Quality of Fried Foods with Palm Oil

MASASHI SAKATA, YOSHIKAZU TAKAHASHI, and MASANORI SONEHARA,
Miyoshi Oil & Fat Co., Ltd., 66-1, 4-Chome, Horikiri, Katsushika-ku, Tokyo 124, Japan

ABSTRACT

The amount of imported palm oil in Japan during the past few years has been 140,000-150,000 tons per year, or about 9% of the total consumption of vegetable oils in Japan.

In 1975, part of the palm oil was imported as refined type from Malaysia. At the present time, almost all of the palm oil from Malaysia is refined. At the starting point quality of the refined palm oil was not so good, but today it is fairly improved by efforts of Malaysian processers.

Palm oil has excellent properties against oxidation, and it has been generally accepted by consumers as a vegetable oil for health foods. There also is a big potential for increasing consumption of palm oil in fried foods.

Severe regulation of food additives restricts the use of artificial antioxidants and therefore strict quality control is required to get stable frying oils. Consumer knowledge of foods is increasing, and our responsibility for making good quality frying fats is very important.

INTRODUCTION

Total consumption of palm oil in Japan reached nearly 150,000 tons in 1982. This is 50% more than 9 years ago and represents 9% of total vegetable oils consumed. Japanese consumption is mainly in edible uses, especially manufacturing of margarine and shortening. In 1982 uses were 45% margarine and shortening, 15% chocolates, 15% for frying and spraying snack products, 15% instant noodles and 10% for chemicals.

In the past, the use of palm oil for edible purposes was limited by its tendency to grow granular fat crystals (2,3) in products and to cause rapid flavor and color deterioration (4). Recently oil processing technology has made great advances in the field of refining, hydrogenation, fractionation, interesterification and material handling, and these technologies are applied to palm oil so that we get better quality oil with expanding usage in various food areas. It is expected that if the price of palm oil declines, consumption will greatly increase.

In this paper, we refer to palm oil as frying oil because the consumption of palm oil for this purpose is about 30% of total consumption. Palm oil has better oxidation stability than other oils. We can expect this from fatty acid composition in Table I, which indicates characteristics of common frying oils.

Ten years ago, palm oil was not so familiar in Japan. At that time we tried to use this for fried foods such as Chinese noodles, fried rice cakes and fried soy curd. There was always the same problem—"flavor."

We tried to solve this problem by various methods including mixing with other oils or modifying the processing conditions, and palm oil has been gradually penetrating into the fried field.

INSTANT CHINESE NOODLE

The output of instant Chinese noodles is about 4,200 million packs/year.

Generally, frying oil for instant Chinese noodles is a blend of lard and palm oil. The reason for blending is the products have good taste and long shelf-life. The ratio of palm oil blended is from 10 to 30% in domestic lard. The blending ratio depends on the product design for flavor and shelf-life.

Recently, riding on the health food tide, the palm oil ratio is increasing because of people's tendency to use more vegetable oil.

Furthermore, BHA cannot practically be used as antioxidant in this field because of consumer resistance. To

TABLE II

Standard Qualities of Frying Oil for Instant Chinese Noodle

AV	Under 0.05
POV (meq/kg)	Under 1.0 (0.5 at the time of shipment)
Color[a]	Under Red 1.5
AOM values (H)	More than 35 (tocopherols content 200-300 ppm)

[a]Lovibond 133.5 mm cell.

TABLE I

Characteristics of Common Frying Oils*

	Soybean oil	Rapeseed oil	Corn oil	Rice bran oil	Lard	Palm oil	Palm olein
IV	125-138	101-122	103-128	104-110	55-70	50-54	56-59
MP (°C)[a]	–	–	–	–	30-38	30-40	20-25
FA compn. (%)							
C14-0	-0.4	–	–	-0.3	1-2	0.9-1.5	1.0-1.5
C16-0	9-11	3-4	11-14	16-18	21-24	42-45	39-41
C18-0	3-5	1-2	2-3	1-2	9-13	3-5	4-5
C18-1	22-25	55-65	34-40	39-44	43-50	39-42	43-45
C18-2	53-57	17-22	43-52	36-39	11-12	9-11	10-12
C18-3	6-9	9-13	0.5-2	1-2	–	-0.4	-0.5
C20-1	–	2-3	–	–	–	–	–
C22-1	–	-2	–	–	–	–	–
Tocopherols content (ppm)[b]	780-1170	490-680	750-1110	270-400	-10	90-130	100-140
AOM values (H)	13-15	14-16	18-20	18-20	5-8	50-70	45-65

*From Japan Association of Fats & Oils Inspection Institute.
[a]Open-tubed melting point.
[b]Determined by high pressure liquid chromatography.

TABLE III

Result of Analysis of Oil Extracted from Fried Instant Chinese Noodles on the Market

Sample No.	Lapse days after packing	Type of packing	AV	POV[a]	IV	Fatty acid composition (%) C14-0	C15-0	C16-0	C16-1	C17-0	C18-0	C18-1	C18-2	C18-3	Component estimated
1	59 days	Plastic bag	0.26	6.59	59.3	1.4	0.2	31.8	2.6	0.2	9.1	44.0	10.2	–	Lard:Palm 50:50
2	42	Plastic bag	0.10	2.02	64.1	1.7	0.2	26.3	3.3	0.3	11.7	44.8	11.1	–	Lard:Palm 85:15
3	49	Plastic bag	0.10	5.19	48.0	1.1	–	44.5	–	–	5.5	41.2	7.6	–	Slightly hydrogenated palm oil
4	42	Plastic bag	0.49	2.39	119.6	0.2	–	13.7	–	–	3.8	26.8	48.9	6.5	Soybean oil:Palm 85:15
5	21	Polystyren cup	0.36	2.14	56.1	1.3	0.1	37.7	1.6	0.2	7.0	41.2	10.8	–	Lard:Palm 30:70
6	43	Polystyren cup	0.27	2.27	63.0	1.6	0.2	27.3	3.3	0.4	11.0	44.8	10.8	–	Lard:Palm 80:20
7	57	Polystyren cup	0.55	4.80	50.0	1.1	–	43.5	–	–	5.5	41.0	8.5	–	Palm oil
8	43	Polystyren cup	0.29	4.80	51.8	1.1	–	43.6	–	–	4.9	40.2	9.9	–	Palm oil

[a]meq/kg

TABLE IV

Characteristics of Raw Palm Oils and Required Quality of Refined Palm Oils

	RBD palm oil Starting point into processing	RBD palm oil Shipping point after processing	RBD palm olein Starting	RBD palm olein Shipping
AV	<0.3	<0.05	<0.3	<0.05
POV (meq/kg)	<5	<0.5	<5	<0.5
Color (R)[a]	<3.0	<1.3	<3.0	<1.3
AOM values (H)	50 ± 10	60 ± 10	45 ± 10	55 ± 10
Tocols content (ppm)	140 ± 20	110 ± 20	160 ± 20	120 ± 20
Bleaching (5) test	<1.3 (R)		<1.3 (R)	

[a]Lovibond 133.5 mm cell.

increase oxidative stability it is necessary to improve oil processing technology and to use natural mixed tocopherols (tocols) as antioxidants. Standard qualities of frying oil required by the noodle processer are shown in Table II.

Main points to increase the oxidation stability of frying oil are increasing palm oil ratio to lard, increasing the content of tocols in the oil, and selective hydrogenation of oils. Results of analyses of some samples on the market are shown in Table III. We found each package of fried Chinese noodles contained about 20 grams of oil. If we assume the frying oil contains 30% palm oil, we eat about 20,000 tons of palm oil from the noodles. For this frying oil, the blending ratio of palm oil has a tendency to increase because of its excellent oxidative stability compared with other oils. Most of the palm oil consumed in Japan comes from Malaysia. Main items of quality control are acid value (AV), peroxide value (POV), active oxygen method values (AOM), tocols content, color, bleaching test (5), iodine value (IV), fatty acid composition (FA Compn.), melting point (MP), saponification value (SV) and solid fat content (SFC by NMR). Table IV indicates the required characteristics of the raw and refined palm oils. From Table IV, we have to re-refine both RBD palm oil and RBD palm olein in order to satisfy the specifications. Even in this case, we sometimes find it hard to satisfy the specification. For example, from the low grade starting oil of POV 10 and AOM 30 hours, it is very difficult to get the good oil for frying by our commercial standard process.

To use palm oil for frying purposes, the addition of silicone oil is indispensable to prevent foaming during frying and oxidation; it also lenthens the shelf-life of the fried products (6,8). Silicone oil is admitted as a food additive

TABLE V

Characteristics of Partially Hydrogenated Palm Oil and Palm Olein

	Partially hydrogenated palm oil	Partially hydrogenated palm olein
MP (°C)	38-40	30-32
IV	46-48	50-52
AOM values (H)	100-130	80-110
SFC (%)		
10 C	62 ± 3 (45 ± 3)[a]	51 ± 3 (31 ± 3)
20 C	40 ± 3 (24 ± 3)	24 ± 3 (6 ± 2)
30 C	16 ± 3 (9 ± 2)	5 ± 2 (0)
FA compn. (%)		
C14-0	-1.0	1.0-1.5
C16-0	42-45	39-41
C18-0	5-7	4-6
C18-1	45-48	47-51
C18-2	3-5	4-6

[a]Figures in parentheses are values before hydrogenation.

(defoamer) in Japan, and limited to 50 ppm. As reported by Freeman et al. (9), it is effective at levels of 0.02 to 0.1 ppm. We recommend the addition of 0.5 to 2 ppm of silicone oil in frying oil. In our experiment, to which we will refer later, at 10 ppm or more silicone oil acts as a foamer and not as a defoamer at the point of putting materials into the frying pan. This phenomenon was reported by Sims et al. (10) and Tomita (11).

Another method to increase resistance to oxidation is to hydrogenate RBD palm oil and olein. Table V shows the characteristics of partially hydrogenated RBD palm oil and olein.

It is obvious from Table V that AOM values of partially hydrogenated palm oil and olein are greatly improved by hydrogenation. We feel the amount of partially hydrogenated palm oil and olein used for frying oil will increase rapidly because there is a limitation on the improvement of oxidative stability by addition of tocols (12,13).

We report now the result of a frying test that was conducted in our laboratory under the following conditions: amount of oil, 500 grams in frying pan (porcelain–diameter, 13 cm); frying material, raw Chinese noodles or frozen potatoes (for french fried potatoes); number of frying times, three times a day; quantities of frying materials, 20 grams each time, and total heating time, 24 hr (3 days, 8 hr each).

Table VI shows the properties of palm oil used in this test. Figure 1 indicates there is quite a difference between oils with silicone and without silicone, but silicone levels do not affect the result. Figure 2 shows the residual tocol content in frying oils with and without silicone after 8 hr use. In Figure 2, we see the residual tocols are about 70% of the original in the frying oil with silicone; none are left in the oil without silicone.

We observed that the frying oil with more than 10 ppm silicone tended to foam vigorously when we put materials into the frying pan. We also checked SFC of the oil before and after frying in different levels of silicone in frying oil (Table VII). The result confirmed that silicone oil is very effective in preserving oil qualities during frying. This is very important from a nutritional point of view because changes in SFC indicate the polymerization of the oil during frying. Table VIII shows the result of residual tocol content and AOM values of palm oil after frying. In this experiment, we also checked acid value, peroxide value and color. From this result it is obvious AOM values drop as the content of residual tocols decreases. Tocols and pigments are retained more in the oil with silicone than in the oil without silicone. This means that silicone might prevent the formation of peroxides which are supposed to attack both tocols and pigments.

TABLE VI

Properties of Palm Oil Used in Frying Test

AV	0.04
POV (meq/kg)	0.34
IV	52.4
Color (R/Y)[a]	1.2/11
SFC (%)	
10 C	45.5
20 C	24.0
30 C	7.8
FA compn. (%)	
C14-0	1.1
C16-0	42.3
C18-0	5.2
C18-1	39.9
C18-2	10.4
Tocols content (ppm)	104
AOM values (H)	62

[a]Lovibond 133.5 mm cell.

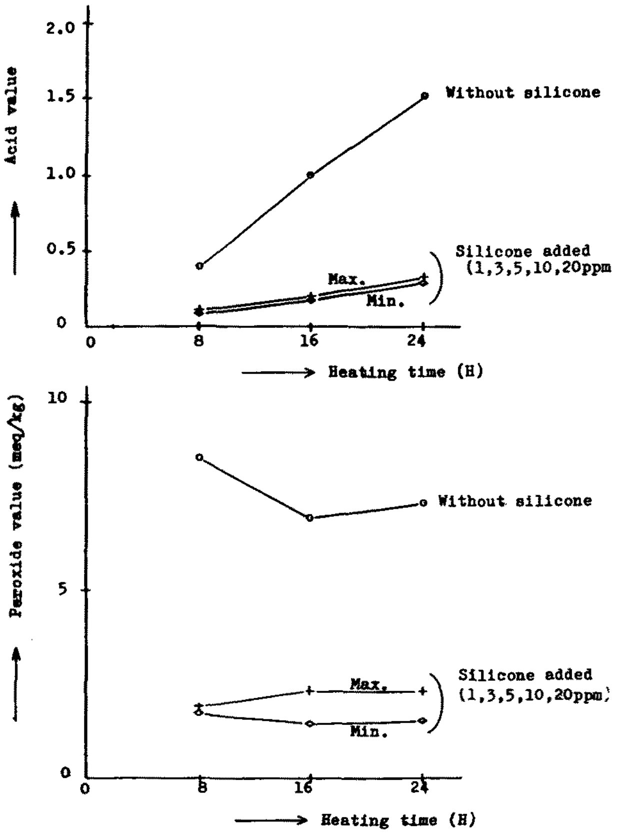

FIG. 1. The changes of acid value and peroxide value by the different amount added of silicone oil. (Frying oil: palm oil; frying temp.: 180 C, frying material: frozen potatoes.)

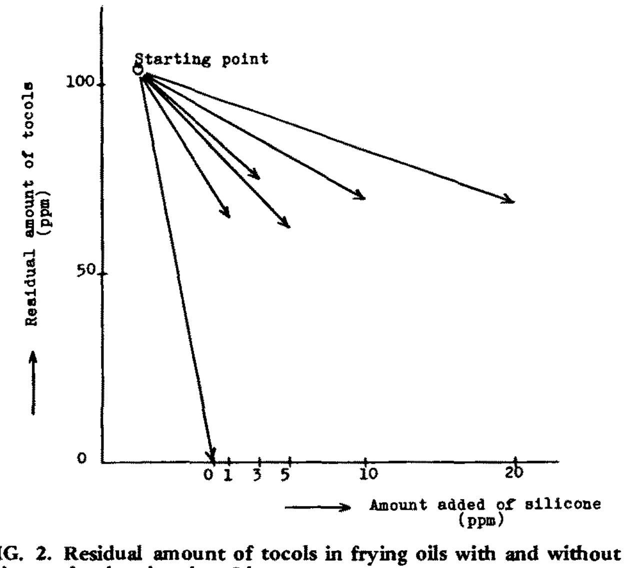

FIG. 2. Residual amount of tocols in frying oils with and without silicone after heating time 8 hr.

SNACK FOODS

Let us discuss frying and spraying oil in the field of snack items, especially of Japanese rice crackers or fried rice cakes. Products of these items are usually made at high temperature between 140 and 250 C and contain much oil.

Furthermore, these products are required to have a long shelf-life. For these reasons, there are many problems to be solved. Table IX shows the amount of production of snacks

TABLE VIII

Frying Raw Chinese Noodles in Palm Oil With and Without Silicone at 150 C

Heating time (H)	AV	POV (meq/kg)	Color (R/Y)	Tocol content (ppm)	AOM values (H)
Before heating				237 (Tocols added)	67
No. 1 Without silicone					
8	0.16	18.1	1.1/10	8 (3.4)[a]	7
16	0.38	9.7	1.0/10	2 (0.8)	5
24	0.47	4.5	1.7/16	1 (0.4)	4
No. 2 2 ppm silicone added					
8	0.08	4.5	1.6/16	171 (72.2)	47
16	0.14	5.9	1.9/19	97 (40.9)	45
24	0.17	5.1	2.5/24	31 (13.1)	30

[a]Figures in parentheses show the remaining percentage.

TABLE VII

The Changes of SFC in Different Level of Silicone in Frying Oil After Frying (heating 24 hr)

	SFC (%)		
	10 C	20 C	30 C
Original	45.5	24.0	7.8
Silicone level (ppm)			
0	14.4	13.7	7.0
1	42.2	20.6	7.2
3	43.2	22.1	8.5
5	42.8	21.8	7.4
10	43.3	21.7	7.8
20	42.6	22.4	8.2

TABLE IX

Consumption of Snacks in Japan (tons)

	1982
Crackers	88,500
Biscuits	267,000
Snacks made from rice	222,000
Other snacks	201,000
Fried sugar cakes	65,000

From statistics of Japan Cake Association.

in Japan. The 850,000 tons of snack foods corresponds to about 45% of the total production of all cake items. The *Bakery Times* of Japan reports that fried snacks contain 24% oil, sprayed snacks 17.6% oil, and cookies 23.6% oil. Most of the oils in these snacks are vegetable or are derived from vegetable oils.

Rice bran oil and corn oil are applied as basic oils to these items because they have good properties of preserving flavor, a requirement with these items.

Refined palm oil is so light in flavor that it is not used alone even though it has good resistance to oxidation. It is applied mainly with the liquid oils to improve oxidative stability of the fried products. On the whole, shelf-life of the products becomes longer in proportion to AOM values of the oil. Palm oil and palm olein are suitable for these items. Palm olein is better because it has a low melting point, gives good mouth feel and has better stability than palm oil. We feel palm olein consumption will increase broadly in these items.

The Japanese Ministry of Welfare recommends the following specification for the oil in these items, and at the same time these are now the quality standards:

TABLE X

Analytical Data of Fried Rice Crackers Bought from Retail Store

Sample no.	AV	POV (meq/kg)	Days after production
1	1.19	6.9	14
2	0.35	5.4	89
3	0.22	11.9	8
4	1.19	1.4	34
5	0.20	7.9	70
6	0.05	2.3	21
7	0.46	4.7	22
8	1.49	5.0	39

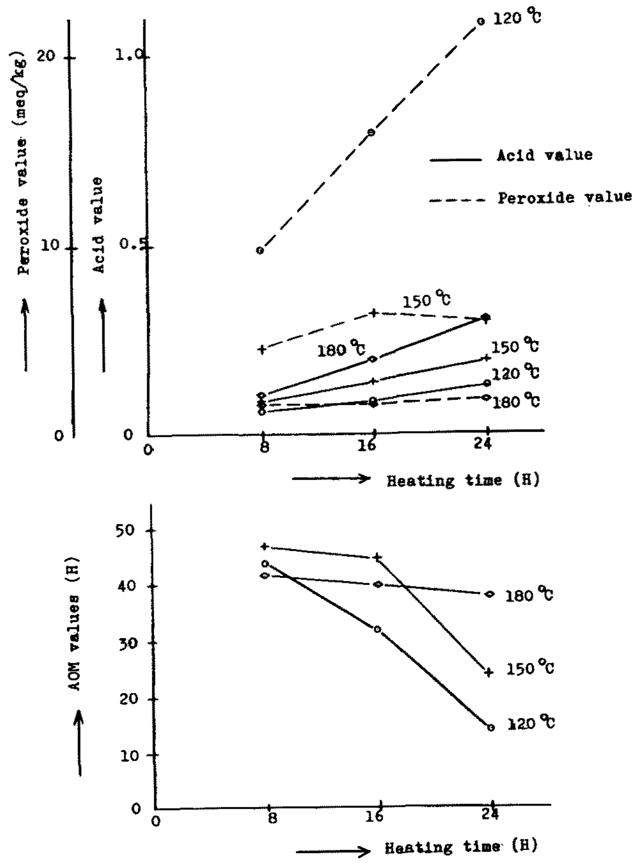

FIG. 3. The changes of acid value, peroxide value and AOM values by different frying temperature under model test conditions. (Frying oil: palm oil; amount of silicone added: 2 ppm; frying material: frozen potatoes.)

TABLE XI

Effects of Frying Frozen Potatoes at 180 C in Palm Oil With and Without Silicone Under Model Test Conditions

Heating time (H)	AV	POV[a]	IV	Color (R/Y)	Tocol content (ppm)	AOM values (H)
Before heating					199 (Tocols added)[b]	65
No. 1 Without silicone						
8	0.21	5.4	50.8	1.8/18	11 (5.5)[c]	14
16	0.70	6.8	48.6	1.6/16	0 (0)	5
24	1.31	7.5	45.0	3.2/32	0 (0)	4
No. 2 2 ppm silicone added[d]						
8	0.11	1.6	51.6	2.1/20	160 (80.4)	42
16	0.20	1.6	51.6	4.1/41	107 (53.8)	40
24	0.31	1.8	50.6	7.2/60	60 (30.2)	38

[a]meq/kg.

[b]Natural mixed tocopherol: Riken Vitamin Co. Ltd., d-Mixed Tocopherol Conc., purity; 58.2%, ratio of isomers; α 9.7%, β 1.3%, γ 59.2%, δ 29.8%.

[c]Figures in parentheses show the remaining ratio (%).

[d]Silicone oil: Toshiba Silicone TSA-750, dimethylsiloxane, purity; 95%.

TABLE XII

Effects of Frying Frozen Potatoes at 180 C in Palm Olein With and Without Silicone Under Model Test Conditions

Heating time (H)	AV	POV[a]	IV	Color (R/Y)	Tocol content (ppm)	AOM values (H)
Before heating	0.04	0.31	57	1.1/10	223 (Tocols added)	63
No. 1 Without silicone						
8	0.19	5.8	54.9	2.3/22	14 (6.3)[b]	17
16	0.63	5.8	52.3	2.1/20		5
24	1.12	7.6	50.4	3.2/32	0 (0)	5
No. 2 2 ppm silicone added						
8	0.09	2.2	56.3	2.1/20	184 (82.5)	53
16	0.25	1.7	55.5	3.1/30		45
24	0.25	1.8	55.1	6.7/62	89 (39.9)	41

[a]meq/kg.

[b]Figures in parentheses show the remaining ratio (%).

TABLE XIII

Effects of Frying Frozen Potatoes in Blends of Palm and Rice Bran Oils (60/40)

Sample	Original			After frying		
	AV	POV[a]	Color (R/Y)	AV	POV	Color (R/Y)
No. 1	0.05	0.00	1.3/12	0.34	1.58	3.0/30
No. 2	0.05	0.38	1.6/15	0.44	1.58	3.1/31
No. 3	0.05	0.98	1.6/15	0.45	1.72	4.0/40

[a]meq/kg.

- AV not over 5.
- POV not over 50.
- AV not over 3 and POV not over 30 at the same time.

Table X shows the results of analyses of snacks bought at retail stores. All packed goods satisfied this standard. Recently, we often are finding oil-sprayed rice crackers in the market. Also, we often find expiration dates printed on packages with production dates.

To study oil qualities, we used palm oil and palm olein at a frying temperature of 180 C under model test conditions. The results of the frying tests are shown in Tables XI and XII. These results agreed well with those of Yuki et al. (14), i.e., palm olein showed better oxidative stability than palm oil after frying, although it was less before frying. Also, the addition of silicone oil prevented hydrolysis and oxidative deterioration and effectively decreased the loss of tocols and the drop of AOM values.

TABLE XIV

The Results of Frying Test[a] Using Partially Hydrogenated Palm and Coconut Oils

	P.H. Palm oil			P.H. Coconut oil		
	AV	POV[b]	Color (R/Y)	AV	POV	Color (R/Y)
Before frying	0.06	0.28	0.6/6	0.06	0.00	0.2/3.0
Frying time (H)						
6	0.10	8.26	2.4/23	0.08	4.41	2.4/22
10	0.12	10.9	1.7/16	0.18	28.6	0.3/4
14	0.17	13.4	1.1/10	0.55	61.6	0.3/3
18	0.17	11.0	1.1/11	0.79	61.1	0.3/3
22	0.21	13.0	1.0/11	1.24	69.1	0.5/5
26	0.26	13.6	1.0/10	1.93	66.6	0.4/7
30	0.35	17.3	1.0/10	2.56	58.7	0.8/10

[a]Amount of oil, 400 grams; frying temp., 150 C; frying material, peeled peanut; quantities of frying materials, 50 grams in each time.

[b]meq/kg.

From the results shown in Table XIII, we concluded that the formation of free fatty acids and peroxides is retarded by silicone oil at such a high temperature, 220 C.

We also presented the changes of AV, POV and AOM values by different frying temperatures in Figure 3.

FRIED PEANUTS

Generally, oils used for frying peanuts are partially hydrogenated coconut or palm kernel oils and partially hydrogenated oils derived from palm oil.

Hydrogenated coconut and palm kernel oils have good stability to oxidation of over 400 hr in AOM values. Furthermore, setting rates of these oils after frying are high, and the surface of peanuts is not sticky.

On the other hand, these oils are apt to be hydrolyzed by moisture and microorganisms and to cause soapy flavors. Another fault with coconut and palm kernel oils is a vigorous, foamy nature in the frying process which may be caused by interaction of the oil with eluted substances from the beans.

In contrast with coconut and kernel oils, partially hydrogenated oil derived from palm oil is not so easily hydrolyzed and does not cause soapy flavor and bubbles in the frying process. As concerns oxidation, refined palm oil has 60 hr AOM values and is improved to 400 hr by partial hydrogenation.

Table XIV shows some results of frying tests using partially hydrogenated palm and coconut oils. It is clear that the increase in acid and peroxide values of the palm oil is slow compared with the coconut oil.

Polymerization of the palm oil during frying is less than that of the coconut oil. Palm oil does have a tendency to increase color, but this does not affect products negatively.

REFERENCES

1. Kawada et al., Yukagaku 33:162 (1984).
2. Ishikawa et al., Ibid. 29:235 (1980).
3. Jacobsberg, B., et al., JAOCS 53:609 (1976).
4. Miura et al., Yukagaku 29:97 (1980).
5. Official Method of the AOCS, 2.2.7-71.
6. Usuki et al., Nippon Shokuhin Kogyo Gakkaishi 25:338 (1978).
7. Kusaka et al., Yukagaku 29:341 (1980).
8. Yuki et al., Ibid. 31:915 (1982).
9. Freeman et al., JAOCS 50:101 (1973).
10. Sims et al., Lipids 8:337 (1973).
11. Tomita, Yukagaku 23:333 (1974).
12. Sherwin, E.S., JAOCS 65:809 (1978).
13. Cort, W.M., JAOCS 51:321 (1974).
14. Yuki et al., Yukagaku 33:265 (1984).

Palm Oil: Quality Requirements from a Customer's Point of View

M.G.A. WILLEMS, Croklaan, BV, Wormerveer, The Netherlands, and **F.B. PADLEY**, Unilever Research Laboratory, Colworth House, Sharnbrook, Bedforshire, England

ABSTRACT

The quality specifications for partly and fully processed oils sold to the European Edible Fats industry are discussed. The industry generally has regarded quality specifications as giving some guarantee of parameters such as FFA, moisture, impurities, iodine value and solids content. However, the availability of processed oils leads us to consider other aspects of quality apart from those normally required. In particular, potential hazards associated with refining and transport procedures become increasingly significant if the European industry is to consider using fully refined oils directly in products. As long as suppliers are unable to make the necessary guarantees, Unilever companies in Europe will be unable to take full advantage of the potential benefits offered by the palm oil industry. The above topics, together with a description of the specification required for the specific product applications, are discussed in this paper.

INTRODUCTION

Numerous fully and partly processed palm oils are now available in the world market. The objective of this paper is to discuss opportunities and problems which these new materials present to the European edible fat industry. Conversely, what do the suppliers of palm oil need in order to guarantee qualities to the edible fat industry so that it can take full advantage of these processed oils (1,2)?

The views presented in this paper are specifically those of the major Unilever companies in Europe, which have experience with palm oils delivered in different process stages from crude to partly and fully refined. The latter varieties are becoming more and more important due to their increased availability.

In the past the European edible fat industry was concerned mainly with upgrading crude oils and fats to make them suitable for human consumption. The industry obviously is now facing a new situation due to the introduction of processed Palm oils.

When using crude oils the refiners are able to adapt their processes to correct for crude oil quality as measured on arrival. However, when the refiner wants to use partially or fully processed palm oils and apply more simplified refining techniques, he has to rely on the regular quality-consciousness of the local producer and the transport organization. In this respect the use of inferior raw materials or incorrect processes at origin could have serious consequences for his business.

It is obvious that in the latter situation, quality aspects other than those normally stipulated in contracts under the general indication GMQ (Good Merchantable Quality), are of importance. Depending on the process applied by the receiving industry and the end application, these more specific requirements may become much more relevant.

In this paper we first discuss the general quality aspects which are relevant to all palm oil applications and second the quality aspects which are more applicable to specific end uses.

QUALITY STANDARDS APPLICABLE TO ALL EDIBLE PALM OIL APPLICATIONS

According to the Unilever standards good refined palm Oils can generally be specified as indicated in Table I. Although in many studies no statistical correlation could be found between crude oil and refined oil characteristics, it is felt that with a proper refining procedure (such as Table II), the above specification should be met using good quality crude oils.