RED PALM-OIL A PANACEA FOR VITAMIN A DEFICIENCY

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INDIA
Oil palm-the world’s No. 1 fruit crop!

• Unparalleled productivity
• Uses-Excellent health food products to engine lubricants to cosmetics
• **Malaysia and Indonesia are the largest producers**
Advent of Oil palm in India

- End of the 19th century in Botanical gardens, Calcutta
- The first oil palm plantation was raised in a systematic manner in 40 ha area by the State Department of Agriculture, Government of Kerala at Thodupuzha in 1960s
- A specially constituted team had identified 7.96 lakh ha in nine states as potential area under the irrigated condition
- The total area existing under oil palm in the country during 2005 was 63513 ha
NRCOP

• NATIONAL RESEARCH CENTER FOR OIL PALM WAS SET UP IN ANDHRA PRADESH IN 1995

• THE OBJECTIVE WAS TO CATER TO THE NEEDS OF OIL PALM RESEARCH UNDER NON-TRADITIONAL ENVIRONMENTS
VALUE ADDITION OF PALM OIL FOR EDIBLE PURPOSES

• (A) Edible grade RPO
• (B) Deacidified, deodourised RPOlein
• (C) Isolated carotenoids, tocopherols and tocotrienols
• (D) Refined palmolein oil
NUTRITIONALLY RICH RED PALM OIL

- β-CAROTENE (500-700 µg/g)
- TOCOPHEROLS AND TOCOTRIENOLS (1100 µg/g)
- 10% PUFA (Linoleic)
- 40% MUFA (Oleic)
- 50% SFA (Palmitic and stearic)
CAROTENOIDS FROM DIFFERENT SOURCES (mg/100g)
BENEFITS OF CAROTENOIDS

- VITAMIN A PRECURSORS
- POWERFUL ANTI-OXIDANTS
- SINGLET OXYGEN QUENCHERS
- NATURAL COLOURANTS
WHY DO WE NEED VITAMIN A?

- Vision and eye health
- Normal cell division
- Growth
- Reproduction and fertility
- Immune system function
- Skin and mucous membrane health
The global scenario of Vitamin A deficiency
THE CONSEQUENCES!

- DIETARY INSUFFICIENCY CAUSING HIDDEN HUNGER
- POOR HEALTH DUE TO INFECTIONS AND ILLNESSES LIKE DIARRHOEA, ARI AND MEASLES
- COMPROMISED IMMUNE FUNCTIONS THAT INCREASE THE RISK OF MORBIDITY AND MORTALITY
- IMPAIRED COGNITIVE DEVELOPMENT AND GROWTH
- REDUCED REPRODUCTIVE AND WORK CAPACITY AND PERFORMANCE
- GRAVE SOCIAL AND ECONOMIC CONSEQUENCES
1. Night Blindness | Difficulty seeing in the dark.
2. Xerosis (Dry Eyes) | The white of the eye loses its shine and begins to wrinkle.
3. Bitot's Spots | Patches of little gray bubbles on the whites of the eye.
4. Corneal Ulceration | Dullness or damage to the cornea.
5. Keratomalacia | Soft or bulging cornea leading to complete blindness.
THE STATISTICS!

- **254 MILLION CHILDREN WORLDWIDE UNDER 5 YEARS OF AGE HAVE CLINICAL, SEVERE OR MODERATE SUB-CLINICAL VAD**

- **5-7% OF INDIAN CHILDREN SUFFER FROM VARYING DEGREES OF EYE DISORDERS ASSOCIATED WITH VAD**

- **THE DEFICIENCY VARIES FROM 0.3 – 3.6 %**

- **INDIA HAS BY FAR THE LARGEST PERCENTAGE AS WELL AS THE LARGEST ABSOLUTE NUMBER OF VITAMIN A DEFICIENT CHILDREN**
PREVALENCE

**Figure 4**

- % children under 6 years estimated to be vitamin A deficient

<table>
<thead>
<tr>
<th>Region</th>
<th>1990</th>
<th>1995</th>
<th>2000</th>
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</thead>
<tbody>
<tr>
<td>Sub-Saharan Africa</td>
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<td></td>
<td></td>
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<tr>
<td>Middle East and North Africa</td>
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<td></td>
<td></td>
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<tr>
<td>South Asia (without India)</td>
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<td></td>
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<tr>
<td>India</td>
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<td></td>
<td></td>
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<tr>
<td>South East Asia (without China)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central America and Caribbean</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Eastern Europe and Central Asia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
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</table>
IMPACT OF VITAMIN A DEFICIENCY

- 250 MILLION AT RISK OF DEATH
- ½ MILLION CHILDREN
- ¼ MILLION CHILDREN

- BLINDNESS DUE TO VITAMIN A DEFICIENCY
- LOWERED RESISTANCE TO INFECTIONS LIKE MEASLES, DIARRHOEA AND ACUTE RESPIRATORY INFECTIONS

DEATH DUE TO COMMON DISEASES
The UN Special Session on Children in 2002 set as one of its goals the elimination of vitamin A deficiency and its consequences by the year 2010.

We are nowhere near achieving the goal!
GLOBAL STRATEGIES

• DIETARY DIVERSIFICATION

• SUPPLEMENTATION

• FOOD FORTIFICATION

• EDUCATIONAL INITIATIVES TO PROMOTE CONSUMPTION OF VITAMIN A/β-CAROTENE RICH FOODS
OIL BLENDS

- Carotino Red Palm & Canola Oil
STRATEGIES THAT COULD BE LINKED TO OTHER PUBLIC HEALTH EFFORTS

- IMMUNIZATION PROGRAMMES THAT INCLUDE DISTRIBUTION OF SUPPLEMENTS TO VULNERABLE GROUPS

- DIARRHOEA CONTROL PROGRAMMES THAT ENHANCE VITAMIN A CONSERVATION

- IMPROVED SANITATION AND PROMOTION OF BREAST FEEDING
IDEAL SUSTAINABLE LONG TERM SOLUTION ACHIEVABLE THROUGH:

- INTRODUCTION OF NEW CROPS – BIOTECHNOLOGICAL APPROACHES
- BETTER COOKING AND PRESERVATION METHODS
- VARIED DIETS THROUGH NUTRITION EDUCATION
- TAPPING OF CORPORATE SOCIAL RESPONSIBILITY FOR PUBLICITY, BETTER COMMUNICATION OF HEALTH AND NUTRITION FACTS, ETC
Golden Rice
A Ray of light for night blindness
The Science behind......

Pathway engineering for development of Golden rice
Moving genes from biological gene pool to rice genome.....
GR Humanitarian Board – Facilitator of technology diffusion

- For making Golden Rice technology freely available to those who need it
- To ensure proper investigation of Golden Rice as a potential solution to VAD
- To support developing countries and national research institutes in Golden Rice research
- To facilitate information sharing between golden Rice projects in different parts of the world

Chair
1. Prof. Ingo Potrykus
2. Prof. Peter Beyer

Members
1. Dr. Ronnie Coffman, Cornell University
2. Dr. Adrian Dubock, Sygenta (Secretary)
3. Dr. William Padolina, IRRI
4. Dr. Ashok Seth, World Bank
5. Dr. Gary Toenniessen, Rockefeller
6. Dr. Gerard Barry, Network Coordinator, IRRI
Golden Rice Technology - Pros

- First example transgenic technology for direct benefit to the consumer
- A perfect role-model for public sector - Private sector interactions
- Has a great potential to complement the existing efforts for combating VAD
- Can still meet the Vit A requirements of poorest of the poor, if provided by the Government through PDS
Golden rice technology - Cons

- The effects of transgene products - β-carotene, lutein, zeaxanthin etc., on human health is yet to be assessed
- The introduction of the technology may serve as a Trojan horse for the entry of more lucrative GM technologies (Bt rice) of the Agri-biotech corporates
- The data on bioavailability of β-carotene in the transgenic rice grain is still forthcoming
Voices against Golden Rice........

Are they justified?

"Genetically Engineered 'Golden Rice' is Fool's Gold"

Greenpeace Statement
February 9, 2001

Greenpeace calculations show however, that an adult would have to eat at least 3.7 kilos of dry weight rice, i.e. around 9 kilos of cooked rice, to satisfy his/her daily need of vitamin A from "Golden Rice". In other words, a normal daily intake of 300 gram of rice would, at best, provide 8% percent of the vitamin A needed daily. A breast-feeding woman would have to eat at least 6.3 kilos in dry weight, converting to nearly 18 kilos of cooked rice per day. (3)

All That Glitters is Not Gold: The False Hope of “Golden Rice”
(short version)

On the contrary, the GE Rice could, if introduced on a large scale, exacerbate malnutrition and undermine food security because it encourages a diet based on one staple food rather than the reintroduction of the many vitamin-rich food plants that were once cheap and readily available. These plants could address a wide variety of micronutrient deficiencies, not just VAD.
CRUDE PALM OIL: NUTRITIONAL AND TOXICOLOGICAL STUDIES IN RATS

- NO ADVERSE EFFECTS ON GROWTH AND BODY WEIGHTS AFTER 90 DAYS FEEDING
- DECREASING EFFECTS ON LIPID PROFILE
- LOWERED HMG-COA REDUCTASE
BIOSAFETY STUDIES

- NO ABNORMALITIES IN ORGAN WEIGHTS
- NORMAL REPRODUCTIVE PERFORMANCE
- NORMAL HEMATOLOGY
- NORMAL HISTOPATHOLOGY
- OIL HEATED UPTO 6, 12, 18 AND 24 HOURS DID NOT PRODUCE ANY MUTAGENICITY in the AMES BACTERIAL SYSTEM OF REVERSE MUTAGENESIS
ACCEPTABILITY OF CRUDE PALM

RPO is acceptable in most Indian preparations like curries, sweet and savory snacks and main meal items as judged by a panel of experts at the National institute of nutrition
### ACCEPTABILITY OF RPO BLENDS

<table>
<thead>
<tr>
<th>BLENDS</th>
<th>ACCEPTABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPO : SFO/GNO</td>
<td></td>
</tr>
<tr>
<td>100 : 0</td>
<td>NOT VERY GOOD</td>
</tr>
<tr>
<td>70 : 30</td>
<td>MODERATE</td>
</tr>
<tr>
<td>50 : 50</td>
<td>MODERATE</td>
</tr>
<tr>
<td>30 : 70</td>
<td>GOOD</td>
</tr>
</tbody>
</table>
STABILITY OF CAROTENES IN PREPARATIONS

• Total and β-carotene content of RPO was found to be stable and retained upto 90% after one year of storage at room temperature in brown bottles.

• Some common Indian preparations incorporated with RPO was found to retain 70 to 90% of total as well as β-carotene.

• Deep fat frying, however, is not advisable as the carotenes are lost and degraded upon continuous heating.
## STABILITY OF CAROTENES AND TOCOPHEROLS

(Sarojini et al, 1996)

<table>
<thead>
<tr>
<th>FOOD ITEMS TESTED</th>
<th>TOTAL CAROTENE (percentage retention)</th>
<th>β-CAROTENE</th>
<th>TOTAL TOCOPHEROLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAKES</td>
<td>78-83</td>
<td>35-85</td>
<td>33-90</td>
</tr>
<tr>
<td>BISCUITS</td>
<td>71-86</td>
<td>61-86</td>
<td>30-87</td>
</tr>
<tr>
<td>SWEETS</td>
<td>52-81</td>
<td>60-90</td>
<td>35-86</td>
</tr>
<tr>
<td>PICKLES</td>
<td>50-71</td>
<td>33-67</td>
<td>55-84</td>
</tr>
</tbody>
</table>
ACROLEIN FORMATION
Abraham et al, 2011

• A 2009 study[^40] tested the emission rates of ACROLEIN, a toxic and malodorous breakdown product from GLYCEROL, from the deep-frying of potatoes in red palm, olive, and polyunsaturated sunflower oils.

• The study found higher acrolein emission rates from the polyunsaturated sunflower oil and lower rates from both palm and olive oils.

• The WHO established a tolerable oral acrolein intake of 7.5 mg/day per kilogram of body weight.

• Although acrolein occurs in FRENCH FRIES, the levels were only a few micrograms per kilogram.

• The 2011 study concluded a health risk from acrolein in food is unlikely.
BIOAVAILABILITY

- RPO FEEDING RESTORES NORMAL VITAMIN A LEVELS IN SERUM AND LIVER

- RPO FEEDING AFFORDS PROTECTION UPTO SIX MONTHS BY REPLENISHING LIVER STORES OF VITAMIN A
FIG. 4. Increases in serum retinol levels in schoolchildren given a dose of vitamin A or a snack containing RPO daily for 60 days

FIG. 5. Decreases in DR:R ratios in schoolchildren given a dose of vitamin A or a snack containing RPO daily for 60 days
Pretreatment with Phos. acid

Neutralization with NaOH

Deodourised under mild heat treatment and vacuum

Carotene retention of about 75%
EFFECT OF DDRPO ON LIPID PROFILE VITAMIN A OF NORMAL ADULTS

BASELINE BLOOD COLLECTION AND ANALYSIS

15 DAYS SNO; BLOOD COLLECTION AND ANALYSIS

EIGHTEEN HEALTHY MEN AND WOMEN

15 DAYS RPO; BLOOD COLLECTION AND ANALYSIS

15 DAYS GHEE; BLOOD COLLECTION AND ANALYSIS

15 DAYS SNO; BLOOD COLLECTION AND ANALYSIS
SERUM LIPIDS (mmol/l) OF SUBJECTS
RETINOL, TOCOPHEROL AND β-CAROTENE
EFFECT OF VITAMIN A DEFICIENCY AND LOW IRON STATUS

• LOWER THE BODY’S RESISTANCE TO INFECTIONS
• INCREASES MORTALITY AND MORBIDITY
• IMPAIRED PHYSICAL AND COGNITIVE DEVELOPMENT
• REDUCED GROWTH
• REDUCED WORK CAPACITY
• DEATH ASSOCIATED WITH PREGNANCY AND CHILD BIRTH
• LOW BIRTH WEIGHT
• FOETAL MORTALITY AND MORBIDITY
INTERACTION OF VITAMIN A AND IRON

- Iron supplementation to anaemic and vitamin A deficient subjects results in exacerbation of existing infections due to competition of pathogenic bacteria for circulation of iron.

- In vitamin A deficiency, liver iron storage increases making it unavailable for incorporation into hemoglobin.

- Better vitamin A status results in reduced infection.
EFFECT OF IRON AND DDRP0 SUPPLEMENTATION TO ANEMIC ADOLESCENT GIRLS

30 DAYS PLACEBO

45 DAYS IRON

45 DAYS RPO + IRON

45 DAYS RPO + Iron + Vitamin C

EIGHTEEN ANAEMIC ADOLESCENT GIRLS
HEMOGLOBIN, RETINOL AND β-CAROTENE LEVELS

HEMOGLOBIN (G/L)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>HemoGlobin (G/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>109.37</td>
</tr>
<tr>
<td>Placebo</td>
<td>84.75</td>
</tr>
<tr>
<td>Iron</td>
<td>116.83</td>
</tr>
<tr>
<td>Iron + RPO</td>
<td>120.72</td>
</tr>
<tr>
<td>Iron + RPO + Vit C</td>
<td></td>
</tr>
</tbody>
</table>

RETINOL (umol/L)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Retinol (umol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>0.56</td>
</tr>
<tr>
<td>Placebo</td>
<td>0.45</td>
</tr>
<tr>
<td>Iron</td>
<td>0.37</td>
</tr>
<tr>
<td>Iron + RPO</td>
<td>1.03</td>
</tr>
<tr>
<td>Iron + RPO + Vit C</td>
<td></td>
</tr>
</tbody>
</table>

B-CAROTENE (umol/L)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>BCAROTENE (umol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>0.185</td>
</tr>
<tr>
<td>Placebo</td>
<td>0.221</td>
</tr>
<tr>
<td>Iron</td>
<td>0.221</td>
</tr>
<tr>
<td>Iron + RPO</td>
<td>0.185</td>
</tr>
<tr>
<td>Iron + RPO + Vit C</td>
<td>0.221</td>
</tr>
</tbody>
</table>
PURIFICATION OF CAROTENES

- Saponification with 17% methanolic KOH
- Transesterification
- Extraction of carotene rich methyl esters with organic solvent
- Release of fatty acids as soaps/detergents/softeners
- Concentration and alumina column purification of CAROTENES by chromatography
OPEN COLUMN CHROMATOGRAPHY

- PETROLEUM ETHER (MOBILE PHASE) AND ACTIVATED ALUMINA COLUMN WITH A STEPWISE GRADIENT OF 0-3% DIETHYL ETHER YIELDED:
  - (1) β-carotene
  - (2) α-carotene
  - (3) β-zeacarotene
  - (4) ξ-carotene
  - (5) Phytoene
BIOTECHNOLOGY?

- Plants as cell factories for production of high value carotenoids?
- Genetic modification relies on the basic biochemical knowledge of carotenoid biosynthesis and regulation of the pathway
- Major limitation is poor knowledge of regulation of endogenous carotenogenic gene expression
Crops already studied

- Tomato
- Arabidopsis thaliana
- Citrus fruits
- Cauliflower
- Maize
- Canola
- Carrot
- Daffodils, marigold, narcissus
- Potato
- Sweet potato
- Rice

REGULATION OF THE PATHWAY

• Metabolic engineering experiments have shed light on regulatory mechanisms
• Qualitative and quantitative changes occur during fruit ripening
• Expression of carotenoid biosynthetic genes increases concurrently with ripening
• Transcriptional regulation is important in controlling carotenoid formation in tissues
Engineering carotenoid content in crops

- Nutritionally important and high-value carotenoids can be altered and generated in crops
- Use of tissue specific promoters reduce unintended effects
- Use of non-homologous target genes overcomes genetic effects like gene silencing/co-suppression
... in the early 21st century 500‘000 children per year become blind and 6‘000 per day die from vitamin A-malnutrition.

This could be prevented.
GLOBAL INITIATIVES

• Global efforts to support national governments in addressing vitamin A deficiency are led by the Global Alliance for Vitamin A (GAVA), which is an informal partnership between A2Z, the Canadian International Development Agency, Helen Keller International, Micronutrient Initiative, UNICEF, USAID, and the World Bank.

• Joint GAVA activity is coordinated by the Micronutrient Initiative.

• Vitamin Angels has committed itself to eradicating childhood blindness due to Vitamin A deficiency on the planet by the year 2020. Operation 20/20 was launched in 2007 and will cover 18 countries.

• The program gives children two high dose vitamin A and anti-parasitic supplements (twice a year for four years), which provides children with enough of the nutrient during their most vulnerable years in order to prevent them from going blind and suffering from other life-threatening diseases caused by Vitamin A Deficiency.
• About 75 per cent of the vitamin A required for supplementation activity by developing countries is supplied by the Micronutrient Initiative with support from the Canadian International Development Agency.

• An estimated 1.25 million deaths due to vitamin A deficiency have been averted in 40 countries since 1998.

• In 2008 it was estimated that an annual investment of US$60 million in vitamin A and zinc supplementation combined would yield benefits of more than US$1 billion per year, with every dollar spent generating benefits of more than US$17.

• These combined interventions were ranked by the Copenhagen Consensus 2008 as the world’s best development investment.
WHY NOT RED INVEST IN RED PALM OIL ???????

- FAO
- WHO
- UNICEF AND OTHERS ALREADY MENTIONED

- Procure Red Palm Oil from Malaysia and distribute to countries where Vitamin A deficiency is rampant ????????
Let us make a concerted effort!
Science is always OPTIMISTIC, so are the Scientists

Thank You........