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QUALITY PRESERVATION DURING TRANSPORTATION

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QUALITY AND TRANSPORTATION

The Significance of Quality

Quality is an essential cost factor in the selection of oils and fats by the end-users. The use of good quality palm oil products as raw materials will contribute to superior properties in the end-products, such as longer shelf-life, consistent quality and ready consumer acceptance. It may also help to reduce further processing and refining. The intrinsic monetary value embodied in good quality should be recognized not only by the buyers and sellers alike, but also by traders, brokers, surveyors and ship-owners.

The Importance of Bulk Transportation

Even though there are some moves towards containerization of edible oils and fats, such as the use of ISO tanks and flexitanks, bulk transportation in parcel tankers, coasters, and barges is still the mainstay of the trade. Up to 20 million tonnes of oils and fats are shipped in bulk world-wide every year.

TECHNIQUES AND PRECAUTIONS IN THE PRESERVATION OF QUALITY

The design of ship and shore tanks, pipelines and heating elements, the materials of construction, tank coatings and the effects of excessive heating and aeration are some of the factors which must be carefully considered in order to prevent or minimize deterioration of quality.

Reducing Aeration

Reducing the aeration of the oil during loading, discharging and despatch is important as this will reduce the risk of increasing dissolved oxygen content (DOC) in the oil and thereby also minimize possible oxidation. Filling and emptying should always be done from the bottom of the tank to avoid aeration. If over-top filling has to be done, the filling outlet should be placed close to the tank wall to allow the oil to flow down the wall without cascading and splashing. Alternatively, it may be useful to have a pipeline which can be raised or lowered with the level of oil to eliminate splashing and to reduce strains on the pump. During despatching into rail or road tankers, a telescopic despatch line should be lowered right to the bottom of the tank, then progressively raised – but keeping it well below the oil level. With ships, loading and discharging should be done through the manifolds as the pipelines mostly lead directly to the bottom of the tank. After loading, line-blowing with compressed air towards the oil should be avoided. Ideally nitrogen should be used. Alternatively, a pigging system would be more suitable than the use of air. Before pumping, pipeline joints, fittings, valves and pumps should be checked for leaks.

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REDUCING DISSOLVED OXYGEN CONTENT (DOC)

Nitrogen Blanketing

During a voyage, oil movement and the turbulence created may increase the level of DOC in the oil. This is especially true when the ship's tank is only partially filled. Exposure to air can be minimized by blanketing with an inert gas such as nitrogen, which is cheap. Reducing the concentration of oxygen by the use of nitrogen in the tank head-space reduces the solubility of oxygen in the oil, thus causing oxygen to migrate out of the oil into the head-space. Blanketing therefore provides a means of oxygen desorption as well as reducing exposure to oxygen.

Nitrogen Sparging

De-aeration of oil or removal of dissolved oxygen can be done more effectively by pipeline sparging with nitrogen during transfer. Oxygen desorption by sparging has the advantage of breaking up the nitrogen atmosphere into tiny bubbles within the oil itself, thus increasing the surface area of oil in contact with the gas. The slow upward migration of nitrogen bubbles removes oxygen. *Figure 1* shows data on four shipments of RBD palm olein from Malaysia to the USA in voyages of 48-63 days. The cargoes, each of 1000 tonnes, were loaded into epoxy-coated ships' tanks. Quality analyses were done on samples taken after loading port (LP) and before discharge at the arrival port (AP). The two shipments sparged with nitrogen showed that 10% nitrogen was effective in controlling the increase in peroxide value (PV) during the voyage. The arrival PV was less than 1 meq/kg in both cases.

In contrast, the peroxide values of unsparged parcels were 3-6 fold higher on arrival than at the start of the voyage. The results also showed that the free fatty acid level of sparged oleins did not increase.

On arrival, the parcels after discharge into shore

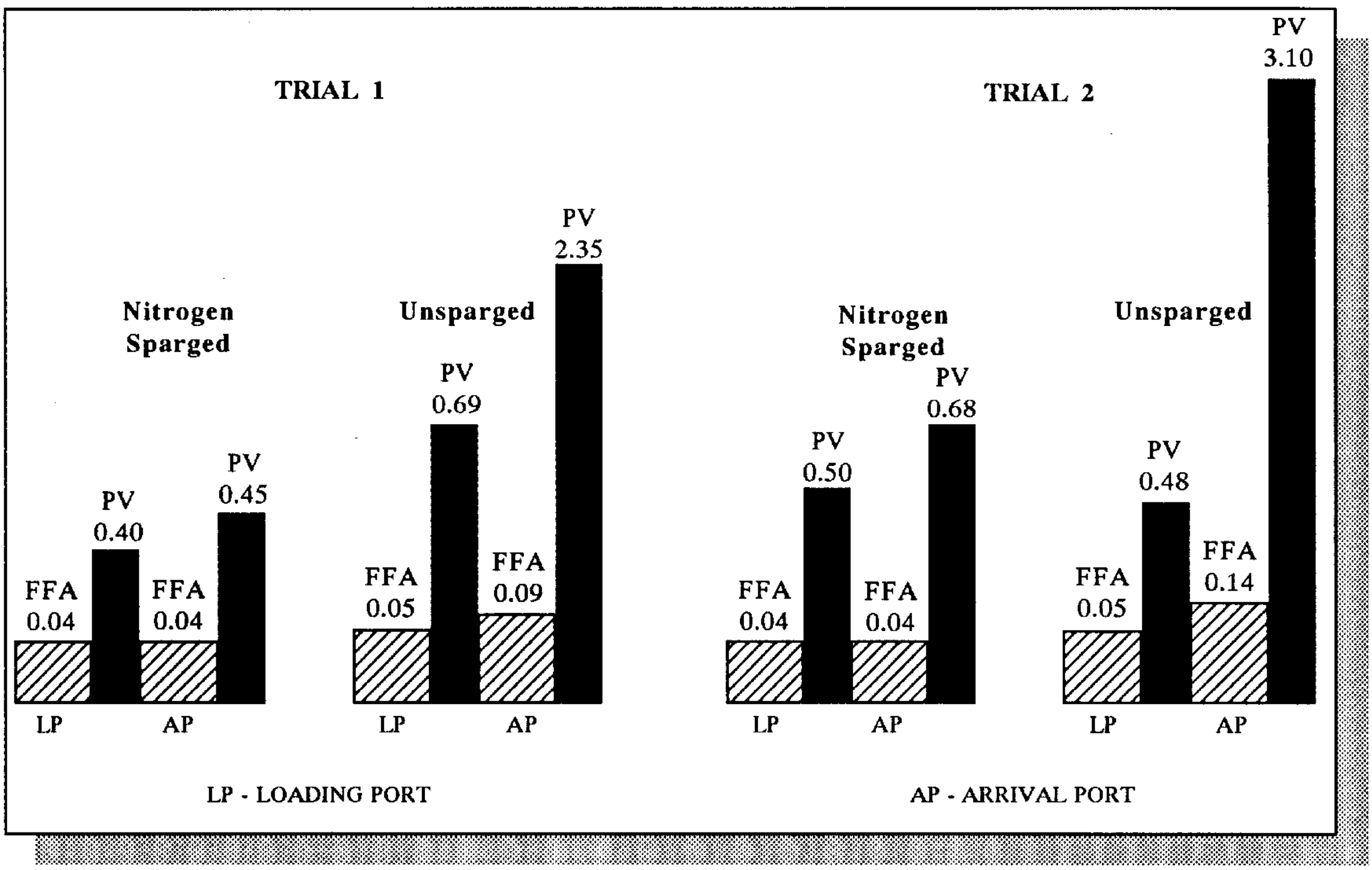

Figure 1. Shipment of RBD Palm Olein to U.S.A. : Nitrogen Sparged vs Unsparged

tanks were monitored further for quality changes during storage. Sampling for analysis continued during the period of 42 days before the parcels were despatched by lorry-tankers or rail-wagons to the manufacturing plants. Nitrogen-sparged parcels were further sparged at a 10% rate during discharge from the ship's tanks and also provided with slow bubbling of nitrogen gas at the rate of 0.14% m^3/hr during storage. The continuous slow bubbling of nitrogen during storage simulates blanketing and helps maintain a positive nitrogen pressure in the tank. *Figures 2(a)* and *2(b)* show the successful suppression of PV and FFA increases during the whole of the storage period of 42 days. The rates of increase in the nitrogen-treated oleins were negligible. The average rates of increase in PV and FFA in the untreated oleins, however, were 0.55 meq/kg per day and 0.0011% per day respectively. Data on peroxide and FFA changes were also obtained during transportation of oleins by trucks and rail-wagons to two different plants at different locations, one requiring a day's journey in trucks and the other requiring 7-14 days in rail-wagons. The nitrogen-treated oleins were further sparged with 10% nitrogen for each despatch by lorry-tanker or rail-wagon. The data in *Table 1* show that for nitrogen-treated oleins, a day's journey in trucks with stainless steel tanks resulted in an average increase in PV of only 0.24 meq/kilogramme. In contrast, transportation by rail-wagons using mild steel tanks and over periods up to two weeks caused an average increase of PV in the untreated oleins of

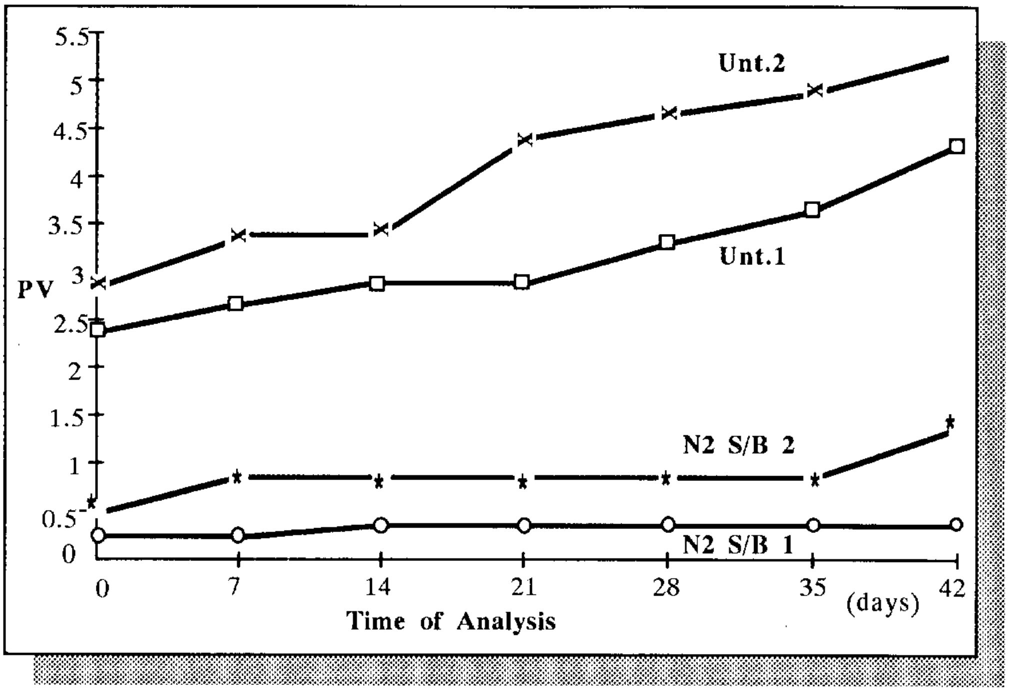

Figure 2(a) Storage Stability PV Changes of RBD Palm Olein

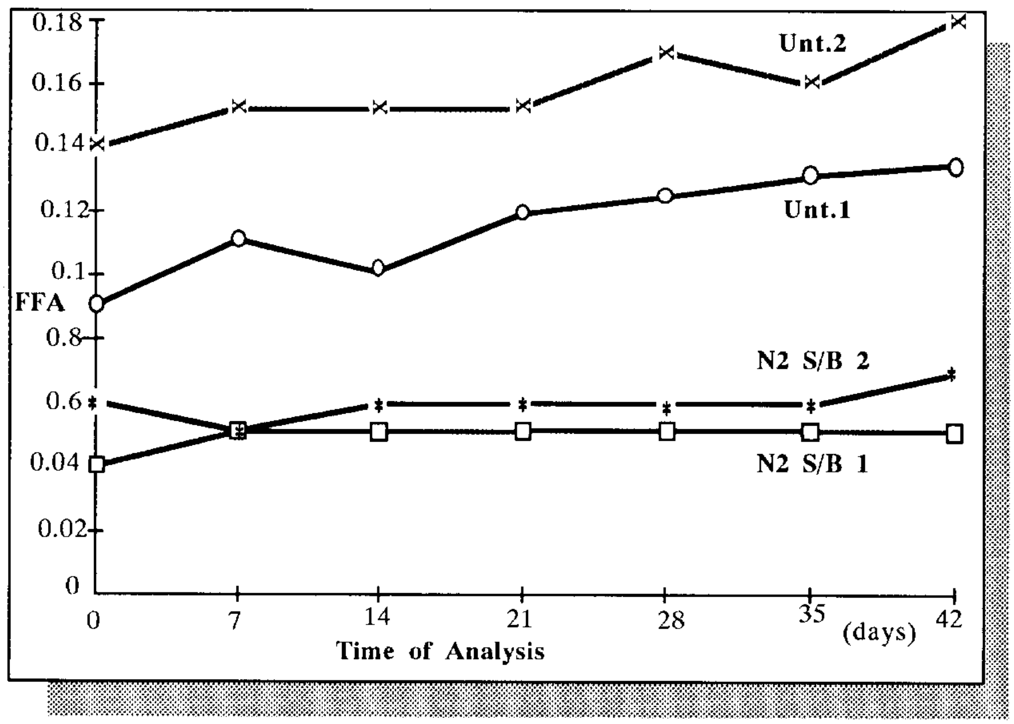

Figure 2(b). Storage Stability FFA Changes of RBD Palm Olein

3.4 meq/kilogramme. The increase in PV in the nitrogen-treated oleins transported by rail-wagons was kept down to 0.71 meq/kg, *i.e.* about five times lower than in untreated olein. There was almost no increase in FFA in nitrogen-treated oleins whether transported by rail-wagons or trucks.

TABLE 1. SUMMARY OF PV & FFA CHANGES FROM ORIGIN TO DESTINATION

		PV(meg/kg)		FFA(%)	
		Nitrogen sparged	Unsparged	Nitrogen Sparged	Unsparged
Voyage	T1	0.05	1.66	0	0.04
	T2	0.18	2.62	0	0.09
Storage	T1	0.35	1.62	0.01	0.04
	T2	0.42	2.20	0.01	0.05
Trucks		0.24	1.22	0.001	0.017
Rail		0.71	3.40	0.003	0.037

The results of this study have thus indicated the surprising beneficial effect of nitrogen sparging in suppressing increases in FFA at all stages during the voyage and up to the receiving plants. As the nitrogen used was an inert dry gas, it possibly helped to keep the moisture content at low levels, thereby preventing the formation of FFA by hydrolysis.

Reducing Catalyst

In order to reduce further the possibility of oxidation, contacts between the oil and metals that catalyze oxidation should be avoided. Pro-oxidant metals like copper, brass, bronze, *etc.* should be avoided in parts such as tank internals, heating coils, temperature gauges, pipelines, pipeline connections, valves, strainers, pumps, ullage tapes and sampling apparatus. Thermometers and sampler encasements should be of stainless steel.

Tank Coatings

Mild steel tanks should be coated with inert food grade material. Stainless steel is best, but for most purposes aluminium is satisfactory. Mild steel is also unsuitable for acid oil or fatty acids. For coated and stainless steel tanks, heating coils should be of stainless steel materials. YUCALBRO heating coils, which can be found in some old tankers, should be completely avoided. For pipelines, mild steel can be accepted for crude and semi-refined products, but stainless steel should be used for refined products and distilled fatty acids. All flexible hoses used as pipeline connections during loading and unloading must be of inert material. Using a tank coating has the added advantage that it makes tank cleaning easier. The choice of a suitable coating is also important in relation to compatibility with the cargoes to be carried. Common tank coatings used by parcel tankers are epoxy, zinc silicate, polyurethane, phenolics, and rubber.

Chelation with Citric Acid

Citric acid can also be used to scavenge any residual trace metals. This is normally done at the cooling stage of the deodorizing cycle by adding about 0.02% citric acid as a 10%-15% solution when the oil is at about 120°C. This will help chelate trace metals picked up during subsequent handling. Citric acid is universally permitted in edible oils and its use in refining is a matter of routine good practice.

Reducing Oxidation

Further protection from oxidation can be obtained by the use of chemical antioxidants. Some of these antioxidants have antimicrobial activity – an added advantage. Although the use of antioxidants is restricted to varying degrees by the food regulations of importing countries, a concentration in the range of 100-200 ppm is well within the legal limit for most of them.

Common antioxidants are BHA, BHT and TBHQ. For storage and transportation it is advantageous to use antioxidants in conjunction with citric acid which acts as a synergist. Where it is legally permitted, the use of 200 ppm TBHQ with 100 ppm citric acid is recommended: this has been proven to be the most effective combination (*Tables 2a* and *2b*).

It is recommended that, where possible, the antioxidant should be added to bulk oil immediately after deodorization in order to obtain the full effect. It is important to ensure complete dispersion and dissolution of antioxidants in the oil. This can be achieved by dissolving the antioxidant either in hot oil (*ca.* 60°C) or in a solvent miscible with oil before addition. Where possible a dosing pump should be used. Complete mixing of the antioxidant can be ensured by the incorporation of a static mixer in the loading line.

Avoiding Overheating

Because of their high melting points, palm oil and its products require heating in order to keep them liquid and homogeneous for easy transfer and discharge. However, care needs to be taken to prevent local overheating, for example near steam coils.

For efficient heating vertical hairpin coils or side heating coils near tank walls are advantageous. Where no provision exists for circulation, a maximum heating rate of 5°C/24 hr should be maintained to avoid local overheating at the coil surface. Where

TABLE 2(a). EFFECT OF TBHQ AND CITRIC ACID ON PV OF RBD PALM OIL

Sample treatment		PV after Weeks											
TBHQ (ppm)	**Citric Acid (ppm)**	**0**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**
0	0	0	21	20	24	28	26	31	27	43	42	49	69
50	0	0	8	6	11	14	18	17	17	25	27	28	39
100	0	0	0	0	0	11	7	9	14	18	18	20	16
150	0	0	0	0	0	4	0	10	10	13	18	12	12
200	0	0	0	0	0	5	0	10	5	17	12	11	26
50	100	0	0	0	0	0	0	7	4	5	10	4	14
100	100	0	0	0	0	0	0	4	4	5	7	4	24
150	100	0	0	0	0	0	0	0	0	8	0	0	10
200	100	0	0	0	0	0	0	0	0	7	0	0	16

TABLE 2(b). EFFECT OF TBHQ AND CITRIC ACID ON PV AND COLOUR OF RBD PALM OIL

TBHQ (ppm)	Sample Treatment Citric Acid (ppm)	PV meq/kg affter 28 weeks' storage	Lovibond Red Colour (initial)	Lovibond Red Colour (after re-Deodorization)
150	0	32	1.75	3.64
200	0	26	1.75	4.30
50	100	14	1.75	1.75
100	100	24	1.75	2.00
150	100	10	1.75	1.75
200	100	16	1.75	1.75

circulation is provided a higher heating rate is permissible. As a guide, a coil area of about 0.1 m^2/m^3 tank capacity is required if the fat has to be melted; about half that value should suffice for heating-up purposes. For better heat distribution to preserve a liquid state and to prevent local overheating, circulation or mixing facilities, *e.g.* side agitators can be provided.

Alternative forms of tank heating include external heating systems and the Frank Mohn Cargo heating system. The heating units can be designed individually as regards materials, heating capacity, tank size and configuration to the owner's specification. Care, however, needs to be taken to ensure no leakage of air into the cargo in circulation.

Reducing Contamination by Foreign Matter

Tank Cleaning

The procedure for tank cleaning may include but is not limited to the following stages:

Pre-cleaning to remove the previous cargo should be carried out as soon as possible in order to avoid it sticking to tank walls. The cleaning proper is then carried out with the aid of a cleaning solution and water. The principal constituents of cleaning agents used are synthetic detergents and alkaline salts together with emulsifiers and peptizers to convert suspensions into dispersions by reducing particle sizes.

Rinsing and steamimg are then done immediately until no residue can be found in the tank or pipelines. This is followed by flushing with fresh water.

During Draining

Any plugs found should be removed. Finally blowing is done with compressed (dry) air which may also help to remove plugs.

Prohibition on Previous Cargoes

Further protection from possible contamination is given by the recent introduction of FOSFA's (Federation of Oil Seed and Fat Association) ban list of last immediate cargoes and NIOP's (National Institute of Oil Seed Products) list of acceptable and unacceptable previous cargoes. These measures have been taken mainly to avoid risks due to negligence and bad handling practice, and to protect and improve the edible oil and parcel tanker trades world-wide. Surveyors and shipowners are reminded to observe the new regulations strictly as failure to do so could lead to breach of contract. This could be a temporary measure as other more practicable ideas are being tried out.

Ship's Tank Screening Device

PORIM and FOSFA International are looking into the possibility of introducing a portable tank screening device that would detect residues of previous cargoes in a ship's tank and pipelines. Some of the pieces of equipment to be tested are infra-red spectrophotometer, MIRAN 1B (Foxboro Co. USA), PHOTOVAC 10S (Photovac International Inc., USA) and the Draeger tubes (Draegerwerk AG Lubeck, West Germany). The possibility exists that these off-the shelf instruments may be further developed to suit the purpose of ensuring 100% clean ships' tanks.

Wall-Wash Screening

Another idea which could be tried out is to rinse a part of the tank that may be inaccessible to cleaning with the intended cargo at high temperatures, using the Butterworth machine for effective removal of the residue, and analyzing the washing for possible remnants.

Reducing Cross-Contaminations

Pigging system

The pigging system is especially important where a number of different products are loaded through a common pipeline system. The pipeline should be pigged between different products or grades. Pigs should be of inert material such as plastic or rubber. Strong flexible pigs shaped into cups are efficient as they can sweep clean. Hot water washing, if done for a pipeline, should be followed by pigging with a sponge or foam pig to absorb the water. When not in use hoses and pipelines should be capped or blanked off to protect them from dirt.

Loading and Discharge Sequence

For loading and discharge, a minimum of three lines are generally required. They are for soft oil, hard fat and technical grade products. When used with pigging the risk of contamination is reduced significantly.

Tank Inspection

Perhaps the most important aspect of quality assurance for port products is tank inspection and the certification that the ship tank is suitable for loading of palm oil and products. Although the decision to accept or reject a ship's tank is the sole responsibility of the surveyor, the ship-owner's co-operation in presenting the most suitable tank and the shippers's or buyer's flexibility in switching tank are both vital.

Other important aspects of tank inspection include studying the ship's three previous cargoes, checking the lightness of heating coils, inspecting the condition of the tank coating, and checking tank valves for sludge and water.

Quality Control During Voyage

During the voyage regular maintenance checks should be made. They should include checking the proper functioning of steam pressure regulation valves, all steam supply valves and steam traps for leakage, and also pressure gauges and all other ancillary equipment.

The use of mercury thermometers in cargo tanks should be avoided, but if used they should be treated with great care to avoid contamination with broken glass or mercury. Thermometers should be securely encased in suitable holders. The temperatures are taken at three levels, the top, middle and bottom.

The top temperature reading will be taken at about 30 cm below the surface of the oil, the bottom reading at 30 cm above the bottom coil and the middle reading in between the two. During the voyage the oil must be kept within the voyage temperatures. In sufficient time before arrival at the port of discharge, heat should be applied gradually so that the cargo will be within its discharge temperature range. A sudden increase in temperature must be avoided as it would result in damage to the oil. The increase in temperature of the oil during a period of 24 hours must never exceed 5°C. Top and bottom temperatures should be maintained as nearly equal as possible, and no large differences in temperature of the oil in different parts of the tank should be permitted. To prevent excessive crystallization during short-term storage and shipping, oil in bulk tanks should be maintained within the temperature ranges given in *Table 3*. These temperatures are chosen to minimize damage to oil. Some crystallization may occur, but not so much as to require excessively long heating before delivery. Thus palm oil stored at 32°C - 40°C will require about three days' heating at 5°C/day to bring it to discharge temperature. Long-term storage of all oils should be at ambient temperature, and heating should be completely turned off.

Temperatures should be taken at least twice daily and more frequently if circumstances demand, depending on the weather and air and sea temperatures. The Master of the ship shall maintain a temperature log and a chart showing a graphical record of temperatures, which are used for maintaining the correct temperature level. The temperatures recorded will be the average of the top, middle and bottom readings.

In the event of abnormal conditions (such as extremely low ambient or water temperatures), receivers at the port of discharge may vary the temperatures stated by giving the shipowners or their agents written instructions to do so. Details of any variations must be duly recorded and the shipper or his representative advised accordingly.

CONCLUSION

Refined palm oil and products as produced by Malaysian refineries are of good quality. Handling, storage and transportation to destination countries may result in some deterioration in quality.

However, quality can be preserved by means of precautions taken during handling and the employment of readily available techniques.

Techniques and practices adopted for the preservation of quality during transportation will benefit end-users and suppliers in the long-run. With the diverse palm oil products that are now readily available from Malaysia, the onus is on the buyers and shippers to choose the right mechanism and mode of transportation to preserve quality.

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TABLE 3. TEMPERATURE DURING STORAGE AND TRANSIT (°C)

Products	Minimum	Maximum
Palm Oil	32	40
Palm Olein	25	30
Palm Stearin	40	45
Palm Mid Fraction	35	40
Palm Kernel Oil	27	32
Palm Kernel Olein	25	30
Palm Kernel Stearin	35	40
Palm Fatty Acid Distillate	52	55
Palm Acid Oil	52	55

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