International Journal of Oil Palm, 3&4 : 31-37

RESEARCH PAPER

Sensory Evaluation and β-Carotene Retention of Foods Cooked in Edible Grade Crude Palm Oil

S. Sindhwani, A. Siddhu, P. Sundararaj[1] and S.K. Saxena[2]
Department of Foods and Nutrition, Lady Irwin College (University of Delhi)
Sikandra Road, New Delhi - 110 001, India.

ABSTRACT

The present study was undertaken to evaluate the acceptance of foods cooked in edible grade crude palm oil (CPO) for various sensory attributes and compare them with the respective foods cooked in conventional oils/fats like groundnut oil/ghee/butter. Beta carotene retention in CPO cooked foods was also estimated. The baseline data for physicochemical characteristics indicated that while the α-tocopherol content of CPO was almost totally destroyed in the batch studied, the normal amount of β-carotene (340mcg/g) was present. Sensory evaluation of the products showed that all the products prepared in CPO - *ladoos, upma, halwa,* cake, *khichri and dalia* were rated acceptable. No significant difference was observed in overall acceptability in the mean scores of *upma, khichri and dalia* as compared to their respective control food samples cooked in traditional fat medium. However, taste and after taste were the sensory attributes most undesirably affected by CPO and significantly ($p<0.05$) lower mean scores were obtained in case of *ladoo, halwa and* cake. The β-carotene retention in *ladoo,* cake, *khichri, upma, dalia* and *halwa,* was 90%, 83%, 77%, 73%, 50% and 46% respectively. The retention of β-carotene was affected mainly by the cooking method used and the duration of heating it was exposed to. It was observed that serving portions of 50g of ladoo, 125g each of upma and halwa and 30g of cake could each meet the recommended dietary allowance (RDA of 1600mcg) of a preschool child for β-carotene. The cost of one serving of these products is nominal and hence could be suitable for supplementary feeding to improve the vitamin A status of children suffering from deficiency of this vitamin.

Key words : Edible grade crude palm oil, groundnut oil, butter, ghee, sensory attributes, β-carotene retention, processing methods.

INTRODUCTION

Suitability of edible grade crude palm oil (CPO) as a deep-fat frying medium determined by preparing poories, french fries and moong dal mangories showed that the products were poorly accepted for several sensory attributes indicating that CPO is not a good deep-fat frying medium (Owuor *et al.,* 2002). Heating and frying regimen also resulted in substantial loss of β-carotene and α-tocopherol in CPO, thus defeating the purpose of advocating palm oil for its nutritionally superior minor components (Gupta *et al.,* 2001). Hence, the possibility of using CPO in the preparation of Indian dishes requiring minimum heat treatment should be explored.

CPO is an unconventional cooking medium having unique properties. The colour of food is a significant factor in determining its acceptance. CPO with its orange red colour can blend with Indian curries, pickles and other preparations. CPO can serve as a natural colouring material in food products. Most Indian foods especially savory items are safely coloured yellow by the addition of turmeric. Hence, the colour imparted by CPO in these preparations was found to be acceptable. However, CPO has a specific odor, which may not find acceptance among people. It was observed that the odor did not prevail strongly in food after cooking but it lingered behind as an aftertaste a few minutes after consumption (Manorama and Rukmini, 1992).

CPO as a cooking medium is advocated due to the presence of β-carotene and tocopherols and tocotrienols. In vivo β-carotene functions as an important antioxidant as well as a precursor molecule for vitamin-A. The β-carotene retention in different food products subjected to different cooking procedures has been reported to vary between 35% 90% (Manorama and Rukmini, 1992; Sarojini *et al.,* 1996).

In the present study, different recipes both sweet and savory not involving deep-frying and in which the oil/fat

[1] Corresponding author
[2] Food Research and Analysis Centre, Tansen Marg, New Delhi - 110 001, India

would be wholly absorbed into the food, were prepared using CPO to ascertain the organoleptic acceptability and retention of β-carotene in the cooked products.

MATERIALS AND METHODS

Procurement of oils/fats: CPO was obtained from NRC for Oil Palm, Regional Station, Palode, Thiruvanathapuram, Kerala in 20 L. plastic can. Refined grade groundnut oil (GNO), ghee (clarified butter) and butter were obtained from the local market in a 5 L green coloured plastic can, in a 2 kg aluminium foil pouch packed in a cardboard carton and in a 3x100 g unit wrapped in butter paper and packed in a cardboard carton respectively. All the oils/fats represent a single batch each. The inherent limitation of the study design was that the batch variations have not been carried out.

Baseline analysis of oils/fats: The two oils and the two fat samples were analysed to obtain baseline data on their physico-chemical characteristics.

- Physical test: Moisture content was determined by air oven method.
- Chemical tests: Fatty acid (FA) composition was determined by gas liquid chromatography (GLC). Fatty acid methyl esters (FAME) were prepared and analyzed as per our earlier publication (Gupta *et al.*, 2001). Fatty acids in negligible amounts. (<1.0%) were not considered. Further oleic (18:1) and linoleic (18:2) acids were considered as MUFA and PUFA respectively. Free fatty acids (FFA), peroxide value (PV), anisidine value (A V) and totox value (TV) were determined according to standard procedures (Anonymous, 1985; Hamilton and Hamilton, 1992).

β-carotene was determined after alkaline saponification of oil and organic extraction. Non-aqueous reverse phase high performance liquid chromatographic (HPLC) analysis with a UV-VIS detector at 450nm was carried out as per an earlier procedure of Gupta *et al.* (2001).

Alpha-tocopherol was also estimated in the organic extract prepared for the estimation of β-carotene. HPLC analysis with a UV-VIS detector was employed (Gupta *et al.*, 2001).

Development and standardization of recipes: The recipes were developed using edible grade CPO in place of the traditionally used groundnut oil (GNO), *ghee* or butter. The basic recipes were taken from 'Basic Food Preparation' manual (Kashyap and Narula, 2001). The recipes were standardized twice and then presented for final organoleptic evaluation. The recipes thus standardized were:

- *Besan ladoo* (sweet Bengal gram flour ball) using unheated oil
- *Upma* (spiced and salted semolina dish) by sauteing
- *Suji halwa* (sweet semolina dish) by sauteing
- Cake (refined flour) by baking
- *Khichri* (rice and pulse gruel) by pressure cooking
- *Dalia* (sweet broken wheat porridge) by pressure cooking

Each recipe was made using CPO and also the traditionally used fat medium (*ghee* for *besan ladoo, suji halwa and dalia*; GNO for *upma* and *khichri*; and butter for cake). For each food product the oil used varied. Finally, two cooking trials were conducted for each set of foods for organoleptic evaluation.

Organoleptic/Sensory Evaluation: A panel of 13 graduate and postgraduate collegiate women was selected for the evaluation of the food products. The same set of panelists was used for all the sensory evaluation throughout the study period. Two samples of each recipe were presented, one cooked in CPO and the other cooked in traditional fat medium. Water was provided as a palate-cleansing agent. The organoleptic evaluation sessions were conducted one hour before lunch. Conditions of temperature, humidity and illumination were adequate.

All the foods were prepared for the second time, a week after the first assessment and presented again for sensory evaluation. The products were evaluated for colour, texture, odour, doneness, absence of waxyness, taste, aftertaste and overall acceptability on a scale of 1 to 5 where, 1 = very poor, 2 = poor, 3 = satisfactory, 4 = good and 5 = very good.

Assessment of β-carotene retention in the food products cooked in CPO: The food samples cooked in CPO were analyzed for β-carotene content to determine the percentage loss of the micronutrient during cooking procedure and thus estimate the percentage retention in the final food product. The amount of β-carotene which should have been theoretically present in the food product was calculated from the β-carotene content of the CPO, quantity of CPO used and the weight of the total food products. This was compared to the actual content of β-carotene estimated in the food product and percentage retention was then arrived at.

Processing of food samples for the estimation of β-carotene content: All the food samples were processed in an identical manner as the one for the oil sample. A weighed amount of the food product was subjected to alkaline saponification followed by organic extraction of β-carotene which was then determined by HPLC (Gupta *et al.*, 2001).

All the data have been expressed as the mean of two analyses. Paired 't' test between food item in CPO and control sample was done to determine significant difference ($p<0.05$) in mean sensory evaluation scores.

RESULTS AND DISCUSSION

The percentage fatty acid (FA) composition of edible grade CPO, GNO, *ghee* and butter is given in Table 1. The principal FA in CPO was palmitic acid constituting 43.1% followed by 40.3% of oleic acid and 11.3% of linoleic acid. CPO contained 47.9% saturated fatty acids (SFA) and 51.6% of unsaturated fatty acids (USFA). The FA composition of CPO in the present study is generally in close agreement with the values reported in our earlier studies and indicates very little batch variation (Agarwal *et al.*, 2000; Padmavathy *et al.,2001*; Gupta *et al.*, 2001).

GNO is an unsaturated oil with 25.8% SFA and 74.2% of USFA in which (MUFA) (37.6%) and (PUFA) (36.6%) are present in almost equal amounts. *Ghee* had a much higher amount of SFA (71.0%) as compared to USFA (26.7%). *Ghee* also contained a small amount (11.8%) of short chain (4:0 to. 12:0) saturated fatty acids and 11.0% of myristic acid. The major SFA of *ghee* was palmitic acid (35.8%) followed by stearic acid (12.4%). Oleic acid (24.6%) was the main MUFA present in ghee. Butter had 67.1% of SFA and 26.9% of USFA. As butter is heated to obtain *ghee*, the FA composition of the two fats bears close similarity. *Ghee* and butter have high amounts of myristic acid (11.0% and 10.3% respectively). Keeping in mind health considerations this is not desirable since myristic acid is the most atherogenic of all saturated fatty acids. Myristic acid is the most powerful cholesterol-raising SFA, being capable of raising LDL from 70mg/dL to 200mg/dl (Enas, 1998). CPO however, contains only 1.2% of myristic acid.

The physico-chemical characteristics of the oils/fats used in the present study are given in Table 2. The moisture content of only GNO (0.06%) was within the ISI specification (0.1 %). The moisture content of CPO (0.43%), *ghee* (2.1 %) and butter (19.7%) exceeded the respective specifications.

The FFA% of the four oils/fats analyzed i.e. CPO, GNO, ghee and butter was within the respective specifications. The PV of CPO and GNO was within the respective specifications. No specification has been given for PV of ghee and butter. Likewise no specifications have been given for AV and TV of oils and fats. Table 2 shows that CPO had highest FFA %, PV, AV and TV as compared to GNO, *ghee* and butter. This may be due to delay in processing fresh fruit bunches (FFB) as lipase activity increases in FFB after harvesting. The enzyme is inactivated only after sterilization during processing. Edible grade crude palm oil (CPO) used in the present study is not a highly refined one.

The β-carotene content of CPO used in the study was 340mcg/g of oil (Table 2). β-carotene content of 370mcg/g and 390mcg/g of CPO has been reported by Manorama and Rukmini (1992) and Gupta *et al.* (2001) respectively.

The α-tocopherol content of CPO in the present study was estimated to be 4.8ppm. This is, very low compared to the value of 197.3 ppm obtained in our earlier study (Gupta *et al.*, 2001). This indicates that the oil had undergone oxidation between the period of extraction, transportation and usage. On physical examination and chemical test (PV) (Table-2) no rancidity was detected and

Table 1: Fatty acid composition (%)[a] of CPO, GNO, *Ghee* and Butter[b]

Fatty acid		% composition			
		CPO	GNO	Ghee	Butter
SFA					
Butyric	(4:0)	-	-	2.3	2.6
Caproic	(6:0)	-	-	2.1	1.3
Caprylic	(8:0)	-	-	1.9	-
Capric	(10:0)	-	-	3.4	1.5
Lauric	(12:0)	-	-	2.1	1.1
Myristic	(14:0)	1.2	-	11.0	10.3
Palmitic	(16:0)	43.1	13.7	35.8	35.9
Stearic	(18:0)	3.6	3.7	12.4	13.0
Arachidic	(20:0)	-	1.8	-	-
Behenic	(22:0)	-	6.6	-	1.4
MUFA Oleic	(18:1)	40.3	37.6	24.6	24.6
PUFA Linoleic	(18:2)	11.3	36.6	2.1	2.3
SFA%		47.9	25.8	71.0	67.1
USFA%		51.6	74.2	26.7	26.9

[a] % totals may not be 100, components<1.0% not reported
[b] Mean of duplicate analysis

Table 2: Physicochemical characteristics[a] of CPO, GNO, *Ghee* and Butter

Characteristic	CPO		GNO		Ghee		Butter	
	Present Study	ISI values	Present study	ISI values	Present study	PFA values	Present study	ISI values
Physical								
Moisture %	0.43	0.25 (max)	0.06	0.1 (max)	2.1	0.5 (max)	19.7	16.0 (max)
Chemical								
Acid value	8.2[b]	10.0[b]	0.28[c]	0.50[c]	1.5[c]	6.0[c]	0.04[d]	0.15[d]
FFA% (Palmitic/oleic/ lactic acid)	4.1[b]	5.0[b]	0.14[c]	0.25[c] (max)	0.75[c]	3.0[c] (max)	0.02[d]	0.075[d] (max)
Peroxide value (PV) ($meqO_2$/kg oil)	4.6	5.0 (max)	1.2	10.0[e] (max)	0.36	-	0.33	-
Anisidine value (AV)	4.3	-	1.9	-	0.47	-	0.89	-
Totox value (TV)	13.4	-	4.8	-	1.2	-	1.6	-
β-carotene (mcg/g)	340	-	-	–	-	-	-	-
α-tocopherol (ppm)	4.8	-	-	-	-	-	-	-

[a] Mean of two analysis
[b] as palmitic acid
[c] as oleic acid
[d] as lactic acid
[e] Codex Alimentarius specification

hence the oil was used in the present study. Lakshmi and Sarojini (1996) reported total destruction of α-tocopherol in palm oil after 3 months of storage at 35°C. The rapid destruction of α-tocopherol in stored oil was assigned to its role as antioxidant. While α-tocopherol had been destroyed in CPO used in the present study, β-carotene was unaffected indicating that α-tocopherol is the first line of defence against lipid peroxidation.

The mean scores obtained for various sensory characteristics and their statistical comparison is presented in Table 3. None of the products prepared in the present study got a mean score below 3. Thus no product was rated poor or very poor by the panelists. No significant difference was observed in mean scores for any sensory attribute including overall acceptability in the case of three products i.e., *upma, khichri and dalia* prepared in CPO and the respective control samples. These three products prepared in CPO also received higher scores for many of the sensory attributes as compared to the mean scores obtained for the corresponding attribute of the other three food items, i.e., *ladoo, halwa* and cake prepared in CPO.

Although overall acceptability of *ladoos, halwa* and cake showed that they were acceptable (mean score >3), significantly ($p<0.05$) lower mean scores were obtained for the CPO based products for colour, odour, taste, aftertaste and overall acceptability as compared to the respective traditional fat medium of the food products. It was observed that CPO imparted a bitter aftertaste to many of its products. Texture and doneness were not affected by CPO in any of its products and waxyness was felt only in *ladoos* prepared with CPO.

The colour of a food is an integral factor affecting its acceptance and when food has unusual colour caution sets in. Addition of CPO imparts a bright orange colour to the *ladoo* and one of the panelists was of the view that it appeared as if artificial colour had been added to the product, thus giving it an adulterated appearance. Similarly, an unusual dark yellow colour imparted by CPO to cake affected its acceptability. However, in the case of *upma* and *khichri*, the dark yellow colour was as well accepted as the control sample. Likewise some of the panelists preferred the dark yellow colour of *halwa* in CPO since it resembled the colour imparted by saffron in many traditional Indian dishes. Surprisingly, some of the panelists found the colour of *dalia* prepared with CPO to be attractive.

Manorama and Rukimini (1992) reported that the specific odour of CPO along with its deep colour did not find acceptance among the population. Further cake was only moderately accepted. Sarojini *et al.,* (1996) also reported that freshly baked cakes were not relished by the panelists during sensory evaluation due to the peculiar colour and flavour of the finished product. Additionally, products like *halwa* containing more of CPO were least accepted. In the present study too, *halwa* and cake with higher amounts of CPO, 20.0 g, and 10.0 g per serving size respectively, had significantly lower mean scores for

four sensory attributes and thus had lower organoleptic acceptance. CPO used in *upma, khichri and dalia* was acceptable (no significant difference in mean scores) probably due to lower CPO content per serving as compared to other three products (Table 5).

Among the food products evaluated, *ladoos* prepared in CPO had least acceptance since 6 of the 8 parameters had significantly lower mean scores when compared to the ladoos prepared in ghee (Table 3). On the other hand, all the 8 parameters of CPO-*khichri* and 6 of the 8 parameters for CPO-*dalia* obtained mean scores of over 4, which signifies a good product. This may be attributed to the fact that in both these food items only a small quantity of CPO (2.5g and 5.0g respectively) per serving (Table 5) is present which does not contribute to any strong odour, taste or aftertaste. Of the 48 mean scores obtained for all the food products cooked in CPO, only 19 scores were 4 or above which indicates good acceptance. On the other hand, for the traditionally cooked products, 42 of the 48 mean scores were 4 or above. This is a pointer that for promoting the use of edible grade CPO, people will have to be especially motivated and encouraged to include this oil in their dietaries. Further, blending CPO with traditional oils so as to provide at least 5g/day and meet Recommended Dietary Allowance (RDA) for β-carotene will be another good approach to promote acceptance of CPO (Gupta *et al.*, 2001). As none of the mean scores for CPO based foods were less than 3, the panelists rated these products at least as satisfactory. An encouraging outcome of the organoleptic evaluation of these foods containing CPO is that it would be possible to promote CPO through such food items. Since CPO is very rich in β-carotene which is a precursor of vitamin A in the body, these foods could act as effective vehicles in supplementary feeding programmes particularly for malnourished children in whom vitamin A and energy deficiency is widely prevalent.

Table 4 gives the β-carotene content and % β-carotene retention in the different food items. This table shows that the loss of β-carotene was mainly dependent on the type of cooking process employed and the time taken for cooking to which the CPO based food had been exposed. *Ladoo* gave highest β-carotene retention (90%). In the preparation of *ladoo*, unheated oil was used. *Besan* and *suji* were roasted, into which oil was added and the mixture formed into *ladoo*. CPO was not subjected to any direct heating or cooking procedure. The 10% loss may be attributed to the fact that the oil was added to a very hot mixture of *besan* and *suji* in a hot *karahi*. However *ladoo* did not fare very well in organoleptic evaluation for taste and aftertaste attributes (Table 3) because of the use of unheated CPO, which gave a raw taste and slightly bitter aftertaste to the product.

The β-carotene retention in *upma* was 73% (Table 4). *Upma* preparation required sauteing of onions and seasonings in CPO for 5 minutes after which suji was added and then roasted for 15 minutes, thus taking a total time of 20 minutes. Manorama and Rukmini (1992) also reported a comparable retention value of 70% of β-carotene in *upma* cooked in CPO.

The retention of β-carotene in suji halwa was only 46%. The low β-carotene retention could be due to the reason that CPO with suji was sauteed for 25 minutes in a *karahi*

Table 3: Sensory evaluation scores[a] for food items prepared in CPO/GNO/*Ghee*/Butter

Food item (Fat/Oil)	Colour	Texture	Odour	Doneness	Absence of waxyness	Taste	After taste	Overall acceptability
Ladoo (CPO)	3.7 ± 0.9[b]	3.4 ± 1.0	3.7 ± 0.9[b]	4.0 ± 0.8	3.2 ± 1.3[b]	3.8 ± 1.0[b]	3.5 ± 1.2[b]	3.6 ± 1.0[b]
Ladoo (*Ghee*)	4.2 ± 0.7	3.9 ± 0.9	4.3 ± 0.8	4.4 ± 0.6	3.9 ± 0.9	4.4 ± 0.8	4.0 ± 0.9	4.2 ± 0.9
Upma (CPO)	3.9 ± 0.8	4.2 ± 0.7	3.8 ± 0.7	4.3 ± 0.6	3.9 ± 0.8	3.5 ± 0.9	3.3 ± 0.9	3.7 ± 0.7
Upma (GNO)	3.7 ± 0.8	4.3 ± 0.7	4.1 ± 0.5	4.2 ± 0.6	4.1 ± 0.7	4.1 ± 0.7	4.0 ± 0.7	4.1 ± 0.6
Halwa (CPO)	4.0 ± 0.8	4.2 ± 0.8	3.7 ± 0.9[b]	4.2 ± 0.7	3.8 ± 0.9	3.4 ± 1.0[b]	3.3 ± 1.1[b]	3.5 ± 0.9[b]
Halwa (*Ghee*)	4.3 ± 0.8	4.3 ± 0.8	4.4 ± 0.5	4.4 ± 0.6	4.2 ± 0.8	4.5 ± 0.6	4.2 ± 0.9	4.4 ± 0.6
Cake (CPO)	3.4 ± 0.9[b]	3.8 ± 0.8	3.7 ± 0.9	4.1 ± 0.6	3.9 ± 1.0	3.3 ± 1.1[b]	3.0 ± 1.2[b]	3.5 ± 1.1[b]
Cake (Butter)	3.9 ± 0.8	3.7 ± 0.9	3.9 ± 0.8	4.2 ± 0.7	4.2 ± 0.9	4.2 ± 0.9	4.2 ± 0.9	4.0 ± 0.9
Khichri (CPO)	4.4 ± 0.7	4.4 ± 0.7	4.3 ± 0.7	4.3 ± 0.7	4.3 ± 0.7	4.3 ± 0.7	4.0 ± 0.8	4.3 ± 0.7
Khichri (GNO)	4.2 ± 0.9	4.4 ± 0.7	4.3 ± 0.7	4.3 ± 0.7	4.4 ± 0.9	4.4 ± 0.9	4.2 ± 0.8	4.5 ± 0.8
Dalia (CPO)	3.8 ± 0.8	4.3 ± 0.6	3.9 ± 0.6	4.7 ± 0.5	4.2 ± 0.7	4.4 ± 0.6	4.2 ± 0.8	4.3 ± 0.6
Dalia (*Ghee*)	4.0 ± 0.6	4.4 ± 0.5	4.2 ± 0.6	4.5 ± 0.5	4.3 ± 0.5	4.2 ± 0.5	4.2 ± 0.5	4.2 ± 0.5

[a] Mean ± SD for two cooking trials (n=13 panelists)

[b] Sigificant difference ($p<0.05$) with paired 't' test between food product in CPO and control sample

Score code : 1 = very poor, 2 = poor, 3 = satisfactory, 4 = good and 5 = very good

Table 4: Amount and % retention of β-carotene in food items cooked with CPO

Food item	Processing method	β-carotene Amount (mcg/100g food item)		% retention in food item
		Theoretical[a]	Estimated	
Ladoo	Short time exposure to heat	11,3000	10,167	90
upma	Sauteing	2,684	1,974	73
Suji halwa	Sauteing	3,238	1,495	46
Cake	Baking	10,074	8,415	83
Khichri	Pressure cooking	390	301	77
Dalia	Pressure cooking	1100	550	50

[a] Based on amount of CPO added in standard recipe

and there was direct exposure to the heated pan during the preparation. In a *karahi* the oil was exposed to a large surface area of heat, for a longer time than in *upma*, resulting in a larger destruction of β-carotene. The difference between *upma and halwa* preparation was in total amount of CPO taken (15g and 20g respectively) and the time taken for sauteing (20 and 25 minutes respectively).

Manorama and Rukmini (1992) reported 71% retention of β-carotene in *suji halwa* cooked in CPO for 15-20 minutes. The higher retention obtained in this case as compared to the present study may be due to difference in cooking method and the time taken for cooking. In southern and western parts of Indla *halwa* preparation involves roasting or sauteing the *suji* in fat for a shorter period of time as compared to the method adopted in north India where *suji* is roasted till it attains a dark brown color.

Table 4 shows that cake retained 83% of β-carotene. Cake preparation involves baking at a temperature of 350°F for 25 minutes. The high retention in cake despite prolonged baking time is due to the fact that CPO is thoroughly blended with other ingredients like flour, sugar and egg, thereby avoiding direct exposure to heat (Manorama and Rukmini, 1992). A comparable retention value of 88% β-carotene in cake baked in CPO was reported by Manorama and Rukmini (1992).

Khichri preparation, which employs pressure cooking retained 77% of β-carotene. In *khichri* preparation, onions were sauteed in CPO for 3 minutes, rice and *dal* were added and then pressure cooked for 5 minutes and again cooked in open pan for 2 minutes, thus making it a total of just 10 minutes of cooking. This may be the reason for appreciable retention of β-carotene in *khichri*.

Table 4 shows that *dalia* had retained 50% of β-carotene. *Dalia* was sauteed for 5 minutes in the oil, pressure cooked for another 5 minutes and then cooked in an open pan over moderate flame for 15 minutes. This extensive cooking procedure may have been responsible for the low retention of β-carotene in the food product. *Khichri* cooked for 10 minutes showed a higher retention value of 77% as against a lower retention of 50% in *dalia* cooked for 25 minutes, thereby reiterating that cooking time also influences the β-carotene retention.

Padmavati *et al.,* (1992) reported that the mean % loss of β-carotene in vegetables varied from 11.3% to 75.9% when different processing methods were employed with different periods of time. Further, the use of combination methods led to progressive losses of the provitamin, whereas when preparation time was optimal and exposure to heat and air was minimal, the loss was lower.

The adequacy of foods cooked in CPO for meeting Recommended Dietary Allowance (RDA) for β-carotene in a preschool child is shown in Table 5. One serving each of *ladoo* (50g), *upma* (125g) *suji halwa* and cake (30g) can supply the daily requirement (1600 mcg) of β-carotene for a preschool child. Further, one serving each of *ladoo, upma* and cake can also supply the daily requirement (2400mcg) of β-carotene for a school going child (not shown in Table). Additionally, *upma* unlike *ladoo* and cake was well accepted in sensory evaluation. Thus upma would be an efficient vehicle for carrying vitamin A which would also be accepted by the population.

In contrast, the amount of β-carotene present in each serving of *khichri* (602 mcg in 200 g) and *dalia* (1100 mcg in 200g) cannot meet the RDA of even the preschool child. At the same time *khichri* and *dalia* were very well accepted by the panelists. Thus, they may be used in supplementary feeding programmes to supply at least a part of RDA for β-carotene owing to their ease in preparation procedure. Further, they would be less likely to have problems in being accepted by the children. Additionally there is scope to add more CPO or vitamin A rich vegetables in *kichri* and *dalia* according to local acceptability.

The cost per serving of the food product was estimated (Table 5) to be in the range of Rs. 0.96 and Rs. 1.29 per serving (cost calculated as on November 2001) for each preschool child. These costs are nominal and would be

Table 5: Adequacy of food items cooked in CPO for meeting RDA for β-carotene in a preschool child

Food item	Serving size	CPO (g) present/ Serving size	β-carotene estimated (mcg)/ Serving size	% RDA of β-carotene met for preschool child[a]	Cost[b] Rs/serving
Ladoo	1 piece = 50g	17.5	5,083	314	1.17
upma	1 small bowl = 125g	7.5	2,468	154	1.29
Suji halwa	1 small bowl = 125g	20.0	1,869	116	1.02
Cake	1 bread slice size = 30g	10.0	2,525	157	1.28
Khichri	1 medium bowl = 200g	2.5	602	37	1.22
Dalia	1 medium bowl = 200g	5.0	1,100	68	0.96

[a] RDA for β-carotene for a preschool child = 1600mcg
[b] Cost caluculated as on November, 2001

easily covered by the amount allocated in most of the supplementary feeding programmes. Hence, the above food products are very promising for inclusion in various feeding programmes in the country. Sarojini *et al.* (1999) reported 98% acceptability when crude red palm oil mixed with "Ready to Eat" food supplement was given to 184 children enrolled in 6 *Anganwadi* centres of Integrated Child Development Services (ICDS) in Hyderabad.

CONCLUSION

The present study indicates that incorporation of CPO in foods, whose preparation does not involve excessive heat treatment and in which the oil would be wholly absorbed into the food is very promising with respect to sensory attributes and retention of β-carotene. Further the low cost of the food items could promote their inclusion in supplementary feeding progarmmes for children to address the widespread problem of Vitamin A deficiency in the country.

ACKNOWLEDGEMENTS

The authors acknowledge the facilities provided by Mr. Gian Batra, Nucon Engineers, Okhla, New Delhi for GLC analysis.

REFERENCES

Agarwal, A., Siddhu, A., Sundararaj, P. and Teneja, K.K. 2000. Strorage stability at household level of edible grade crude palm oil. *Journal of Oil Technologists Association of India*, **32(3)** : 124-128.

Anonymous 1985. *ISI Handbook of Analysis*. SP:18, Parts XII, XIII, XIV, XV. Indian standards Institution, New Delhi.

Enas, E. A., 1998. Management of coronary risk factors : Role of lifestyle modification. *Cardiology Today*, **II(1)** : 17-26.

Gupta, N., Siddhu, A. and Sundararaj, P. 2001. Oxidative stability of edible grade crude palm oil blends with sunflower oil or groundnut oil as deep frying medium *Internation Journal of Oil Palm*, **2(1)** : 11-18.

Hamilton, R.J. and Hamilton, S. 1992. *Lipid Analysis. A practical approach*. Oxford University Press, New York, 45-48.

Kashyap, S. and Narula, V. 2001. *Basic Food Preparation-a complete manual*, II edition Orient Longman, New Delhi.

Lakshmi, B. and Sarojini, G. 1996. α-tocopherols in red palm oil (*Elaeis guineensis*)-stability during storage and heating. *Journal of Oil Technologists Association of India*, **28(3)** : 79-81.

Manorama, R. and Rukmini, C. 1992. Crude palm oil as a source of β-carotene. *Nutrition Research*, **12(Suppl.1)** : S223-S232.

Owuor, R.O., Siddhu, A. and Sundararaj, P. 2002 Suitability of edible grade crude palm oil as a deep-fat frying medium. *The Indian Journal of Nutrition and Dietetics*, **39:**173-181.

Padmavathy, A., Siddhu, A. and Sundararaj, P. 2001. Effect of blending edible grade crude palm oil with refined groundnut oil or sunflower oil on storage stability and sensory attributes. *Journal of Oil Technologists Association of India*, **33(3)** : 93-103.

Padmavati, K., Udipi, S.A. and Rao, M. 1992. Effect of different cooking methods on β-carotene content of vegetables. *Journal of Food Science and Technology*, **29(3)**:137-140.

Sarojini, G., Radha, L. and Bhavani, K.N. 1996. In : *Proceedings of PORIM International Palm Oil Congress*. pp. 271-279.

Sarojini, G., Nirmala Devi, G. and Geetha R. 1999. Meeting the Vitamin A requirement of preschoolers of ICDS through crude red palm oil. *Journal of Oil Technologists Association of India*, **31(4)** : 189-192.