Technologies for storage and preservation of coffee beans in India

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Abstract

India produces around 200000 tonnes of coffee seeds annually. The hot humid climate and high rainfall required for coffee cultivation is not suitable for storage of coffee seeds and therefore the Coffee Board and curers in India transport all coffee seeds to interior country depots to preserve the quality.

The Ballooning Technique was developed to enable coffee seeds to be stored in places where coffee is produced and cured. This technique involves enclosing the coffee bag stacks with two low density polyethylene sheets of 100 microns thick with the open ends of the top and bottom sheets sealed together. Coffee seeds with an initial moisture content of 10–11% stored under this technique retained all their original quality attributes even at the end of 5 months storage.

Coffee seeds above 13% moisture are susceptible to infestation by the coffee bean weevil *Araecerus fasciculatus* (De Geer). Control of the weevil with methyl bromide alone or in a mixture with ethylene dibromide was found to be effective at 32 g/m^3 with an exposure period of 24 hours under covers, with no loss of chemical constituents and other attributes. In view of the restrictions of the use of bromides, fumigation trials were carried out with aluminium phosphide tablets at a concentration of 1.5 gm of phosphine/m^3 and an exposure period of 7 days—this gave 100% control of insects. Fumigation trials with carbon dioxide were carried out on coffee stacks, and complete insect control was achieved with no reduction in the quality of coffee.

Introduction

The varieties of coffee grown in India are Arabica and Robusta. Coffee is grown on the hill slopes in the humid and semi-humid areas with an annual rainfall of 200–250 cm and a temperature of 35–40°C. Around 200000 t of coffee are produced in the country. Only one crop is produced and harvested annually. Indian coffee may be processed by the wet process (washed) in which parchment or plantation coffee is prepared, or the dry process (unwashed) in which 'natural' or 'cherry' coffee is prepared. Both parchment and cherry coffee are further processed in curing works which are situated in the coastal and high rainfall areas. The two important problems in the storage of coffee beans are moisture and insects. In this paper the techniques adopted for the storage and protection of coffee beans in India are outlined.

Ballooning Technique

The moisture content of coffee beans at harvest ranges from 18–22%, and this has to be brought down to around 10% for curing. During rainy months both raw and finished coffee absorb moisture. In the hot humid climate during storage, coffee loses its colour, aroma, flavour and the body of the brew. Hence the bulk of the coffee beans produced has to be transported to the interior areas where humidity and rainfall are lower (50–60% and 75–125 cm, respectively), before the onset of monsoon rains. Green coffee beans pick up moisture from the humid atmosphere and undergo changes in colour and density. The chemical constituents are not altered as a result of imbibition of moisture; however, the cup quality is affected. Microbial population increases with an increase in moisture content (Natarajan et al. 1961). Coffee beans transported and stored in the low humidity and rainfall areas of the interior do not undergo any significant change in quality.

However, the cost of transportation is high. To preserve the quality of coffee stored in high humidity areas, the Central Food Technological Research Institute has developed the 'ballooning technique' (Fig. 1). This technique prevents the ingress of moisture to the dried coffee beans. Storage studies were carried out using this technique in different coffee curing works situated in high humid areas (Majumder et al. 1961a). The technique involves enclosing the coffee bean stacks with two low-density polyethylene sheets of 100 microns thickness. The open ends of the top and bottom sheets are rolled and sealed. The moisture content of coffee beans at the time of storage was 10.0%. Storage trials with 75 million t of coffee beans were carried out in the coastal areas for a period of 5 months following the ballooning technique. It was observed that the stored coffee maintained its original colour, bulk density, bushel weight, caffeine, chlorogenic acid and cup quality. There was no increase in moisture content and microbial load. The control coffee beans stored in bags outside the balloons recorded a microbial load of 20000–30000 colonies/g and a bushel weight of 17.6 to 20.4 kg as against 6500–7000 colonies/g and a bushel weight of 24.8 kg in the coffee beans stored in polyethylene balloons.

The ballooning technique was originally demonstrated three decades ago, but the Coffee Board and the curers in India did not adopt this storage technique, for various reasons. In 1991, the 'ballooning technique' was simplified (reducing the cost), the sealing of the sheets improved, and better use made of films like liniar low density polyethylene—multilayered cross laminated low density polyethylene films having better functional and handling properties and service life. Due to the high costs of transporting coffee to inland warehouses and back, high handling and storage costs, and quality requirements in importing countries, the Coffee Board and the curers adopted the ballooning method. Since 1991, around 2000–2500 t of cured and uncured coffee have been stored using the ballooning technique. With the preference for organic coffee expressed by importers, many coffee planters have tried to store the coffee under polyethylene balloons until exported. Table 1 gives the cost analysis of storing 1000 t of coffee using the ballooning technique. The cost of transportation to, and storage in, the interior warehouses is around Rs574/t while the cost of storage using the ballooning technique is around Rs452/t in the first year and Rs118/t in subsequent years—the materials including the floor sheet and cover sheet can be reused for 4–5 years. With the introduction of new

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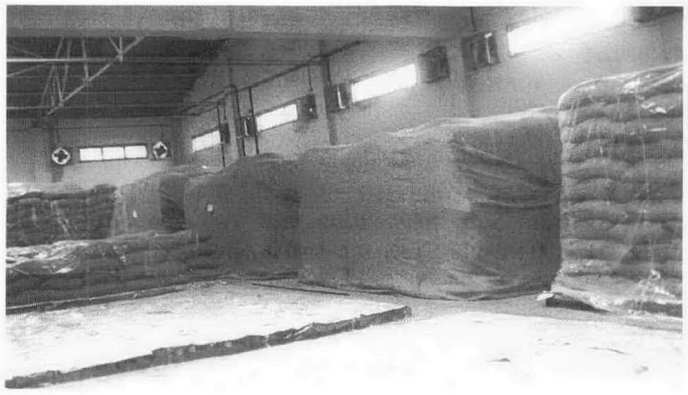

Fig. 1. Coffee stacks under balloon technique.

films, fumigation can be carried out in the balloon when long storage is required. Cross infestation is protected by spraying a deltamethrin formulation on the hessian cloth draped on the balloon.

Table 1. Cost of storage of coffee beans in coastal/ high rainfall areas using the ballooning technique (cost in rupees to store 1000 t for one year).

Site no.	Material	1st year	2nd year
1	Polyethylene sheet	5183	–
2	Hessian cloth	23800	–
3	Adhesive tapes and accessories	2272	2272
4	Residual spray	1852	1852
5	Wooden pallets	231200	–
6	Labour	20000	20000
7	Depreciation for items 1,2,5 @ 20% for Rs306935	61367	61367
8	Interest on Rs330959 @ 10%	33095	33095
	Total	425421	118586
Cost of storage/t		425	120

Infestation control in coffee beans

Coffee bean weevil *Araecerus fasciculatus* is one of the serious insect pests of coffee beans, especially in the coastal climatic conditions. However, they have also been recorded in the inland warehouses where the moisture content of stored raw coffee is high. Coffee bean weevil infests all varieties of coffee beans. 'Monsooned' coffee beans, which are in demand in several countries in Europe (particularly Scandinavian countries), are very susceptible to this insect. The process of monsooning involves exposing Arabica or Robusta cherry coffee beans to monsoon weather for slow uptake of moisture (15–16%), causing the coffee to swell in size, to attain golden colour and to have natural mellow flavour. Narasimhan et al. (1972) report that irrespective of varieties and the place of storage, infestation can develop when the moisture content of coffee beans in storage exceeds 13.0%. They also report the effect of insect infestation on quality changes in coffee beans. Majumder et al. (1961b) carried out extensive field trials on curative and prophylactic measures for coffee beans. Based on their recommendations, the Coffee Board is adopting fumigation of coffee beans with methyl bromide followed by a prophylactic spray on the coffee bean stacks. A dosage of 16–32 g/m^3 with an exposure period of 24–48 h has given 100% mortality of all stages. The bromide residue was in the range of 7–37 ppm in different varieties of coffee beans. Methyl bromide did not affect the cup quality.

In view of the restrictions on the bromide residues and the use of methyl bromide itself in industrial countries, fumigation trials were carried out with aluminium phosphide tablet preparations. A dosage of 1 and 1.5 g PH_3/m^3 and exposure period of seven days gave 100% control of all stages of coffee bean weevil. Polyvinyl chloride (PVC), nylon supported linear low density polyethylene (LLDPE) and multilayered cross laminated low density polyethylene are the choice as fumigation covers/sheets. The terminal concentration of phosphine in the stacks ranged from 0.1 to 0.5 g/m^3. PVC sheets retained phosphine better than other sheets tested, irrespective of varieties (Figs. 2 and 3). Phosphine did not affect the chlorogenic acid content and the cup quality.

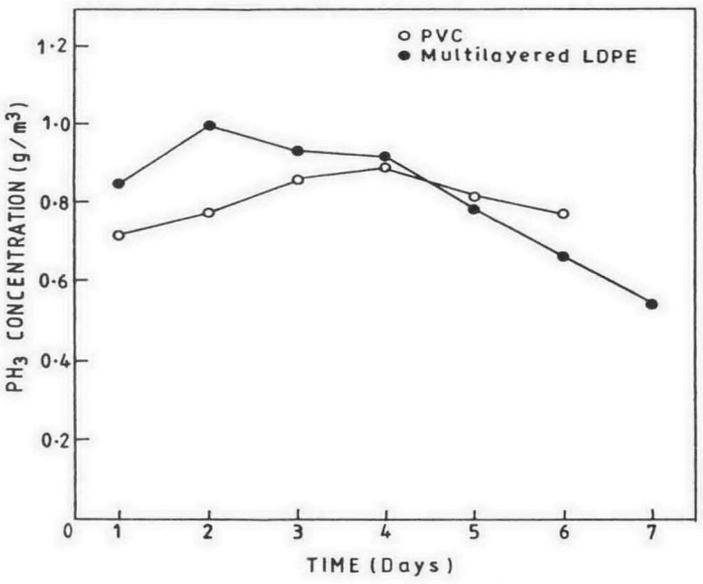

Fig. 2. Phosphine concentration levels during fumigation of Robusta parchment coffee (11.4% moisture content) with phosphine at 1.5 g/m^3.

Controlled atmosphere storage of coffee beans

The existing practice of fumigation with methyl bromide or phosphine may have to be reviewed in view of global concern about pesticide residues in commodities. This holds good for coffee beans also, as importing countries might restrict the use of fumigants in the coffee imported to their country. Furthermore, development of resistance to phosphine has been reported for many stored-product insects. Hence use of controlled atmosphere for disinfestation and storage of coffee beans is the alternate choice. Studies were carried out with

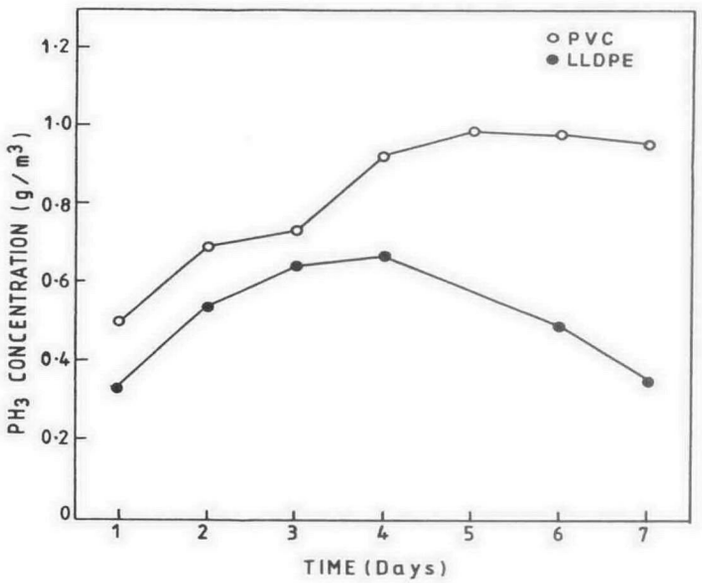

Fig. 3. Phosphine concentration levels during fumigation of plantation coffee beans (9.5% moisture content) with phosphine at 1.5 g/m^3.

CO_2-rich atmosphere on the disinfestation and storage of coffee beans in curing works situated in different agro-climatic conditions in South India. Experiments were conducted on 30 t lots packed in jute bags using plain PVC base sheet (500µm thick) and cover sheet (200 µm thick). A dosage of 3 kg CO_2/t of coffee beans was needed to get the required concentration of 80% at the top (Fig. 4). The methodology of CO_2 application was followed as described for grains (Narasimhan et al. 1994), following the technique of Annis and Graver (1991). Monsooned coffee beans with 14.6% moisture were treated with CO_2. It was terminated at the end of 40 days. The CO_2 concentration at the end of 40 days was 30%. Coffee beans had retained their original flavour, physical and chemical attributes. Coffee beans with higher moisture contents (15%) had higher sorption rate compared to the coffee beans with moisture content of 10–11%. There was no change in the physical and chemical constituents; coffee beans maintained their original flavour and cup quality. Cost analysis of CO_2 treatment in comparison with PH_3 is given in Table 2.

Conclusion

The ballooning technique has gained importance in recent years for the storage of coffee beans in the coastal areas.

Table 2. Cost analysis of treatment of 30 t bagged coffee beans with CO_2 or PH_3 fumigation (rupees).

Site no.	Material	CO_2 (rupees)	PH_3 (rupees)
1.	Man-day charges—technical	750	750
2.	Labour	400	400
3.	Sandsnakes	-	-
4.	Floor sheet (PVC 500µm)	1500	–
5.	Cover sheet (PVC 200µm)	2250	2250
6.	Cost of CO_2/PH_3	540	75
7.	Residual spray	-	65
8.	Sealants and accessories	375	–
9.	Dunnage	6800	6800
	Total	12615	10940
Treatment cost/t		420	365

Storage by the curers and Coffee Board has gone up from 1000 million t in 1991 to 3000 million t in 1993. Disinfestation of coffee beans using aluminium phosphide formulations will be adopted by the Coffee Board and the curers following trials in different agro-climatic situations. Use of carbon dioxide as an alternate control technique to conventional fumigation is also likely to increase.

Acknowledgments

The authors would like to thank the Coffee Board and the coffee curers for extending facilities to carry out the trials. The authors also thank the Director, CFTRI, for his support in the program.

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