

FT-18
April 17, 1967

IFT Review of Ms #FT-18

Authors: V. Subrahmanyam, I. C. Abdon, E. M. Payumo, D. T. Salon, V. A. Paterno,
J. G. Palad, E. C. Eusebio and P. L. Maniquis

Title: A protective mechanism in coconut and its application for the control of
infection in the production of copra, dehydrated coconut and protein-rich
flour

Too long, and all inclusive

Summary: Much too long. Irrelevant for a summary. Not clearly set off in format.

Overall quality of the paper is satisfactory. Experiments, although unsophisticated, are original and useful in their practical implications. Pages 4-10 could be condensed to a concise literature review, including unpublished earlier observations; table on p. 7 seems especially informative. Actually the meat of the paper is contained between pp. 12-16 (cf 1st sentence, last paragraph, p. 23). Pages 18-21 could be reduced to several short statements pointing up potential economic value to industry. Increase of yield as shown in table VII (p. 19) would seem to reflect increase in water content. If so is this a "major attraction" for the buyer? Pages 21-23 would seem to warrant a separate paper, based on more complete experimental background.

Discussion should be brought together in one place and held pertinent to the experimental presentation.

A protective mechanism in coconut and
its application for the control of
infection in the production of copra,
dehydrated coconut and protein-rich flour

V. SUBRAHMANYAN, I.C. Abdon, E.M. Payumo,
D.T. Salon, V.A. Paterno, J.G. Palad, E.C.
Eusebio and P.L. Maniquis

Food and Nutrition Research Center,
National Institute of Science and
Technology, Manila, Philippines

SUMMARY

Spoilage and loss (10-15% or more) of coconut material through microbial and insect action, during the drying of the kernel for the production of copra, is a major problem for the tropics and, particularly, for the Philippines, which, with an annual production of about 10 billion nuts, is the world's largest producer of copra. The present studies have shown that the rapid unidirectional movement of water, sugar and other solutes towards the surface is the main cause of spoilage. At the same time, the kernel has the property of resisting the penetration of a variety of chemicals, including strong acids, alkalis, salts etc. By utilising this property and using permissible, protective chemicals as surface coats and dip solutions, it has been possible to ensure control of all forms of infection and infestation, both during the drying and subsequent storages of copra. Field trials have shown that increased yields ranging from 10-20% can be obtained. The producers have already taken to the application and treated a few million coconuts. The treated product is free from odour and the oil from it is almost colourless with F.F.A. of 0.1% even after four months of storage, and transport in ship's holds. The technique has been extended to the preparation of qualities suitable for flour and protein and for edible segments. The possible application to other perishable materials has also been indicated.

Coconut is an important food crop of the world, though it is generally classified and treated as an oil-bearing material in most of the producing countries. The graceful palm tree that produces the nut is now being extensively grown in practically every region where there is good seasonal rainfall and adequate drainage. Because of its strong root system and tolerance for salt, it is one of the few economic crops that can be raised on steep hill slopes and also on sandy sea shore. The area under the crop is extending so fast, and the statistics are so inadequate, that most of the figures for production have turned out to be under-estimates. The present world's production may be placed at over 100 billion nuts with fresh kernel weights ranging from over 600 grams to less than 200 grams each. The Philippines is the largest single producer, with an annual production of about 10 billion nuts with an average kernel weight of over 400 g. Indonesia, India, Malayasia, and other South East Asian countries, Ceylon,

Kenya, Congo, Cameroons, Nigeria, Carribeans, Central and equatorial South America, are all large producers of coconut; besides tens of thousands of islands that dot the Pacific and the Indian oceans and for a large number of which it is the most important economic crop. Over 100 million people depend on the crop for their livelihood. In the Philippines, with a population of about 33 millions, the crop provides either the entire livelihood or a large part of the income to over 10 million people: in some of the provinces nearly 90-95% of the people are dependent on the return from coconut for most of their requirements. India is one of the few countries where a large part of the production is used as human food. In most of the others, it is chiefly converted into a dry product, the copra, which is marketed as a source of oil and cake. Carefully dried kernel from 'base' or 'medium' mature coconut which is generally used for the purpose contains, on the average, 63-65% of oil with a free fatty acid (F.F.A.) content of about 0.1%. The copra of commerce contains, however, 70-72% and some times even a higher percentage of solvent extractable matter with a F.F.A. content ranging from 3-5% and some times as high as 10%. The oil is generally obtained by expelling under high pressure and the residual cake contains anything from 5-15% oil, depending on the efficiency of the pressing. Solvent extraction is used only to a limited extent, and the resulting cake contains less than 0.5% of oil and about 24% protein.

In the Philippines, about 95% of the total production of coconut is converted into copra. Besides the large internal consumption, chiefly for production of oil, over 1.5 million tons of copra are exported, either as such or as oil and cake, thus earning the equivalent of about 350 million U.S. dollars per annum. The return is not, however, commensurate with the number and potential value of the coconuts used for the production. At least 10% of the coconut material is lost, through microbial spoilage, during the production of copra with a moisture content of 5-6%, while there is a further loss 5-10% or more, through insect damage, during storage and transport. If these losses can be avoided and the penalties levied by the overseas buyers (3-5% or more) for poor quality of oil can be at least minimised, the Philippines alone can save the equivalent of over 800 million coconuts, produce about 200,000 tonnes more of copra and earn the equivalent of over 35 millions U.S. dollars more per annum from the same number of coconuts as are now being processed. The other copra producing countries, which have similar problems, can also increase their yield and earning in a similar manner.

During the past six decades or more, a large number of investigators in different parts of the world have thrown much valuable light on the nature and extent of spoilage and the various factors and agencies responsible for them. They

have suggested various methods of minimising the spoilage and improving the quality; and the most important of these have been through the design and demonstration of the use of improved types of driers. While some of the improvements have found application at the hands of a small section of enlightened producers, the great majority of the latter, including a good section of large producers, have continued in the same old way and have been content to accept what they receive for their low yields and poor quality. To the food technologist, the conditions on the field are highly disheartening, with the continued deposition of dust and dirt; bites by flying insects, cockroaches, lizards, rats etc; partly eaten by cows, pigs, horses, poultry and oftentimes even wild animals at night; and rough handling, with frequent trampling by the workers themselves. There is no early possibility by changing these conditions; and if scientific methods are to succeed, they should do so in the face of all types of conditions which promote and encourage massive infection and infestation. The object of the present paper is to deal with some basic findings which have thrown some fresh light on the problem and to report about their practical application under field conditions. Possible application of the same principles for the production of new and better classes of products will also be dealt with.

Moisture content of the Coconut Kernel
in relation to spoilage

Starting with the pioneering contributions of Walker (1906), Brill, Parker and Yates (1917), a succession of workers have drawn attention to the influence of the moisture content on the nature and extent of spoilage of the coconut material. They have shown that spoilage can occur at all stages of drying and even after the equilibrium moisture level of about 5% is reached. As the dried copra in heaps or in jute bags, it can reabsorb moisture in humid weather and that will encourage surface growths of fungi. Our observations have shown that the spoilage is largely favoured by the unidirectional movement of water, together with dissolved sugars and other solutes towards the surface which then becomes the most vulnerable part of the kernel. It was also observed that the discharge, especially from the freshly opened coconut, is continuous and under high pressure. If the coconut is opened at the eye (the point where the sprout emerges), the enclosed water drained out and then sealed with a plug, the pressure is so high that the thick shell will crack within a few hours, though it may some times happen within a few minutes. The cracking is generally at the centre. When the cracked coconut or the segment prepared out of it is dried in the shade, sun or hot smoke (as often practised) the water is removed at a fairly fast rate until a moisture content of about 15% is reached.

contd.....4

TABLE I

Loss of moisture from coconut kernel during drying.

Temperature, 23-28°C, Relative humidity, 75-90%
Initial moisture content: 54%

Time	Percentages of moisture		
	In the shade, with cover against rain	Tapahan (smoke drying) Temp. of gases, 150-200°C	Sun-drying (with heaping and cover at nights)
In hours		Heating in shell for 6 hours on 1st day (moisture, 35%)	
24	42	Heating of cut pieces (6 hours) on second day (moisture 15-20%)	40
48	32	Then stored in heaps in the warehouse for 4 weeks	30
72	23		20
96	15		14
<u>In weeks</u>			
1	10	9	10
2	9	8	9
4	5-6	5-6	5-6

The advantage of smoke drying (which yields a dark coloured product with deposit of creosote and other constituents of smoke) is primarily in the initial reduction of moisture. Subsequent drying is slow in all the cases.

Nature and chronology of infection and infestation

The agencies involved and the pattern of spoilage of the coconut kernel during the production of copra are not very different from those which occur during the composting of a perishable material. All the commoner soil organisms take part in the process and it is only the inherent drying

capacity of the kernel that saves it from complete destruction by the penetrating fungi. Later, when insect infestation sets in, it is the predatory habits of certain forms that keep down the extent of destruction by others. The spoilage changes, however, never stop and even after the copra is crushed for oil they continue in the cake unless special precautions are taken.

There is extensive literature on the spoilage organisms associated with copra production. Among the earlier contributions, special mention should be made of the work of Ward (1937) and Corbett et al (1937) who have made fairly exhaustive study, chiefly of the fungi and the insect fauna associated with the spoilage. The earlier work and also our observations on the chronology of infection would show that several species of bacteria and yeasts are the first to appear and, especially in moist weather, they discolour and soften the surface with the accompanying production of different acids (chiefly, lactic). They also start the production of the characteristic copra odour with accompanying development of oxidative rancidity. This is particularly noticeable in the case of sun-dried copra, but in the case of tapahan dried copra which starts with a lower moisture content and a thin coat of creosote and other constituents of the smoke, bacterial action is not so pronounced. In this case, the fungi start appearing almost within 12 hours of the bagging of the product and spoilage changes with the accompaniment of intense odour follow rapidly if the product remains within the bag for 2-3 days - as is often the case - before it is spread out to dry further in the warehouse. Though insect eggs are present right from the start and more are added from dust and the copra bags, which are used repeated without cleaning, the actual multiplication of insects is seen only when the copra is comparatively dry. The order of appearance and activity of different forms of flora and fauna may be presented as follows:-

Agencies, pattern and chronology in the spoilage and destruction of coconut material*

Time after opening the coconut	Form of Life	Effects
12-24 hours (depending on the season)	I. Bacterial, prominently <u>Staphylococcus aureus</u> sp. some bacilli and yeasts	At 20-50% moisture Discolouration, softening of surface, development of off-flavor, pro-oxidants leading to rancidity of oil.

contd....6.

Time after opening the coconut	Form of Life	Effects
48-96 hours	<p>Prominent fungi</p> <p>II. <u>A. flavus-oryzae</u> <u>R. nigricans</u></p>	At a moisture level of 15-40%, highly penetrating with development of copra odour, heat gases and rancidity.
At later stage	<p>III. <u>A. tamarii</u> <u>A. niger</u></p> <p>IV. <u>A. Glaucus</u> <u>Pencillia</u></p> <p style="text-align: center;"><u>Insects</u></p> <p>V. <u>Carpophilus dimidiatus</u> (copra bug)</p> <p>VI. <u>Necrobia rufipes</u> De Geer (copra beetle)</p> <p>VII. <u>Ahasverus advena</u> <u>Waltl.</u></p>	<p>At a moisture level of 8-12% - also penetrating with similar effects.</p> <p>Chiefly surface growths at less than 8% moisture.</p> <p>Attracted by mould copra - makes copra powdery</p> <p>Also attracted by mouldy copra and by the presence of <u>Carpophilus</u>-Voracious feeder on copra and <u>Carpophilus</u> grubs.</p> <p>Attacks and consumes surface moulds-does not attack uninfected material.</p>

*This table does not include bacteria and fungi, which have already entered the stored coconut through the "eyes" and through cracks and other physical damage through rough handling.

The growth of S. aureus is most pronounced during the wet months when it may appear in less than 12 hrs. It was examined for us by Dr. Barua, WHO bacteriologist, who reported that it is of the non-pathogenic type. Among the penetrating fungi, A. flavus, R. nigricans and A. tamarii are the most damaging and they are chiefly responsible for the development of heat and gases (chiefly CO_2) both during the drying of the kernel and the subsequent warehousing of the moist copra under poor ventilated conditions. The surface growing fungi appear only at low levels of

contd....7

moisture and although they do not cause much loss of weight, they do nevertheless make the product unattractive and smelly. Insects are attracted primarily to fungus infected copra on which they lay eggs and multiply rapidly.

We have carried out several studies to determine the actual extent of loss of dry matter through microbial action in different seasons. It is generally at a minimum during dry months, but, even then, it is not less than about 10% between the stage of opening the coconut and the production of copra (resecada quality) with a moisture content of 5-6%. The maximum loss is during storage in bags or in heaps. During the wet months, the losses are greater and they are chiefly due to the action of penetrating fungi. In the early stages the losses are chiefly in the form of non-oil fractions. Later, there are losses of both oil and non-oil fractions. Earlier workers in the Philippines and also in other countries have reported the total losses to be as high as 30% or more within 3 months of storage. In one of our trials, we obtained a loss of 25% in two months and it was chiefly due to the action of insects. About a third of this loss is in the form of powder which is rejected by the buyers. This phenomenon is popularly known as 'shrinkage' as the copra continues to shrink in size and volume, while losing weight.

The following table will illustrate the manner of destruction of both oil and the non-oil fractions and its influence on the apparent oil content of copra.

TABLE III

Influence of loss of oil and non-oil fractions on the oil content of copra.

Average initial (on moisture free basis): oil, 64%; non-oil fractions, 36%.

		Composition of final product as per cent			
		Losses	Total	Oil	Non-oil
Oil	Non-oil				
0	8		8	69.5	30.5
0	10		10	71.1	28.9
2	10		12	72.7	27.3
5	10		15	71.7	28.3
10	15		25	72.0	28.0
12	15		27	70.2	28.8
15	15		30	70.0	30.0

contd....8

It may be seen from the above that even when there is loss of coconut material to the extent of 30%, the percentage of oil is still at a high level of 70%. Such a copra may contain about 7% or more of F.F.A. As the result of this, the producer is the chief loser, because he gets a reduced weight and a low price for his product. The overseas buyers do not evaluate the copra in terms of the apparent oil content, but levy a penalty when the F.F.A. exceeds 3%. They also pay a premium when the oil is light coloured and has a F.F.A. of less than 3%.

Experiments on surface protection

Our earlier attempts, involving a few hundred trials, were directed towards washing the coconut kernel with dilute solutions of a variety of permissible chemicals with bacteriostatic and/or fungistatic action followed by dipping the kernels into solutions or media that would leave thin protective coats around the product and thus facilitate its drying without the entry of fresh infection. The chemicals, that were used, included different mineral acids, alkalis, neutral salts, hypochlorite, metabisulfite, benzoic acid, calcium propionate, acetic acid, sorbic acid, etc. and excepting in the case of sorbic and benzoic acids which were tried at 0.1% they were tried at concentrations up to 3.0%. The protective coats were in the form of gums, mucilages, waxes, resins, plastics, protein-formaldehyde complexes etc.

At the concentrations which were tried, most of the chemicals were not effective for more than 24 hours, while some were of benefit up to 2 days. The physical coats failed because of the shrinkage and, often, the cracking of the kernel during drying.

The exclusive use of chemicals had been tried by a number of earlier workers. Among these special mention should be made of the work of Surrige (1931) and Blackie (1931) who recommended fumigation with sulfur dioxide and washing of copra with a variety of chemicals. Sulfur dioxide is effective in a closed system, but in the case of sun and tapahan dried products, the treatment has to be repeated a number of times; but, even then, the effect is not sustained. Soda ash (5 and 10%) and caustic soda (3-5%) were not effective in the case of the copra, especially after the infection had penetrated to some depth. Soda ash, however, proved effective under other conditions and that would be discussed in a later section of the paper.

Our efforts were next directed towards the use of calcium hydroxide, which is a cheap and permissible chemical, primarily as a surface coat. It was observed that this chemical was effective at concentrations of 10% and above in completely controlling infection at all stages; but the coating had a tendency to crack and portions to peel off as the drying advanced. A second application, preferably to the

kernel in shell, was more effective. Dusting of the dry product with powdered slaked lime had the added benefit of controlling all insect infestation. It was also found that the resulting product was a dehydrated coconut, which after washing and soaking in water, can re-constitute into fresh coconut, with the flavour and taste of the original product. Even after storage for four months the oil was clear and colourless, the F.F.A. about 0.1% and the peroxide value, nil. Examination of successive batches also showed that there was no penetration of the chemical below a depth of half a millimeter though the application was repeated. The dried portion below this layer had the same composition and properties of the fresh coconut dried in the oven at 100°C or in a current of hot air at 50-60°C. On repeating the trials at concentrations up to 100% or on prolonged soaking of cut pieces of the kernel in lime water or suspensions of lime, the effect was still found to be the same, thus showing that the chemical had not penetrated into the coconut. These observations, having suggested the possibility of an unique property, the experiments were repeated with a variety of normally penetrating chemicals such as strong acids, alkalis, salts, soluble dyes etc. and in all cases the effects were found to be nearly the same. The following tables will illustrate the results:-

TABLE IV

Effect of application of chemicals to kernel surface:
Acid and Alkali

		Quantity of chemical in mg.		Hydrogen-ion concentration (pH)			
		As applied to surface	As found on washed surface after 24 hrs.	Percentage retained	Untreated (control)	Treated (whole) After washing	Treated (surface)
Conc.	H ₂ SO ₄	1104	20.0	1.8	5.6	3.1	2.8
1:2	H ₂ SO ₄	368	11.5	3.1	5.6	4.0	1.1
1:4	H ₂ SO ₄	221	15.9	7.2	5.8	4.0	2.8
40%	NaOH	240	0.86	0.36	5.8	6.1	6.8
20%	NaOH	120	0.86	0.72	5.8	6.2	6.5
10%	NaOH	60	2.15	3.6	5.8	6.4	8.2

contd.....10

TABLE V

Effect of application of chemicals to kernel surface.
Calcium hydroxide - penetration of chemical with
effect on H-ion concentration.

Treatment	Whole kernel		Surface only		
	(as mg. in 100 gms.)		(as mg. in 100 gms.)		
	Untreated (control)	Treated (after washing)	Untreated (control)	Surface (after washing)	Surface (without washing)
10% Ca(OH) ₂	65(5.7)	122(5.75)	176(5.8)	...(6.35)	293(6.30)
20% Ca(OH) ₂	64(6.0)	83(6.10)	106(6.10)	244(6.35)	246(6.35)
30% Ca(OH) ₂	61(5.8)	98(6.10)	212(5.75)	344(6.40)	624(6.55)

The figures in brackets give the H-ion concentration as determined with a pH meter.

TABLE VI

Penetration of sodium chloride

Treatment	Quantities in mg.		Concentration in whole kernel as %		Concentration on surface as %	
	As applied	As present in kernel	Control (un- treated)	Treated	Control (un- treated)	Treated
Coated with 15% solution and allowed to stand for 48 hours	90	7.0	0.45	0.73	0.70	1.2
Coated with 25% solution and allowed to stand for 48 hours	150	12.5	0.30	0.80	0.65	1.36
Dipped in 10% solution for 5 days	1250	96	0.40	3.83	0.70	4.84

contd....11

The treated kernels were washed for about 30 seconds in running water and then dried before analysis by AOAC method.

The above observations would show that the coconut kernel resists the entry of chemicals and that even strong and reactive substances are retained mostly at the surface. It would logically follow that if such substances have protective action against infection and infestation, they can help to control the spoilage without, at the same time entering the coconut. This action will be analogous to that of a plaster or poultice to the body.

Based on these studies, followed by nearly 1500 experiments, with various types of treatments under conditions similar to those on the field led to the evolution of the following procedures which were found to be effective.

Sun-drying - I

Coconut Kernel in shell (after removal of husk) (moisture, 53-55%)

Surface dabbed with protective chemical and allowed to dry for 24 hours.

Kernel then removed and cut to pieces

Cut pieces - (moisture 40-45%)

Steeped for 5 mins. in a second solution and then dried for 4 days

Partially dried kernel (moisture 10-15%)

Stored in warehouse in heaps or in bags for 2-3 weeks.

Copra (moisture, 5-6%)

Sun-drying - II

Pieces of fresh kernel (as removed from whole coconut with husk)

Steeped for 5 mins. in protective chemical solution

dried for 4 days

Partially dried copra (10-15% moisture)

Stored in warehouse in bags or heaps for 2-3 weeks

Copra (moisture, 5-6%)

The following were found effective:- Sun-drying I - Coating or surface with 10% slaked lime followed by dipping of cut pieces in 30% soda ash (sodium carbonate, technical) solution; or coating of surface with 5% acetic acid followed by dipping in a mixture of 5% sulfuric acid and 7% acetic acid. Sun-drying II - Dipping of cut pieces in 30% soda ash solution; or dipping in a mixture of 5% sulfuric acid and 10% acetic acid. Treatment with lime followed by soda ash or soda ash alone yields a dull coloured product, but the oil obtained from it is clear and colourless with F.F.A. of 0.1-0.3 even after 4 months of storage. There is no infection at any stage and the dried copra is also resistant to insect infestation. It can also withstand rain for short periods without the risk of its being completely washed away. The acid treated product yields an attractive, white coloured product. Acetic acid which helps as an effective fungistat volatilises away during drying and only the mineral acid is left behind as final protection against surface growths of fungi. The oil from this type of copra has a light yellow colour and the F.F.A. is 0.5-1.0% after 3 months of storage. There is no infection at any stage, but the dried copra is less resistant to insects than that obtained with soda ash. It cannot also stand continued exposure to rain.

As applied to smoke drying (tapahan)

The following procedure has been found to be in keeping with the traditional practices that are followed over many parts of the Philippines:-

Tapahan (smoke drying)

Coconut kernel in shell (moisture of kernel, 53-55%)

Smoke dried in layers for 6-8 hours

Kernel then removed

Cut pieces of kernel (Moisture 30-35%)

Dried for second time for 6-8 hours

A High moisture copra (moisture, 15-20%)

Dipped when hot in protective chemical solution

And spread overnight to dry

Treated copra

Stored in warehouse for 3-4 weeks

B Copra (moisture, 5-6%)

A - classed as coriente or bien coriente.

B - classed as Resecada - the best quality for export.

contd...13

The smoke is produced by burning coconut shell alone or a mixture of shell and husk. Copra coming in Class A is often sold at that stage by a large section of the producers. The buyers levy a heavy penalty (20-25%) for accepting such a product.

Variations of the above procedure will be to dip the kernel in shell in the protective solution and then to continue with the heating till the moisture content comes down to about 5%; or to dip the fresh kernel (as cut pieces) in the solution then to pile it up in the drier and then continue with the heating, with gradual reduction in the use of the fuel, till the final product has a moisture content of about 5%. Both of these are rather hazardous because there is always the risk of excessive heating, with over-deposition of smoke and caramelisation, especially in the bottom layers.

Use of coconut ash extract as a partial substitute for soda ash

In addition to burning shell or shell and husk as fuel for drying, all surplus quantities are burnt away on the plantations, with the result that large quantities of ash are produced on each day. Chemical examination of such ash, as produced in different areas, showed that though they all contain a high percentage of potassium carbonate which can be easily extracted by boiling with 3-4 volumes of water. The highest concentration of 30-35% is present in coconut shell ash, while lower concentrations of 15-20% are present in mixed ashes. Even without any further concentration, the first ash extract will correspond to 7-10% of soda ash. By concentrating in the open pan, a specific gravity of 1250 can be attained after a few hours. This has been found to be quite efficacious in controlling infection.

In the course of these studies, it was observed that the concentrated ash extract which was giving a more attractive product than soda ash contained varying amounts of aluminium partly as aluminate and partly as carbonate. This led to a further study on the effect of aluminium and other metals particularly on the paring from which some colour is extracted on treatment with soda ash.

Effect of aluminium salts on the extraction of colour from coconut paring:- Many metals have been found to react with the coconut paring and to render the colour unextractable. The action is very similar to that of a mordant in fixing a dye. Among the permissible metals, iron salts impart a dark colour to the paring; Zinc and aluminium salts preserve the original colour. They act best if the kernels are first allowed to dry for a few hours before dipping in soda ash solution. Aluminium salts also act in combination with soda ash. An effective procedure has been found to be that of first dissolving aluminium sulfate, which is easily

contd....14

available, (1-2 parts) in minimum amount of water and then to add soda ash gradually till a homogenous mixture is formed. The use of such a mixture has the advantage that it will yield a whiter and a more attractive product than that obtained with soda ash alone.

Colour of the copra:- The oil millers have found by long experience that the smoke-dried copra yields a coloured oil which involves the use of extra large quantities of bleaching earths to remove them to produce a colourless oil both for edible and industrial uses. They have therefore learnt to associate a dark shade of copra with a coloured oil. Our studies showed however that the external appearance is due to a number of factors, many of which have no effect on the colour of the oil.

Effect of different conditions and treatments on the colour of copra and the oil

<u>Origin and nature of colour</u>	<u>Effect on external appearance</u>	<u>Effect on oil</u>
1) Effect of soda ash or any other alkaline substance on the colouring matter of the paring -most noticeable in the case of immature coconuts.	Gives a dull colour to copra	None, as it is not soluble in oil
2) Development of a latent colour already present in coconut - becomes more pronounced with alkaline reaction - Green in the beginning and slate gray to a darker shade in the late stages.	Gives copra a gray colour which tends to become deeper on extended strong especially without proper ventilation	None, as it is not soluble in oil
3) Effects of tannins (polyphenols) present in coconut - the colour is catalyzed by an enzyme and the presence of traces of iron which are unavoidable.	Light blue-black darkening with time	-do-

contd....15

- | | | |
|--|---|---|
| 4) Effect of interaction between sugars and amino-acids present in coconut - (Maillard reaction) - catalyzed by heating or prolonged storage in a warm atmosphere. | Yellowish in the beginning but turning brown with time | None, as it is not soluble in oil |
| 5) Direct effect of heat on the sugars of the coconut - noticeable in the case of over-cooked tapahan dried product. (Caramelization). | Red-brown in the early stages - turning dark | Colour partially extractable in oil - mixture of red and yellow. |
| 6) Deposition of creosote and other some constituents - brown to black-variable extent of deposition. | Dark deposit chiefly at the surface of the kernel | Colour partially extractable in oil - predominantly yellow shade with some red. |
| 7) Effect of microbial growth, insect damage and insect residues. | Mixture of colours from white to red-brown green and black. | Imparts red and yellow shade to the oil |
-

It was observed that a 0.3% solution of sulfur in dilute alkali or sodium sulfide at a concentration of 0.5% was effective in preventing the development of the latent colour present in the kernel. Many reducing agents were also found to have a similar effect. As there was objection from the oil millers to the presence of sulfur and as aluminium salts, at even low concentrations were almost equally effective, the use of the latter was preferred when alkaline solutions had to be used for the treatment.

Field trials in collaboration with the industry

In association with a leading oil-milling firm in Manila, the following were tried:- 1) sun-drying with lime (10%) followed by dipping in alkali (3.0% NaOH); 2) tapahan drying without any further treatment; and 3) tapahan followed by dusting with soda ash (1%). Six batches of 1000 coconuts each were treated partly in Alaminos and partly in Manila. The processed products with a moisture content ranging from 15-20% were warehoused partly in the factory and partly at the National Institute of Science and Technology. Analyses were carried out at 4 days

contd.....16

intervals over a period of 35 days for each batch. At the end of the period the moisture content ranged from 5-6%; the loss of dry matter from 1-2% in the case of (1), which was practically free from infection; 5-7% in the case of (3) which carried a slight infection; and 10-12% in the case (2) which was most heavily infected. The oil from (1) had the lightest colour (Red/Yellow in Lovibond units 1/3), whereas (2) had a colour ratio of 3/20 and (3) a ratio of 2.6/15. The F.F.A. of the oil was less than 0.3% in the case of (1), 0.5-0.7% for (3) and 1.0-1.5% for (2). The manufacturers were highly appreciative of (1) which yielded oil of edible quality which required practically no refining or bleaching.

Field trials in collaboration with the producers

These were carried out with financial assistance from the National Science Development Board and the cooperation of the producers in the provinces of Cotabato, Lanao del Sur and Misamis Oriental in Mindanao. Out of the several possible treatments, we selected only that with soda ash as being the most convenient and at the same time the most effective under field conditions. The treatment was applied by packing the kernels with and without shell in wire baskets holding 50-60 kg. each and dipping in a solution ranging in specific gravity from 1.270 to 1.250 for 5 minutes. In the case of sun-drying they were spread out on the drying yard during the day and then heaped at night with G.I. sheet covers. In the case of tapahan, they were packed into the driers up to a depth of 3-4 feet before starting the heating. The producers followed their own traditional methods in respect of removal of the kernel, extent of heating, period of drying, packing, storage etc. Control trials were also carried out under identical conditions without any treatment. After completion of the processing, the copra was stored in bags for periods ranging from 10-15 days and then weighed before sale. The following are some of the results:-

TABLE VII

Estate	Number of coconuts	Method of removal of kernel and drying	Treated or Untreated	Weight of Copra	Increase in yield through treatment	
					In kg.	As percent-age over untreated
1	2	3	4	5	6	
A	10545	'Lugit' and sun-dried	Untreated	2659	554	20.8
"	-do-	-do-	Treated	3212		

contd.....17

1	2	3	4	5	6	
A	69747	-do-	Untreated	18356	} 2850	15.5
"	-do-	-do-	Treated	21206		
B	57650	Dried as split coconut for one night, the Lugit and sun- dried	Untreated	15171	} 1651	10.9
"	-do-	-do-	Treated	16822		
C	4728	Kernel in shell and tapahan dried	Untreated	1182	} 213	18.0
"	-do-	-do-	Treated	1395		
D	4990	Lugit and tapahan dried	Untreated	1088	} 160	12.8
"	-do-	-do-	Treated	1248		

'Lugit' a method of removing the kernel with a sharp curved instrument.

The most significant observation was that none of the treated products showed any sign of infection. The products were clean, attractive and completely free from copra smell. There was also higher yield in every case as the result of the treatment. The untreated products carried infection to varying extents depending on the local conditions and methods of processing and storage. The extent of increase in yield in each case may be regarded as a measure of the loss normally incurred by the producer. The oil from the treated product was invariably of superior quality and had a F.F.A of 0.1% as compared with over 1.0% in the case of the untreated product at the time of sale.

Consequent on the successful application of the treatment the producers themselves have now taken to the application in the areas where the trials were carried out. Within a period of about 2 months nearly 2 million coconuts have been treated by the improved method. The local buyers are now offering a premium for the treated product. Two shipments

contd.....18

The total yield of oil is over 60% on the dry weight and the products obtained by pre-pressing and subsequent solvent extraction are almost of the same quality, with the same intensity of colour and F.F.A., which is quite low. The flour attains a pH of about 4.5 as the result of maceration and distribution of the residual acid from the surface. This has the effect of softening the fibre and the material breaks up easily on grinding. The yield of fine flour-passing the 60 mesh sieve is about 80%. The flour contains 18-19% protein and has a soft feel and taste. The residue left after extraction of flour is rather coarse and coloured as it contains a fair proportion of the coconut paring. It is however richer in protein (23-24%) and can be used for either admixture with other foods or as an animal feed. Studies on the nutritive value of the flour and its various uses are now in progress. The reaction of the flour being at the isoelectric point of the protein, the reaction has to be adjusted, preferably, to pH 5.5-6.0 for extraction of the protein. The protein has so far been prepared only on a small scale and further work on the production and use of the isolate are in progress.

Because of its attractive colour, bland flavour and taste, the possible uses of the flour from the acid treated product has already attracted the attention of the food industries in the Philippine and abroad who are interested in developing various uses for the product. The Philippines has vast scope for the development of this class of product which will, not only supplement the available food resources, but also go a long way towards meeting the much needed protein supplement in the dietary of the people.

Preparation of dehydrated coconut segments for use as human food

Although it suffers by familiarity in countries where it is abundantly available, coconut is nevertheless valued for its attractive flavour and taste in countries where it is either not being grown or where it is in short supply. Like many other food products, it is, by itself, an unbalanced article of food; but when mixed with other food products which are low in fibre and fat, it makes a welcome supplement, improving the flavour, taste and nutritive value of the food. The whole coconut in shell has however only a very limited World market firstly because it can be transported only in the highly mature condition, when it is very fibrous, and secondly because it is both heavy and fragile. Desiccated coconut is virtually a luxury product for most developing countries. On the other hand, if the kernel from 'base' mature coconut can be dried by some cheap method in the form of attractive segments with good keeping quality, the problems of packing and transport will be greatly simplified. Such a product can be used, either as such, or after re-constitution by soaking in water and used in the same way as fresh coconut.

Our studies were directed primarily towards determining (1) the effect of different treatments on the edible quality of the dried product; (2) the best means of removing the protective chemical after drying; and (3) final processing before packing. We could carry out only preliminary studies on the packing. Among the various treatments, dipping in a solution of lime (10-15%) followed by dusting of the dried product with lime powder yielded a product which, on washing, had the most acceptable taste and flavour. Dipping in 0.5% metabisulfite, followed within 24-36 hours, with a second dipping in 0.1% sorbic acid also yielded an acceptable product. The drying was done on trays which were placed on racks with a wire netting enclosure permitting of free flow of air. The product had to be given a final drying at 40-50°C for a few hours to reduce the moisture to less than 5%. We found that in sealed containers the dried product preserves the edible quality when inpacked with metabisulfite. The product deteriorates in quality on prolonged storage in polythene bags. Further research is needed to introduce some pre-treatment with antioxidants and edible surface coats to facilitate its storage and marketing in small lots in polythene at other cheap packs.

The most significant part of the present contributions was the finding and the application of a certain property of coconut which facilitates the use of protective chemicals to control infection, reduce spoilage and loss, eliminate the unpleasant odour and to improve the quality of oil. Similar problems exist in respect of a number of oil-bearing materials and some of them have already attracted extensive attention and even caused alarm in certain cases. The possible extension of the same principles and methods to those and to other perishable materials may offer scope for further study and application in many fields.

REFERENCES

- Blackie, W.J., 1931, Fiji Agric. Jour., 4, 111
- Brill, H.C., Parker, H.D. and Yates, H.S., 1917 Copra and Coconut Oil, Phil. Jour. Sci., A 12, 55
- Corbett, G.H., Mohamed Yusope and Abu Hasan. Insects associated with copra in Malaya, Malayan Agric. Jour., 20, 1, 84
- Surridge, H.R., 1931, Fiji Agric. Jour., 4, 90
- Walker, H.S., 1906, The Keeping qualities and causes of rancidity in coconut oil. Phil. Jour. Sci., 1, 111
- Ward, F.S., 1937 Deterioration of copra caused by bacteria and moulds. Malayan Agric. Jour., 2, 95

The author's thanks are due to Chairman Dr. Juan Salcedo Jr., of the National Science Development Board, Commissioner Dr. Canuto G. Manuel of the National Institute of Science and Technology, Director Dr. Conrado R. Pascual and Assistant Director Dr. C. Ll. Intengan; Chairman Mr. Godofredo P. Reyes of the Philippine Coconut Administration; President and Members of the Philippine Coconut Producer's Federation; and Messrs Philippine Refining Company for their keen interest and active support for the furtherance of the project.

"JAIN"
1.9.66