COPRA DETERIORATION DURING STORAGE AND SHIPMENT*

INTRODUCTION

COPRA is a perishable commodity. The amount of deterioration and loss of actual copra which can occur varies in different circumstances. Commencing with a given quantity of fresh coconut meat the ultimate quality and the quantity of copra received at the mill, depend on four factors :—

(*a*) Care exercised in the preparation of the product.

(*b*) Moisture content of the freshly prepared copra.

(*c*) Treatment during bulking, storage and transport.

(*d*) Length of time elapsing between production and milling.

PERIOD OF STORAGE

The time elapsing between production and milling is dependent on locality of production, difficulties of collection and local transport, seasonal variation in crop, freight charge fluctuations, amount of cargo space available in ocean-going steamers, and the state of the copra market.

In the case of Straits copra, when shipments keep pace with purchases, the normal interval is just over 2 months, but, in exceptional circumstances, the copra may be held in store for 2 or 3 months prior to shipment. Thus for example, during the Great War it was impossible, on occasions, to obtain cargo space from certain ports and more recently, a long period of low prices resulted in considerably reduced shipments. When such situations arise, stocks accumulate in the warehouses, and small dealers, and even producers, may be forced to hold up their copra.

Table I. provides a rough detailed estimate of the time taken to pass copra from the small-holder in this country to the miller in Europe.

Some of the operations shown therein may be omitted or all may be included in full, so that small-holders' copra which is exported may take from one to seven months to reach the oil mill.

Estate copra is nowadays generally exported from the estate direct to Europe on a through bill of lading and little more than a month need elapse between production and milling. Copra milled locally is seldom kept for more than a month after production.

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* By F. C. Cooke, Chemist (Coconut Products), Department of Agriculture, S.S. & F.M.S. in *The Malayan Agricultural Journal*, Vol. XXVII., No. 11, November, 1939.

COPRA TRADING

In the case of the small producer, a small quantity of " raw," half-cured or somewhat under-dried loose copra may perhaps be kept for as long as a week before

TABLE I.

Approximate Times for Various Operations which may occur between Producing and Milling Small-holders' Copra.

Operation	Time.
	Days.
House storage	1 to 7
Shophouse storage	0 to 7
Local dealers' stores	0 to 7
Road, river or coastal transport	1 to 4
Warehousing at export centre	0 to 150
Ocean shipment	30 to 40
Bulk storage before milling	3 to 14
Total ..	35 to 229

the collector calls or delivery is arranged. Whenever possible the copra is sold without delay. These small parcels of copra are bulked by a succession of buyers—the shop-keeper, the transporter, the small local dealer, and ultimately the export dealer and shipper—into consignments of gradually increasing size.

Since he usually buys his copra at a flat rate from producers and then may sell it on a dry-weight basis to the merchants, the local dealer, will usually lay the wettest copra out in the sun for further redrying, particularly when it is likely to pay him to delay resale. Conversely, when copra is sold at a flat rate, cases have occurred where the lowest grades of copra have been deliberately moistened by the seller to increase the weight.

The bulked copra which ultimately arrives at the export centres, Singapore, Penang and Port Swettenham, from the different production centres is variously dry and exhibits different features and degrees of deterioration depending on the treatment accorded to the product and effect of weather conditions on production, storage and shipment. It is for this reason that it is described as " mixed " copra, *i.e.*, a mixture of f.m.s. and f.m. copra* ; the geographical origin is added to this description, *e.g.*, Kelantan " mixed " copra, and this serves to identify the quality, since each coconut district has its particular standard of quality, or a recognized f.m.s./f.m. ratio for " mixed " copra.

The small-holders' bulked copra now being received from most districts is reasonably dry and of high quality and the " ratio " for copra from these districts has distinctly improved; nevertheless some of the copra coming generally from the more remote regions still continues to be of inferior quality. In exceptional cases, such copra is wholly f.m. quality and is offered in a " raw " condition.

* The terms f.m.s. and f.m. are expressions of quality and denote respectively " fair merchantable sundried " and " fair merchantable," the latter being the inferior quality.

CONDITIONING OF COPRA BY STORAGE

" Raw " or half-cured copra, if produced near the export centres is usually received at the export warehouses in a fresh condition but that from the more distant and inaccessible regions or from those places where collection is difficult, is more often badly deteriorated, except when the local dealers or shippers have redried the product before sending it to the export centres.

Fresh " raw " copra, as received, is warm, has a pale yellow gummy surface, is free from mould, and exudes a not unpleasant yeasty odour. Deteriorated " raw " copra is hot, black, soft, matted and glutinous, insect-ridden and dirty ; it is covered with a thick layer of wet slime and black mould and has a revolting sour smell.

All bags of " raw " copra are usually emptied without delay, and the contents built up into a huge stack.

Continuous records show an initial rise in temperature inside such a stack from 35° to 52°C. in about 3 hours. Subsequently the temperature declines slowly to about 38°C. on the eighth day of storage and after that even more gradually to about 30°C. in about three weeks, by which time the moisture content has been reduced to between 4 and 5 per cent. During this period the temperature of the stack rises each night when the warehouse doors are closed.

The condition of fresh " raw " copra which has been expeditiously reconditioned may be surprisingly good in spite of previous superficial development of bacterial slimes. In one instance, although a sample of such copra after reconditioning had a dirty greyish-yellow appearance, it showed little internal discoloration while only 4 per cent. of the pieces were deeply corroded and there were only 8 per cent. of " smalls ". The copra had a not unpleasant smell and the acidity of the contained oil was only 0·8 per cent., calculated in terms of lauric acid.

" Raw " copra which has been permitted to deteriorate seriously before warehousing cannot be satisfactorily reconditioned. After warehousing, the whole of the copra is internally discoloured, the range of colour being light-brown to black. The bulk of the pieces are very deeply corroded and all are in process of breaking down into small fragments. There is very high percentage of " small ", foreign matter and dust, and the acidity of the contained oil, calculated as lauric acid, is usually in excess of 5 per cent. Such copra is therefore below Straits f.m. quality and requires to be " brightened " with copra of somewhat better quality before shipment.

Irrespective of their condition, the various consignments of " mixed " copra received at the warehouses are usually all made up into large stacks of loose or bagged copra as described above. In this way, copra is self-dried by its own heat of decomposition,* the contained moisture being reduced from anything between 7 and 25 per cent. to between 4 and 7 per cent. according to season. A relatively stable and reliable product is thus obtained which may be sorted, blended and graded for export. The length of storage required

* For discussion on heat of decomposition see Special Bulletin No. 28, General Series, Department of Agriculture, S. S. & F. M. S. Copra Deterioration, pp. 20 to 22.

depends principally on the moisture content of the copra on receipt, but occasionally self-drying may be curtailed to make up a consignment when copra is short. Dry copra requires about a week's storage, fairly dry copra about 14 days, and very wet copra as much as three weeks before it is ready for shipment.

BLENDING AND BULKING FOR SHIPMENT

Copra is exported in two grades, Straits f.m.s. and Straits f.m. After warehouse drying, the various lots of " mixed " copra are either up-graded by the removal of defective pieces or down-graded by the removal of good pieces whichever is necessary to produce the required grade. Occasionally there is no picking over, since a parcel may be used to brighten up or bring down a consignment of bulked copra to the desired standard. The method of bulking is to build up, layer upon layer, the various parcels of copra from different sources, so that blending and mixing takes place when this stack of loose copra is broken up and the copra shovelled into sacks. The copra then remains in bags until shipment can be arranged.

During ocean shipment a certain amount of self-heating again occurs in the copra, which is subjected to considerable pressure and disturbance due to the movement of the ship. The individual bags of copra enter the ships' holds at about air temperature (28°C.) ; subsequently there is a slow daily rise for three days to about 35°C. or more according to the efficiency of ventilation in the holds and the condition of the copra ; ultimately when more temperate regions are reached the temperature gradually declines.

The merchant shipper who prepares the copra for export takes full responsibility for the ultimate quality of the copra on arrival and for any serious loss in weight in transit.

The foregoing remarks do not usually apply to estate copra which is nowadays mostly of uniformly good quality and can, in consequence, be shipped direct from the estate to Europe without any warehousing, inspection or blending being necessary. Such copra is classified as Straits f.m.s. although for copra to be forwarded without inspection or warehousing it has, of necessity, to be above normal quality to avoid the possibility of subsequent disputes and arbitration. It is obvious that the interval between production and milling will be much reduced with direct shipment and the amount of handling will also be considerably less. For these reasons, copra of this type usually obtains a small premium.

The agents of deterioration during transport and storage are yeasts, bacteria, various moulds and insects, and the heat of decomposition, but it is the moisture present in the copra which makes deterioration possible and determines which (if any) of the agents may operate and the extent of the deterioration and loss which occurs.

The individual effects of these several agents cannot be separately determined, as it is not practicable to restrict deterioration to a single factor. Nevertheless it is possible to determine, by experiment, the total deterioration and loss which may be expected to occur with a given set of conditions. Even then it is still not possible to follow normal trading, transport, storage and blending practice since copra under observation has to be periodically sampled and cannot therefore be mixed with other copra.

STORAGE TRIALS

In order to ascertain the extent of the loss which occurs when different types of copra are kept for long periods under normal conditions of storage, two storage trials have been carried out with the six different types of produce copra shown in Table II. These may be regarded as representative of the different types of copra produced in Malaya. The majority of estates nowadays produce copra corresponding to grade W1., while the best small-holder producers offer grades W1. and W2. Nevertheless copra of grade W3 does still continue to be made in one or two inaccessible regions and this degenerates, according to the absence of care in production or to the treatment accorded to it by the local dealer, to yield copra corresponding to grades R 1, R 2, and R 3.

TABLE II.

Types of Copra used in Storage Trials

Lot.	Initial Condition.	Moisture Content. Per cent.
W1	Dry smooth white copra	About 8
W2	Fairly dry white copra	9 to 12
W3	Half- dried " raw " white copra	About 20
R1	Dry unscorched " red " copra	About 8
R2	Fairly dry " red " copra	9 to 12
R3	Half-dried " raw red " copra	About 20

The various lots described in Table II. were each prepared from 100 nuts collected from the same estate. The " red " copra was produced by allowing bacterial decomposition to be initiated prior to drying and to continue to develop subsequently through deliberate carelessness during drying. All the copra was carefully kiln-dried over open smokeless fires.

Two methods of storage were used, the period of storage being 2 months in each case. In one, Trial A, the six lots of copra were sent immediately after manufacture for bulk storage in a Singapore warehouse with copra of corresponding qualities (continuous warm storage). In the other, Trial B, there was an initial period of 14 days during which the six lots of copra were kept in a cool place as individual isolated bags (cool storage). Subsequently this copra was warehoused as in the first trial.

It was not possible in either of these trials to simulate exactly the handling and movement, and the conditions of temperature and pressure to which copra is normally subjected during local trading, warehousing and ocean shipment. The conditions of the first trial may nevertheless be considered roughly to correspond to the treatment accorded to the copra from large producers, while those of the second trial are meant to simulate the treatment accorded to the copra made by small producers, amounting to about two-thirds of the total copra produced in Malaya.

The various lots of copra were each examined, weighed and sampled before, during, and after storage. These samples were analysed for moisture, and the acidity of the contained oil was also determined. At the conclusion of the period of storage, the amount of " smalls " and dust associated with each lot, which in practice is reckoned as copra, was also ascertained and the copra was examined qualitatively by a Singapore merchant.

Thus it was possible to estimate the true loss of copra which occurs during storage and to measure the amount of deterioration under the various conditions stated.

The comparative results of the two trials are shown in Tables III. to IX. inclusive.

TABLE III.

Total Loss in Weight during Storage.

(Weights correct to nearest ¼ lb.)

Lot.	Trial A. Continuous Warm Storage.			Trial B. Cool and Warm Storage.		
	Original Weight.	Loss in Weight.	Loss.	Original Weight.	Loss in Weight.	Loss.
	lb.	lb.	Per cent.	lb.	lb.	Per cent.
W1	63·75	1·50	2·3	56·25	3·25	5·8
W2	68·75	5·50	8·0	64·25	6·00	9·3
W3	78·75	18·75	23·8	79·75	20·50	25·7
R1	60·50	3·25	5·3	58·50	3·25	5·6
R2	67·50	6·00	8·9	64·25	10·00	15·6
R3	78·50	17·00	21·6	74·50	20·25	27·2

The total loss in weight in storage includes not only loss of free moisture, but also loss of actual dry copra through decomposition. The loss is expressed as a percentage of the original weight of copra, including contained moisture. It is to be noted that in the transportation of "raw" copra (W 3 and R 3) about a fifth by weight of the consignment consists of avoidable moisture, thus increasing freight costs.

The final moisture content of the copra after warehouse drying was between 4 and 5 per cent. in all cases.

TABLE IV.

Loss of Actual Copra during Preparation and Storage.

(Weights correct to nearest ¼ lb.)

Lot.	Trial A. Continuous Warm Storage.				Trial B. Cool and Warm Storage.				
	Original Dry Weight.*	Preparation Loss.	Storage. Loss.	Total Loss.	Original Dry Weight.*	Preparation Loss.	Cool Storage.	Warm Storage.	Total Loss.
	lb.	lb.	lb.	Per cent.	lb.	lb.	lb.	lb.	Per cent.
W1	59·25	N	N	N	52·00	N	0·50	1·50	3·8
W2	61·75	N	1·75	2·8	56·50	N	N	1·50	2·6
W3	63·25	N	6·00	9·5	65·00	N	6·75	2·25	13·9
R1	55·25	1·50	0·25	3·2	55·25	1·50	2·00	1·00	8·1
R2	59·25	1·50	0·25	3·0	58·25	1·50	5·25	1·25	13·7
R3	61·25	1·50	2·50	6·5	58·50	1·50	5·25	2·00	15·0

N = nil or negligible.

* The figures in these two columns were determined by converting the actual weight of each lot according to its moisture content.

It is perhaps surprising that lot W3 ("raw" white copra) of Trial A showed a greater loss than lot R3 ("raw red" copra) of the same trial. It was also more rank and infested by insects. This is doubtless because smoke adheres readily to the surface of slimy "red" copra and this film of smoke serves to provide a temporary check to insect attack and bacterial deterioration during the short period before warehouse-drying. Where there is prolonged cool storage before warehousing, as in Trial B, the agents of deterioration are able to operate freely once the protective smoky film has been broken down and penetrated.

The high spoilage for lots W3 and R3 of Trial B is not exceptional. Such extensive deterioration and breakdown can and do occur in practice.

In the extreme, with abnormally prolonged storage of deteriorated "raw" copra, maintained continuously in a wet condition, it is even possible for the loss to be in the neighbourhood of 99 per cent. since long sustained insect attack and progressive decay due to moisture produced during decomposition may leave only fragments of brown testa, or skin.

Attention is next drawn in Table V. to the high production of "smalls" resulting from the storage of "raw" copra in Trial B. Individual pieces of copra were so deeply corroded as a result of deterioration during the period of cool storage that they readily broke down when pressure was applied to the copra or if the copra was disturbed.

TABLE V.

Reduction of Copra to "Smalls" and "Dust"

Lot.	Trial A. Continuous Warm Storage.				Trial B. Cool and Warm Storage.			
	Original Dry Weight.	"Smalls"	"Dust."	Percentage Spoilage.	Original Dry Weight.	"Smalls"	"Dust."	Percentage Spoilage.
	lb.	lb.	lb.		lb.	lb.	lb.	
W1	59·25	N	N	N	52·00	0·75	N	1·4
W2	61·75	0·25	N	0·4	56·50	0·75	0·25	1·8
W3	63·25	0·75	0·25	1·6	65·00	10·25	0·75	16·9
R1	55·25	N	N	N	55·25	1·00	N	1·8
R2	59·25	N	N	N	58·25	0·50	0·25	1·3
R3	61·25	0·75	0·25	1·6	58·50	11·75	0·75	21·3

In Malaya any "smalls" and "dust" are included and sold as copra, but their presence in any quantity is a serious matter to the miller. Seriously deteriorated copra will suffer further size reduction during shipment and transport to the oil mills, so that a larger surface is exposed to the agents of deterioration and losses of small pieces and dust will occur when the material is transported loose in conveyors.

It is to be observed from Table VI. that the development of acidity is not serious during the period of cool storage when the loss of copra is greatest (W3, R1, R2, and R3 of Trial B). Samples W3 in both trials had a revoltingly sour smell.

TABLE VI.

Acidity of Oil in Stored Copra

(Calculated as lauric acid)

Lot.	Trial A.	Trial B.	
	After 2 months' Warm Storage.	After Cool Storage only.	After Cool and Warm Storage.
	Per Cent.	Per Cent.	Per Cent.
W1	0·17	0·11	0·30
W2	0·22	0·16	0·32
W3	2·61	0·81	3·11
R1	0·25	0·17	0·47
R2	0·58	0·15	0·39
R3	2·20	0·40	6·12

Table VII. gives the average depth of discoloration in the stored samples of copra. Actually the extent of deterioration varied considerably from piece to piece. Some pieces showed only localized deterioration whereas in others discoloration was complete.

TABLE VII.

Average Extent of Discoloration in Copra on Storage.

Lot.	Trial A.	Trial B.
W1	All white	One-third
W2	One-third	One-half
W3	Three-quarters	Total
R1	One-sixth	One-third
R2	One-quarter	One-half
R3	Three-quarters	Total

The six lots of stored copra were inspected by a leading exporter and the result of this examination is given in Table VIII. It will be seen that the various lots were classified with respect to the export grades Straits f.m.s. and Straits f.m. as is the case with all copra after it has been stored and when it is ready for blending.

TABLE VIII.

Effect of Storage on Quality of Copra

Lot.	Quality of Copra after Storage.	
	Trial A. Continuous Warm Storage.	Trial B. Cool and Warm Storage.
W1	Straits f.m.s. + +	Straits f.m.s.
W2	,, f.m.s. +	,, f.m.s.
W3	,, f.m. +	,, f.m. —
R1	,, f.m.s.	,, f.m. + +
R2	,, f.m. +	,, f.m. +
R3	,, f.m.	,, f.m. —

The ratings above and below the recognized export standards indicate to what extent each parcel needed to be blended with inferior or superior copra before export. Two plus and one plus mean "well above" and "above" respectively while a minus indicates that a consignment is below the export

standard for the specified quality. It will be noted that with only one exception, *viz.*, lot R2, each lot from Trial A is superior to the corresponding lot from Trial B.

Sub-grade copra, *i.e.*, f.m.—can easily be recognized when the copra is purchased from the dealer and so can be and is usually penalized, but parcels of copra which may ultimately prove to be superior to the two recognized export grades receive no special premium above the recognized quotation although they have an added value when the various parcels are being blended for shipment.

Finally, Table IX. gives the comparative values of the various types of copra derived from the same theoretical amounts of fresh coconut meat. The necessary calculations were based on the losses of actual copra as scheduled in Table IV., the ultimate quality of the material (whether f.m.s., f.m., or sub-grade), and the following prices of copra per picul :—

	Per picul.
	$
Estate copra, shipped direct	.. 3·40
Straits f. m. s.	.. 3·30
Straits f. m. copra	.. 3·00
Sub-grade copra	.. 2·70

TABLE IX.

Relative Market Values of Produce Obtained from the Same Theoretical Weight of Coconut Meat

Lot.	Trial A. Continuous Warm Storage.			Trial B. Cool and Warm Storage.		
	Final Dry Weight.	Price of Copra per picul.	Value of Copra.	Final Dry Weight.	Price of Copra per picul.	Value of Copra.
	Piculs.	$	$	Piculs	$	$
W1	100	3·40	340·00	96·2	3·30	318·00
W2	97·2	3·30	321·00	97·4	3·30	321·00
W3	90·5	3·00	271·50	86·1	2·70	232·00
R1	96·8	3·30	319·00	91·9	3·00	275·70
R2	97·0	3·00	291·00	86·3	3·00	258·90
R3	93·5	3·00	280·50	85·0	2·70	229·00

The figures show clearly the extent to which deterioration can affect the value of the copra. Thus in the case of Trial B, lots W3 and R3, the value of the copra is only about two-thirds that of the highest grade.

CONCLUSIONS

(i.) Copra is subject to loss and deterioration during storage and transport, unless properly prepared and promptly warehoused.

(ii.) Such deterioration proceeds most rapidly at air temperatures and is reduced or checked at higher temperatures and temporarily by a film of smoke on the surface of the product.

(iii.) Loss and deterioration are very considerable in the case of " raw " half-dried copra if there is delay before it is suitably bulk stored.

(iv.) When there is serious deterioration, the individual pieces of copra readily break down to yield " smalls " and " dust."

DISCUSSION

Since the foregoing investigations reveal that half-cured copra is such an unstable and unsatisfactory product, it may seem strange that well in excess of

half the world's copra is produced in this condition while, here in Malaya, much of the imported copra and some even of the copra produced in this country still continues to be of this quality. It is an unfortunate fact that such copra has a trade value and so is saleable. It offers peculiar opportunities for profit-making to the small dealer which are not realizable with a more stable and reliable copra. Where all producers offer the same low grade of product, they cannot readily appreciate that they are not obtaining the maximum return from their palms.

It is not appreciated sufficiently, if at all, that not only are deterioration, previous to, during, and immediately after production, and the moisture content taken into account in the prices paid by local traders for " mixed " copra but also that the ruling or basic price, paid in any one district, is a reflection of the ultimate general quality of the copra from that particular district, and includes adequate compensation to the dealer to discount all loss and deterioration which normally occur with such copra during transport and storage subsequent to production.

Small dealers have never been found willing to encourage the production of a stable and reliable product as they claim that small lots of such copra are of little use to them. In those districts where a market for low-grade " raw " copra is firmly established it is therefore quite useless for an individual small producer to make drier and better copra, since he then obtains less copra, which is nearly always paid for only at the current local price. The most he can ever expect in return for his extra trouble is a price strictly proportionate to the reduction in moisture content but this allows no extra profit whatever for improved appearance and quality.

The best copra is usually made and the best local prices are paid in the immediate neighbourhood of the export centres and the oil mills. This is because little time normally elapses between production and storage in bulk, and thus any " raw " copra which may be produced will not seriously deteriorate subsequent to sale. It is thus possible for a high standard of quality to be established, and in such circumstances low-grade copra is exceptional and is likely to be penalized if offered.

The worst copra is usually produced in the more inaccessible regions whence parcels can be shipped only at irregular or long intervals, with consequent long delay before bulk storage. Despite the desirability of producing only dry copra in such regions, there is here, as elsewhere, an unfortunate natural tendency for the quality of copra produced to decline during periods of low or falling prices, particularly the latter, since drying is then liable to be curtailed so as to obtain a greater weight of copra or to make a quick sale while prices are still high.

This is a trend which it is not easy to reverse for it is not reasonable to expect individual producers to lose money by producing copra which is above the local standard of quality and dryness. It is frequently stated that producers are apathetic but it would be more correct to say they are helpless in the face of existing trading conditions.