Summary and conclusions

It has been suggested that the vitamin A status of pregnant women can influence vitamin A stores in the fetal liver. Moreover, the breast-fed neonates also depend on breastmilk vitamin A for their requirements. Prophylactic treatment with synthetic vitamin A is warranted only during lactation but not during pregnancy for its possible teratogenic effects. A safe alternative is to use β-carotene at physiological dosage. Therefore, a longitudinal-hospital based study involving 133 pregnant and lactating women residing in slum areas of Mumbai suburbs was undertaken to assess the efficacy of spirulina (a cyanobacterium) supplement as a source of β-carotene in their diets. Three grams of spirulina supplement fulfilled 100% and 65% of RDA for β-carotene during pregnancy and lactation respectively. Maternal and fetal serum retinol, β-carotene, breastmilk retinol were analyzed by HPLC method.

♣ The total carotenoids and β-carotene content in spirulina was estimated to be 2840μg/g and 828μg/g respectively.

♣ Out of 133 pregnant and lactating women recruited for the study, only 94 completed the study (29% dropouts).

♣ Baseline data relating to the subjects is as follows:

♦ All the subjects belonged to low-socio-economic group with per capita daily income ranging between Rs 15 and Rs 25.

♦ Their diets were inadequate in both quantity and quality with vitamin A intake around 45-66% deficit during pregnancy and lactation respectively.

♦ All the subjects under study reported moderate risk of deficiency with marginal status of vitamin A, the initial mean serum retinol and β-carotene concentration in Group I and II being 22.2 ± 0.99μg/dl & 67.3 ± 4.50μg/dl and 23.4 ± 1.34μg/dl & 73.0 ± 5.36μg/dl respectively.

♦ Mean serum total proteins were 7.1± 0.71g/dl and 6.3 ± 0.46 g/dl at 7th month of gestation and third day post-partum respectively.
Summary and conclusions

Â Around 75% of the subjects under present study had their hemoglobin levels below 10g% and none of them were above the cut-off point given by WHO (11g%).

Â Post-supplementation data:

Â The mean serum total protein of the neonates of the pregnant women were 5.2 ± 0.5 g/dl and 5.7 ± 0.8 g/dl for control and experimental group I respectively with positive correlation (r = 0.6, p < 0.05) between the maternal and the neonatal values indicating importance of optimal protein status of mother during pregnancy.

Â In group I and II, serum total proteins were normal after 45 days post-partum. Serum total proteins rose significantly (p < 0.01) for both control and experimental groups. These changes are normal, physiological adaptations.

Â Pregnant women from experimental group I showed improvement (p < 0.01) in their initial hemoglobin levels from 9.7 ± 0.5 g/dl to 10.9 ± 0.9 g/dl at term within three months and 12.1 ± 0.96 g/dl at 45 days post-partum suggesting the positive effect of spirulina supplementation on hemopoesis.

Â A slight but statistically significant (p < 0.01) increase in the hemoglobin concentration at 45 days post-partum in the lactating mothers from experimental group II (supplementation only during lactation) was noticed. However, the improvement was most likely due to recovery from pregnancy rather than to a response to the supplementation as similar increment was found in the control group also.

Â Fetal hemoglobin was found to be 15.6 ± 2.7 g/dl and 16.3 ± 3.1 g/dl in neonates of women from experimental and control group I respectively. There was no significant association between maternal and fetal hemoglobin.

Â The mean values of serum retinol at the beginning of the third trimester (21.9μg/dl ± 0.91) further lowered at term (20.6μg/dl ± 0.80) in the control
group I ($p < 0.01$). On the contrary, the betacarotene levels in the same group presented a different picture with higher levels at term (70.2$\mu$g/dl ± 5.08) than at the 7th month (67.0$\mu$g/dl ± 5.14) ($p < 0.01$).

Such a lowering trend was not observed in the women from experimental group I who were supplemented with betacarotene from spirulina. The initial values increased from 22.4 ± 1.02 $\mu$g/dl to 35.4 ± 1.53 at term and 38.5 ± 1.29 at 45 days post-partum. No reversal of serum retinol and betacarotene levels after delivery or a further fall during lactation as seen in the control group I was noticed in women receiving supplements.

Mean serum $\beta$-carotene concentration in pregnant women from experimental Group I also showed increase from 67.6 ± 3.83 $\mu$g/dl at 7th month of gestation to 98.6 ± 5.60 $\mu$g/dl at term and 102.3 ± 7.96$\mu$g/dl at 45 days post-partum.

Although, pregnant women from the control group I showed an increase in the $\beta$-carotene levels from 67.0 ± 5.41 $\mu$g/dl at the beginning of the third trimester to 70.2 ± 5.37 $\mu$g/dl at term, the concentration decreased significantly ($p < 0.01$) to 64.1 ± 5.03 at third day post-delivery.

The difference between the $\beta$-carotene values at term for control and experimental groups was statistically significant ($p < 0.01$) indicating the positive effect of spirulina supplementation in experimental group I.

It was also seen that pregnant women with lowest initial retinol levels responded better to the supplements with higher increase.

Lactating mothers from group II supplemented with spirulina showed mean increase in serum retinol and betacarotene levels from the baseline as 4.8 ± 3.41 $\mu$g/dl and 22.0 ± 5.27 $\mu$g/dl respectively. However, the control group exhibited lowered serum retinol and betacarotene levels at 45 days postpartum ($p < 0.01$).
Summary and conclusions

- The percentage increases in serum retinol and β-carotene after spirulina supplementation during pregnancy and lactation (Group I-PL) was observed to 72 and 51% respectively. The supplementation only during pregnancy (Group I-P) exhibited 58 and 46% increase in serum retinol and β-carotene, and that of for group II was 20 and 30% respectively.

- The spirulina supplementation resulted in improved cord vitamin A levels (p < 0.01), the values being 27.3 ± 1.34 μg/dl for retinol and 50.1 ± 1.99 μg/dl for betacarotene. The control group had the values as 15.0 ± 1.32 μg/dl & 36.6 ± 3.61 μg/dl respectively.

- A distinct feature observed in the present study was that the maternal β-carotene levels at term were highly correlated with fetal retinol values (r = 0.83, p<0.01).

- A positive correlation was found between fetal and maternal betacarotene values at term (r = 0.3, p < 0.05).

- This confirms that β-carotene from spirulina is bioavailable and thus apprehensions about effectiveness of dietary carotenes in alleviating VAD need rethinking.

- Supposition with more relevance to feto-placental transfer of vitamin A that carotenes from spirulina are utilized by the placenta to synthesis retinol for the fetal circulation is confirmed in the present study.

- Pregnant women from group I supplemented with spirulina did not show any increase in the fetoplacental function as indicated by the serum progesterone levels, the values at term being 131.7 ± 12.03 ng/ml and 132.6 ± 8.55 ng/ml for control and experimental groups respectively.
Summary and conclusions

* In the present study a significant correlation was observed between serum retinol levels at term and colostrum \( r = 0.6, p<0.01 \), transitional milk \( r = 0.5, p<0.01 \) and mature milk \( r = 0.4, p<0.01 \).

* Women belonging to the experimental Group I (PL) reported the highest retinol concentration in colostrum \( (144.2 \pm 8.01 \mu g/dl) \) compared to its unsupplemented counterpart \( (98.2 \pm 6.59 \mu g/dl) \) which was statistically significant \( (p<0.01) \).

* The increased breast milk retinol in women from Group I-PL was maintained at higher level \( (68.0 \pm 4.02 \mu g/dl) \) compared to other groups which received spirulina supplementation either during pregnancy- Group I-P \( (43.2 \pm 3.46 \mu g/dl) \) or lactation- Group II \( (51.1 \pm 1.99 \mu g/dl) \).

* The vitamin A content of breast milk decreased nearly by 50% over the first one and half month in experimental Groups I-PL and II. The decrease was around 60 and 65% in their respective control groups. Groups I-P exhibited around 70 and 60% decrease in breast milk retinol in experimental and control groups respectively.

* From the results of the present study, it is concluded that monitoring and improving maternal vitamin A status is warranted during critical periods of pregnancy and lactation, which may help ameliorate fetal hepatic reserves of vitamin A and provide adequate amount of the vitamin in breast milk. Both consequences may contribute to effectively address the issue of childhood blindness due to VAD. Daily spirulina supplementation at physiological level during pregnancy and lactation has found to be efficacious in improving maternal and neonatal vitamin A status, and thus holds potential to be used as a wholesome food supplement that can target not only VAD but also other micronutrient deficiencies prevalent in Indian women.
Summary and conclusions

Based on the evidences from the present investigation, a few recommendations are proposed:

- The foremost need of the hour is to reassess the vitamin A requirements during pregnancy. An upward modification seems justified in view of both the fetal liver deposit and breast milk vitamin A content.

- It is strongly recommended that the concept of "Reproductive Health" requires a holistic approach rather than isolated single nutrient approach. Introduction and significance of spirulina in Public Health Programs is substantiated in view of the existing strong evidences about its role in betterment of health.

- The cost-benefit analysis would reveal that benefits derived from spirulina outweigh the cost-inputs due to its invisible benefits on health.