Open Journal of Pediatrics, 2018, 8, 106-116
http://www.scirp.org/journal/ojped
ISSN Online: 2160-8776
ISSN Print: 2160-8741

Vitamin A Status in the Mother-Child Couple at the University Teaching Hospital of Angondje in Gabon

Eliane Kuissi Kamgaing[1,2*], Steeve Minto'O Rogombé[2], Morgane Mboungani Igondjo[1], Raissa Koumba Maniaga[1], Jean Koko[2], Simon Ategbo[1,2]

[1]University Teaching Hospital of Angondje, Libreville, Gabon
[2]Department of Pediatrics, University of Health Science, Libreville, Gabon
Email: *steeve.mintoo@hotmail.fr

How to cite this paper: Kuissi, E., Minto'o, S., Mboungani, M., Koumba, R., Koko, J. and Ategbo, S. (2018) Vitamin A Status in the Mother-Child Couple at the University Teaching Hospital of Angondje in Gabon. *Open Journal of Pediatrics*, **8**, 106-116.
https://doi.org/10.4236/ojped.2018.82013

Received: March 12, 2018
Accepted: April 23, 2018
Published: April 26, 2018

Abstract

Introduction: Vitamin A deficiency is responsible for severe disorders, and sometimes irreversible consequences in children. We aimed to evaluate the Vitamin A status of newborns in Gabon. **Method:** prospective study from August to December 2017 at the maternity of the University Teaching Hospital of Angondje (Gabon). We included at random mother-child pairs. A nutritional inquiry on Vitamin A was ran in the selected parturient. We performed the measurement of serum retinol booth in mother and child according to standardized and strict criteria, in Gabon and in France. World Health Organization defines Vitamin A deficiency by serum retinol < 0.7 µmol/L. **Results:** We included 75 mother-child couples. The mean age of the mothers was 25.7 ± 7 years, 89.3% of neonates were an age gestational ≥ 36 weeks, and 10.7% were premature. Mango was the most commonly used source of Vitamin A and 27% of women consumed more than 3 times a week. The mean serum retinol of the mothers was 0.87 µmol/L ± 0.35 extremes [0.22 µmol/L - 1.79 µmol/L], the mean serum retinol of the newborns was 0.92 µmol/L ± 0.30 extremes [0.24 µmol/l - 1.84 µmol/L].Vitamin A deficiency was observed in 23.3% (n = 25; CI 95% [22.1% - 25.8%]) of mothers and 20% (n = 15; CI 95% [18.2% - 22%]) newborns. There was a weak correlation between the serum retinol of mothers and serum retinol of newborns (r = 0, 17). **Conclusion:** The prevalence of Vitamin A deficiency is quite important in neonates of our investigation, and justifies a systematic supplementation.

Keywords

Vitamin A, Children, Mother, Gabon

1. Introduction

Vitamin A deficiency (Vit A), defined as serum retinol < 0.70 µmol/L, is a public health problem in low- and middle-income countries and affects 190 million children under the age of five years and 19 million pregnant women. Currently, night blindness, a major symptom of Vitamin A deficiency, affects 5.2 million pre-school children and 9.8 million pregnant women worldwide with an increased prevalence during the third trimester of pregnancy [1]. According to the World Health Organization (WHO), the most affected regions for both population groups are Africa and Southeast Asia. Vitamin A deficiency has been responsible for 6% of deaths of children under 5 in Africa and 8% of deaths in Southeast Asia [1] [2] [3].

Vitamin A is essential for the health of the mother and the development of the fetus. This vitamin plays an important role in cell division, development maturation of the fetal organs and skeleton, and maintenance of the immune system responsible for reinforcing defense against infection. Vitamin A is the only vitamin involved in the preservation of the eye health and night vision of the mother [4]. Low Vitamin A consumption during pregnancy has been shown to be linked with maternal or infant complications such as infections, maternal or fetal anemia, and childbirth complications. For all these reasons, the WHO strongly recommends regular supplementation in Vitamin A during pregnancy, lactation and in the newborn with the aim of improving the vitamin status in the mother-child pair [1] [2]. Teratogenic effects related to hypervitaminosis A have been known since the 90s. Hypervitaminosis A causes malformations affecting the limbs, the craniofacial structures, the skin, the organs and functional disorders of the nervous and cardiovascular systems [4]. This is why this recommendation is reserved in areas where endemic Vitamin A deficiency exists [1].

In Gabon, the Vit A status of the mother and the newborn is unknown, while the Ministry of Health undertook supplementation campaigns for children aged 0-5 according to WHO recommendations. In neonates, in particular, Vitamin A supplementation is routine until 6 months of age.

Given the diversity of food rich in Vitamin A in Gabon, we wanted to know what Vit A status was in the mother-child pair. The purpose of our study was therefore to make a maternal and neonatal focus by assessing the Vitamin A status in the mother-child couple at the University Teaching Hospital of Angondje (CHUA).

2. Material and Methods

It was a prospective cross-sectional descriptive and analytical study that took place from June to December 2016 and focused on CHUA mother-child pairs.

The number of subjects was determined from the Schwartz formula $n = \frac{t^2 \times p(1-p)}{e^2}$, taking into account the prevalence of Vitamin A deficiency (76%) obtained from a study conducted in 2002 on Gabonese children not supplemented with Vitamin A [4]. This calculation of the number of subjects required allowed us to estimate the number of newborns needed for the study at 70 (70 mother-child pairs). Our study grouped 75 mother-child pairs, regardless of gestational age, selected from pregnant women followed at the CHUA. After the informed consent was signed, the mothers included in the study had to carry a single pregnancy and be fasting for at least 12 hours before or after delivery. This survey did not include all mothers with a pathological pregnancy, mothers who received Vitamin A supplementation, or those who denied participating to the study.

2.1. The Progress of the Study

Each parturient included in the study was subjected to a clinical and obstetrical examination upon arrival in the birth room. The clinical and anamnestic parameters collected were as follows: age, weight (kg), height (cm), night blindness or night vision loss, pregnancy monitoring. Then, a venous blood sample was taken for the determination of serum retinol during the peripheric vein catheterization in the birth room. In the same, mothers were interviewed again on their knowledge about Vit A (information of foods rich in Vitamin A, and the usefulness of Vit A), the frequency of consumption of foods rich in Vitamin A in a week. We defined that consumption was "low" if it was from 1 to 2 days per week, "middle" if it was 3 days per week, and "high" when it was more than 3 days. We also noted the socioeconomic level based on whether or not mothers were active, previous parity (mostly dependent children) and type of housing (precarious or hard).

Immediately after delivery, the newborn was included. The parameters reported were gestational age, Apgar score, weight (g), height (cm), cranial perimeter (PC) (cm). A cord blood sample was taken for the determination of retinol.

The maternal and neonatal samples were collected in vacuum Ethylen Diamine Tetra-acetate (EDTA) tubes. On arrival at the laboratory, centrifugation at 4000 rpm for 10 minutes allowed, after decantation, to collect between 1 and 3 ml of plasma in a cryotube covered with aluminum foil, and then stored at −80˚C until it was transported, at the CERBA Laboratory in Paris, France, where serum retinol was measured. At the CERBA Laboratory, serum retinol is determined by high performance liquid chromatography (HPLC).

2.2. Ethical Approval

Our survey received the authorization of the Ministry of Health, and the Ethical Committee of the Hospital before investigation.

2.3. Data Analysis

The data entry and analysis were performed with the EPI INFO 7 software version 7.0.2.1. The qualitative variables were compared with the chi-2 test, the quantitative variables (averages) with the student's test. The alpha significance threshold of less than 5% has been retained.

3. Results

3.1. General Characteristics of the Sample

Our study population consisted of 75 mother-child pairs.

- Epidemiological and socioeconomic profiles of the mothers.

The mother's age ranged from 15 to 41 years with a mean of 25.7 ± 7.05 years. Ante-natal consultations (ANC) were performed on average 4.2 times ± 1.7 with a minimum of 0 and a maximum of 8. Follow-up of pregnancy was provided by a midwife in 56% (n = 42) of cases, by an obstetrician-gynecologist in 37.3% (n = 28) of cases, in 6.7% (n = 5) no ANC was performed.

Overall, mothers lived in a poor neighborhood in 93.3% (n = 70) of cases and lived in a brick dwelling in 88% (n = 66) of cases. They were self-employed in 72% (n = 54), of whom 51.8% (n = 28) were students.

- Mothers knowledge about Vitamin A.

Overall, the percentage of mothers with Vitamin A knowledge was 14.7% (n = 11). We found a significant difference ($p = 0.04$) between Vitamin A knowledge of mothers at the secondary level and that at the upper level (Table 1). All mothers who knew about Vitamin A knew that the carrot was rich in carotene and that it was good to consume it to have a good view.

- Distribution of mothers according to their dietary pattern.

Mango and carrot were the most consumed foods, 27% of mothers consumed more than 3 times per week (Table 2).

3.2. Epidemiological Profile of the Newborns

Of the neonates, 67 (89.3%) had a gestational age ≥ 37 weeks, and 8 (10.7%) were born prematurely. Females represented 56% (n = 42) and males 44% (n = 33), a sex ratio of 0.78. The average weight of newborns was 3059 g ± 524.8 with extremes ranging from 800 to 4000 g. The average size was 48.9 cm ± 2.9 with a minimum of 32 cm and a maximum of 53 cm. No newborns had intrauterine growth retardation.

3.3. Serum Retinol Rates

- Serum retinol rates in the mothers.

Mean maternal serum retinol was 0.87 µmol/l ± 0.35 with extremes ranging from 0.22 to 1.79 µmol/L. Of these, 33.3% (n = 25, 95% CI [22.1% - 25.8%]) had Vitamin A deficiency with retinol less than 0.70 µmol/L. Retinol < 0.35µmol/L was observed in 4 (5.3%) mothers.

- Serum retinol rate in the newborns.

Mean retinol in neonates was 0.92 µmol/l ± 0.30 with extremes ranging from 0.24 to 1.84 µmol/l. Vitamin A deficiency was observed in 20% (n = 15, 95% CI [18.2% - 22%]) with a serum retinol lower than 0.70 µmol/L. Retinol < 0.35 µmol/L was observed in 2 (2.7%) neonates.

Table 1. Mother's knowledge on Vitamin A according to their grade level.

Knowledge of Vitamin A	High school		University		Total		p
	n	(%)	(%)	(%)	(%)	(%)	
Yes	2	(4)	9	(36)	11	(14.7)	
No	48	(96)	16	(64)	64	(85.3)	<0.001
Total	50	(100)	25	(100)	75	(100)	

Table 2. Frequency of weekly intake of foods rich in Vitamin A.

Foods rich in Vitamin A	Frequency of weekly intake		
	Low (% 1 - 2 days)	Middle (% 3 days)	High (% > 3 days)
Carrot	55	18	27
Mango	41	32	27
Orange	28	52	20
Sorrel	52	36	12
Amaranthus green	47	41	12
Corn	73	16	11
Cassava leaves	66	25	9
Lettuce	88	7	5
Papaya	93	3	4
Cheese	77	15	8
Butter	95	4	1
Palm oil	97	3	0
Liver	99	1	0
Fish	56	20	24
Kidney	94	5	1

The mean serum retinol of neonates born from deficient mothers was 0.79 ± 0.29 µmol/L and that of neonates from non-deficient mothers was 0.98 ± 0.3 µmol/L. There was a statistically significant difference between these two averages with a $p = 0.01$.

The proportion of premature newborns who were absent from the study, 3/8 (37.5%) was significantly higher than the proportion of newborns at term 12/67 (17.9%) $p = 0.002$.

We did not find any relationship between the Vitamin A status of the newborn and the socio-economic characteristics of the mother.

- Relationship between the serum retinol of the mother and her newborn.

There was a linear correlation (r = 0.17) between retinol of the mother and that of her newborn (**Figure 1**). Among neonates born to mothers deficient in Vit A (n = 25), we observed that 9 (36%) were deficient in Vitamin A (retinol < 0.7 µmol/L). In the group of neonates from mothers with a normal Vitamin A status (n = 50), 6 (12%) were deficient in Vitamin A (retinol < 0.7 µmol/L). The

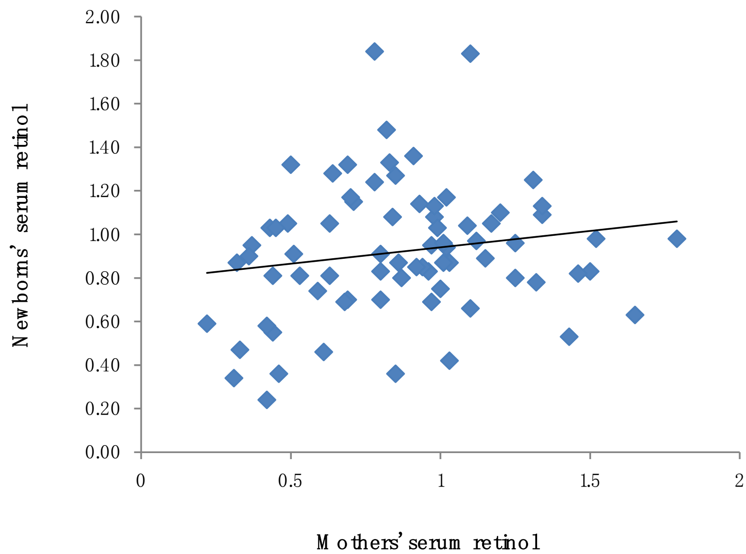

Figure 1. Correlation between mothers' serum retinol and their newborns' serum retinol.

2 neonates with serum retinol < 0.35 µmol/L were from mothers whose retinol was 0.42 µmol/L for one and <0.35 µmol/L for the second.

- Relationship between Vitamin A status of the newborn and gestational age.

The proportion of premature newborns who were absent from the study, 3/8 (*i.e.* 37.5%) was significantly greater than the proportion of newborns at term 12/67 (*i.e.* 17.9%) $p = 0.002$.

- Relationship between Vitamin A status of the newborn and maternal parameters.

We did not find any relationship between the Vitamin A status of the newborn and the socio-economic characteristics of the mother.

4. Discussion

The Vitamin A deficiency has an impact on the health of the mother and newborn, there is no study on the vitamin status of the mother and her newborn in Gabon. The high cost of retinol testing was a challenge in this investigation as the team had to pay fund the assays in the CERBA laboratory itself. Our second difficulty was to collect the frequency of Vitamin A consumption in mothers accurately. This high cost of serum retinol dosage was the main limitation of this study because it is monocentric and is not necessarily representative of the general population of Gabon which has 9 provinces and therefore as much difference in dietary habits. Our second limitation was the accuracy in collecting the frequency of consumption of Vitamin A rich foods in mothers given the low rate of mothers with knowledge of this vitamin (147%).

The mean age of mothers was 25.7 ± 7.05 years. The majority of the pregnancies were attended by a midwife, in 93.3% of the cases. The mothers reside in a working-class district and are without wage income in the vast majority of cases.

This maternal profile in Vitamin A deficiency is also observed by Williams *et al.* in Nigeria [6], Hamdy *et al.* in Egypt [7] and Lee *et al.* in Bangladesh [8].

In our study, mean maternal serum retinol was 0.87 ± 0.35 µmol/L. Among them, 33.3% had a deficiency in Vitamin A and 5.3% of cases; the deficiency was severe with a retinol rate < 0.35 µmol/L. In neonates, mean serum retinol was 0.92 ± 0.30 µmol/L. Vitamin A deficiency was observed in 20% of cases. Of these, 2.7% had a severe deficiency with retinol < 0.35% µmol/L. We observed a link between retinol in the mother-child couple.

The deficiency rate in Vitamin A is very high in our study whether in the mother or the newborn. This observed deficiency rate shows that Vitamin A deficiency is a real public health problem in our country because it is well above the 5% threshold that WHO sets for talking about a public health problem in children under 5 years old, and 20% in pregnant women [1] [9]. In Kenya in 2007, 33.3% of pregnant women had a retinol rate < 0.7 µmol/L at the 36th week of amenorrhea [10]. In Nigeria, only 36.5% of women out of 101 had normal retinol in 2011 [6]. In Bangladesh, more than half of women out of 200 have a low rate of retinol, and 18.5% of them are deficient in Vitamin A [8]. In India, Radhika *et al.* found that 27% of women have Vitamin A deficiency in a population of 736 pregnant women [11]. In Egypt, in a study of a population of 80 mother-child pairs, 20% of mothers had Vitamin A deficiency and a significant difference between mean retinol of newborns from deficient mothers and those from non-deficient mothers [12]. In Egypt, Hamdy *et al.* found a proportion of 23.5% of pregnant women with a low rate of Vitamin A in a population of 736 with a positive correlation with the rate of Vitamin A of newborns [7]. In the Hanson *et al.* USA study, [13] 10% of mothers and 80% of neonates in a population of 189 mother-infant pairs had retinol ≤ 0.70 µmol/L with a strong correlation between concentrations of the Vitamin A compounds of the mother and the child. In the USA and Brazil, the prevalence of Vitamin A deficiency in pregnant women was 8% and 5% respectively in 2012 and reached 25% in lactating women in northern Brazil [14].

In fact, at the global scale, deficiency in life A affects 19.1 million pregnant women, and 9.8 million of them suffer from night blindness, and this, mainly in Africa and Southeast Asia [1] [2] [3].

The main cause of deficiency in Vitamin A is inadequate intake because it is not synthesized by the body [15] [16] and its manifestation is more observed during periods requiring a high nutritional intake regarding quality and amount. Thus, the deficiency in Vitamin A is particularly severe in pregnant, breastfeeding women and during infancy, which are pivotal periods of need in Vitamin A, [17]. It is therefore easy to understand that there may be a correlation between the micronutrient concentrations of maternal blood and umbilical cord blood as shown by the work of Weber *et al.* [7] [18]. This explains why the retinol of newborns from deficient mothers is in the majority of studies inferior to that of newborns born to non-deficient mothers [12]. This finding was also observed in our study.

Vitamin A deficiency during pregnancy is associated with a rise in maternal and infant mortality and morbidity and mortality in the first year of life. Some authors do not find a direct link between maternal and neonatal mortality and Vitamin A deficiency [19]. They all agree that Vit A plays an important role in hematopoiesis, and that anemia is a frequent consequence of its deficit, that it is essential for the embryogenesis, the immune system, the regeneration of the epithelial tissues of various organs, the vision and in several metabolic ways of the organism. For example, maternal Vitamin A deficiency is associated with maternal and neonatal anemia, low birth weight, toxemia of pregnancy, premature labor, and susceptibility to infection and renal hypoplasia of the newborn [7] [11] [12] [13] [19].

Although pregnant women are susceptible to Vitamin A deficiency throughout pregnancy, this deficiency is more common in the third trimester due to the accelerated fetal development and physiological increase in blood volume [1]. It is also during this period of pregnancy that Vitamin A liver reserves are formed, and they depend entirely on the quality of the maternal diet. In a context of regular and sufficient intake of Vitamin A in pregnant women, as in developed countries, or in pregnant women with moderate Vitamin A deficiency. Plasma and liver concentration of Vitamin A in the life of the fetus remains constant during the pregnancy and allows a sufficient supply of Vit A to the fetus for its development [1] [20]. This partly explains the fact that Vitamin A supplementation is recommended only in developing countries where malnutrition, a source of Vitamin A deficiency, is sustained by poverty [1] [2] [3].

However, this Vitamin A dequacy of the fetus is at the expense of the reserves of the mother, while she will need, in the coming months, to provide her child with a sufficient quantity of Vit A to ensure adequate development. Because, despite this Vitamin A dequacy of the fetus, it is well known that during the first 6 months of life liver reserves in Vit A infant is very limited and breast milk remains the best source of supply to mitigate this failure [21] [22]. WHO recommends Vitamin A supplementation in pregnant women, breastfeeding women and children under 5 years of age [2].

In Gabon, Ovono *et al.* showed that Vitamin A deficiency was a public health problem in children [4], and Vitamin A supplementation as recommended is not systematic in this population and almost non-existent in pregnant women. The intake of food rich in Vitamin A remains the only reliable source. Taken on a regular and daily basis, they are proven to increase the level of Vitamin A in blood and breast milk [23] [24]. In our study, the frequency of food consumption of these foods is low. Animal products rich in retinol are almost inaccessible in the basket of the housewife because of the high cost. Fruits and vegetables (especially carrots) are the most consumed, but these fruits and vegetables are seasonal and do not allow a regular and constant supply of the Vitamin A on the one hand. Moreover, on the other hand, these products are not affordable for the majority of the population as they are largely imported. In the case of their accessibility, the loss of Vitamin A activity during storage, processing, and cooking is known and harms its bio-disponibility [25] [26]. Red palm oil is very rich in β-carotene, and it is almost the only affordable product on the market. The production is well developed locally, but it was the least consumed food in our survey while several studies have shown that daily consumption of Red palm oil improved Vit A status in breast milk, in women and children with efficacy equivalent to that of synthetic retinol supplements [25] [27].

5. Conclusion

From our study, it appears that the deficiency in Vit A poses a problem of public health in our country as well for the pregnant woman as for the newborn. Synthetic Vitamin A supplementation sporadically occurs in general and in particular in these two vulnerable groups of the population and therefore does not solve this serious nutrition problem. It is, therefore, appropriate to focus on promoting the regular consumption of foods rich in Vitamin A because many products rich in provitamin A including β-carotene are available despite their high costs.

Funding Source

Team's members funded the survey on their resources. The team did not receive any fund from any institution.

Conflict of Interest

The authors declare no conflict of interest.

Contribution of Authors

Dr. Kuissi Kamgaing drafted the protocol and the manuscript. Dr. Minto'o Rogombe, Mboungani Igondjo, and Koumba Maniaga provided data collection and statistical analysis of this work. Dr. Minto'o Rogombe provided the English translation of the article. Professors Koko and Ategbo supervised all the work.

All authors have approved the latest version of this manuscript.

References

[1] OMS (2011) Supplémentation en Vitamine A chez la femme enceinte. Organisation Mondiale de la Santé, Consulté le 15 février 2018. http://apps.who.int/iris/bitstream/10665/44727/1/9789242501780_fre.pdf

[2] OMS (2011) Supplémentation en Vitamine A pendant la période néonatale. Organisation Mondiale de la Santé, Genève, Consulté le 20 février 2018. http://apps.who.int/iris/bitstream/10665/44719/1/9789242501797_fre.pdf

[3] Food and Nutrition Board and Institute of Medicine (2011) Vitamin A Dietary Reference Intakes for Vitamin, Vitamin K, Arsenic, Boron, Chronium, Copper , Iodine, Manganèse, Molydenum, Nickel, Silicon, Vandium, and Zinc. National Academy Press, Washington DC, 82-146.

[4] Ovono Abessolo, F., Kuissi, E., Calvin Nguele, J., Lemamy, G.J. and Ngou Milama, E. (2009) Vitamine A chez les enfants gabonais non supplémentés: Relation avec les pathologies oculaires et nutritionnelles. *Cahiers d'études et de recherches francophones/Santé*, **19**, 29-33.

[5] Hathcock, J., Hattan, D., Jenkins, M., McDonald, J., Sundaresan, P. and Wilkening, V. (1990) Evaluation of Vitamin A Toxicity. *The American Journal of Clinical Nutrition*, **52**, 183-202. https://doi.org/10.1093/ajcn/52.2.183

[6] Williams, I.O., Essien, E.U. and Eka, O.U. (2011) Socioeconomic Factors and Vitamin A Status of Pregnant Women in Calabar Urban, Southeastern Nigeria. *Maternal and Child Health Journal*, **15**, 943-948. https://doi.org/10.1007/s10995-009-0541-7

[7] Hamdy, A.M., Abdel Aleem, M.M. and El-Shazly, A.A. (2013) Maternal Vitamin A Deficiency during Pregnancy and Its Relation with Maternal and Neonatal Hemoglobin Concentrations among Poor Egyptian Families. *ISRN Pediatrics*, **2013**, Article ID: 652148. https://doi.org/10.1155/2013/652148

[8] Lee, V., Ahmed, F., Wada, S. and Ahmed, T. (2008) Extent of Vitamin A Deficiency among Rural Pregnant Women in Bangladesh. *Public Health Nutrition*, **11**, 1326-1331. https://doi.org/10.1017/S1368980008002723

[9] WHO (2011) Concentration sérique en rétinol pour déterminer la prévalence de la carence en Vitamine A dans les populations. Système d'information nutritionnelle sur les vitamines et les minéraux, Organisation Mondiale de la Santé, Genève, Consulté le 20 février 2018. http://www.who.int/vmnis/indicators/retinol_fr.pdf

[10] Ayah, R.A., Mwaniki, D.L., Magnussen, P., Tedstone, A.E., Marshall, T. and Alusala, D. (2007) The Effects of Maternal and Infant Vitamin A Supplementation on Vitamin A Status: A Randomised Trial in Kenya. *British Journal of Nutrition*, **98**, 422-430. https://doi.org/10.1017/S0007114507705019

[11] Radhika, M.S., Bhaskaram, P., Balakrishna, N., Ramalakshmi, B.A., Devi, S. and Siva Kumar, B. (2002) Effects of Vitamin A Deficiency during Pregnancy on Maternal and Child Health. *BJOG: An International Journal of Obstetrics & Gynaecology*, **109**, 689-693. https://doi.org/10.1111/j.1471-0528.2002.01010.x

[12] El-Khashab, E.K., Hamdy, A.M., Maher, K.M., Fouad, M.A. and Abbas, G.Z. (2013) Effect of Maternal Vitamin A Deficiency during Pregnancy on Neonatal Kidney Size. *Journal of Perinatal Medicine*, **41**, 199-203.

[13] Hanson, C., Schumacher, M., Lyden, E., Furtado, J., Van Ormer, M., McGinn, E., *et al.* (2017) Status of Vitamin A and Related Compounds and Clinical Outcomes in Maternal-Infant Pairs in the Midwestern United States. *Annals of Nutrition and Metabolism*, **71**, 175-182. https://doi.org/10.1159/000481292

[14] Marques Andreto, L., Grande de Arruda, I.K., Impieri Souza, A., Figueiroa, J.N. and Da Silva Diniz, A. (2012) The Effects of Two Maternal Vitamin A Supplementation Regimens on Serum Retinol in Postpartum Mothers: A Randomised Controlled Trial in Brazil. *ISRN Public Health*, **2012**, Article ID: 121697. https://doi.org/10.5402/2012/121697

[15] Augusto, R.A., Cobayashi, F. and Cardoso, M.A. (2015) Associations between Low Consumption of Fruits and Vegetables and Nutritional Deficiencies in Brazilian Schoolchildren. *Public Health Nutrition*, **18**, 927-935. https://doi.org/10.1017/S1368980014001244

[16] West, K.P. and Jr. Mehra, S. (2010) Vitamin A Intake and Status in Populations Facing Economic Stress. *The Journal of Nutrition*, **140**, 201S-207S. https://doi.org/10.3945/jn.109.112730

[17] West Jr., K.P. (2003) Vitamin A Deficiency Disorders in Children and Women. *Food and Nutrition Bulletin*, **24**, S78-S90. https://doi.org/10.1177/15648265030244S204

[18] Weber, D., Stuetz, W., Bernhard, W., Franz, A., Raith, M., Grune, T. and Breusing, N. (2014) Oxidative Stress Markers and Micronutrients in Maternal and Cord Blood in Relation to Neonatal Outcome. *European Journal of Clinical Nutrition*, **68**, 215-222. https://doi.org/10.1038/ejcn.2013.263

[19] McCauley, M.E., Van den Broek, N., Dou, L. and Othman, M. (2015) Vitamin A Supplementation during Pregnancy for Maternal and Newborn Outcomes. *Cochrane Database of Systematic Reviews*, No. 10, Article No. CD008666.

[20] Ayoubi, J.M., Hirt, R., Badiou, W., Hininger-Favier, I., Favier, M., Zrik-ayoubi, F. *et al.* (2012) Nutrition et femme enceinte. *EMC—Obstétrique*, **7**, 1-13. https://linkinghub.elsevier.com/retrieve/pii/S024603351270039X

[21] Azaïs-Braesco, V. and Pascal, G. (2000) Vitamin A in Pregnancy: Requirements and Safety Limits. *The American Journal of Clinical Nutrition*, **71**, 1325S-1333S. https://doi.org/10.1093/ajcn/71.5.1325s

[22] Ribeiro Neves, P.A., Cláudia Saunders, C., Cavalcante de Barros, D. and Ramalho, A. (2015) Vitamin A Supplementation in Brazilian Pregnant and Postpartum Women: A Systematic Review. *Revista Brasileira de Epidemiologia*, **18**, 824-836. https://doi.org/10.1590/1980-5497201500040012

[23] Grune, T., Lietz, G., Palou, A., Ross, A.C., Stahl, W., Tang, G., *et al.* (2010) *β*-Carotene as an Important Vitamin A Source for Humans. *The Journal of Nutrition*, **140**, 2268S -2285S. https://doi.org/10.3945/jn.109.119024

[24] Soudy, I.D., Minet-Quinard, R., Mahamat, A.D., Ngoua, H.F., Izzedine, A.A., Tidjani, A., *et al.* (2018)Vitamin A Status in Healthy Women Eating Traditionally Prepared Spirulina (*Dihé*) in the Chad Lake Area. *PLoS ONE*, **13**, e0191887. https://doi.org/10.1371/journal.pone.0191887

[25] Zagré, N.M., Delisle, H., Tarini, A. and Delpeuch, F. (2002) Évolution des apports en Vitamine A à la suite de la promotion d'huile de palme rouge chez les enfants et les femmes au Burkina Faso. *Cahiers Santé*, **12**, 38-44.

[26] Gouado, I., Démasse Mawamba, A., Etame Loe, G., Meyimgo Ouambo, R.S., Ejoh Aba, R. and Fokou, E. (2011) Impact of Three Cooking Methods (Streaming, Roasting on Charcoal and Frying) on the *β*-Carotene and Vitamin C Contents of Plantain and Sweet Potato. *American Journal of Food Technology*, **6**, 994-1001. https://doi.org/10.3923/ajft.2011.994.1001

[27] Delisle, H., Zagré, N., Bakari, S., Codjia, P. and Zendong, R. (2003) A Food System Approach to Vitamin A Deficiency. *Recent Patents on Food, Nutrition & Agriculture*, **32**, 40-50.