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Fumigation of semolina at Madras

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In September and October 1948 two shipments of semolina (840 tons) were received from Australia and taken to the Provincial Reserve Storage at Madras. A further quantity of 550 tons was added to this stock in January 1949. The off-take of this commodity was very low at this period and the stocks had to remain in storage for a long time. The semolina was free from insects at the time of receipt but in the godowns it became infested within six weeks. The examination of the stocks in November showed the presence of flour beetles (*Tribolium castaneum*) ranging from 9 to 96 per pound sample in the various stocks. Stray *Rhizopertha dominica* beetles were recorded from 3 out of the 20 stacks examined. The insect population increased in January 1949 when the *Rhizopertha* beetles became more widespread. A further increase of both the insects was recorded in February and it was evident that the infestation would become more marked in subsequent months. The increase in insect population from November onwards was as below :

Increase in the temperature, due to insect activity developed in several stacks and it was necessary to take up some chemical treatment like fumigation to prevent deterioration.

The main draw backs in the fumigation of milled products appeared to be the greater absorption of the fumigant in the outer layers. The penetration of the fumigant inside the stacks which occurred mainly by diffusion and displacement of the air inside the chamber was very poor on account of the density of the flour. The fumigants was generally absorbed to some extent in the foodsuffs and the residues which were considerably higher in milled products than in whole grains might be harmful to the consumers.

Trial fumigations were conducted with Cyanogas 'A' dust and Killoptera (a mixture of ethylene dichloride and carbon tetrachloride 4 : 1) in wooden barrels each holding one bag (150 lbs.) of semolina. The barrels were made air tight by pasting strips of old news-paper along the joints. The dosages adopted were 3 pounds of cyanogas and 20 pounds of Killoptera for 1,000 c.ft. of space for an exposure of 48 hours. The required quantity of fumigants were calculated on the cubic capacity of the barrels and introduced before sealing the lid.

Samples were drawn with a sampling probe before and after fumigation from these bags both from the outer layers and from the centre of the bags. The insect population and its density in the outer and central portion of the bags were recorded. The percentage of mortality due to the effects of the fumigation was worked out taking into consideration the different species of insects, alive and dead, present in the samples before and after fumigation. The results were as below :

Details of stocks examined			Average insect population in one pound sample											
			November 1948				January 1949				February 1949			
Particular of consignment	No. of stock	Number of bags and Fumigated in	Tri	Rhizo	Grubs	Total	Tri	Rhizo	Grubs	Total	Tri	Rhizo	Grubs	Total
New IV														
S.S. Dogola	9	6,256 Feb. 1949	9	0	5	14	26	11	19	56	36	21	9	66
New V														
S.S. Casteldore	11	7,296 April 1949	9	2	20	31	19	11	25	55	39	34	25	98
Now I														
S.S. Devanah	7	6,905 May 1949									*20	34	22	76

* Examined in April 1949 (Received in January 1949)

Fumigated samples were sent to the Government Analyst, King Institute, Guindy for the analysis of residues. In the case of Cyanogas, the residue was found to be below 5 parts per million. The analysis of Killoptera fumigated samples was not done for want of facilities. The Government Analyst was in favour of adopting Cyanogas fumigation since the degassing and the subsequent aeration would be easier and more complete than the other fumigant. It was therefore decided to fumigate the first batch of semolina bags with Cyanogas 'A' dust making suitable provisions to ensure greater degree of penetration of the fumigant and insect kill.

The big fumigation chamber in the Mint group of godowns was selected for the first fumigation. This chamber was 93′ long 32′ broad and 15′ high with eighteen gas inlet tubes distributed 6 on each side along the length and 3 on each side along the breadth of the chamber. 3,306 bags of semolina were transferred from Mint New IV into this chamber for fumigation.

The stacks inside the chamber were arranged in single file to a height of 8 tiers along the outer margins and 10 tiers around the pillars leaving sufficient space between the rows to provide for free access of the gas for every bag. The stacks arranged around the pillars were two deep and had two exposed faces — one in the space provided around the pillar and the other along the alleyways.

Passages were provided along the entire length and breadth of chamber facing the gas inlets. After the stacking was completed the bags were thoroughly brushed and the spillings collected. Samples were drawn from the different stacks and the insect infestation recorded. 48 samples were taken in all, 32 from individual stacks, 10 from stacks around the pillars, from the sides facing the pillars (as these faces would not be in direct line of Cyanogas dust) and 6 from the centre portions of the bags. The chamber was then closed and made gas proof by pasting strips of newspaper. The gassing was commenced at 8 A.M. and completed by 2 P.M. on 25—2—1949. A higher dosage — 196 lb. of Cyanogas 'A' dust at the rate of 4½ lb. of the fumigant for 1,000 c.ft. of space was applied in this instance to ensure a greater degree of insect kill. The dust was introduced into the chamber with foot-pumps through all the 16 inlets in equal quantities. The chamber was opened after 48 hours on 27—2—1949 at 2 P.M. for degassing and after sufficient aeration, samples were drawn. A second series of 48 samples were drawn under the identical conditions as were drawn before fumigation and the insect population was compared with those of the first drawn samples. The fumigation resulted in the complete kill of adults and grubs of *Tribolium* and *Rhizopertha* beetles. Samples drawn after three days of natural aeration for analysis of residual HCN were declared to be fit for issue by the Government Analyst.

The introduction of Cyanogas left a coating of fine residual dust on the bags. After degassing the bags had to be brushed thoroughly to remove this dust. Though the brushing and the collection of spillings were done before and after fumigation considerable quantities of spillings got mixed up with the dust and the mixed sweepings had to be discarded. In order to avoid this wastage the application of the fumigant was modified in the second fumigation, which was done in the small fumigation chamber (34′ x 24½′ x 13½′) on 3—3—1949. 1375 bags of semolina were transferred from Mint New IV godown and arranged in single file as before. The Cyanogas 'A' dust was spread in thin layers over old news-papers spread on the floor all along the alleyways using gas masks during the operation. 50 pounds of Cyanogas 'A' dust was used at the rate of 3¼ lb. per 1,000 c.ft. of space. From the average of 8 samples it was seen that the insect kill was not as high as in the case of the first fumigation. All the adult *Rhizopertha* and 47% of *Tribolium* beetles were killed as a result of this fumigation. The effect on immature stages was not very significant.

The above two fumigations, involved transfer of bags to the fumigation chambers and an elaborate method of stacking. To avoid these, Methyl bromide, a fumigant reported to have remarkable penetrating qualities and which left no residual dust in the chamber or on the bags was tried in the third fumigation. This was conducted by Messrs. May & Baker (India) Ltd., Bombay on 27—3—1940 as a demonstration in the small fumigation chamber. 1650 bags of semolina were transferred from New IV godown and arranged in four stacks with central gangway dividing the stacks. The bags were stacked to a height of 14 tiers and 8 rows deep arranged in brickwise manner.

The fumigant was stored in a liquid form under pressure in a steel cylinder fitted with a delivery end and a stop-cock. On opening the stop-cock, the contents would be discharged in the form of a heavier than air gas which was pushed out of the cylinder by the pressure inside. The discharge into the chamber was made by connecting the delivery end of the cylinder to a rubber hose, leading into the chamber through one of the gas inlet openings. Inside the chamber this was carried over the nearest stack and fixed at the top of the stack with the other end pointing down towards the central space inside the chamber. The cylinder was counterpoised by weights on a beam scale and the required quantity 16 pounds (@ 1½ lb. per 1,000 c.ft. of space) was let into the chamber by opening the stop-cock. The discharge was completed in 10 minutes. Degassing was commenced after 24 hours by opening the doors and windows from outside, taking care to see that the operator did not directly come in contact with the gas. The stocks were examined after it was found safe to enter the chamber by testing the gas concentration inside with a Tilley lamp. Samples were drawn from the peripheral and central layers of the bags and also from bags in the interior of the stacks. Eight samples were drawn before and after fumigation and the results of analysis compared. There were no live insects either adults or grubs in all the samples after fumigation. The penetration of the gas inside the bags and inside the stacks was very good. Samples of fumigated semolina were drawn at different periods after natural aeration and analysed for bromide residues by the Government Analyst. The analysis of samples drawn after 48 hours of degassing gave 89 parts per million of residual bromide expressed as potassium bromide. A fortnight later it was 58 parts per million after 48 days this came down to 24 parts per million.

The results of this fumigation indicated that methyl bromide was very effective as a fumigant in the case of semolina compared to the earlier fumigations with Cyanogas This had also the advantage of greater ease in handling and did not leave any residual dust. Because of these advantages the next fumigation which was the fourth of the series was done on 15—4—1949 with Methyl bromide in Mint New V godown without shifting or restacking the bags. This godown had a dimension of 140′ x 32′ x 16½′ walls and a gabled roofing (height of roof 10′) covered with Mangalore tiles over flat tiles. The godown wss made air-tight by pasting strips of paper over the doorways and windows. The ventilators and skylights were covered with cardboards and pasted with strips of paper. 8,038 bags of semolina (540 tons) were fumigated using 105 pounds of Methyl bromide at 1 pound for 1,000 c.ft. of space for 24 hours. The gas was discharged into the godown from two points. The discharge in this case was completed in two hours. Within the first half hour the cylinder became ice cold due to the rapid evaporation inside and the delivery of the gas became very slow. To accelerate the discharge, the cylinder was heated from outside by burning small quantities of trash around it. Degassing was commenced on the next day. Samples drawn after fumigation revealed that there was a complete mortality of all adult beetles and grubs after fumigation. Samples drawn six weeks later for analysis of the residual bromide gave a residue of 24 parts per million.

The fifth and final fumigation of the series was done on 10—5—1949 in Mint New I godown having the same dimensions as New V. 7,618 bags (510 tons) of semolina received in January 1949 were fumigated in this godown. 35 pounds of Methyl bromide (the total quantity of Methyl bromide available) were discharged into the godown at one point. The exposure period for this fumigation was extended to 72 hours. The results obtained were not satisfactory. All the insects flying about in the godown and the insects infesting the surfaces of the bags were found killed. Samples drawn from inside the bags on analysis showed the presence of a large number of adults and grubs. The analysis for bromide residues gave 22 parts per million potassium bromide from samples drawn 48 hours after degassing and 17 parts per million from samples drawn 3 weeks later.

The result of the different fumigations and their comparative costs were as below :

TABLE III.

Comparative cost of different fumigations.

Serial No. of fumigation	Number of bags	Fumigant used	Quantity in lbs.	Cost of fumigation in Rs.	Incidental charges in Rs.	Total per ton charges in Rs	Cost per ton in Rs.	Remarks.
I	3306	Cyanogas 'A' dust.	196	245	20	265	1-3-3	Very effective.
II	1375	do.	50	75	5	80	0-14-0	Partially effective.
III	1653	Methyl Bromide	16	32	5	37	0-5-5	Very effective.
IV	8038	do.	105	210	20	20	0-6-10	do.
V	7618	do.	35	70	20	90	0-2-10	Partially effective.

In the case of the first two fumigations, the cost of shifting and stacking worked out to approximately Rs. 1 4 - per ton. This was not necessary in the case of the last two fumigations done with Methyl bromide in the godowns I & V. In the third fumigation, done with Methyl bromide, the bags were shifted to the chamber and back but stacked in the normal way.

The total number of bags treated in all these fumigations were 20,337 bags. The fumigations resulted in the death of the beetles and their grubs in the bags. These dead insects had to be removed by screening before the stocks could be issued. Since the volume of stocks to be cleaned was considerable screening by manual labour was impracticable. The first 300 bags were cleaned at a rice mill situated 3 miles from the Mint godowns at a cost of Rs. 4—4—0 per ton. In addition transport, loading and unloading charges to an extent of about Rs. 2—10—0 per ton was incurred. This was discontinued and a cleaning machine of the type of a tea drier with a 5 H.P. electric motor was installed in the godowns at a cost of Rs. 3,000 -. A sieve suitable for screening semolina was fitted up to this machine and the entire stocks were cleaned at a daily average of 400 bags. This resulted in a considerable saving in trasport and supervision charges and the wastage was reduced to the minimum.

There were differences in opinion regarding the permissible degree of bromide residue in the fumigated stocks. The Government Analyst, Guindy held that 15 parts per million of bromide residues expressed as potassium bromide was the permissible limit and to

reduce the concentration of bromides in the fumigated stocks, the bromide fumigated stocks were diluted by mixing with non fumigated or Cyanogas fumigated stocks at the time of their cleaning.

Methyl bromide was a fumigant widely used in America and the Federal Bureau of Entomology and Plant Quarantine were recommending the use of this fumigant for grains and milled cereals at the rate of one to two pounds for 1,000 c.ft. of space for an exposure of 24 hours. Both the Federal Bureau of Entomology and Quarantine and the Food and Drug administration, Washington, were of opinion that the residues in wheat products when fumigated at the above concentrations did not result in a residue which would be a matter of concern from the stand-point of the enforcement of the Federal drug and Cosmetic Act. A residue of 37 parts per million would not be a matter of concern.

Milled products had not been subjected to fumigation so far in Madras. Of the above five fumigations, two with Cyanogas and three with Methyl bromide the latter had given comparatively better results from the point of view of insect kill, penetration, easier handling and low cost. The toxicity of the gas, its lack of warning odour in concentrations likely to be harmful and the absence of easy and reliable tests and the toxicity of the residues might require further examination. The evidence from literature on these aspects were abundantly in favour of its increased adoption.

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TABLE I.

Comparative effects of Killoptera and Cyanogas A-dust

Details of samples examined	Average Insect population per pound sample												Effect of fumigation on immature stages and adults Percentage of mortality		
	Before Fumigation						After Fumigation								
	Tribolium		Rhizopertha		Grubs		Tribolium		Rhizopertha		Grubs		Tri	Rhizo	Grubs
	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead			
Fumigated with "Killoptera" Average of 3 fumigation (5—2—1948)															
Outer portions of the bags ...	40	9	17	9	11	1	4	52	6	36	8	11	73	51·1	49·6
Central portions of the bags ...	16		9	12	21	1	4	16	4	3	12	9	50	...	38·4
Fumigated with "Cyanogas 'A' dust — Average of 3 fumigations (5–2–1948.)															
Outer portions of the bags ...	25	9	25	6	18	2	5	27	...	24	3	3	57·9	100	40·0
Central portions of the bags ...	26	24	3	2	9	1	7	18	...	19	1	5	24·0	100	73·3
Distribution of insects in outer and central portions was 69·1% & 30·9%															

TABLE II.
Results of different fumigations

No. of samples	Particulars	Average Insect population per pound sample												Effect of Fumigation on adults and immature stages % age of mortality		
		Before Fumigation						After Fumigation								
		Tribolium		Rhizopertha		Grubs		Tribolium		Rhizopertha		Grubs		Tri	Rhizo	Grubs
		Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead			
	First Fumigation :— Big Fumigation Chamber–Cyanogas @ 4½ lbs per 1000 cft. of space for 48 hours. 3306 bags 25—2—1949															
32	Drawn from peripheral layers from 32 stocks ...	18	...	20	19	25	...	...	All	...	All	...	...	100	100	100
10	Drawn from around the pillars ...	19	4	15	13	29	...	...	All	...	All	...	...	100	100	100
6	Drawn from centre of bags ...	17	6	40	24	21	...	...	All	...	All	...	...	100	100	100
	Second Fumigation: Small Fumigation Chamber–Cyanogas @ 3¾ lbs. per 1000 cft. for 48 hours 1375 bags 3—3—1949															
8	Average of 8 samples ...	12	4	26	14	...	...	12	22	...	40	...	...	47·1	109	...
	Third Fumigation :— Small Fumigation Chamber–Methyl Bromide @ 1-1/5 lbs. per 1000 cft. of space for 24 hrs 1650 bags 27–3–49															
4	Drawn from peripheral layer from stocks ...	20	5	54	32	19	...	...	All	...	All	...	...	100	100	100
2	Drawn from top layers in pheripheral layers ...	11	1	24	12	5	...	...	11	...	All	...	...	100	100	100
2	Drawn from top layers from centre of bags ...	4	...	18	...	4	...	...	11	...	11	...	...	100	100	100
	Fourth Fumigation :— Mint and New V Methyl Bromide @ 1 lb. for 1000 cft. of space for 24 hours 8038 bags 15—4—1949															
12	Drawn from different stock including central portion of bags ...	59	18	71	70	32	...	...	11	...	11	...	...	100	100	100
	Fifth Fumigation :— Mint New I Methy Bromide @ ⅓ lb. per 1000 cft. of space for 72 hours 7618 bags 10—5—1949															
8	Drawn from different stocks including central portions of bags ...	25	3	42	4	Not received		29	9	58	41	Not received		13·0	33·3	