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Investigations into the contamination of Ceylon desiccated coconut

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INTRODUCTION

The contamination of Ceylon desiccated coconut with *Salmonella* and the steps taken to eradicate the contamination were discussed in a previous paper (Velaudapillai, Nitiananda & Meedeniya, 1963). A list of salmonella serotypes isolated from desiccated coconut in the first 3 months of the setting up of the Ceylon Coconut Board Laboratory was also given. Although the hygiene of the product improved tremendously in the following years, samples of desiccated coconut received in the laboratory from a few mills (factories) showed continuous contamination with different salmonella serotypes, and consequently these mills sustained a heavy financial loss. The most persistent serotypes were two strains of *Salmonella senftenberg* (one positive and the other negative for H_2S production), *S. typhimurium*, *S. tennessee* and *S. cubana*. Other contaminants frequently found were *S. paratyphi B*, *S. bareilly* and *S. waycross*.

Investigations were carried out into the reasons for the frequent and persistent contamination as well as to try to trace the source of contamination and to find out at what stage in the manufacturing process the contamination was taking place.

The processing of desiccated coconut can be divided into three main stages: (1) the picking of the fruit and the removal of the outer husk. (2) The preparation of the coconut kernel prior to the disintegration of the coconut meat. (3) The disintegration, drying and packing of the product. The regulations which now govern the manufacture of desiccated coconut (Coconut Products Ordinance, 1961) make it compulsory that stages (2) and (3) be carried out in completely separate parts of the mill, and that there be no access from one part to the other. At stage (2) the outer shell is removed by means of a small hatchet and the brown testa is pared away with a special type of knife to leave only the white kernel. The kernel is then cut up roughly and put into metal tanks containing chlorinated water where the kernel is washed (the section in which this takes place is known as the 'wet' section). The washed kernel is then placed in baskets which are hooked on to a screw conveyor, or placed in a slatted conveyor which takes it through a tank of very hot water (95–100° C.) in 90 sec., one end of the tank is in the wet section, and the other in the dry section (stage 3). The operations at stages (1) and (2) are

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carried out manually and the tank of near boiling water is used to sterilize the coconut.

At stage (3) the coconut kernel which comes off the conveyor is sent down a chute into a hopper which feeds the disintegrator or cutter where it is milled into minute pieces (disintegrated). The disintegrated coconut is collected into aluminium bins placed under the cutter and taken to the Driers. The driers are of two types; the old-fashioned, tray-type drier as described by Galbraith, Hobbs, Smith & Tomlinson (1960) where the drying process can take up to 45 min. for each load, and the newer, semi-automatic type where the coconut is fed into the top of a machine in which very hot air circulates. After about 10–15 min. the coconut emerges from the bottom of the machine, dried. The coconut is dried to about 2% moisture content and then placed on cooling tables. The cooled desiccated coconut is then graded into medium and fine cuts by mechanical sifters from which they are collected into Kraft paper bags ready for export. Grading and packing is done in a separate room which by regulation has to be strictly vermin proof. All manual handling of coconut is forbidden. The entrances to the section where stage (3) is carried out (the 'dry' or 'sterile' section as it is sometimes called), have foot baths containing disinfectant and any person entering this section is expected to use these and also to wash his hands with soap and water which is provided at the entrance. Workers from the 'wet' section are prohibited from entering. One would therefore expect that the coconut at stage (3) would be entirely free of pathogens, if not sterile. However, our investigations revealed that this was not so.

METHODS

Samples of fibre and soil were collected from the places where the husk was removed before transport to the mill. However, as many of the mills were supplied by contractors who gather husked nuts from the estates in the area, this was not always possible.

Samples of material which might harbour salmonellas were collected from inside and around the mill premises. Particular attention was paid to animal faeces, and soil from the yard where the nuts were stored before processing. Samples of water from the wells supplying the mill were collected aseptically and examined for salmonellas and faecal coliform bacilli.

Samples of coconut fibre, parings and kernel were collected at the different stages of processing, and the hands of individual workers were swabbed. As no single worker was ever shown to be the only person in the mill with contaminated hands, all workers are referred to collectively and not individually in the results given in Table 1.

Samples collected at the mills were brought back the same day and examined for salmonellas in the Ceylon Coconut Board Laboratory. These were incubated in tetrathionate and selenite F enrichment broths at 37° C. for 18–24 hr. and plated on bismuth sulphite agar (Difco) and S.S. agar (Oxoid). After 24 hr. incubation at 37° C. suspicious colonies were picked into combined urea-soft agar-Kligler medium (Velaudapillai, 1962) and incubated overnight. Bismuth sulphite plates were

Table 1. *Isolations of salmonellas at the desiccated coconut mills*

Mill	Dung	Soil	Water from drains	Stage of coconut processing: 2	2–3	3*a*	3*b*	3*c*	3*d*	3*e*	Hands
A	2/5 *senft.*	0/6	NE	20/25 *senft.*	0/10	7/10 *senft.*	7/10 *senft.*	10/20 *senft.*	10/20 *senft.*	0/2	NE
B	None	1/9 unident.	NE	11/25 *new.* 3 *para. B* 1 *senft.* 7	0/3	2/5 *senft.*	2/4 *senft.*	NE	1/1 *senft.*	NE	NE
C	0/3	0/3	0/3	0/12	0/2	1/1 *senft.*	3/3 *senft.*	3/4 *senft.*	2/3 *senft.*	NE	3/3 *senft.*
D	2/9 *senft.* 1 *bar.* 1	0/4	0/4	0/10	0/3	0/3	0/5	NE	0/4	0/1	NE
E	0/2	0/2	0/2	4/5 *unident.*	0/1	0/1	2/4 *senft.*	NE	3/5 *senft.*	NE	1/4 *senft.*
F	1/4 *ten.*	4/10 *ten.*	2/3 *ten.*	7/15 *ten.*	0/2	6/8 *ten.*	4/5 *ten.*	3/6 *ten.*	2/2 *ten.*	1/3 *ten.*	NE
G	None	0/1	0/2	3/12 *senft.*	0/1	0/2	0/6	0/1	2/2 *senft.*	NE	NE
H	None	0/2	0/2	0/6	0/1	0/1	0/2	NE	1/1 *ty.mur.*	NE	NE
I	None	NE	NE	0/7	NE	2/2 *para. B*	2/2 *para. B*	1/1 *para. B*	3/5 *para. B* 2 *bar.* 1	NE	2/3 *para.* B
J	None	NE	0/1	0/4	0/1	1/1 *cubana*	3/3 *cubana*	0/1	0/3	1/1 *cubana*	NE

Material examined at different stages of process:

Stage 2. Fibre from shell-removing section, parings, water and coconut from wash tanks.

Stage 2–3. Coconut pieces after immersion in boiling water for 90 sec.

Stage 3*a*. Wet disintegrated coconut meat from cutter.

Stage 3*b*. Wet coconut meat and swab from collecting bin and implements in use.

Stage 3*c*. Partially dried coconut meat from desiccator/drier.

Stage 3*d*. Dry coconut from cooling tables, sifter (grading) and packed bags.

Stage 3*e*. Swabs from hands of workers at cutter.

Hands. Swabs from hands of workers at desiccators or automatic driers.

senft. = *S. senftenberg* (H_2S+ in A, B, C and G; H_2S- in D, E and F); *new.* = *S. newport; para. B* = *S. paratyphi B; bar.* = *S. bareilly; ten.* = *S. tennessee; ty.mur.* = *S. typhimurium;* NE = not examined; unident. = unidentified.

incubated for a further 24 hr. Organisms showing salmonella-like reactions on Kligler medium were identified serologically.

Over 20 mills which sent salmonella-contaminated samples of desiccated coconut were examined in this way, with several sets of samples collected on different days. Tables 1 and 2 give the results of investigations carried out at 10 mills. These mills are considered to be the most representative of all the results obtained. There were some mills where salmonellas were not isolated at any stage of the processing although some of the samples of desiccated coconut, the final product sent to the laboratory, were found to be contaminated.

Table 2. *Number of isolations of salmonella serotypes from routine samples of desiccated coconut from the ten mills shown in Table* 1, *July* 1962 *to August* 1967

Salmonella serotype	Mills									
	A	B	C	D	E	F	G	H	I	J
S. senftenberg H_2S+	40	29	37	.	.	.	7	.	.	.
S. senftenberg H_2S-	.	.	.	49	29	4	.	.	.	.
S. newport	.	2	.	.	.	.	.	.	.	.
S. paratyphi B	.	1	1	.	.	.	.	.	11	3
S. poona	.	.	2	.	.	.	.	.	.	.
S. bareilly	.	.	.	1	.	.	.	.	4	.
S. tennessee	.	.	.	.	.	25	.	.	.	.
S. typhimurium	.	.	.	.	.	.	.	14	.	.
S. litchfield	.	.	.	.	.	.	.	5	.	.
S. cubana	.	.	.	.	.	.	.	.	.	9

Table 3. *Salmonella serotypes isolated from desiccated coconut*

**S. paratyphi B*	*S. butantan*	*S. newport*
**S. typhimurium*	*S. chester*	*S. poona*
**S. senftenberg* H_2S+	*S. cubana*	*S. oslo*
**S. senftenberg* H_2S-	*S. ferlac*	*S. perth*
**S. waycross*	*S. frintrop*	*S. rubislaw*
**S. bareilly*	*S. hvittingfoss*	*S. simsbury*
S. angoda	*S. lanka*	*S. tennessee*
S. adelaide	*S. litchfield*	*S. welikada*

* Most frequent contaminants.

It was not possible to collect stool samples from mill workers for examination for carriers owing to the non-cooperation of the workers who were suspicious that they would lose their jobs. On one occasion the management of Mill D sent some samples collected into Stewart transport medium. No salmonellas were isolated.

A list of salmonella serotypes isolated from desiccated coconut in the Ceylon Coconut Board Laboratory is given in Table 3.

The frequency of isolation of five of the more commonly isolated serotypes is shown in Table 4. The average number of routine samples collected each week from a mill was 3–4 if the mill was not contaminated; if the mill was contaminated, daily samples were collected (5–6/week). Most mills work an average of about 9 months steadily. The off-peak period is December to March when many mills work only a few days in each month.

Heat resistance studies were carried out on strains of *S. senftenberg* producing H_2S (1) and not producing H_2S (2), and also on *S. typhimurium* and *S. bareilly* isolated from desiccated coconut. Cultures suspended in neutral phosphate buffer were sealed in ampoules in 0·2 ml. amounts and heated in a water bath at different temperatures. Survivors were counted on blood agar plates and the time taken for a tenfold reduction (90 %) of numbers was noted. This is the D value (decimal reduction time) for a particular temperature and serotype. Table 5 gives the D values at 57 and 60° C. for the three serotypes.

Table 4. *Salmonella serotypes most frequently isolated from desiccated coconut*

	Number of times isolated (from no. of mills)				
	1962 July–Dec.	1963 Jan.–Dec.	1964 Jan.–Dec.	1965 Jan.–Dec.	1966 Jan.–Dec.
S. senftenberg H_2S+	32 (3)	100 (9)	23 (6)	8 (3)	12 (3)
S. senftenberg H_2S-	5 (1)	1 (1)	34 (3)	4 (2)	21 (4)
S. typhimurium	21 (3)	3 (3)	3 (1)	2 (2)	0
S. bareilly	3 (1)	10 (5)	1 (1)	0	7 (4)
S. paratyphi B	17 (8)	18 (9)	3 (3)	1 (1)	24 (7)
S. waycross	22 (16)	11 (6)	3 (3)	3 (2)	11 (8)

Table 5. *Decimal reduction time* (*D value*) *at* 57 *and* 60° C.

	Time taken in seconds to reduce the viable count by 90 % at	
	57° C.	60° C.
S. senftenberg H_2S+	105	15
S. senftenberg H_2S-	60	12
S. typhimurium	120	30
S. bareilly	100	24

Pigs are common in the areas of major production of desiccated coconut and could have access to some mill premises, therefore pig faeces collected from the animal slaughter house at Colombo were examined for salmonellas. Faeces from a portion of the rectum were squeezed into a sterile jar after slaughter. In the laboratory the specimen was divided into two portions and incubated in selenite and tetrationate liquid enrichment broths for 18 hr. before plating on S.S. and bismuth sulphite agar. Specimens from 93 animals were examined and salmonellas were isolated from 28 (30 %).

RESULTS

The results of ten mills selected as typical of the rest are summarized in Tables 1 and 2.

Mill A

Samples of desiccated coconut were found to be contaminated with *S. senftenberg* in October 1962 and this heavy contamination continued for about 2 months. It was the first mill to show persistent contamination with *S. senftenberg* (40 isolations

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in 11 months); more than 20 visits were paid to the mill and as many sets of samples were collected.

After the isolation of *S. senftenberg* from the droppings of cattle and other unidentified animals—probably polecats—the yard where the nuts were stacked before use was cleaned and tarred in early 1963. The heavy contamination then ceased but occasional samples were still found to be contaminated up to August, 1963. Since then no contaminated coconut has been found at this mill (August 1967).

Mill B

The first contaminant detected was *S. newport* (2 samples) in June 1963, subsequently *S. paratyphi B* (1 sample) and later *S. senftenberg* (H_2S+), which proved to be the most persistent contaminant, were found. This mill was not hygienic and has stopped production.

Mill C

The salmonella serotype first detected here was *S. poona* (2 samples) followed by *S. paratyphi B* (1 sample) and subsequently *S. senftenberg* which was persistently isolated (37 times). Salmonellas were isolated from wet coconut meat coming direct from the cutter, and it was recommended that the cutter be dismantled and thoroughly cleaned preferably by immersion in the sterilizing tank. This was done and appeared to eliminate the contamination. It was also recommended that the cutter should be mounted on metal stands and all wood round the cutter should be removed (before this was done salmonellas were isolated from all parts of the dismantled cutter). No contamination was detected after the recommendations were carried out until August 1967.

Mill D

The condition of the surroundings was poor, as the fibre pit, the site where the coconuts were husked and the cattle shed were all very near to the desiccated coconut mill. Salmonellas were not isolated from the husking site or from stage (2) of the manufacture, but were isolated from cattle dung (*S. senftenberg*) and from a pet monkey on the premises (*S. bareilly*). *S. bareilly* was the first contaminant isolated from this mill, in August 1963 from desiccated coconut; *S. senftenberg* (H_2S-) was isolated later in 1964 and this contamination persisted until August 1967.

Mill E

The desiccated coconut was contaminated in January 1964 with *S. senftenberg* (H_2S-). The mill is situated about 80 miles from Colombo and consequently it was not investigated as thoroughly as one would have wished. No evidence of a source of *S. senftenberg* contamination was found outside the mill but several unidentified salmonella-like organisms (dulcite and citrate positive) were isolated from fibre, parings and wash tanks (Stage 2).

Mill F

In May 1965 *S. tennessee* was isolated 12 times in 4 weeks, but after the dismantling and boiling of the cutter rings and tightening up of hygienic practices

the contamination was eliminated. In the following year an H_2S- strain of *S. senftenberg* appeared and the mill stopped production indefinitely. Table 1 shows the results of the investigation into *S. tennessee* contamination. *S. tennessee* was isolated from cattle dung which may have been the source of contamination.

Mill G

S. senftenberg (H_2S+) was occasionally isolated from desiccated coconut samples from this mill. Contamination was neither persistent nor heavy. *S. senftenberg* was isolated from fibre and parings in the 'wet' section and from desiccated coconut. There is no other clue as to a possible source.

Mill H

This mill is also about 50 miles from Colombo and investigation was inconvenient. The first contaminant found in 1962 was *S. typhimurium* which was very persistent. The organism was isolated from desiccated coconut only and not from earlier stages in manufacture. The mill was closed for some years. In 1966 when it was reopened the desiccated coconut was found to be contaminated with *S. litchfield*. While the second infection was being investigated *S. weltevreden* was isolated from well-water but as the serotype was different, the water was not considered to be the source of contamination, although the probability of there being mixed salmonella serotypes in the water could not be ruled out.

Mill I

Samples gave a mixed contamination with *S. bareilly* and *S. paratyphi B* on about 11 consecutive days in October 1966; the contamination disappeared after the cutter was dismantled and boiled.

Mill J

S. cubana was persistently isolated from routine samples of desiccated coconut from this mill. Table 1 gives the results of only one visit to the mill. It was found that the chute leading to the cutter, the coconut pieces going down the chute, the hands and feet of the worker attending the cutter and the floor surrounding it were contaminated with *S. cubana*, but not the coconut directly from the sterilizing tank. It is possible that the worker or workers brought this contamination into the dry section where it flourished in the favourable environment of the cutter and surroundings.

DISCUSSION

The results of these investigations showed that in the great majority of instances contamination of the coconut took place before drying and not after. The contamination could often be traced back to the 'wet' section of the mill where the coconuts were prepared for processing, and in some instances to animal droppings found in the mill yard.

The results also showed that the main site of contamination inside the mill was the cutter or disintegrator. With the exception of one or two mills, there is only one cutter at each mill, and all the coconut processed at the mill must pass through it before going on to be dried.

The cutter, which disintegrates the pared and sterilized coconut into very small pieces, is made up of two cutting (also called grinding) rings with numerous teeth. These work together at high speed to shred the coconut. During this process some of the milk from the coconut is extracted and remains in the small interspaces. This milk contains fat, sugars, protein and minerals and provides a good source of nutrition for the bacteria. Once in the cutter, the salmonellas are difficult to dislodge. Neither boiling water nor disinfectants can reach the interspaces, and fresh coconut going through the cutter provides increasing nutriment for the salmonellas. It was found that to rid the cutter of salmonellas, it had to be dismantled and the separate parts scrubbed and boiled. As this piece of equipment weighs several hundred pounds, it could only be boiled in the sterilizing tank. This was a tedious process resulting sometimes in the loss of a working day, and was generally carried out only when contamination was detected at the mill. The usual daily practice was to flush it out with the water from the sterilizing tank. Disinfectants were not encouraged as they tended to flavour the coconut. Dismantling and boiling the cutter was successful in the case of Mill C where 37 consecutive samples were found to be contaminated before the cutter was cleaned. After cleaning the product remained free from contamination during the period of investigation up to August 1967. At other mills, however, e.g. Mills B, D and E, the measure was only temporarily successful; the plants were thought to have become recontaminated.

Table 1 shows that when wet, disintegrated coconut meat was contaminated, the bins used for collecting the wet meat, the implements used for handling it, the hands of the workers at the cutter (Mills F, J) and even at the desiccators (Mills C, E) were contamined. Recontamination of fresh batches of coconut, from the hands of these workers, would also take place. The workers could become infected and even act as symptomless excretors. As previously stated this aspect could not be investigated.

The disintegrated coconut meat is sometimes dried in old tray-type desiccators at 85–95° C. for 30–45 min. Operation of these desiccators requires some handling. Coconut is also dried in new semi-automatic driers which require less handling, at even higher temperatures (95–100° C.) but for a shorter time. The moisture content is reduced to about 2 % in this process. The numbers of bacteria are considerably reduced during drying, but not all the vegetative forms are killed. Desiccated coconut after grading and packing had total bacterial counts up to about 10,000/g. and some coliform counts of over 1000/g. Table 1 shows that salmonellas did survive the drying process. A possible explanation is that, although the temperatures in the desiccator are in the range 85–95° C., some of the coconut may reach this temperature only momentarily, if at all. Heat penetration is not uniform, for as the coconut dries it tends to clump together, and salmonellas can survive in these clumps. Laboratory experiments in which about 50 organisms/gram were introduced into wet coconut gave a recovery of over 11 organisms/gram after drying at oven temperatures of 75–90° C. for 30 min. No systematic counts of salmonellas in naturally contaminated samples of desiccated coconut were made but there are indications that in some instances they could be as low as 1/100 g.

This shows that if salmonella organisms are present in the coconut before desiccation in sufficiently high numbers, some will be present in the dried product.

In five of the ten mills shown in Table 1, the same salmonella serotypes were found on the mill premises, or in the stages before sterilizing, as were isolated from the cut coconut meat before drying, and from the desiccated product. It is concluded that contamination is somehow finding its way into the cutter from the outside. Theoretically this should not happen as all the pared coconut must pass through a tank of near-boiling water after which there should be no more handling before it passes along a chute into the cutter. Precautions are also taken to prevent contamination coming in to the dry section in other ways. The problem is how does the cutter become contaminated?

One possibility is that contaminated coconut reaches the cutter despite the sterilization tank. Our investigations showed that salmonellas were absent from the coconut coming out of the sterilizing tank when it was properly operated. However, there is a possibility that certain heat-resistant strains of *Salmonella* were surviving this. This seemed most probable with the two strains of *S. senftenberg* which are the most common contaminants of desiccated coconut. But heat-resistance studies carried out on four strains of *Salmonella* in the laboratory showed that this was not likely. The D values given in Table 5 for these strains when heated in phosphate buffer at 57 and 60° C. with initial cultures of approximately 10^8 organisms/ml. show that the organisms would be destroyed in a matter of minutes at 60° C.

However, Jensen (1945) and Yesair, Boher & Cameron (1946) have shown that when micrococci, for example, are heated in fat their resistance to heat is greater than when heated in water or nutrient broth solution. The fat on the surface of the coconut could have a protective effect on the bacteria. This would be true if the coconut pieces, which are sometimes in the shape of half cups, are cupped together when immersed in the sterilization tank, and so prevent a proper circulation of the boiling water between the surfaces.

T. Velaudapillai (personal communication) suggests that the organisms are only 'shocked' in the sterilizing tank, and recover in the favourable medium of the coconut in the cutter.

In the Phillipines, which is the other large production centre for desiccated coconut, the coconut is sterilized by passing through water at 80° C. for 8–10 min. (Schaffner, Mosbach, Bibit & Watson 1967). This is considered to be satisfactory.

Another likely explanation is that owing to careless supervision the temperature of the water in the sterilizing tank is not strictly maintained at over 95° C. This is likely to happen when long hours are worked at peak periods of production, and has been known to occur.

A further possibility is that as salmonellas are in the mill environment, workers even inside the mill and looking after the cutter and desiccators pick up the organism on their hands, and bring it into the dry section where it thrives in the favourable surroundings of the cutter. It has been shown in Table 1 that hands of workers in this area were contaminated, as well as implements, bins and tables.

Sources of contamination

The investigations led to the conclusion that contamination of the coconuts took place on the mill premises and was due chiefly to infection from animal excreta, and that the organisms multiplied and were encouraged during the stages of manufacture in the 'wet' section. This was passed through to the dry section chiefly to the cutter, and there was another build-up of bacteria in the cutter.

The desiccated coconut industry in Ceylon is situated in the main coconut growing districts of the island, to the north and north-east of Colombo, in rural areas. Many domestic animals are reared in these parts in a rather haphazard fashion. Poultry, cattle and pigs are the most common, and these animals can and do forage in the coconut estates. Cattle are often tethered very near to desiccated coconut mills. Most transportation is by bullock-drawn carts, and cattle droppings are thus scattered around the area. Dogs and semi-wild animals such as polecats and other small creatures could also have access to mill premises at night.

Table 6. *Salmonella serotypes isolated from pig faeces*

S. javiana	*S. give*
S. bareilly	*S. chester*
S. senftenberg H_2S-	*S. stanley*
S. typhimurium	

Table 6 gives a list of salmonella serotypes isolated from pigs, and Schmid & Velaudapillai (1963) isolated *S. paratyphi B*, *S. typhimurium*, *S. virchow*, *S. dublin* and *S. gallinarum* from domestic animals in Ceylon. *S. bareilly*, *S. senftenberg* (H_2S-) and *S. typhimurium* were the serotypes found in both pigs and desiccated coconut; while *S. paratyphi B* and *S. typhimurium* found in other domestic animals have also been isolated from desiccated coconut. In the course of our investigations *S. senftenberg* strains, H_2S+ and H_2S-, were isolated from cattle droppings, and *S. senftenberg* (H_2S+) was isolated from the droppings of an unidentified animal. *S. tennessee* was isolated from cattle droppings and *S. bareilly* from the dung of a pet monkey found in the mill premises. While it may be argued that the animals were contaminated from the coconut, they could still become a reservoir of infection.

It was not possible to investigate whether humans were the chief source of contamination, which they may have been, particularly in the case of *S. paratyphi B* and *S. typhimurium*. Only once was a salmonella isolated from well water—*S. weltevreden* from Mill I.

Whether the source of contamination was animal or human, the contamination of the cutter is the most important factor to be avoided from the point of view of the mill. Not only does the coconut passing through become contaminated, but the contamination is transferred to implements and workers and so to the entire mill, and results in a continuous circle of contamination. This is probably the reason why some mills found it so difficult to eliminate salmonellas despite cleaning and boiling of the cutter. It must be emphasized that to obtain a salmonella-free product with any degree of certainty, the cutter must be regularly and efficiently cleaned, and some method of carrying this out must be evolved.

A special mention must be made of *S. senftenberg* which was the most frequent and persistent serotype found in desiccated coconut; this serotype was also the predominant organism mentioned in connexion with the contamination of Phillipine coconut, where 75% of the salmonellas isolated were found to be *S. senftenberg* (Schaffner *et al.* 1967).

SUMMARY

Investigations were carried out at the desiccated coconut manufacturing 'Mills' in Ceylon to attempt to trace the source and sequence of salmonella contamination of desiccated coconut. It was found that one of the sources of contamination was animal excreta found on the mill premises—the yard where the nuts were stacked. Contamination was passed through the successive stages of preparation for manufacture and into the cutter which became the focal point of contamination within the dry section of the mill. The coconut appeared, in the majority of cases, to have been contaminated before drying. Some of the organisms survived the drying process. Two strains of *S. senftenberg* were found to be the most frequent contaminants of desiccated coconut.

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