Red palm oil for combating vitamin A deficiency

R Manorama¹, M Sarita and C Rulkini²

¹Center of Advanced Studies, Department of Foods and Nutrition, Post graduate and Research Centre, Andhra Pradesh Agricultural University, Rajendraranagar, Hyderabad, AP, India
²Pradhan University, Rajendranagar, Hyderabad, AP, India

Red palm oil (Elaeis guineensis, RPO) is nutritionally rich and superior in comparison with other edible oils as it has a high content of β-carotene (400 ppm). It is ideal 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 (240 μg) of β-carotene for ages 7-12 years. 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 red palm oil. In the latter group retinol levels increased from 0.74 ± 0.09 to 1.94 ± 0.33 μmol/L. Dose response (DRR) index was calculated and the results showed that both groups had increased their retinol levels. The results showed that RPO supplementation brought about a significant increase (P<0.05) from 0.96 ± 0.02 to 2.51 μmol/L. In the control group there was no difference observed after the dose.

Introduction
The prospects for augmenting the cultivation of red palm oil (RPO) in India’s warrant research into its nutritional and health benefits, and food uses of RPO. RPO is the unrefined, unbleached, thick, orange-colored oil extracted from the oil palm fruit with it’s carotenoid content intact. 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 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 carotenoids, and could serve as an excellent vehicle for vitamin A supplementation which has been reported to have beneficial effects on child mortality and morbidity. Vitamin A deficiency, despite being a preventable problem, continues to be a major public health problem in developing nations. Prevalence of xerophthalmia in India was reported to be 0.7%. A baseline survey for a vitamin A supplementation project, in Tamil Nadu, India, noted high xerophthalmic rates including night blindness (3.7%), BitorPont (7.2%) and total xerophthalmic rates 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. Undernourished, especially with respect to micronutrients like vitamin A, iron and iodine, persists in developing countries despite the rapid laps and bounds in production of food grains and food availability in counties like India. New and alternative sources of foods rich in micronutrients could alleviate these lacunae.

At the 1995 world summit for children, WHO and UNICEF emphasized 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 in the tropics, 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 a higher risk of death from common diseases, which is 20-35% higher than normal.

Thus, a detailed investigation was undertaken to evaluate the efficacy of RPO as a vitamin A supplement, its distribution could serve as one of the long term strategies to improve vitamin A status of children in India. A series of experiments were conducted to study the effect of RPO supplementation on vitamin A status.

Methods
Study 1
Two hundred children of 7-9 years of age comprising of twelve years 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 groups.

The first group was fed "suri khana" (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 vitamin A in addition to a piece of "suri khana" placebo made with GNO.

The snacks were distributed in the evening and above their normal diet which was vitamin A deficient. The Modified Relative Dose Response (MRDR) test was conducted to assess the vitamin A status of children with respect to micro-nutrients like vitamin A, iron and iodine, persists in developing countries despite the rapid laps and bounds in production of food grains and food availability in counties like India.

Results
Table 1. Serum retinol and DRR of children fed RPO and vitamin A.

<table>
<thead>
<tr>
<th>Group</th>
<th>Retinol (μmol/L)</th>
<th>DRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>Final</td>
<td></td>
</tr>
<tr>
<td>Vitamin A</td>
<td>0.74 ± 0.09</td>
<td>1.94 ± 0.23</td>
</tr>
<tr>
<td>Red Palm Oil</td>
<td>0.86 ± 0.13</td>
<td>1.89 ± 0.23</td>
</tr>
</tbody>
</table>

Values are Mean ± SEM. Apheresis in superscript indicates significant difference (P<0.05) between columns (retinol).

Consequences of increased PO supplementation for children fed red palm oil and olive oil in a study.

Correspondence address: R. Manorama, Assistant Professor, Department of Foods and Nutrition, Post Graduate and Research Centre, A.P. Agricultural University, Rajendraranagar, Hyderabad-500010.
Tel: 245317; Fax: 040-845831.
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R Manorama1, M Sarita and C Rukmini2
1Center of Advanced Studies, Department of Foods and Nutrition, Post graduate and Research Center, Andhra
2Pradesh Agricultural University, Rajendranagar, Hyderabad, AP, India

Red palm oil (Elaeis guineensis, RPO) is nutritionally rich and superior in comparison with other edible oils as it has a high content of β-carotene (400 ppm). It is ideal 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 (2040 μg) of β-carotene for children. A significant increase in serum retinol levels from 0.86 ± 0.14 to 1.89 ± 0.23 μmol/L, comparable with a control group fed red meat, was observed. Serum retinol levels increased from 0.74 ± 0.09 to 1.94 ± 0.35 μmol/L for the RPO group and from 0.95 ± 0.23 to 0.05 ± 0.01 μmol/L in the vitamin A group, indicating saturation of liver reserves of vitamin A. The cut-off point for inadequate status was <0.7 μmol/L.

In another study, school children fed RPO snacks for one month were compared with a group of children given vitamin A alone. Serum retinol levels increased significantly in both groups. Serum β-carotene increased from 0.86 ± 0.02 to 0.21 ± 0.01 μmol/L in the RPO group, but remained the same in the control group.

A third study indicated that RPO can afford protection for as long as six months, similar to vitamin A alone. School children fed RPO snacks 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 (>0.7 μmol/L) at the end of 6 months. Hence, periodic boosts of RPO feeding twice or three times 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 warrant research into its nutritional and health benefits, and food uses of RPO. RPO is the unrefined, unbleached, thick, orange colored oil extracted from the red palm oil fruit with its carotenoid content intact. 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 alive. 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. Vitamin A deficiency, despite being a preventable and preventable problem, continues to be a major public health problem in developing nations. Prevalence of xerophthalmia in India was reported to be 0.7%. A baseline survey for a vitamin A supplementation trial in Tamil Nadu, India, noted high xerophthalmic rates including night blindness (8.53%), Bitot’s spots (7.2%) and total xerophthalmic rates of 10.95%. Biochemical data from the same survey indicated that 37.5% had retinal levels <0.7 μmol/L.

The reason for continued prevalence is inadequate dietary intake. Understandably, especially of retinol of some 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 in countries like India. New and alternate sources of foods rich in micronutrients could alleviate these lacunae.

At the 1995 world summit for children, WHO and UNICEF emphasized 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 in sub-Saharan Africa, 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 lower resistance to infections and disease because of milder forms of deficiency, and are at a higher risk of death from common diseases, which is 20-35% 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 children. A series of experiments were conducted to study the effect of RPO supplementation on vitamin A status.

Methods

Study 1

The two 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 and sex matched groups. The first group was fed "safi 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 vitamin A in addition to a piece of "safi halwa" placebo made with GNO.

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 "safi 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 HPLC20,21.

Study 3

100 children (7-9 years) belonging to an interior village called "Nandha" in Puri, Bhavnagar, Gujarat, 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) administered 100,000 I.U. of vitamin A palmitate drops as a single massive dose.

Group 2 received 8 g RPO providing 100,000 I.U. of vitamin A from "safi halwa". 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, after cessation of supplementation.

Serum was analysed for retinol by HPLC20.

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

The 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 1.94 ± 0.021 μmol/L, DRR ratio decreased from 0.073 ± 0.025 to 0.025 ± 0.003 in the RPO group, and from 0.95 ± 0.023 to 0.023 ± 0.004 in the control group, indicating liver saturation with vitamin A in both groups.

Table 1. Serum retinol and DRR ratio of children fed RPO and vitamin A.

<table>
<thead>
<tr>
<th>Group</th>
<th>Retinol (μmol/L)</th>
<th>DRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>Final</td>
<td>Initial</td>
</tr>
<tr>
<td>RPO</td>
<td>0.74 ± 0.09</td>
<td>1.94 ± 0.023</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>0.86 ± 0.13</td>
<td>1.89 ± 0.023</td>
</tr>
</tbody>
</table>

Values are Mean ± SEM. Alphabets in superscript indicate significant differences (P<0.05) between columns (retinol).

* denotes significantly different (P<0.05) between columns (DRR). Figures in parenthesis indicate n of subjects.

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

<table>
<thead>
<tr>
<th>Group</th>
<th>Retinol</th>
<th>β-Carotene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>Final</td>
<td>Initial</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>1.40 ± 0.05</td>
<td>1.76 ± 0.09</td>
</tr>
<tr>
<td>Red Palm Oil</td>
<td>0.95 ± 0.05</td>
<td>1.85 ± 0.08</td>
</tr>
</tbody>
</table>

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 n of subjects.
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. 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 contrast to RPO, which is a source of carotenoids in a fat medium, systems 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.

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 be used for other biological functions like anti-oxidant activity.

Study 3

This study was undertaken to ascertain whether high retinol levels of β-carotone observed after 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 in once 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.

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 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 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. Further studies on larger scales 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 malnutrition 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.

Acknowledgements

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R. MANORAMA, M. SARITA, C. RUKMINI


Red palm oil (Elaeis guineensis RPO) contains β- carotene and other provitamin A, as well as other nutrients, which have been shown to improve vitamin A status. In this study, children were given red palm oil and their serum retinol levels were measured. The results showed that red palm oil increased the serum retinol levels significantly.

The authors concluded that red palm oil is a good source of vitamin A and can be used as a supplement to improve vitamin A status in children. The authors also suggested that red palm oil could be a viable alternative to synthetic vitamin A supplements in the treatment of vitamin A deficiency in children.

References

5. National Nutrition Monitoring Bureau (NNMB) Indian Council of Medical Research. India's Nutrition Resources: a fact sheet on vitamin A.

Bibliographic references for this article are not provided.
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, with 0.67% 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

Stud 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. Fat provides the vehicle for transporting vitamin A and carotenoids from the stomach to 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 contrast RPO, which is a source of carotenoids in a fat form, it 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 ± 0.14 | 1.07 ± 0.02 | 0.90 ± 0.23
4 g RPO | 0.57 ± 0.12 | 1.05 ± 0.07 | 0.67 ± 0.10
8 g RPO | 0.60 ± 0.13 | 1.09 ± 0.07 | 0.72 ± 0.62

Values are Mean ± SEM; Intermediate: After 3 months of supplementation; Final: 6 months from cessation of supplementation. *Indicates significantly different columns (P<0.01); **denotes significantly different rows (P<0.01). Figures in parenthesis indicate no. of subjects.

The DRR ratio is a reflection of liver stores of vitamin A, and has been reported to be inversely proportional to retinol levels, providing a valid quantitative measure of vitamin A stores. 3,4-didehydroretinol (DRD) 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 stored 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, both DRR ratio was >0.03 before supplementation, and decreased to 0.023 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.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Initial (12)</th>
<th>Intermediate (12)</th>
<th>Final (12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massive vitamin A</td>
<td>92 ± 0</td>
<td>0 ± 0</td>
<td>0 ± 0</td>
</tr>
<tr>
<td>4 g RPO</td>
<td>92 ± 0</td>
<td>0 ± 0</td>
<td>0 ± 0</td>
</tr>
<tr>
<td>8 g RPO</td>
<td>92 ± 0</td>
<td>0 ± 0</td>
<td>0 ± 0</td>
</tr>
</tbody>
</table>

Figures in parenthesis indicate no. of subjects.

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

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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 malnutrition has been demonstrated to have profound effects. RPO not only improved vitamin A status and circulating β-carotene levels, but also afforded protection for at least six months. Hence, it could be beneficial if RPO were promoted for consumption as a health food.

Acknowledgments

The authors acknowledge the help and encouragement given by Dr Vernon Reddy, former Director of the National Institute of Nutrition, ICMR, India. The technical help of Mr Indra Raveendran, Mr N B Nair Shaktar and Mr Chennaiah, Technical staff of the National Institute of Nutrition is also acknowledged. The cooperation rendered by Mr Pushkar Kamar Mohanty, Pathologist, Government Hospital, Bhubaneswar, Oas, Mr PK Mahapatra, Mr D Sanyasi, Director, Regional medical research centre, Bhubaneswar, and Dr Arundhita Mahapatra is acknowledged. The authors thank the Indian Council of Agricultural and Medical Research for financial assistance.

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Reference