

# Commercial Experience of Sealed Storage of Bag Stacks in Indonesia

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## Abstract

BULOG has adopted the use of sealed plastic enclosures purged with CO<sub>2</sub> as one option for the long-term storage of bagged, milled rice. This system has been successfully implemented in two phases beginning in 1984 and since then some 90,000 tonnes of milled rice have been stored for periods up to 2.5 years. Although the technique has been an operational success, in that the outturn quality has met with considerable approval, technical and managerial improvements are possible.

Technically, there is a need for further developments to reduce costs, by increasing the potential for reuse of sheets and by lowering the rate of failure in gas retention. It is believed that the failure rate could be much reduced by further technical refinement.

On the management side, there remains considerable scope for the full integration of the CO<sub>2</sub> method into BULOG's operational system. This could be achieved through a more comprehensive cost-benefit analysis, better forecasting of requirements for long-term storage, and more accurate identification of the best locations for long-term stocks. It appears that the CO<sub>2</sub> system may become a permanent feature of the BULOG rice storage system, its extent being governed by the need for longer term storage.

THE long term storage of bagged, milled rice under carbon dioxide (CO<sub>2</sub>) in fully sealed plastic enclosures offers an alternative to the regular use of fumigation and insecticide spraying for grain preservation. The initial development of the technique was undertaken by CSIRO in Australia, and the technology transferred to the humid tropics through a collaborative small-scale project with BULOG, at Tambun, West Java (Annis et al. 1984). The technique was successfully used to store about 700 tonnes of rice, with a 12% moisture content, for periods of up to 4 months. The practicalities of implementing the technique were considered and it was found that the enclosures could be built by two men in just over an hour.

As the method was clearly practicable, BULOG undertook a larger scale trial using

6400 tonnes of rice at 13-14 % moisture content (Sukardi & Martono 1984; Suharno et al. 1984). This trial compared the use of CO<sub>2</sub> and phosphine in sealed enclosures for periods of up to 16 months. From the results, it was concluded that CO<sub>2</sub> treatment was more effective than phosphine in controlling both insect pests and mould growth and would be ideal for use in long-term storage, provided the enclosures remained undamaged. Some consideration was also given to the economics of the method. An analysis was performed on costs and anticipated rice losses. This gave the minimum break-even period with normal pest control methods as about 9 months. Later analysis based on costs alone put the break-even period at about 12 months (Suharno 1986).

Against this background of successful experimental trials, it was with some confidence that BULOG embarked upon operational CO<sub>2</sub> storage in 1984. To date, some 90,000 tonnes of milled rice have been stored at various locations in Indonesia (Table 1). The

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techniques employed are summarised in the Appendix. This short paper describes the operational methods used by BULOG, gives summaries of some of the data collected by the operational teams, and considers technical and management aspects that might be improved.

## Operational Considerations

### CO<sub>2</sub> Concentration

Stocks in the BULOG system are purged with CO<sub>2</sub> to give an initial concentration of the gas of 80%, declining to a minimum of 50% after 10 days and not less than 10% after 6 months. This dosage schedule is somewhat higher than the latest recommendations for the technique, which are for 70% CO<sub>2</sub> initially, declining to 35% after 15 days or longer (Annis 1986). At the time the technique was developed in Indonesia, an initial concentration of 60% was required. However, this was increased when live, but moribund, specimens of *Sitophilus oryzae* were

discovered some weeks after treatment. It is well established that this species is particularly tolerant of CO<sub>2</sub> (Annis 1986).

The gas levels achieved in 57 rice stacks in East Java during the 1987-88 program are shown in Figure 1. (Data from stacks with substantial leaks have not been included.) The profile of decline in gas concentration matches that recorded during experimental studies by Sukardi and Martono (1983). The concentration regime has been successful in destroying existing infestations and preserving rice quality.

Two practical questions concerning the gas concentration are worthy of consideration:

- Is it necessary to insist on so high an initial gas concentration?*
- What should be done if the gas concentration drops below 10%, as it invariably does after about 8 months, and continued long-term storage is envisaged?*

Currently, BULOG regulations would stipulate regassing, but there is no conclusive evidence that this is necessary. If regassing is performed, it is not known what extent of regassing would be cost effective for any given additional storage period.

**Table 1.** Tonnages of milled rice preserved at various locations in Indonesia using the CO<sub>2</sub> method

Region	Phase1	Phase2	Total
Jakarta Raya	28200	14116	42316
West Java	4750	0	4750
Central Java	2700	1500	4200
East Java	11578	19730	31308
South Sulawesi	4900	0	4900
North Sumatra	4500	0	4500
Total	56628	35346	91974

### Failures in Gas Retention

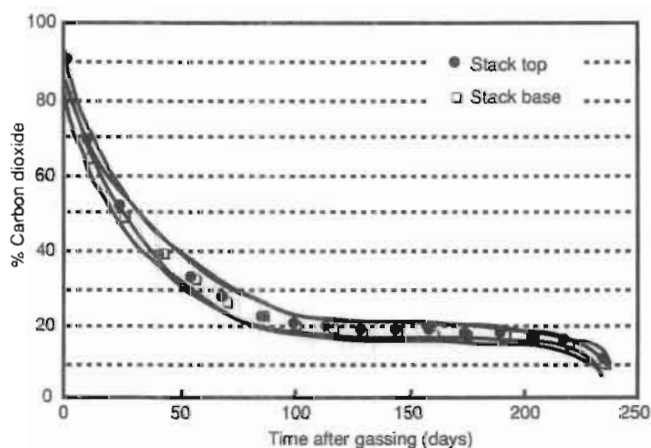
Gas retention failure in stacks can take three forms:

- large gas leaks in the first 10 days, resulting in the initial fumigation by CO<sub>2</sub> being ineffective;
- subsequent failures due to large holes made in the sheets by, for example, rodents; and
- failures due to small leaks that result in a gradual fall in the CO<sub>2</sub> concentration to below 10% during the first 6 months after gassing.

The frequency of failure has been found to

**Table 2.** Records of failures in gas retention at various locations in Indonesia (incomplete data).

Location	No. of stacks	No. of failures	% Failure
Jakarta	109	32	29
West Java	12	7	58
Central Java	16	0	0
East Java	70	13	17
South Sulawesi	6	3	50
North Sumatra	12	2	17



**Figure 1.** Mean CO<sub>2</sub> concentration in rice stacks.

vary between locations (Table 2) averaging around 25%. Much higher failure rates were encountered in those stores suffering from heavy rodent infestation, e.g. in West Java, South Sulawesi, and Jakarta (Table 2). In East Java, about 17% of stack treatments failed. In the first 10 ten days after purging, 3 of 70 stacks required regassing. These failures all occurred at a particular site and, together with the somewhat higher than specified gas dosages needed to achieve an 80% initial concentration, resulted in use of an average of 3.2 rather than 2.4 kg of CO<sub>2</sub>/tonne. In the most recent phase of CO<sub>2</sub> storage in East Java, failures to retain more than 10% gas were remedied without financial loss as the stocks concerned were distributed soon after the enclosure atmosphere had fallen below 10% CO<sub>2</sub>. While this management option may frequently present itself, in a well planned CO<sub>2</sub> program where all stacks are stored for the minimum period required to break-even with normal stock protection methods, such failures would necessarily represent an undesirable loss.

Recorded causes of failures are rodent damage, inadequate sealing, manufacturing defects in the plastic sheets, and holes caused by contact with the wooden pallets. Birds and insects (e.g. *Rhyzopertha dominica*) made holes in sheets on only two occasions. It seems probable that the failure rate could be much reduced if (a) an effective anti-rodent strategy involving rodent barriers and poison baits were developed for those godowns used in the CO<sub>2</sub>

program, (b) better quality sheets were used, and (c) pallets were abandoned and the bags stacked directly on the base sheet.

### Rice Quality and Value

Quality changes in rice stored for 70–250 days under CO<sub>2</sub> in East Java are given in Table 3. Samples were taken from marked bags on the stack surface at the start of the storage period and again from the same bags at the end. All the sampling and analyses were undertaken by Pest and Quality Control staff as part of their normal routine.

Overall, there seems to be a general trend towards a small increase in the numbers of brokens and yellow grains, and in the moisture content. Small increases in moisture content and yellowed grains in the outer bags of stacks have been observed previously (Sukardi and Martono 1983; Suharno et al. 1984). In contrast, observations on rice stored in Jakarta for 2.5 years showed a very slight decrease in moisture in the outer layers, but agreed in other respects. In Table 3 a comparison is also made of quality factors for stacks which had a period of storage at below 10% CO<sub>2</sub> concentration for an average of 34 days (range 15–66 days), with those from stacks maintained at a higher concentration throughout the storage period. It would appear that storage at the lower concentration had, on average, no detrimental effects. In fact, the rice quality from these stacks appeared somewhat better. Even those stacks held for the longest

**Table 3.** Quality analysis of rice from the East Java CO<sub>2</sub> program (Mean % ±sd)

Storage period (days)	Number of stacks	M.C.			Brokens			Yellow/Damaged grains		
		Start	Finish	Change	Start	Finish	Change	Start	Finish	Change
70–100	17	13.41	13.83	0.43	22.82	24.44	1.62	2.30	2.28	-0.03
		0.36	0.11	0.37	3.38	2.50	2.81	0.58	0.57	0.40
101–200	24	13.42	13.38	-0.04	26.29	28.25	1.96	2.22	1.98	-0.24
		0.32	0.48	0.38	2.43	3.06	3.19	0.61	0.78	0.66
201–250	21	13.44	13.74	0.32	5.37	25.42	0.05	1.62	2.19	0.57
		0.26	0.23	0.15	4.79	5.57	2.42	0.41	0.38	0.40
Overall mean ±sd		13.42	13.63	0.21	25.03	26.24	1.22	2.04	2.13	0.09
		0.31	0.39	0.38	3.89	4.30	2.96	0.62	0.62	0.62
Stacks* >10% CO <sub>2</sub>	47	13.40	13.64	0.24	23.88	25.51	1.64	1.92	2.01	0.10
		0.30	0.39	0.41	3.59	4.40	3.11	0.54	0.54	0.63
Stacks** <10% CO <sub>2</sub>	15	13.48	13.60	0.11	28.33	28.35	0.02	2.40	2.47	0.07
		0.35	0.38	0.25	2.64	3.18	2.05	0.68	0.73	0.60

\* Mean % ±sd for stacks always maintained above 10% CO<sub>2</sub>

\*\* Mean % ±sd for stacks stored part time below 10% CO<sub>2</sub>





