001    |
| C14:1       | 0.53(0.91)        | 0.56(0.27)          | 0.86(0.39)     | 0.024    |
| C16:1       | 1.80(0.52)        | 1.43(0.59)          | 1.36(0.34)     | 0.001    |
| C17:1       | 0.47(0.22)        | 0.00(0.45)          | 0.19(0.15)     | 0.001    |
| C18:1n9    | 0.99(0.87)        | 1.17(0.31)          | 0.43(0.11)     | 0.023    |
| C18:1n9c   | 24.10(7.52)       | 25.51(16.7)         | 23.88(6.92)    | 0.747    |
| C18:2n6c   | 0.23(0.09)        | 0.14(0.37)          | 0.05(0.14)     | 0.001    |
| C18:2n6c   | 2.88(0.40)        | 2.82(0.45)          | 2.53(0.71)     | 0.018    |
| C18:3n6    | Nd                | 0.00(0.03)          | Nd             | 0.048    |
| C18:3n6b   | 0.00(0.02)        | 0.00(0.02)          | 0.00(0.08)     | 0.858    |
| C20:4n6    | Nd                | 0.00(0.05)          | 0.07(0.18)     | 0.000    |
| C18:3n3c   | 0.22(0.28)        | 0.21(0.24)          | 0.21(0.18)     | 0.962    |
| ΣFA         | 68.79(10.42)      | 67.76(9.91)         | 69.88(5.59)    | 0.647    |
| ΣMUFA      | 27.85(5.53)       | 28.86(6.38)         | 27.20(17.5)    | 0.837    |
| ΣPUFA      | 3.36(0.43)        | 3.36(0.72)          | 2.92(0.98)     | 0.089    |
| LA/ALA      | 13.09(4.88)       | 13.42(3.26)         | 12.04(3.85)    | 0.118    |
| ARA/DHA    | Nd                | Nd                  | Nd             | 1.000    |
| EPA/DHA    | Nd                | Nd                  | Nd             | 1.046    |
| n-6/n-3    | 14.14(5.73)       | 14.10(3.39)         | 12.62(4.67)    | 0.648    |

a The result was presented as Median (inter-quartile).
b The 'Nd' indicate targets that were below the limits of quantitation or not detected.
c The Data were analyzed by SPSS 13.0 with the method of Kruskal-Wallis (p < 0.05). There was no significance difference between the data if the P-value > 0.05. Otherwise, a significant difference was presence.
d El resultado se presenta como Promedio (intercuartil).
e 'Nd' indica los objetivos que estuvieron por debajo de los límites de cuantificación o no detectados.
f Los datos fueron analizados mediante SPSS 13.0 con el método de Kruskal-Wallis (p < 0.05). No se encontraron diferencias significativas entre los datos si el valor P > 0.05. Por el contrario, se presentaba una diferencia significativa.
Tabla 3. Ácidos grasos en la leche humana, la leche bovina y la fórmula infantil (% del total de ácidos grasos).

| FAs   | Human milk (n = 24) | Bovine milk (n = 20) | Formula milk (n = 16) | P-Value
|-------|---------------------|----------------------|-----------------------|--------
| C4:0  | Nd                  | 1.60(1.47)           | 2.10(1.46)            | 0.000  
| C6:0  | Nd                  | 1.31(1.76)           | 1.59(0.65)            | 0.000  
| C8:0  | 0.17(0.05)*         | 0.76(0.72)           | 0.96(0.33)            | 0.000  
| C10:0 | 1.20(0.24)          | 2.68(0.98)           | 1.53(0.49)            | 0.000  
| C12:0 | Nd*                 | 0.29(0.18)           | 0.00(0.12)            | 0.000  
| C14:0 | 4.44(1.03)          | 3.32(0.58)           | 2.19(0.96)            | 0.000  
| C16:0 | Nd                  | 0.16(0.22)           | Nd                    | 0.000  
| C18:0 | 3.29(0.92)          | 10.62(2.23)          | 5.50(1.59)            | 0.000  
| C20:0 | 0.07(0.02)          | 1.17(0.25)           | 0.49(0.35)            | 0.000  
| C22:0 | 19.43(2.88)         | 31.15(5.26)          | 22.12(3.73)           | 0.000  
| C24:0 | 0.25(0.13)          | 0.61(0.36)           | 0.37(0.31)            | 0.000  
| C26:0 | 4.90(1.14)          | 11.80(4.26)          | 7.52(2.40)            | 0.000  
| C20:0 | 0.12(0.04)          | 0.17(0.18)           | 0.29(0.09)            | 0.000  
| C21:0 | Nd                  | 0.60(0.23)           | 0.31(0.45)            | 0.000  
| C22:0 | 0.04(0.03)          | Nd                    | Nd                    | 0.000  
| C23:0 | 0.13(0.09)          | 0.00(0.14)           | Nd                    | 0.000  
| C24:0 | Nd                  | Nd                    | 0.00(0.06)            | 0.000  
| C25:0 | 0.04(0.03)          | Nd                    | 0.34(0.23)            | 0.000  
| C26:0 | 0.09(0.02)          | Nd                    | 0.20(0.08)            | 0.000  
| C27:0 | 0.04(0.01)          | Nd                    | 0.01(0.14)            | 0.000  
| C28:0 | 0.04(0.03)          | Nd                    | 0.00(0.08)            | 0.000  
| C29:0 | 0.10(0.05)          | 0.19(0.15)           | 0.00(0.08)            | 0.000  
| C30:0 | 0.34(0.13)          | 0.00(0.12)           | 0.24(0.14)            | 0.000  
| C31:0 | 0.04(0.01)          | Nd                    | Nd                    | 0.000  
| C32:0 | 0.04(0.03)          | Nd                    | Nd                    | 0.000  
| C33:0 | 0.05(0.15)          | 0.61(0.68)           | 0.61(0.68)            | 0.000  
| C34:0 | 25.85(28.87)        | 2.53(0.71)           | 20.56(3.33)           | 0.000  
| C35:0 | Nd                  | 0.00(0.12)           | 0.00(0.12)            | 0.000  
| C36:0 | 0.44(0.14)          | Nd                    | Nd                    | 0.000  
| C37:0 | 0.34(0.12)          | 0.00(0.12)           | 0.01(0.14)            | 0.000  
| C38:0 | 0.29(0.11)          | 0.07(0.18)           | 0.05(0.18)            | 0.000  
| C39:0 | 1.99(0.92)          | 0.21(0.18)           | 2.83(0.30)            | 0.000  
| C40:0 | 0.04(0.02)          | Nd                    | Nd                    | 0.000  
| C41:0 | 0.25(0.14)          | Nd                    | 0.08(0.16)            | 0.000  
| C42:0 | 33.12(5.26)         | 69.88(5.59)          | 46.38(5.77)           | 0.000  
| C43:0 | 36.47(6.89)         | 27.20(7.15)          | 29.26(3.62)           | 0.000  
| C44:0 | 30.72(8.79)         | 2.92(0.98)           | 24.34(4.78)           | 0.000  
| C45:0 | 12.58(2.88)         | 12.04(3.85)          | 7.12(2.27)            | 0.000  
| EPA/DHA | 1.08(0.37)   | Nd                   | 1.28(1.79)            | 0.000  
| n-6/n-3 | 11.74(1.77)   | 10.19(4.67)          | 7.29(0.28)            | 0.002  

The result was presented as Median (inter-quartile).

b The 'Nd' indicate targets that were below the limits of quantitation or not detected.

c The Data were analyzed by SPSS 13.0 with the method of Kruskal-Wallis (p < 0.05). There was no significance difference between the data if the P-value> 0.05. Otherwise, a significant difference was presence.

d El resultado se presenta como Promedio (intercuartil).

e La 'Nd' indica los objetivos que estuvieron por debajo de los límites de cuantificación o no detectados.

f Los datos se analizaron mediante SPSS 13.0 con el método de Kruskal-Wallis (p > 0.05). No se encontraron diferencias significativas entre los datos si el valor P > 0.05. Por el contrario, se presentaba una diferencia significativa.

The content of LA in mature bovine milk was 2.92 % and lower than the contents in mature human milk (30.72 %) and formula milk (including infant and older infant formula)
(24.34 %), the ALA level of bovine milk (0.21 %) was the lowest among them, the reason could be due to the dietary PUFA which are bio-hydrogenated in the rumen of cow (Fuquay et al., 2011). The levels of ARA and DHA in human milk (0.29 % and 0.25 % respectively) were higher than the levels in formula milk (0.05 % and 0.08 % respectively). The EPA and DHA are so small amount that cannot be detected in the bovine milk, the EPA did not be detected likewise in formula milk (Figure 2).

The FA compositions were significant difference among human milk, bovine milk and formulas. The infant is in the first peak of growth and the development. Without doubt, human milk can be the best choice in this period. However, the lower rate of breast feeding is an indisputable fact (WHO, 2010). At the same time, formula are ‘one-size-fits-all’ under many regulations (Australia New Zealand Food Standard Code [ANZFSC], 2013; Codex Alimentarium Commission: Codex standard for follow-up formula, 1987; CAC, 1981; FDA, 2014). Thus, it is urgent to make the formula meet the infant’s personalized nutritional requirement.

4. Conclusions

According to the results, we found that the FA compositions are different significantly with the change of lactation or infant age in the human and formula milks. The FA composition of formula should be guided by human milk, especially for LA, ALA, ARA, DHA. Infant develops quickly in the early life stage and they need a great deal of FA to ensure the energy supply and promote the developments of brain and retina. Thus, the personalized nutrition of infant formula becomes very important for formula-fed infant’s survival. We recommend that there should be a more detailed distinction in the infant formula that just like human milk, especially the FA composition in the 1st month after delivery. There is a little information about the trend of FA composition in human milk from the 2nd to the 4th month. Further studies are needed to definitively establish the personalized nutrition of infant formula in fatty acid composition.

Disclosure statement

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