Journal of Oil Palm Research Vol. 18 June 2006 p. 181-188

HOUSEHOLD USAGE OF AND RECIPE CREATION WITH CONDIMENT SAUCES BASED ON RED PALM OIL: EXPLORING THE POTENTIAL FOR TARGETED MICRONUTRIENT DELIVERY TO DIFFERENT FAMILY MEMBERS

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ABSTRACT

Combining foods that are naturally rich in essential micronutrients with other foods commonly used in the diets of low income households (food-to-food fortification) can be a sustainable way to deliver micronutrients. Properly conceived, the nutrients can be selectively targeted to different generations within the family. In a convenience sample of Guatemalan women, the feasibility of this approach using red palm oil (RPO, Carotino®), a food with extraordinary high pro-vitamin A carotenoids of up to 0.08% (w/w) of the crude oil, tocopherols and tocotrienols, was explored. Dishes were prepared with RPO as both red tomato and hot green sauces. Both had high acceptability to rural and urban low income women. Two hundred forty-five grammes of red tomato sauce and hot green sauce were distributed free. The women prepared many dishes with the red tomato sauce, but only five with the hot green sauce, which was instead mostly used as a garnish. We concluded that oils added to condiment sauces can enhance the nutrient contents in foods on the family table, and selective direction to adult members is feasible. More nutrient-rich oil will deliver more nutrients in this food-to-food fortification with RPO.

Keywords: red palm oil, pro-vitamin A carotenoids, food fortification, recipe creation, Guatemala.

Date received: 8 August 2004; **Sent for revision:** 8 September 2004; **Received in final form:** 14 December 2005; **Accepted:** 8 February 2006.

INTRODUCTION

Micronutrient deficiencies have been recognized as a major public health problem of the 21st century, robbing individuals in low income countries of their growth potential, physical and cognitive function, and resistance to infection by virtue of their consumption of poorly diversified and unbalanced diets (Trowbridge *et al.*, 1993; Maberly *et al.*, 1994). The poverty that is a major risk factor for micronutrient deficiencies limits the options for a sustainable solution of the problem. High dose supplements are often resorted to as the first response with the notion of reducing the deficiency rapidly (Solomons, 2001). But the presentation of large amounts of a nutrient in a concentrated preparation often produces a reticence to consume them due to the disagreeable taste, as in the case of iron (Schultink *et al.*, 1993), or the perceived risk of harmful consequences, as in the case of vitamin A capsules (Solomons and Schümann, 2002). Moreover, the costs and logistics are complex, the supplementation programmes often dependent upon imported pharmaceuticals, and the control centralized and not devolved to the community. In contrast, the delivery of supplements can be precisely targeted to specific groups, *e.g.* toddlers, pregnant women, *etc.*, within a population.

Fortification of staple foods is a potentially less cumbersome and more sustainable format to distribute micronutrients (Nilson and Piza, 1998). It can be mandated as part of national regulations, for

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example that all milk, flour, sugar or salt must contain added vitamins and minerals at certain concentrations. In developing countries, access to the individual fortificants can be precarious, and quality control in the production plants often lax. Some of the staple food market may be from small producers outside the network of fortifiers, and salt and sugar can only carry one or two micronutrients at most. The impact on the population of food fortification is generally dependent upon patterns of voluntary consumption, and it is often difficult to target and guide the micronutrients to the age groups or physiological conditions most at risk. An exception to this generalization is the institutional distribution of specially fabricated fortified foods, such as the cookies and gruels in the school-snack programme of Guatemala.

The root cause of micronutrient deficiency, however, is the paucity of nutrient-rich foods in the diet. Hunter-gatherers are believed to have had more complete nutritional balance than the agrarian populations (Cordain, 1999). By opting for a settled, agrarian existence, mankind has sacrificed micronutrient security for stability of its food supply. Rediversifying the human dietary fare by establishing new traditions of using nutrient-rich — but affordable — food items is considered to be the most sustainable strategy over the long-term (Underwood, 1998; Reddy, 2002). Moreover, such nutrient-dense foods can be combined in recipes to produce food-to-food fortification (Underwood, 1998).

An issue that arises with the notion of distributing complementary micronutrients through the household diet is the same as that arising with fortification, *per se*: how to direct the intervention to the members within the family who are in the greatest differential nutritional need. This concept of targeting within the family has been widely discussed, but the reality of Latin American households is that everyone above toddler age consumes a common, family fare (Bengoa *et al.*, 1988). Only with foods that are culturally identified with young children, or proscribed for the juvenile members of the family, can one steer or guide specific nutrients to specific groups. The widespread use of hot sauces (chillies) in tropical countries can be turned to advantage in intrafamilial targeting of nutrients or dietary substances for the health needs of the adults.

Red palm oil (RPO) is extracted from the oil palm (*Elaeis guineenis*) fruit. It derives its red colour from the high content of alpha- and beta-carotenes, which can make up 0.08% (w / w) of the crude oil. The crude oil content of lecithins and free fatty acids that impart adverse organoleptic qualities has necessitated its refining before use. However, the normal refining destroys most of its nutrients. Carotino is the oil refined in a novel way to conserve its nutrients. An extension of this processing to enhance food-to-food fortification is to incorporate RPO into the food for populations at risk of hypovitaminosis A.

Guatemalan cuisine is a major challenge to an oil-based solution, as the fat content of the traditional diet is low (Mata, 1978) and the purchasing power is also low for the vast majority of the population (Engle, 1993). This study sought to examine the acceptability and feasibility of condiment sauces, prepared with Carotino , to provide a model for food-to-food fortification among low income residents of this Central American republic.

EXPERIMENTAL

Subjects

The subjects were all women, from 22 to 77 years old. All were heads of households with children and of low income. Fifteen were from the rural community of Magdalena, Milpas Altas, Sacatepéquez in the highlands, and the other urban from Guatemala City. For the preference assessment, another group of 15 female middle-class professionals and students recruited at CeSSIAM participated. The subjects gave their written or verbal consent to participate in this study

Preparation of the Standard Condiment Sauces

Three different batches of red tomato sauce of 5017 g and two of hot green sauce of 3776 g were prepared. Each batch of red tomato sauce contained 40 g of Carotino , crude palm oil or refined palm. For the hot green sauce, only refined palm oil and Carotino were used. The composition of a kilogramme of the prepared sauces is shown in *Table 1*. RPO constituted 0.8% (w / w) of the red sauce and 1.8% (w / w) of the green sauce. In the first series of household studies, each subject was provided approximately 245 ml of the prepared sauces. In a second series, the household aliquot was raised to 400 ml.

Acceptability and Preference Assessment

For assessment of acceptability and preference of alternative presentations, they were presented with either two samples of green sauce prepared with refined palm oil and Carotino oil or three (coded) samples of tomato sauce prepared with crude palm oil, refined palm oil and Carotino . The subjects were asked which one they liked the most. We tried to elicit a single election, but if a woman insisted on equal preferences, proportional fractional scores were given for each of the sauces sampled. With the educated sample of subjects, a numerical rating was used in which the most favoured of three samples

TABLE 1. COMPOSITION OF THE PREPARED SAUCES (kg)

Red tomato sauce		Hot green sauce	
Ingredient	**Amount (g)**	**Ingredient**	**Amount (g)**
Carotino®	8.0	Carotino®	10.6
Chopped onion	62.7	Husk tomatoes	582.6
Tomato puree	226.2	Hot peppers	8.5
Basil	0.4	Vinegar	381.3
Oregano	0.4	Black pepper	1.3
Bay leaves	0.4	Oregano	1.3
Salt	4.4	Garlic	6.4
Water	697.6	Salt	7.9

*Note: In standard preparations, 40 g Carotino® added to a final weight of ~5 kg red sauce and ~3.8 kg green sauce.

was given a 3, the least favoured 1 and the intermediate preference 2. For the green sauce, the rating used 1 for the least favoured and 2 for the most preferred.

Household Usage and Recipe Creation

In the first series, all the subjects (15 rural and 15 urban) were contacted in their homes or through a local contact. They were given aliquots of 250 ml each of green and tomato sauces with the following instructions: 1. Use them to prepare a meal; 2. record the ingredients used in the recipe or the format in which the sauce was combined with other ingredients in the meal; 3. note the number of household members partaking of the meal; 4. record the general opinion of the sauce by yourself and family; and 5. bring back any unused sauce the next day to be weighed. In the second series, the first instruction was more emphasized on as it was of interest to us to see how they used the hot green sauce incorporate in their dishes.

Data Analysis and Interpretation

The study was primarily descriptive to study the variety or monotony of food presentation by a small number of women of limited means. For distinction in preference, we were interested in whether there was a strong inclination toward or against a given presentation of RPO-containing sauce. The collected data were entered into an electronic spreadsheet. For statistical analysis, ANOVA (Epi Info 6 version 6.04d - January 2001) was used to determine the significance of the differences in the sensory tests.

RESULTS

Nutrient Delivery of the Basic Sauce Recipes

RPO is also extraordinarily rich in tocopherols and tocotrienols, both of which have antioxidant activity (Institute of Medicine, 2001). According to published data on pigmented palm oils, 100 g Carotino have 80 mg total tocopherols and tocotrienols. This would result in 0.01 mg g^{-1} red tomato sauce and 0.013 mg g^{-1} hot green sauce.

The basic ~245 g aliquot of red sauce provided 1.56 mg total tocopherols and tocotrienols. The contribution of all-*rac*-alpha-tocopherol per standard aliquot was 0.33 mg (21%). The corresponding contents of the combined species and the all-*rac* component were 25% higher, respectively, in the green spicy sauce.

Acceptability of and Preference for Red Tomato and Hot Green Sauces Based on Different Oils by Rural and Urban Volunteers

A preference trial was performed with all 30 women. To determine if they could detect flavour differences between three samples of tomato sauce prepared with Carotino , crude palm oil and refined commercial palm oil. Two samples of green hot sauce were also tested, prepared with Carotino oil and with commercial refined palm oil. The rural area subjects preferred the red tomato sauces prepared with commercial palm oil over the sauces prepared with Carotino and crude palm oil. The difference was, however, not statistically significant. In the urban women, no significant differences were found between the three red tomato sauces, but the differences between the hot sauces were significant ($p = 0.001$).

Use of Tomato Sauce in Rural and Urban Households

The same 15 rural and 15 urban women who participated in the acceptability series were re-contacted and given 245 g of the red tomato sauce and five-step instructions for using the sauce in their family meal. All 15 of the rural women cooked with the sauce. Examples of the dishes prepared are shown in *Table 2*.

TABLE 2. INGREDIENTS USED BY RURAL AND URBAN WOMEN IN DISHES WITH TOMATO SAUCE

Chicken stew	**Spaghetti with tomato sauce**	**Pizza**	**Fried eggs with red sauce**
Chicken	Spaghetti	Pizza dough	Eggs
Tomato sauce	Tomato sauce	Ham	Tomato sauce
Powdered bouillon	Margarine	Cheese	Salt
Onion salt	Salt	Red pepper	-
		Tomato sauce	-
Meat with red sauce	**Beet salad with red sauce**	**Beef patties with tomato sauce**	***Loroco** pastry**
Beef meat	Beet	Beef meat	*Loroco*
Tomato sauce	Onion	Tomato Sauce	Corn flour
Onion	Parsley	Red pepper	Vegetable oil
Garlic	Tomato sauce	Onion	Tomato sauce
	Vinegar		

Note: **Loroco* is a local aromatic flower used in certain dishes.

Fourteen of them in the rural area (93%) used all of their sauce (245 g) while the other only half (122.5 g). All of them and their families liked the sauce with the food consumed by every household member over two years old. The number of persons consuming the meals in the rural households ranged from 2 to 9 (median: 4). From this, the individual distribution of the index nutrients from RPO could be estimated. The amount of vitamin A activity, in RAEs, for each member of the household unit ranged from 30.3 to 286.0, with a mean of 119.2 ± 77.9 and median of 93.0 RAE. This included the vitamin A from the RPO as well as that from the other ingredients of the dish. The maximum contribution from the RPO was ~184 RAE per consumer. For the vitamin E-related constituents, the individual distribution of tocopherols and tocotrienols ranged from 0.13 to 1.21 mg, with a mean of 0.39 ± 0.3 and a median of 0.26 mg.

Of the 15 urban women, 14 used all of their sauce in their meals and one woman only half (122.5 g). They liked the sauce as did their families.

In the 31 recipes from the 30 households, pasta (including pizza) (n = 9), meats (n = 6), and eggs (n = 4) were the principal components. Interestingly, in the rural households, pasta or meat dishes (n = 10) were twice as common as they were in the urban homes (n = 5). Chicken and eggs, in contrast were more common in the urban areas than in the countryside. The complexity of the dishes was generally low, with anywhere from one to six other ingredients in the dish with the tomato sauce.

The number of consumers of the prepared dish per urban family ranged from 2 to 6. Hence, the vitamin A activity in RAEs, for each member of the household, ranged from 60.8 to 301.1, with a mean of 150.3 ± 81.1, and median of 138.0 RAE. Again, this calculation included both the extrinsic (RPO) and intrinsic vitamin A. For the vitamin E-related constituents, the individual distribution of tocopherols and tocotrienols ranged from 0.26 to 0.52 mg per person, with a mean of 0.37 ± 0.11 and median of 0.39 mg.

Use of Hot Green Sauce in Rural and Urban Households

In a final round with the cohort of 15 rural heads of households, an additional household use inquiry with the hot green sauce was conducted. The women were given 245 g hot green sauce and identical instructions. Only three (20%) actually prepared meals with the sauce. The remaining 80% only used the sauce as garnish and was generally only taken by the parents and older children. Examples of the dishes cooked are detailed in *Table 3*. As garnish, the hot sauce was used on foods ranging from beans to chicken and rice.

TABLE 3. INGREDIENTS USED BY RURAL AND URBAN WOMEN IN DISHES PREPARED WITH HOT GREEN SAUCE

Chicken with green sauce	**Meat with green sauce**	**Eggs with green sauce**	**Stomach with green sauce**
Chicken	Beef	Eggs	Coriander
Green sauce	Green sauce	Green sauce	Red pepper
Tomato	Salt	Hot peppers	Onion
Salt			Stomach
			Green sauce

Among the 15 urban households, cooking (precombine) with the green sauce was done by 2 (13.3%), with the rest using it as garnish. Both the subjects who cooked with it used all the sauce. Those who used it as garnish did so over various meals throughout the day, although not by the young children.

Because the nature of the sauce could have been difficult for the children to take, we performed another series of studies with the hot pepper-based green sauce. In this 15 women from both rural and urban communities were given 245 g of the spicy sauce, and told that we wanted their recipes for using it and to know how much was used. So we requested them to specifically create recipes with the sauce, record the preparation, and specify the amounts consumed by each family member. The leftovers were to be brought in for weighing the next day.

Even with this more direct request for recipe-creation, not all the women complied. In the rural area, only 11 (73.3%) followed the instructions; the remaining four (26.6%) used the sauce to garnish. The amounts used per individual were estimated to be 5 to 15 g. In the urban area, all of the subjects followed the instructions and cooked with the sauce.

In total, we had 31 recipes from 60 volunteers who cooked with the sauce. The number of consumers of the meals was 175, that is, 87.5% of the 200 total members of these households. Some children and family members did not take the sauce as it was too hot and spicy. The amount of vitamin A activity, in RAEs, for each consumer ranged from 81.3 to 7174.1 RAE, with a mean of 484.4 $\pm$ 1255.4 and median of 98.5 RAE. This calculation included both the extrinsic (RPO) and intrinsic vitamin A. The maximum contribution from palm oil was ~240 RAE per consumer. Consumption of vitamin E-related constituents by each consumer in the households ranged from 0.065 to 1.3 mg, with a mean of 0.6 ± 0.33 mg, and median of 0.5 mg.

Upper Limits of Combination of Tomato Sauce with Household Recipes

Based on the results of the first series of exposures of households to the sauces, we found that all of the women who cooked with them used their full 245 g aliquot. It was as if they fully used their sauces because they were free. Based on a market survey of the various presentations of commercial tomato sauces in a local supermarket (*Table 4*), we enrolled another 10 low income women from an urban setting and offered them 400 g sweet tomato sauce, with the same basic instructions as before. All of the subjects consumed the whole 400 g of sauce. Two subjects added water or flour to increase the volume of their sauce.

Maximal Acceptable Tolerance of Condiment Sauces for Red Palm Oil

The total retinol activity equivalent in 40 g Carotino (the standard amount added to the bulk preparations of the condiment sauces) was 7360 RAE. Clearly, more nutrients could be delivered if more oil was added. A forced-ranking test of preference based on organoleptic properties of the sauces made with 40, 60 and 80 g RPO in the base recipes for the red and green sauces was performed with 15 middle-class professionals and students. Each subject was offered coded samples of the sauces with the three levels of RPO on saltine crackers, and asked to rank their preferences of five organoleptic properties (appearance, flavour, texture, colour and odour). *Table 5* presents the cumulative scores awarded for appearance, flavour, texture, colour and odour. The lowest score, for the low oil preparation, was 91% of the highest. The lowest score, for the high oil preparation, was 81% of the maximum. Specifically, the hot green sauce, with 80 g oil in the base, had a statistically inferior colour rating.

TABLE 4. PRESENTATIONS OF COMMERCIAL TOMATO SAUCES IN A LOCAL SUPERMARKET

Brand	Origin	Packing (g)	Price (USD)	Price (USD g^{-1})
Prego	USA	794	3.17	0.0040
Hunt's	USA	751	1.66	0.0022
Cirio	Italy	700	1.90	0.0027
Barilla	Italy	400	3.84	0.0096
Ragú	USA	390	2.48	0.0064
Hero	Spain	370	2.34	0.0063
Naturas	Honduras	227	0.65	0.0029
Ducal	Guatemala	114	0.28	0.0024
Del Monte	Guatemala	113.4	0.33	0.0029
Knorr	Costa Rica	113	0.31	0.0028
Naturas	Honduras	113	0.33	0.0029

TABLE 5. SUMMATED ACCEPTABILITY RATINGS FOR RED AND GREEN SAUCES MADE WITH THREE LEVELS OF RED PALM OIL (RPO)

Amount of RPO	40 g*	60 g*	80 g*
Tomato sauce			
Appearance	30	29	31
Flavour	29	32	29
Texture	29	32	29
Colour	22	29	25
Odour	30	31	29
Total score	140	153	143
Hot green sauce			
Appearance	33	31	26
Flavour	25	31	27
Texture	30	33	27
Colour	**28**	**32**	**16**
Odour	29	30	31
Total score	145	157	127

Note: *Amount added to be standard bulk preparation of sauces.

Statistical analyses showed no significant differences between the colour, texture, appearance and flavour or odour parameters in either sauce, except in colour of the green sauces, in which significant differences were detected by the panel**.**

DISCUSSION

Since the recognition of multiple micronutrient deficiencies in low income populations (Trowbridge *et al.*, 1993; Maberly *et al.*, 1994), a concerted effort to develop public health interventions that would be safe, effective and sustainable has begun. Of the four options for improving micronutrient nutrition, supplements, food fortification, dietary diversification public health measures to reduce infections (Underwood, 1998) those related to foods are considered to be the most sustainable over time, but albeit with least latitude to be directed to specific vulnerable subgroups in the population. In those countries in which micronutrient deficiency is no longer a public health problem, it is the micronutrients added in enriched and fortified foods that accounts affords the country-wide protection (Backstrand, 2002; Berner *et al.*, 2001; Subar *et al.*, 1998). As a matter of both justice and practicality, the introduction of foods rich in micronutrients is worthy of exploration for public health.

The subjects in their communities had no difficulty using these two types of sauces for their family meals. The dishes cooked with both sauces were simple. This probably has more to do with the limitation in their household budgets and, hence, the lack of fancy ingredients than on their innate culinary creativity. With large households and low incomes, the basic simplicity was not unexpected. Nevertheless, the dishes cooked supplied the Guatemalans of limited economic resources with animal protein, primarily chicken, other meats and eggs. Potato, rice and flour dough were virtually not among the starches cooked with the red sauce as their culinary culture were based on the Italian use of pasta, including pizza, as the carbohydrate complement to tomato sauce. So, although few dishes were cooked with hot sauce, no generalities can be drawn.

Whereas the spicy green sauce was used sparingly, almost all the tomato sauce was consumed. Since the study provided free sauces, the households might have cooked based on the free tomato sauce, and not necessarily in their normal way. Therefore, the amounts of sauce used in the dishes in this study may well have been higher than that normally used. Both with the first offering of 245 g red sauce, as well as in the follow-up study in with 400 g of the sauce provided to 10 additional homemakers, the dishes cooked generally used all the sauce. This was admittedly an artificial situation.

Obviously, for any leftover sauce to be used, there must be refrigeration to store the excess. Only about 50% of the low income households in one neighbourhood studied by CeSSIAM had refrigerators (Mayorga, per. comm., 2001). The culinary culture of the lower classes is, therefore, based on daily purchases for cooking. Thus, the tomato sauce unit for low income use would likely be 114 g foil sachets, with one or two used a day. It may not be until the RPO-containing sauces are purchased by the women at market price that the normal behaviour of cooking with red tomato sauce is known.

The basic amount of oil added to the condiment sauces is low, less than 1.5% of total weight of the product, limiting the total delivery of fat-soluble micronutrients to the consumer. In a series of post-hoc studies, we examined the acceptability of incorporating 50% and 100% more RPO in the red and green sauces. Interestingly, in almost every aspect of acceptability, both the higher levels were virtually equivalent up to 80 g oil to their base 5 kg preparation. If we can assume this level of acceptability, we can double the per person intake of dietary vitamins A and E from the sauces. Yet another option could be to substitute the commercial Carotino®, with an oily concentrate derived from the refining of the crude palm oil for cooking or dressing. Given its much deeper red colour, however, the maximum incorporation of this concentrate for acceptance must first be ascertained.

Our findings are on the within household targeting of micronutrients with food-to-food fortification. We tested for conscious resistance to hot and spicy condiments to by children by offering

some low income urban women 245 g of hot green sauce, and asking them to try cook a dish with it as is routinely done with red tomato sauce. Of a possible 60 dishes that can be prepared with the hot sauce, only 30 (50%) were cooked, even though we specifically requested this to be done. This indicates that to supply micronutrients to Guatemalan low income households, making the sauce hot will limit the consumption by children. This approach would be relevant, for instance, in supplying folic acid to fertile women preconceptionally to reduce the risk of neural tube defects (Botto *et al.*, 1999). With the particular nutrient profile of RPO and the need to support the vitamin A content of human milk (Underwood and Stoltzfus, 1995), targeting lactating mothers with an adult flavoured condiment sauce might be a viable application of the present experience. By contrast, any nutrients in a sweet tomato sauce preparation would be taken by the household occupants.

The potential for taking advantage of the natural micronutrients in the oil palm fruit is vast, but the application has been limited. Because red edible oils are not normally used for salad dressing, frying or baking, a concerted effort to introduce them into the diet in a compatible colour carrier is needed. Tomato sauce is one such colour-compatible vehicle readily consumed in Guatemalan households. Hence, the promise of food-to-food fortification can be realized with condiment sauces based on RPO. With this, the further promise of directing extra nutrients to certain target segments of the household can then be addressed.

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