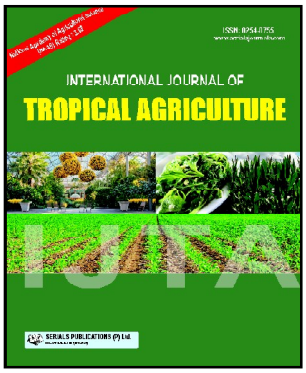

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Sustainable Remedy of Vitamin A Deficiency Through Biofortified Golden Sweet Potato

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Abstract: India is the top Asian country for Vitamin A deficiency (VAD) as 60,000 children go blind annually due to it. Eye diseases like night blindness, bitot spot, xerothalmia and others are also caused by VAD. Among poor children in Gorakhpur, VAD averages to 42%, as high as 73% in primary schools. Government of India supported by international organizations distributed free vitamin A capsule but failed due costs, distribution and corruption. Sustainable solution is popularization of Orange Fleshed Sweet Potato (OFSP) or Golden Sweet Potato (GSP) or *Sunhari Shakarkand*, which have yellow-orange flesh due to very high level of β-carotene (precursor of Vitamin A). Besides, GSP produces more edible energy per unit area than any other crop and can grow throughout the year. PRDF tested more than 50 GSP varieties and identified ST-14, CIP-440127 and VA-43 adapted to the region. 18 products of leaves and tubers have been developed, "VitA Snacks" being the top one. 50 grams of these products provides daily need of children, reveal the lab analyses.

Key words: Eye diseases, Biofortification, Golden Sweet Potato, OFSP, Vitamin A deficiency.

INTRODUCTION

Vitamin A deficiency is one of the most damaging forms of undernourishment [18]. Among infant and children vitamin A deficiency results into eye problem and blindness. An estimated 190 million pre-school children and 90 million pregnant women are affected globally. In India 60,000 children go blind each year due to vitamin A deficiency (www.microneutrient.org). Other than complete blindness, a number of eye diseases like night blindness, partial blindness, bitot spot, Xerothalmia, stunting, inadequate energy uptake, subnormal

functioning of the immune and reproductive systems are caused by vitamin A deficiency. More than 6% children in Uttar Pradesh suffer from clinical vitamin A deficiency, which is highest even among Indian states.

Regarding malady of vitamin A deficiency, India is lumped with African countries while the developed world is almost free of it. B. R. D. Medical College, Gorakhpur did excellent studies during 1985-1998. Gupta [7] estimated the prevalence of vitamin A deficiency in different age groups at Gorakhpur, based on hospitalized children for diarrhoea related diseases (Table 1). Sharma [14] estimated the prevalence of vitamin A deficiency among children of 3-5 years' age group of Gorakhpur at 10.97%. Night blindness in children observed was 5.5%, conjuctival xerosis in 15.74%, Bitot's spot in 4.72% cases with active corneal involvement in 14.94% children [5]. Kansal [7] studied the prevalence of vitamin A deficiency among rural and urban population at Gorakhpur. Overall prevalence of vitamin A deficiency was 6.8% under 5 years of age and it was more prevalent in rural areas (9.3%) than urban areas (3.1%).

Table 1
Vitamin A deficiency among hospitalised children suffering with diarrhoea in Medical College Gorakhpur [5]

S. No.	*Age group*	*Children suffering from vitamin A deficiency*
1	2 month-1 year	10%
2	1-2 year	43.3%
3	2-3 year	45.8%
4	3-4 year	61.9%
5	4-5 year	53.8%
6	5-6 year	55.3%
	Average	40.9%

Table 2
Nutritional value of common Golden Sweet Potato (per 100 g of fresh tuber); mg = milligram; % indicates daily dietary requirement of an adult (Data source: USDA, CTCRI)

Nutrient	*Value*	*Nutrient*	*Value*
Energy	359 kJ (86 kcal)	Sugars	4.2 g
Carbohydrate	20.1 g	Dietary fibre	3 g
Starch	12.7 g	Fat	0.1 g
β-carotene	20 mg (283%)	Protein	1.6 g
Thiamine (B1)	0.078 mg (7%)	Calcium	30 mg (3%)
Riboflavin (B2)	0.061 mg (5%)	Iron	0.61 mg (5%)
Niacin (B3)	0.557 mg (4%)	Magnesium	25 mg (7%)
Pantothenic acid (B5)	0.8 mg (16%)	Manganese	0.258 mg (12%)
Vitamin B6	0.209 (16%)	Phosphorus	47 mg (7%)
Folate (B9)	11 ug (3%)	Potassium	337 mg (7%)
Vitamin C	2.4 mg (3%)	Sodium	55 mg (4%)
Vitamin E	0.26 mg (2%)	Zinc	0.3 mg (3%)

OFSP POSSIBLE SOLUTION FOR THE MALADY

Sweet potato (*Ipomoea batatas* L. Lam), the second most important root tuber of the world, but in India categorized as "poor man's food" or "famine crop", has tremendous potential to contribute to a food based approach to promote food and nutrition security. It has diverse range of positive attributes like high yield with limited inputs, short duration, high nutritional value and tolerance to various biotic and abiotic stresses. Orange-fleshed sweet potato (OFSP) is now emerging as an important type of sweet potato to tackle the problem of vitamin A deficiency as noted by Mukherjee *et. al.* [11, 12]. Apart from being rich source of vitamin A in the form of β-carotene (Table 2), benefits may also occur from other health enhancing features of sweet potato like adequate calories, vitamin C, vitamin D and micronutrients such as iron and zinc. The various preparations of OFSP tubers and tender leaves and vine could also be eaten [2] . Thus, the poor people having only limited access to the expensive vitamin A rich animal foods like fish oil, egg, and cow milk

or plant products like papaya, mango, carrot etc. can consume it. As a biofortified crop many African countries are using it to alleviate Vitamin A malnutrition [4].

Orange-fleshed Sweet Potato (OFSP) is potential solution [13, 15, 16, 17, 11, 12, 8] with rich β-carotene, which is converted to vitamin A by the human body (Table 2). 100 g of sweet potato may supply enough β-carotene to satisfy 0 to 100% of the daily-required amount of vitamin A, depending on the β-carotene content of the sweet potato variety used [12]. It is estimated that 300-450 micro-gram equivalents of retinol per day satisfy the daily requirements for infants up to 10 years old, which is equivalent to about 2100-2400 micro-grams of β-carotene. Usually a ratio of 4:1 to 8:1 is used to convert β-carotene into retinol since not all β-carotene can be converted by the human body. Therefore 100-120 g of a yellow flesh sweet potato containing 2500 micro-gram/100 g fresh weight of β-carotene is adequate to meet the daily requirement of Vitamin A [ ]. Regular intake of 100g per day orange-fleshed sweet potato roots provides the recommended daily dose of vitamin A for children [6, 9, 10]. Current level of VAD in schools is alarming (Table 3).

MATERIAL AND METHODS

Available exotic and indigenous cultivars of OFSP were tested in two locations during Kharif 2014-15, Kharif 2015-16 and Kharif 2016-17 in randomized block design with two replications (Table 4). Plot

Table 3
Baseline survey of vitamin A deficiency in the project area in Gorakhpur and Sant Kabir Nagar districts (Ophthalmologists: Dr. Anita Khan and Dr. K. P. Singh) project Area in November, 2015

	Gorakhpur: Ramnagar – Karjahan				*Sant Kabir Nagar: Kateya Primary School*			
Age Group	*Beneficiaries + Students*	*Normal*	*Bitot Spot*	*VAD*	*Primary Student*	*Normal*	*Bitot Spot*	*VAD*
00 – 10	67	47	20	–	118	45	2	71
11 – 20	10	7	3	–				
21 – 40	52	14	–	38				
41 – 60	31	17		14				
61- Ab.	2	1	0	1				
Total	162	86(53%)	23(14%)	53 (33%)	118	45(38%)	2 (1%)	71(60 %)

Table 4
ANOVA for yield (kg/ha) of OFSP in Gorakhpur, and Sant Kabir Nagar, during 2014, 2015 and 2016

		Ramnagar Karjahan, Gorakhpur			*Khairgar, Sant Kabir Nagar*		
	D. F.	*Variance Ratio*			*Variance Ratio*		
Factor	*Year*	*2014*	*2015*	*2016*	*2014*	*2015*	*2016*
Replication	1	18.779	1.452	1.566	0.702	0.147	0.019
Treatment	10	9.779 **	2.936 **	4.866**	21.05**	6.020**	3.476**
Error	10	–	–	–	–	–	–
Total	21	–	–	–	–	–	–

** Highly significant at 1% P.

size for each test entry was 2.5m × 1.35 meters = 3.375 m^2 and normal crop care was taken. The crop was dug out after 120 days and tuber yield (kg/plot) was recorded. The prevalence of Vitamin A deficiency (VAD) was surveyed in the project areas in Gorakhpur and Sant Kabir Nagar districts of eastern U.P. using qualified Ophthalmologists. They based their observations on the presence of "Bitot Spot" and general symptoms Vitamin A Deficiency (VAD). School children and beneficiaries were examined for it to create a baseline (Table 3).

RESULTS AND DISCUSSION

Baseline Survey for Vitamin A Deficiency

To create a baseline of current status of vitamin A deficiency in the project a survey was conducted in Gorakhpur and Sant Kabir Nagar districts. Beneficiaries and school, children were examined by qualified ophthalmologists. Though the period conceded with the season when green leafy vegetables are consumed maximum, still the vitamin A deficiency was noticeable (Table 3) in form of Bitot's Sport and Vitamin A Deficiency syndrome (VAD). It was surprising to note that in Ramnagar Karjahan primary school, 23% children were spotted with Bitot's Spot and 33% with VAD. In Kataya Primary school though Bitot Spot was only 1% yet 60% children were diagnosed with VAD.

VARIETAL INTRODUCTION AND TESTING

During the years 2003 to 2005 more than 50 varieties were introduced through CIP New Delhi office and tested by PRDF in farmers' fields but none of these had acceptable levels of yield and β-carotene. Therefore, these were rejected and fresh introduction were made. After due verification trials a manual on cultivation of OFSP was developed by Chaudhary *et. al.* [1]. During the year 2014 out of 11 breeding lines and varieties tested at 2 locations ST-14, PRDFS-1, PRDF-S2, Shree Kanaka, CIP440127 and Gauri yielded satisfactory (Table 4). Significant variations in yield of the tubers were observed among the genotypes of orange-fleshed sweet potato (Table 4). Based on the yield and β-carotene content ST-14, Shree Kanaka, PRDFS-1 and CIP440127 were repeat tested during Kharif 2015 along with the new introductions (Table 5). Kharif 2015 was drought year thus yield levels were low yet ST-14, CIP440127 and VA43 showed promise. These varieties were selected for further multiplication and distribution among farmers.

POPULARISING OFSP

Sweet potato can be grown three times annually using the poor soils and rainfed agriculture. In the selected villages farmers are well aware of sweet potato growing. Thus introduction of OFSP simply meant change of the variety. Sweet potato weevil is the most serious pest, which was controlled by supplying pest free planting material. Nurseries and multiplication systems have been developed by Chaudhary *et. al.* [1] using farmers in varied locality to produce maximum quantity of planting material. Farmers were trained and demonstrations were done on their fields. Most importantly a system of round the year cultivation and variety multiplication using normal land to riverbeds and riversides were amalgamated for moving around the planting for making available the planting materials. A system of using vine multipliers was developed by supplying them clean planting material grown in project's screen houses.

PRODUCT AND PRODUCTION

Schools were chosen as the entry points for popularization of the new nutritious products using OFSP plat parts (Table 6). The trained girls will prepare at their homes and the chosen product will move from home to homes and village-to-village. OFSP product development entrepreneurs and whole sellers are vital to the profitability of the beneficiaries. In shortest run it will encourage some

Table 5
Yield (kg/plot) of various varieties tested at two locations in Gorakhpur and Sant Kabir Nagar districts during the years 2014, 2015 and 2016

	Variety/Village	*Ramnagar Karjahan, Gorakhpur*			*Khairgar, Sant Kabir Nagar*				
S. No.	*Year*	*2014*	*2015*	*2016*	*2014*	*2015*	*2016*	*Mean yield*	*Dry Matter % (in tubers)*
1.	ST-14	0.705	1.718*	1.495*	8.268	2.886	4.669	3.290	28.55
2.	PRDF -S1	4.099	0.211	1.377	14.518	0.653	4.774	4.272	22.42
3.	Shree Kanaka	2.245	0.951*	0.644	7.299	0.00	2.552	2.281	23.52
4.	CIP 440127	5.558	2.084*	8.786*	44.64*	10.145*	38.696 *	18.318	18.23
5.	PRDF-S2	2.047	–	0.557	6.047	–	0.790	2.360	–
6.	Kanpur Hybrid	6.048	0.046	1.439	2.446	3.248	15.037	4.710	–
7.	Local Red	0.00	0.156	6.76*	10.188	0.061	29.975	7.939	–
8.	ST-13	0.032	–	–	1.075	–	–	0.553	–
9.	Ranchi Local	3.901	–	–	17.568	–	–	10.734	–
10.	Gauri	3.816	–	–	7.975	–	–	5.895	–
11.	PRDF-S3	0.999	–	–	1.650	–	–	1.324	–
12.	VA 43	–	1.849*	5.499*	–	6.122*	21.522*	8.748	18.97
13.	Roshani	–	0.065	–	–	0.00	–	0.033	–
14.	Ujjawal	–	0.00	–	–	1.587	–	0.790	25.42
15.	GSP 15	–	0.118	–	–	0.614	–	0.141	–
16.	VA 44	–	0.413	–	–	3.046	–	1.729	19.69
17.	Kamla Sundari	–	–	0.649	–	–	4.749	2.699	–
18.	PRDF -D5	–	–	0.681	–	–	3.981	2.331	–
19.	GSP-20	–	–	0.370	–	–	0.00	0.185	–
	CD	1.131	0.308	0.953	4.188	0.905	4.483	–	–

* Significantly different at 5% P.

women to produce commercial quantity of the products and local entrepreneurs will develop for Orange fleshed sweet potato products. A total of 15 of products using leaves (*pakora*, green vegetable) and tubers (chips, cutlets, *gulab jamun*, *halwa*, , jam, juice, *kheer*, noodles, pickle, *sabji*, salty fries, *samosa*, sauce sweet dimons, and sweet fries) were developed by Chaudhary *et. al.* [2, 3]. Home Science students in the local intermediate colleges were trained (Table 7). This made excellent entry point for the new products to become popular. More needs to be done on research and awareness front as discussed by Chaudhary *et. al.* [3].

CONCLUSIONS

Malady of Vitamin A is rampant in eastern part of U. P. and awareness need to be generated about its ill effects and ways to ameliorate through consuming OFSP. Many breeding lines were introduced and tested for 2 years in Gorakhpur and Sant Kabir Nagar districts of U. P. Superior ones like ST-14, CIP 440127, VA 43, and PRDF S1 were identified and being distributed to farmers on large scale. System of vine multiplication was streamlined to supply healthy planting material on a sustainable basis. More than 300 farmers were involved. Introducing a marginal change in the diet like switching varieties is

Table 6
Nutrition from the stem, leaves, tubers and chips of Golden Sweet Potato variety ST-14 (Courtesy: R-FRAC, Lucknow, Food Lab of government of U. P.), 2016

Parameter	*Stem*	*Leaf*	*Tuber*	*Chips*	*Method of estimation*
Carbohydrate %	11.2	8.2	23.05	66.65	SP: 18 (P-6) 1981
Fat %	0.4	0.8	1.165	21.35	AOAC
Protein %	8.62	5.01	1.02	1.02	AOAC 978.04
Fibre %	206	2.1	3.0	9.0	IS: 10226 (P-1) 1982
Dry matter %	12.00	5.00	25.95	93.28	
Energy	–	–	106.77	462.83	
Beta Carotene (µg/100g)	1,776	1,833	1,196	1,150	IS: 512-1988
Vitamin (µg/100g)	2,664	2,447	1,794	1,725	IS: 5886-1970
Iron (mg/100g)	1.3	1.2	0.26	6.3	SP: 18 (P-1) 1980
Zinc (mg/100g)	0.32	0.13	0.4	0.3	AAS Flame
Magnesium (mg/100g)	0.39	0.36	25	75	AAS Flame

Table 7
Farmers participated and students trained during 2014-2017

	Trained in 2014-15		*Trained in 2015-16*		*Trained in 2016-17*		
District	*Farmer*	*Student*	*Farmer*	*Student*	*Farmer*	*Student*	*Total*
Gorakhpur	54	86	140	48	157	100	585
Sant Kabir Nagar	53	58	94	250	210	350	915
Total	107	141	234	298	367	450	1,597

likely to be easier than introducing a completely new food. Thus, replacing the white-fleshed sweet potato varieties consumed with new OFSP cultivars like ST-14, CIP 440127, VA 43, and PRDF S1 having high β-carotene would be helpful in alleviating vitamin A deficiency. Production of OFSP was linked to consumption by developing 15 different products in addition to roasting and boiling to promote in diets. Awareness generation among masses and training of school students on Vitamin A malnutrition *vis-a-vis* different food products of OFSP was generated. Sustainable and cheapest solution to combat vitamin A deficiency is through the use of Orange fleshed Sweet Potato (OFSP) or Sunhri Shakarkand (Golden Sweet Potato). Many African and Latin American countries where Vitamin A deficiency is severe are promoting use of OFSP and have strong research and development projects for it. India must follow the same path if it has to eradicate Vitamin A deficiency by biofortification. Once with the farmers, no cost is involved to the government, and no room for corruption and mismanagement.

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REFERENCES

Chaudhary, R.C.; Kumar, R.; Sahani, A.; and Mal, P. (2017a), Improved cultivation of Golden Sweet Potato, PRDF Gorakhpur, U. P., India; 16 pp.

Chaudhary, R.C.; Gandhe, A; Padale, K.; Sahani, A.; Kumar, R.; and Mal, P. (2017b), Recipe of Food Products from Golden Sweet Potato, PRDF Gorakhpur, U. P. , India; 42 pp.

Chaudhary, R.C.; Gandhe, A.; and Kumar, R. (2016), Biofortification to combat Vitamin A deficiency sustainably through promoting Orange-fleshed Sweet Potato in eastern Uttar Pradesh, International Jour. Science, Techn. and Soc.; Vol. 2 (Nos. 1 & 2); 58 -63.

CIP (2015), Orange-fleshed Sweetpotato Investment Implementation Guide. International Potato Centre, Nairobi, Kenya, 57 pp.

Gupta A. K. (1987), Vitamin deficiency in hospitalized children suffering form Diarrhoea, respiratory infections and protein energy malnutrition: A cross sectoral study: Thesis submitted for M.D, to B.R.D. Medical College, Gorakhpur, 121 pp.

Hagenimana V., and Low J., (2000), Potential of Orange-fleshed sweet potatoes for raising vitamin A intake in Africa. Food Nutr Bull **21**: 414-418.

Kansal S. (1997), Role of Vitamin A deficiency, protein energy malnutrition and various socio-economic factors on acute respiratory infection in underfives of some areas of district of Gorakhpur" Thesis for Docotor of Medicine, B.R. D. Medical College, Gorakhpur, 139 pp.

Laxminarayana K. (2013), Sweet potato for livelihood and nutritional security in coastal saline soils. Tech Bull # 9, 28 pp, CTCRI Regional Centre, Bhubaneswar, Odisha.

Low, J.; Walker T. and Hijmans R., (2001), The potential impact of orange-fleshed sweet potatoes on vitamin A intake in Sub-Saharan Africa. Paper presented at a regional work shop on food based approaches to human nutritional deficiencies. The VITAA Project, Vitamin A and orange-fleshed sweet potatoes in Sub-Saharan Africa, 9-11 May, Nairobi, Kenya.

Mitra, K. (2012), Nutritional status of Orange-Fleshed Sweet Potatoes in alleviating vitamin A malnutrition through a food-based approach. J. Nutr. Food Sci. Vol. **2** (8); 160–163.

Mukherjee, P.K.; Chaudhary, R.C.; Arya, S. and Ilangantileke, S. 2003. Sweetpotato a possible solution for combating vitamin A deficiency: A clinical health problem in South and West Asia. CIP News Letter Vo. **6** (1): 6 – 7.

Mukherjee, A.; Naskar, S. K. and Edison, S., 2009. Salt tolerant biofortified and purple flesh sweet potato: coastal food and nutrition security. CTCRI, Thiruvanthapuram, Kerala, 36 pp.

Purcell, A. E. and Walter, J. R. (1968), Carotenoids of Centennial variety of sweetpotato. J. Agric. Food Chem. 16, 769-770

Sharma, S. K. (1985), A clinical epidemiliogical study of Vitamin deficiency in pre-school children I.C.D.S. Urbal Project, Gorakhpur. M.D. Thesis, B.R.D. Medical College, Gorakhpur, 100 pp

Simonne, A. H.; Kays, S; J.; Koehler, P. E. and Eilenmiller, R. R. (1993). Assessment of carotene content in sweetpotato breeding lines in relation to dietary requirements. J. Food Compos. Anal. **6**, 336-345

Takahata, Y.; Noda, T. and Nagata, T. (1993), HPLC determination of carotene content in sweetpotato cultivars and its relationship with color value. Japanese J. Breed. **43**, 421-427.

Tsou, S. C. S. and Hong, T. L. (1992), "The Nutrition and Utilization of Sweet potato", Section 4 in Hill, Walter A., Conrad K. Bonsi, Philip A. Loretan, eds. Sweetpotato Technology for the Twenty-first Century, Tuskeegee University Press, Tuskegee University.

WHO, (1996), Indicators for assessing vitamin A deficiency and their application in monitoring and evaluating intervention programmes. World Health Organization, Geneva, Switzerland.