Red palm oil for combating vitamin A deficiency

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Red palm oil *(Elaeis guineensis,RPO)* is nutritionally rich and unique in comparison with other edible oils as it has a high content of β-carotene (400 ppm).It is the ideal choice for combating vitamin A deficiency in developing countries. The Modified Relative Dose Response test was conducted to assess the vitamin A status of school children fed RPO in the form of a sweet snack supplying the RDA (2400 µg) of β-carotene for two months. A significant increase was seen in serum retinol levels from 0.86 ± 0.14 to 1.89 ± 0.23 µmol/L, comparable with a control group fed oral vitamin A drops daily whose retinol levels increased from 0.74 ± 0.09 to 1.94 ± 0.21µmol/L. The dehydroretinol/ retinol ratio (DR/R) decreased from 0.073 ± 0.025 to 0.023 ± 0.003 in a RPO group and from 0.095 ± 0.023 to 0.023 ± 0.004 in the vitamin A group, indicating saturation of liver reserves of retinol, the cut-off point for inadequate status being > 0.03.

In another study, school children fed RPO snacks for one month were compared with massive vitamin A dosed groups. Serum retinol level increased significantly in both groups. Serum β-carotene increased from 0.06 ± 0.002 to 0.21 ± 0.01 µmol/L in the RPO group, but remained the same in a control group.

A third study indicated that RPO can afford protection for as long as six months, similar to massive vitamin A doses. School children fed RPO snack for one month as per the RDA, maintained normal levels even after six months of cessation of supplementation. Children fed 50 % of RDA from RPO snack also maintained normal levels (>0.7µ mol/L) at the end of six months of supplementation. Hence, periodic bouts of RPO feeding twice or thrice a year may help in maintaining adequate vitamin A status throughout the year. Hence RPO has great promise in maintaining the nutritional well-being of the population.

Introduction

The prospects for augmenting the cultivation of red palm oil (RPO) in India[1] warrant research into it's nutritional and health benefits, and food uses of RPO. RPO is the unrefined, unbleached, thick, orange coloured oil extracted from the oil palm fruit with it's carotenoid content intact[2]. Carotenoids are precursors of vitamin A in the human biological system, β-carotene being the most active. In addition to vitamin A activity, carotenoids along with tocopherols, are also powerful anti- oxidants which have been implicated in keeping both, cancer and cardiovascular disease[3] at bay. RPO contains about 500-700 PPM of carotenoids and 1000 PPM of tocopherols and tocotrienols. It is easily one of the richest natural sources of carotenes, and could serve as an excellent vehicle for vitamin A supplementation which has been reported to have beneficial effects on child mortality and morbidity[4]. Vitamin A deficiency, despite being a preventable nutritional problem, continues to be a major public health problem in developing nations[5]. Prevalence of xerophthalmia in India was reported to be 0.7%. A baseline survey for a vitamin A supplementation trial in Tamilnadu[6], India, noted high xerophthalmic rates including night blindness (3.7%), Bitot's spots (7.2%) and total xerophthalmia rate of 10.95%. Biochemical data from the same survey indicated that 37.5% had retinol levels <0.7 µmol/L.

The reason for continued prevalence is inadequate dietary intake. Undernutrition, especially with respect to micronutrients like vitamin A, iron and iodine, persists in developing countries despite the rapid leaps and bounds in production of food grains and food availability[7] in countries like India. New and alternate sources of foods rich in micronutrients could alleviate these lacunae.

At the 1995 world summit for children[8], WHO and UNICEF emphasised the need to improve the intake of foods rich in micronutrients as a low cost strategy for reducing illness, blindness and death among children of the developing world. It was estimated that half a million children were still going blind due to vitamin A deficiency, and among those, 50 were dying from common diseases. This tragedy of half a million children was considered to be the tip of a much larger problem. 500 times that number have lowered resistance to infections and disease because of milder forms of deficiency, and are at a higher risk of death from common diseases, which is 20-30% higher than normal children.

Thus, a detailed investigation was undertaken to evaluate the efficacy of RPO as a vitamin A supplement, as its distribution could serve as one of the long term strategies to improve vitamin A status of vulnerable groups.

A series of experiments were conducted to study the effect of RPO supplementation on vitamin A status.

Methods

Study 1

Twenty four children of 7-9 years of age comprising of twelve boys and twelve girls belonging to the low socio-economic group and residing in government aided homes in Hyderabad city, were selected and assigned to two age and sex matched groups.

The first group was fed "*suji halwa*" (a sweet snack made of semolina, sugar and RPO in the ratio of 1:1:1) providing 2400 µg (RDA) of β-carotene.

The second group was administered 600 µg of vitaminA in addition to a piece of "*suji halwa*" placebo made with GNO.

The snack was distributed in the evening over and above their normal diet which was vitamin A deficient. The Modified Relative Dose Response (MRDR)[9] test was conducted to assess the vitamin A status of children before and after supplementation. The test was conducted by oral administration of 3,4-didehydroretinol acetate (DRA) after an overnight fast at the rate of 100 µg / kg of body weight. A blood sample was drawn five hours after the oral dose, and retinol (R) and dehydroretinol (DR) were estimated by High Performance Liquid Chromatography (HPLC) according to the method of Beiri *et al*[10]. The DR/R ratio was calculated and used to measure vitamin A status as it was reported to be a valid indicator of vitamin A nutriture[9].

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Study 2

Thirty-six school children of 7-12 years having mild to severe clinical signs of vitamin A deficiency, studying in Government schools in urban Hyderabad, were randomly distributed to two groups.

The first group were supplemented with "*suji halwa*" made with RPO and providing 2400 µg of β-carotene.

The second group was administered 100,000 I.U. of synthetic Vitamin A as a single massive dose. Blood samples were drawn before and after supplementation/dose and serum was analysed for retinol and β-carotene by HPLC[10,11].

Study 3

100 children (7-9 years) belonging to an interior village called "*Nakhaur*" in Puri, Bhubaneshwar, Orissa, India, were screened for clinical signs of vitamin A deficiency and 36 of these were selected for the study. They were assigned to three age and sex matched groups.

Group 1 (control) was administered 100,000 I.U. of vitamin A palmitate drops as a single massive dose.

Group 2 was given 4 g RPO for 30 days providing 50,000 IU of vitamin A in the form of "*Besan laddu*" (a sweet snack made of chick pea flour, sugar and fat in the form of balls).

Group 3 received 8 g RPO providing 100,000 IU of vitamin A from "*Besan laddu*". Group 2 provided only 50 % of the vitamin A supplied by groups 1 & 3. Blood samples were drawn in three phases:

- Initial, before supplementation;
- Intermediate, after one month of supplementation;
- Final, six months after cessation of supplementation.

Serum was analysed for retinol by HPLC[10].

Statistical analysis

One way analysis of variance was done to compare results of different groups as well as different time points of study.

Clinical and anthropometric measurements

Clinical signs of deficiency and anthropometric measurements were recorded for all children before and after supplementation in all studies.

Results

Study 1

Results of the MRDR study are presented in Table 1 and Figures 1 and 2. Serum retinol levels increased from basal 0.86 ± 0.13 to 1.89 ± 0.023 µmol/L in the RPO group. These values are comparable to control group whose retinol levels increased from 0.74 ± 0.09 to I.94 ± 0.021 µmol/L. DR/R ratio decreased from 0.073 ± 0.025 to 0.025 ± 0.003 in the RPO group, and from 0.095 ± 0.023 to 0.023 ± 0.004 in the control group, indicating liver saturation with vitamin A in both groups.

Study 2

Table 2 and Figures 3 and 4 depict the retinol and β-carotene levels of school children fed RPO and massive vitamin A dose for one month. Considerable improvement of more than two fold was seen in retinol levels after supplementation in both groups. Basal β-carotene levels were low in both groups, but in the RPO group, supplementation brought about a significant increase ($P<0.05$) from 0.06 ± 0.002 to 0.21 µmol/L. In the control group there was no difference observed after the dose.

Figure 1. Mean serum retinol levels (µmol/L) of children fed RPO and vitamin A.

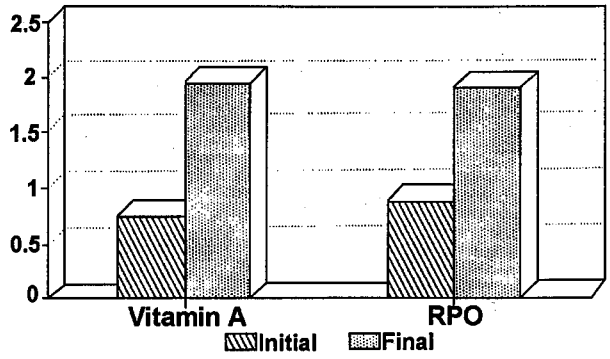
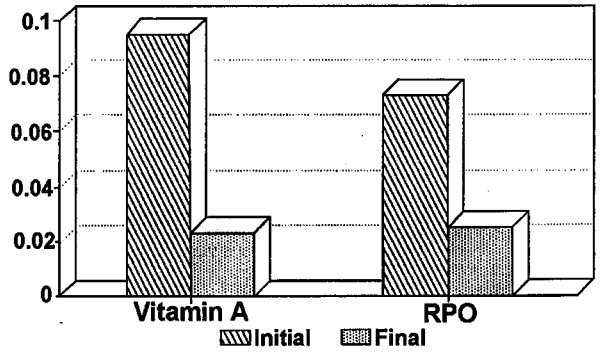


Figure 2. DR/R ratio of children fed RPO and Vitamin A.



Study 3

Mean serum vitamin A levels of all three groups are presented in Table 3 and Figure 5, and the percentages of children having serum retinol levels < 0.7 µmol/L are shown in Table 4.

In the massive dose group, initial levels were significantly different ($P<0.01$) from intermediate and final values. In the 4 RPO group, Intermediate levels were significantly higher ($P<0.01$) than Initial and Final levels. In the 8 g RPO group, all three values were significantly different ($P<0.01$) from each other. In groups 1 and 3, serum retinol levels were maintained >0.7 µmol/L even at

Table 1. Serum retinol and DR/R ratio of children fed RPO and vitamin A.

Groups	Retinol(µMol/L)		DR/R	
	Initial	Final	Initial	Final
	(12)	(12)	(12)	(12)
Vitamin A	$0.74^{b} \pm 0.09$	$1.94^{a} \pm 0.021$	0.095 ± 0.023	0.023* ±0.004
Red Palm Oil	$0.86^{b} \pm 0.13$	$1.89^{a} \pm 0.023$	0.073 ± 0.025	0.025* ± 0.003

Values are Mean ± SEM; Alphabets in superscript indicate significant differences ($P<0.05$) between columns (retinol)
* denotes significant differences ($P<0.05$) between columns (DR/R). Figures in parenthesis indicate no. of subjects.

Table 2. Retinol and β-carotene(µmol/L) levels of school children fed red palm oil and massive vitamin A dose

Groups	Retinol		β-Carotene	
	Initial	Final	Initial	Final
	(18)	(18)	(18)	(18)
Massive Vitamin A	$1.40^{b} \pm 0.05$	$1.76^{a} \pm 0.09$	0.07 ± 0.005	0.06 ± 0.006
Red Palm Oil	$0.95^{b} \pm 0.05$	$1.85^{a} \pm 0.08$	0.06 ± 0.006	0.21* ± 0.016

Values are Mean ± SEM; Alphabets in superscript indicate significantly different ($P<0.05$) columns (retinol).
* denotes significantly different ($P<0.05$) columns (β-carotene). Figures in parenthesis indicate no. of subjects.

the end of six months. In the 4 g RPO group, the mean serum retinol levels at the end of six months were slightly below 0.7 µmol/L (0.67 µmol/L). It can be seen that 33% of children in this group had retinol levels < 0.7 µmol/L at the end of six months.

Figure 3. Mean serum retinol (µmol/L) of children fed RPO and massive vitamin A dose.

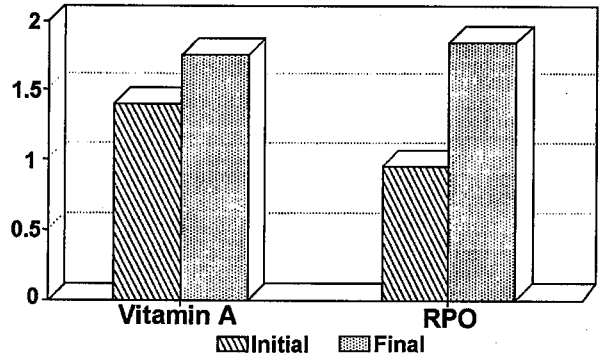
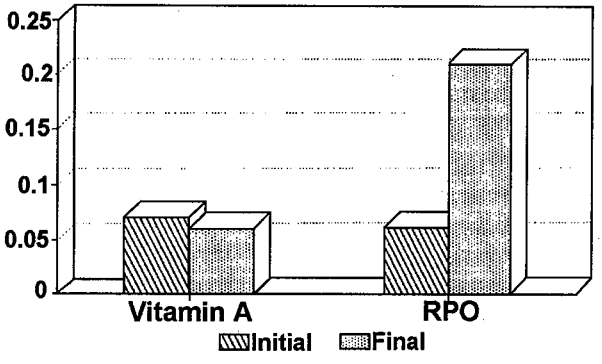


Figure 4. Mean β-carotene (µmol/L) of children fed RPO and massive vitamin A dose.



Discussion

Study 1

The efficiency of dispersion and absorption of vitamin A and β-carotene is affected by the presence or absence of many factors, among which fat in the diet is of utmost importance[12]. Fat provides the vehicle for transporting vitamin A and carotenoids from the stomach into the intestinal lumen, and is also the source of some of the digestion products which interact with bile salts and micelles and solubilize the vitamins. In this context RPO, which is a source of carotenoids in a fat medium, seems to serve as an ideal vehicle by simultaneously increasing the fat as well as pro-vitamin A intake. This probably explains the high efficiency of conversion of β-carotene to vitamin A, as demonstrated in this study.

Table 3. Mean serum retinol (µmol/l) levels of children fed red palm oil and massive vitamin a dose.

Groups	Initial (12)	Intermediate (12)	Final (12)
Massive vitamin A dose	$0.56^{a} \pm 0.11$	$1.07^{b} \pm 0.25$	$0.90^{b} \pm 0.23$
4 g RPO	$0.53^{a} \pm 0.12$	$1.05^{b} \pm 0.27$	$0.67^{a} \pm 0.10$
8 g RPO	$0.60^{a} \pm 0.13$	$1.79^{c} \pm 0.70$*	$0.97^{b} \pm 0.62$

Values are Mean ± SEM; Intermediate: After 1 month of supplementation; Final: 6 months after cessation of supplementation; letters in superscript indicate significantly different columns (P<0.01); * denotes significantly different rows (P<0.01); Figures in parenthesis indicate no. of subjects.

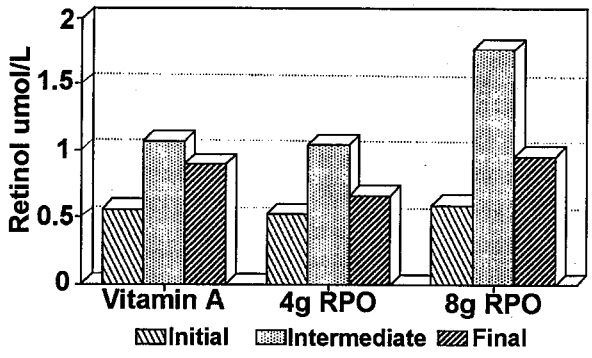
The DR/R ratio is a reflection of liver stores of vitamin A[9], and has been reported to be inversely proportional to retinol levels, providing a valid quantitative measure of vitamin A nutriture. 3,4-didehydroretinol (DR) is a ligand for binding accumulated apo-retinol binding protein (RBP) in vitamin A depleted liver. It is a naturally occurring analog of retinol which is found as an RBP complex in serum five hours after dosing. A ratio of > 0.03 was reported to be indicative of poor status. In this study, in both groups, DR/R ratio was >0.03 before supplementation, and decreased to 0.025 after supplementation. A clear indication has therefore been obtained that β-carotene from RPO is bioavailable and comparable to synthetic vitamin A in improving nutritional status.

Table 4. Percent distribution of children with serum retinol levels <0.7 µmol/L.

Groups	Initial (12)	Intermediate (12)	Final (12)
Massive vitamin A dose	92	0	0
4 g RPO	92	0	33
8 g RPO	83	0	0

Figures in parenthesis indicate no. of subjects.

Figure 5. Mean serum retinol (µmol/L) levels of children of three groups.



Pee *et al*[13], reported that β-carotene from dark green leafy vegetables was poorly absorbed in comparison with wafers enriched with synthetic β-carotene in lactating women with low hemoglobin status.

Hume and Krebs[14] stated that bioavailability of β-carotene from vegetables and carrots was only a third of that of β-carotene in oil. Since RPO is a fat in which β-carotene is naturally present, it appears to be more bioavailable, as indicated in the study.

Study 2

In this study, children belonging to the lower socio-economic group and having clinical signs of vitamin A deficiency were examined for both vitamin A and β-carotene after RPO supplementation. Both, retinol and β-carotene levels were high in RPO fed group. This indicates that RPO is supplying β-carotene not only for conversion to vitamin A, but these high circulating levels could come of use for it's other biological functions like anti-oxidant activity.

Study 3

This study was undertaken to ascertain whether high serum levels of retinol observed on RPO supplementation could sustain vitamin A status over a period of non-supplementation similar to vitamin A. When massive doses of vitamin A are administered once in six months, they afford protection till the next dose is given, because of the capability of the liver to store in the form of retinyl esters and release them as retinol bound to RBP when the need arises[15].

The results of this study indicate the possibility that RPO is able to afford similar protection at the end of six months of non-supplementation in the 8g RPO group which provided the same amount of vitamin A as control group. The 4g RPO group received only half the amount of vitamin A as the other two groups, hence serum retinol levels were depleted to marginal

values at the end of six months. 33% of children in this group had values < 0.7 μmol/L which is the cut-off point for normal vitamin A status.

Indications are that the children are ready for the next dose. It can be seen that both groups which received β-carotene from RPO sustained retinol levels for up to six months, but the only difference was that 8 g RPO group still had sufficient stores to maintain them on an adequate status for a further period.

All the above studies confirm the bio-availability of RPO carotenoids and prove that RPO is a good substitute for synthetic vitamin A in supplementation programmes and preventive therapy. Moreover, the third study indicates that probably smaller periods of intermittent supplementation of RPO may suffice to maintain adequate status, without the need for regular daily intake. This information could prove useful while planning programmes to combat vitamin A deficiency. However, long term studies on larger samples would yield more reliable information.

Conclusion

RPO is a unique vegetable oil with unusual benefits on health and nutrition. Its inclusion in supplementary feeding programmes to vulnerable children suffering from morbidity has been demonstrated to have profound effects. RPO not only improved vitamin A status and circulating β-carotene levels, but also afforded protection for as long as six months. Hence, it could be beneficial if RPO were promoted for consumption as a health food.

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紅棕櫚油對抗維生素A缺乏

摘要

紅棕櫚油〔Elaeis guineensis RPO〕富含β-葫蘿卜素〔400ppm〕，營養較優于其它食用油，因此，在發展中國家被選用以對抗維生素A缺乏．作者以學齡兒童爲對象，以甜小食喂RPO補充β-葫蘿卜素〔RDA 2400 μg〕2個月，比較補充前后的維生素A營養狀況．結果發現補充RPO 2個月后，血清視黃醇明顯增加．從0．86±0．14增至1．89±0．23微克分子量/升，與口服維生素A組比較，該組血清視黃醇從0．74±0．09增至1．94±0．21微克分子量/升．RPO組脱氫視黃醇/視黃醇比值〔DR/R〕從0．073±0．025減至0．023±0．003，而補充維生素A組則從0．095±0．023減至0．023±0．004，這顯示肝臟儲存視黃醇已達飽和狀態．

另一研究用RPO小食喂學齡兒童1個月，并與喂大劑量維生素A組比較，結果發現兩組血清視黃醇水平均明顯增高．RPO組血清β-葫蘿卜素從0．06±0．002增至0．21±0．01微克分子量/升，但維生素A喂養組保持不變．

第三個研究顯示RPO組與大劑量維生素喂養組相似，可提供長達6個月的保護作用．該研究以RPO小食喂學齡兒童1個月（每日β-葫蘿卜素2400 μg〕，可維持血清正常視黃醇水平，甚至停止補充6個月也是如此．如果用RPO小食補充β-葫蘿卜素50%的RDA，亦可維持血清正常視黃醇水平（>0．7微克分子量/升〕長達6個月之久．因此每年定期喂養RPO 2或3次，也許可維持全年維生素A充足狀態．作者得出結論，RPO在維持人群良好維生素A營養狀態是大有可能的．

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